

CHAPTER 12

SPECIES TREATMENT (Enumeration of the

220 obligate or near-obligate cremnophilous succulent and bulbous taxa)

FERNS

POLYPODIACEAE

Pyrrosia Mirb.

1. *Pyrrosia schimperiana* (Mett. ex Kuhn) Alston

PYRROSIA Mirb.

1. *Pyrrosia schimperiana* (Mett. ex Kuhn) Alston in Journal of Botany, London 72, Suppl. 2: 8 (1934).

Cremonophyte growth form: Cluster-forming, subpendulous leaves (of medium weight, cliff hugger).

Growth form formula: A:S:Lper:Lc:Ts (p)

Etymology: After Wilhelm Schimper (1804–1878), plant collector in northern Africa and Arabia.

DESCRIPTION AND HABITAT

Cluster-forming semipoikilohydric plant, with creeping rhizome 2 mm in diameter; rhizome scales up to 6 mm long, dense, ovate-cucullate to lanceolate-acuminate, entire. Fronds ascending-spreading, becoming pendent, 150–300 × 17–35 mm, succulent-coriaceous, closely spaced to ascending, often becoming drooping (2–6 mm apart); stipe tomentose (silvery grey to golden hairs), becoming glabrous with age. Lamina linear-lanceolate to linear-obovate, rarely with 1 or 2 lobes; margin entire; adaxial surface tomentose becoming glabrous, abaxial surface remaining densely tomentose (grey to golden stellate hairs); base cuneate; apex acute. Sori rusty brown dots, 1 mm in diameter, evenly spaced (1–2 mm apart) in distal two thirds on abaxial surface, emerging through dense indumentum.

Phenology: Sori produced mainly in summer and spring. Spores dispersed by wind, coinciding with the rainy season.

Habitat and aspect: Sheer south-facing cliffs and rocky embankments, among lichens and other succulent flora. Plants are scattered, firmly rooted in crevices and on ledges. The average daily maximum temperature is about 26°C for summer and 14°C for winter. Rainfall is experienced mainly in summer, 1000–1250 mm per annum.

Altitude: 1400–1600 m.

Associated vegetation: Mosaic of Northern Mistbelt Forest (Forest Biome) and the Sub-Escarpment Savanna Bioregion of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aeollanthus parvifolius*, *Aloe spicata*, *Cotyledon barbeyi*, *Delosperma leboomboensis*, *Peperomia blanda* and *Plectranthus cylindraceus*.

Geology: Quartzitic sandstone of the Black Reef Formation (Transvaal Supergroup) with many fissures, ledges and crevices ideal for establishment of plants.

DISTRIBUTION

Widespread in Africa and reaches its southernmost limit in Mpumalanga at the Blyde River Canyon (altitude of 1400–1650 m).

RELATED SPECIES

Differs from *Pyrrhosia africana* by its adaxial leaf surface which is densely hairy at first, becoming glabrescent with scattered sori on the lower surface. *Pyrrhosia africana* is an epiphyte occurring in coastal forest of the Eastern Cape and KwaZulu-Natal, with the upper leaf surface subglabrous and the sori clustered on the lower leaf surface. The succulent, semipoikilohydric leaves and dense, hairy surface of *P. schimperiana* are probably an adaptation to its xeric cliff-face habitat.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants clustered, with creeping rhizome rooting in crevices, with spreading to drooping fronds. Slow-growing, long-lived perennial.

Size and weight: Heads small, of medium weight.

Stem: Creeping rhizome covered in rhizome scales.

Leaves

Orientation: Spreading and drooping, semipoikilohydric, in winter becoming desiccated but recovering after rain. Well adapted to the dry, xeric habitat.

Succulence: Succulent.

Colour and texture: Green, covered with dense tomentum, becoming glabrescent on adaxial surface; lower surface densely hairy and probably contributing to conservation of water.

Age and persistence: Long-lived, perennial.

Armament: None.

Sexual reproduction

Sori: Scattered on lower surface.

Spores

Dispersal: Spores wind-dispersed, germinating in suitable habitats.

Time: Spores released in the rainy season.

Vegetative reproduction: Plants form clusters from short, creeping rhizomes, thus ensuring a hold on the cliff-face habitat. Spreading by means of vegetative growth, proliferating and rooting where the rhizome touches a crevice (vegetative backup).

CONSERVATION STATUS

Classified as of least concern (Raimondo *et al.* 2009). A rare species, but not threatened owing to the safe cliff habitat.

ADDITIONAL NOTES

Horticulture: *Pyrrhosia schimperiana* is a worthwhile introduction to horticulture and thrives in small containers or hanging baskets. It can also be grown on rocky embankments. It is best grown in a loamy, well-drained soil, with ample feeding during the summer growing season. It is recommended for moist savanna or warm subtropical gardens and should be kept in semishade and well watered in summer. Plants can be divided in spring. In regions with frost the plants should be brought indoors in winter.

VOUCHER

Van Jaarsveld 17246 (NBG).

ILLUSTRATIONS AND MAP

Plate 1, Figures 1a–1c, Map 1.

FLOWERING PLANTS

Monocotyledons

AMARYLLIDACEAE

Cyrtanthus Aiton

2. *C. falcatus* R.A.Dyer
3. *C. flammosus* Snijman & Van Jaarsv.
4. *C. flanagani* Baker
5. *C. herrei* (F.M.Leight.) R.A.Dyer
6. *C. inaequalis* O'Brien
7. *C. junodii* P.Beauv.
8. *C. labiatus* R.A.Dyer
9. *C. montanus* R.A.Dyer

Haemanthus L.

10. *H. albiflos* Jacq.
11. *H. humilis* Jacq. subsp. *humilis*
12. *H. paucifolius* Snijman & A.E.van Wyk

CYRTANTHUS Aiton

2. *Cyrtanthus falcatus* R.A.Dyer in *Herbertia* 6: 76, t. 138, fig. 1 (1939).

Cremnophyte growth form: Cluster-forming, epigeous, bulbous, with pendent leaves (of medium weight to heavy, cliff hugger).

Growth form formula: A:B:D:C:Lp (e) (vb) (eg)

Etymology: Latin *falcatus*, sickle-shaped, pertaining to the leaves.

DESCRIPTION AND HABITAT

Deciduous, epigeous, cluster-forming bulbous plants. Bulbs ovoid to globose, up to 80 mm in diameter, sprouting from base, tapering to a neck up to 120 mm long; tunics dense, brown to grey, membranous. Leaves up to 4, linear, up to 350 × 30 mm, leathery, green; apex acute. Scape up to 300 mm long, glaucous, 15 mm in diameter near base and about 10 mm distally, characteristically recurved at the top with a pendent umbel of up to 10 flowers; bracts 4.50 × 12.5 mm, linear-lanceolate, soon withering; pedicels up to 14 mm long. Perianth pendulous, red, zygomorphic, up to 70 mm long; tube up to 40 mm long, throat about 10 mm in diameter; outer surface greenish, buff, red on lobes; lobes reddish, obovate-oblong, the outer up to 25 mm long and 12.5 mm broad, shortly cucullate at throat, inner lobes 13 mm in diameter, slightly retuse at apex. Stamens arising from base of perianth; anthers yellow, dorsifixed. Ovary up to 10 mm long. Capsule and seed not seen.

Phenology: Synanthous, flowering mainly in spring (October–November).

Pollinators: Sunbirds.

Habitat and aspect: Vertical or near-vertical cliffs, from about 1500–2000 m in the Drakensberg midlands. Habitat consists of wooded valleys and mountainous terrain. Plants are firmly rooted in crevices; size often depends on the growing space allowed by the crevice. Average daily maximum temperature is about 25°C and average daily minimum 10–11°C. Winters are colder, with frost and occasional snow. Rainfall occurs mainly in summer and ranges from 1000–1500 mm per annum (mainly thunder showers).

Altitude: 1100–1800 m.

Associated vegetation: Drakensberg Foothill Moist Grassland (Grassland Biome) (Mucina *et al.* 2005).

Associated cremnophytes: At the Nzinga Waterfall, farm Belmont, *Cyrtanthus falcatus* grows together with *Aloe aristata*.

Geology: Mudstone (Emakwezini Formation), Beaufort Group (Karoo Supergroup). Substrate with sufficient ledges, crevices and fissures for establishment of plants.

DISTRIBUTION

Impendle and Underberg districts, central KwaZulu-Natal.

RELATED SPECIES

Cyrtanthus falcatus is not closely related to other *Cyrtanthus* species. It is perhaps nearest to *C. herrei*, another cremnophyte from the winter-rainfall Richtersveld in the Northern Cape and adjacent mountainous parts of Namibia.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming exposed clusters up to 1 m in diameter. Bulbs firmly wedged, habit often drooping, exploiting the vertical cliff-face habitat and absence of disturbance by larger herbivores. A slow-growing, long-lived perennial.

Size and weight: Heads of medium weight to heavy, clusters.

Bulb: Epigeous, ovoid to round, fleshy and tolerant of warm, dry conditions. Its succulent state suggests an adaptation to its xeric habitat.

Leaves

Orientation: Appearing in spring, distichous, vertically orientated, thus minimising exposure to direct sunshine. The leaves are phenotypically adjustable to the vertical habitat and aspect.

Succulence: Leaves are fleshy, an adaptation to the dry habitat.

Colour: Light grey-green, reflecting excessive light.

Age and persistence: Deciduous, leaves withering in autumn, maximising survival on the dry rock face.

Armament and camouflage: Lack of armament or a camouflage defence strategy and the conspicuous clustered habit suggest an adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: Inflorescence a compact, conspicuous umbel of reddish flowers attractive to sunbirds feeding on the nectar. The ascending scape is decurved at the top, a unique feature in *Cyrtanthus*, and the flowers and pedicels are pendent.

Fruit/Seed

Size: Presumably compressed.

Dispersal: Capsule dehiscent, seeds wind-dispersed (anemochory).

Time: Seeds ripening in summer, coinciding with the rainy season.

Vegetative reproduction: *Cyrtanthus falcatus* is a prolific sprouter from the base, forming dense clusters. The many bulbs are a successful vegetative dispersal strategy, with ledges and crevices continuously being populated with clones, ensuring long-term survival on the cliffs.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened owing to the inaccessible cliff habitat.

ADDITIONAL NOTES

Horticulture: Although *Cyrtanthus falcatus* is a slow grower, it does well in cultivation. It is best grown in dappled shade in cool highveld gardens, excellent for steep embankments, gabions or terraforce. It is also well suited to containers. It is ideal for thicket gardens and plants are best grown in containers, on rockeries or window sills. The species is easily grown from seed or division. Outside its habitat it should preferably be grown under controlled conditions in a cool greenhouse. Its very easy growing nature maximises survival rate on the cliff face.

VOUCHER

Van Jaarsveld 18266 (NBG).

ILLUSTRATIONS AND MAP

Plate 2, Figures 2a–2d, Map 2.

3. *Cyrtanthus flammosus* Snijman & Van Jaarsv. in Flowering Plants of Africa 54: 100–103 (1995).

Cremnophyte growth form: Solitary, evergreen, bulbous (of medium weight, cliff squatter).

Growth form formula: A:B:Lper:So:La (r)

Etymology: Latin *flammosus*, like a flame, pertaining to the flowers.

DESCRIPTION AND HABITAT

Bulbs solitary, partially epigeous, 40 × 40 mm, ovate and covered with dry brown papery scales. Roots slightly fleshy. Leaves 2–4, spreading, linear-lanceolate, ascending to recurved, up to 290 × 20 mm, thick-textured, glaucous, tinged reddish brown. Inflorescence single-flowered, ascending-spreading, with a hollow scape up to 170 mm long, glaucous, green. Perianth large, up to 100 mm in diameter. Scape 250 × 8 mm, fruiting capsule solitary, oblong, 70 × 5 mm, tapering slightly from both ends, ascending when dry. Seed black, 15 × 5 mm, flat and wind-dispersed (June, July), lobes becoming recurved, seed pendulous, dislocated by wind, part containing embryo 6 × 5 mm with wing towards one side (aerobatic propeller type).

Phenology: Flowering in late summer and autumn (March). Seeds wind-dispersed.

Habitat and aspect: Mainly south-facing quartzitic sandstone cliff faces overlooking the Kouga River. Plants grow on fairly large inaccessible rocky ledges with sufficient soil substrate. Summers are hot and dry. The average daily maximum temperature is about 27°C and the average daily minimum temperature about 12°C. Winters are cooler but frost is a rarity or absent. Rainfall mainly in summer and winter, about 400–500 mm per annum.

Altitude: 250–500 m.

Associated vegetation: Mainly Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus cristatus* var. *schonlandii*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula perforata* subsp. *kougaensis*, *Gasteria glomerata*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna lobata* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Cyrtanthus flammosus is known only from cliff faces along the lower reaches of the Kouga River (Eastern Cape), being confined to inaccessible spots.

RELATED SPECIES

Related to two non-cremnophytes, *Cyrtanthus guthrieae* (Bredasdorp, Western Cape) and the coastal *C. elatus* (George to Humansdorp, Eastern Cape) and differing from these by its glaucous, leathery leaves and larger, conspicuous flowers. The inflorescence of *C. flammosus* is reduced to a solitary (rarely two), highly conspicuous flower (enriched flowering). This

enriched flowering compensates for the lack of bulbil formation when compared to *C. montanus* and *C. labiatus*. The glaucous, leathery leaves and somewhat exposed bulb covered with dry, papery, purplish grey tunics suggest an adaptation to a hot and arid environment.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants solitary, with partially epigeous bulbs and spreading leaves, the latter retained in cultivation. A slow-growing, long-lived perennial.

Size and weight: Bulbs of medium size and weight.

Roots: The slightly fleshy roots grow firmly wedged in crevices and soil pockets.

Bulb: The ovate bulb is covered with papery tunics forming a protective cover over the fleshy bulb scales, thus assisting to reduce transpiration and penetration of light. Exposed parts of the bulb are photosynthetically active.

Leaves

Orientation: Ascending-spreading, apically grouped.

Succulence: Leaves fleshy, an adaptation to the dry habitat.

Colour: Glaucous.

Age and persistence: Becoming deciduous from the base.

Armament: Exposed bulbs suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the surrounding thorny but heavily grazed thicket vegetation.

Sexual reproduction

Inflorescence and flowers: The solitary, large, red flower is very conspicuous (rich flowering), maximising visibility for pollination and compensating for the lack of vegetative reproduction in the vertical cliff environment. It is very possible that the flower is pollinated by the butterfly *Aerpetes tulbaghia* (Table Mountain Beauty), pollinator of similar flowers in the Western and Eastern Cape.

Fruit/Seed

Size: Seed 15×5 mm (solitary lateral wing included), relatively large size ensuring greater establishment on ledges and in crevices.

Dispersal: Dispersed by wind (anemochory). Each seed has a single lateral wing and displays a propeller action in flight, thus maximising its flying ability and ensuring a well-dispersed distance, settling in crevices.

Time: Seeds ripening in autumn and winter, coinciding with winter rainfall. The cooler conditions and moist environment facilitate successful establishment. Germination after 14–21 days.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Although classified as critically rare (Raimondo *et al.* 2009) and a local endemic, it is not threatened.

ADDITIONAL NOTES

Horticulture: Plants thrive in cultivation. Their very easy growing nature maximises their survival rate. *Cyrtanthus flammosus* is a slow grower but does well in cultivation, in dappled shade. It is ideal for thicket gardens and plants are best grown in containers, on rockeries and window sills. It is also suitable for establishment in terraforce and gabions. Plants are easily grown from seed and flowering can occur within the third or fourth years. Outside its natural habitat it should preferably be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17109 (NBG).

ILLUSTRATIONS AND MAP

Plate 3, Figures 3a & 3b, Map 3.

4. *Cyrtanthus flanaganii* Baker in *Flora capensis* 6: 532 (1897).

Cremnophyte growth form: Cluster-forming, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:D:C:La (vb)

Etymology: After Henry George Flanagan (1861–1919), Eastern Cape farmer and plant collector who collected this species on the Drakensberg.

DESCRIPTION AND HABITAT

Deciduous, semi-epigeous, cluster-forming geophytes. Bulbs ovoid to globose, up to 30 mm in diameter, sprouting from base, tapering to a neck up to 110 mm long; tunics dense, brown, membranous. Leaves up to 4, linear, up to 200 × 19 mm, leathery, lorate, falcate, green, obtuse. Scape up to 200 mm long, compressed; spathe valves (bracts) white with red veins, 50 mm long, 11 mm wide at base; bracts white, 20 mm long, linear-filiform; pedicels up to 25 mm long. Perianth yellow, ascending, trumpet-shaped; tube 46 mm long, 6 mm in diameter at throat; lobes ascending, 15 mm long, the outer 9 mm in diameter and slightly hooded, the 3 inner 8 mm in diameter, not hooded. Stamens not exerted. Ovary 8 mm long, cylindrical-oblong, faintly 3-lobed; style shortly 3-lobed.

Phenology: Synanthous, flowering mainly in December.

Pollinators: Probably sunbirds.

Habitat and aspect: Vertical cliffs on the central Drakensberg Escarpment. Plants firmly rooted in crevices. The average daily maximum temperature is about 16°C and average daily minimum about 4°C. Winters are colder, with frost and regular snow. Rainfall occurs mainly in summer and ranges from 1000–1500 mm per annum.

Altitude: 2750–3000 m.

Associated vegetation: Ukahlamba Basalt Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Mont-aux-Sources, *Cyrtanthus flanaganii* grows among tufts of grass and other species such as *Crassula lanceolata* subsp. *lanceolata*, *C. sarcocaulis*, *C. setulosa* var. *longiciliata* and *Eucomis schijffii*.

Geology: Basalt.

DISTRIBUTION

Widespread from Barkly East to Mont-aux-Sources in central KwaZulu-Natal.

RELATED SPECIES

Cyrtanthus flanaganii is not closely related to other *Cyrtanthus* species. It is superficially similar to *C. falcatus*, another cremnophyte from the Drakensberg midlands, the latter with larger, reddish flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming exposed clusters up to 300 mm in diameter. The bulbs are firmly wedged in crevices. A slow-growing, long-lived perennial.

Size and weight: Clusters of medium weight.

Bulb: Bulb hypogeous to semi-epigeous, ovoid to round. The leathery, semisucculent leaves suggest an adaptation to the xeric habitat.

Leaves

Orientation: Leaves appearing in spring and are spreading to ascending. They are phenotypically adjustable according to the availability of light.

Succulence: Fleshy, well adapted to the dry habitat.

Colour: Green.

Age and persistence: A deciduous species; leaves withering in autumn, thus maximising survival on the dry rock face.

Armament and camouflage: Lack of a camouflage defence strategy and the conspicuous clustered habit suggest an adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: The inflorescence is a conspicuous compact umbel of yellow sweetly scented flowers.

Fruit/Seed

Dispersal: Capsule dehiscent, seeds with a lateral wing, wind-dispersed.

Time: Seeds ripening in summer, coinciding with the rainy season.

Vegetative reproduction: Bulbs of *Cyrtanthus flanaganii* are prolific from the base and this successful vegetative dispersal strategy ensures that ledges and crevices are continuously being populated with clones, thus ensuring long-term survival on the cliffs.

CONSERVATION STATUS

A Drakensberg endemic, not threatened owing to the inaccessible cliff habitat.

ADDITIONAL NOTES

Horticulture: Plants are easily grown by division or from seed and thrive in cultivation. Its very easy growing nature maximises its survival rate on the cliff face.

VOUCHER

Van Jaarsveld 16989 (NBG).

ILLUSTRATIONS AND MAP

Figures 4a & 4b, Map 4.

5. *Cyrtanthus herrei* (F.M.Leight.) R.A.Dyer in *The Flowering Plants of Africa* 33: t. 1281 (1959).

Cremonophyte growth form: Cluster-forming, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: After Hans Herre (1895–1979), Curator of the Hortus Botanicus at Stellenbosch University Gardens.

DESCRIPTION AND HABITAT

Bulbs large, cluster-forming, obclavate, epigeous, up to 60 mm in diameter. Roots succulent, terete. Leaves synanthous, distichous, lorate, up to 450 × 50 mm, leathery, glaucous; apex

obtuse. Scape up to 400 mm long, glaucous, up to 28-flowered; bracts up to 80 × 13 mm, linear-lanceolate, soon withering; pedicels up to 40 mm long. Perianth pendulous, reddish, zygomorphic, up to 55 mm long; tube up to 40 mm long, red; lobes yellowish green. Stamens fused to tepals, filaments up to 6 mm long; anthers yellow, dorsifixed. Ovary up to 8 mm long. Capsule 3-loculed, ovoid, 23 × 10–14 mm. Seed black, compressed, 10 × 5 mm.

Phenology: Flowering in late summer and autumn (March–April). Seeds wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: Mainly south- and east-facing ledges and crevices of quartzitic sandstone and granite cliff faces. Plants grow on fairly large inaccessible rocky ledges that allow for sufficient soil substrate. The average daily maximum temperature is about 24°C and the average daily minimum about 10°C. Winters are cooler but frost is rare or absent. Rainfall mainly in winter, ranging from 150–250 mm per annum.

Altitude: 400–1500 m.

Associated vegetation: Rosyntjieberg Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: On the Rosyntjieberg, plants share their habitat with *Aloe meyeri*, *Othonna cyclophylla*, *Tylecodon buchholzianus* and *T. ellaphieae*.

Geology: Quartzitic sandstone (Stinkfontein Subgroup, Gariiep Supergroup) and granite of the Tatasberg Complex (Cape Granite Suite). Substrate with many ledges, crevices and fissures, providing ample habitat.

DISTRIBUTION

Cyrtanthus herrei is restricted to cliff faces and steep slopes of northern Namaqualand, the Richtersveld (Northern Cape) and adjacent territory in southern Namibia.

RELATED SPECIES

Related to *Cyrtanthus obliquus* from the southeastern Cape which also sometimes occurs on steep slopes and cliffs. It also resembles *C. falcatus* from the Drakensberg, the latter with leaves becoming deciduous in winter and the peduncle characteristically recurved at the top, with a pendent umbel.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with clusters of epigeous bulbs and ascending leaves, the latter retained in cultivation. A slow-growing, long-lived perennial.

Size and weight: Bulbs of medium weight.

Roots: Slightly fleshy, wedged in crevices and soil pockets.

Bulb: The obclavate bulb is covered with papery tunics forming a protective cover over the fleshy bulb scales and probably reducing transpiration and penetration of light. Bulb is photosynthetically active.

Leaves

Orientation: Ascending-spreading, apically grouped.

Succulence: The fleshy leaves are an adaptation to the dry habitat.

Colour: Glauous.

Age and persistence: Becoming deciduous from the base.

Armament: The exposed bulbs suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the surrounding heavily grazed succulent karoo vegetation.

Sexual reproduction

Inflorescence and flowers: The large red and green flowers are conspicuous, maximising visibility for pollination by sunbirds.

Fruit/Seed

Dispersal: Winged seed dispersed by wind, propeller action maximising its flying ability and ensuring a well-dispersed distance, settling in crevices.

Time: Seeds ripening in early winter, coinciding with winter rainfall and cooler conditions ideal for establishment of seedlings. Germination after 14–21 days.

Vegetative reproduction: *Cyrtanthus herrei* is proliferous from the base, forming dense and large colonies that occupy extensive sections of crevices. This successful vegetative dispersal strategy ensures that ledges and crevices are continuously being populated with clones, thus ensuring long-term survival in the cliff environment.

CONSERVATION STATUS

Classified as near threatened (Raimondo *et al.* 2009) in South Africa and as rare in Namibia (Loots 2005). However, often locally abundant on cliffs and not threatened.

ADDITIONAL NOTES

Horticulture: *Cyrtanthus herrei* requires warm, dry conditions and ample winter rainfall. It is best grown in groups in succulent karoo gardens and should do well on steep embankments, gabions, rockeries or in containers (Van Jaarsveld 2000b). *Cyrtanthus herrei* can be grown in partial shade or full sun. Plants are slow-growing but easily established from seed or division and thrive in cultivation. This easy growing nature maximises its survival rate. Keep dry in summer. Grow it in a well-drained, sandy soil mixture.

VOUCHER

Van Jaarsveld 18788 (NBG).

ILLUSTRATIONS AND MAP

Plate 5, Figures 5a–5d, Map 5.

6. *Cyrtanthus inaequalis* O'Brien in *The Gardeners' Chronicle* 37: 261 (1905).

Cremonophyte growth form: Solitary to cluster-forming, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: Latin *inaequalis*, unequal, pertaining to the length of the pedicel.

DESCRIPTION AND HABITAT

Bulb epigeous, globose, 40–70 × 60–80 mm, purplish green, solitary or forming groups, bulbiferous from base; tunics withering papery brown. Leaves synanthous, evergreen, 2 or 3, glaucous, linear-oblongate, leathery, 300–400 × 9–11 mm; apex subacute; upper surface channelled. Scape 400–450 × 14 mm (narrowing to 6.5 mm), glaucous, 3–5-flowered; bracts 65 × 8 mm, triangular-lanceolate, acuminate, soon withering; pedicels 35–48 mm long. Perianth orange-red, zygomorphic, labiate, 75–90 mm long, tubular, curved; tube 3.5 mm diameter at base expanding to 8 mm at throat, infundibuliform; upper lobes 4, linear-lanceolate, forming a hood, lower lobes 2. Stamens fused to tepals, free for 13 mm; anthers yellow, 7 mm long, oblong. Style 72–78 mm long, 3-lobed; ovary oblong-triangular, 6 × 4 mm. Capsule and seed not seen.

Phenology: Flowering in midsummer (January). Seed wind-dispersed.

Habitat and aspect: Confined to east- and west-facing cliffs. Plants grow in crevices and on ledges of the lower and upper slopes, in ample soil. The climate is hot and dry. The average daily maximum temperature is more or less 25°C and average daily minimum about 10°C, with frost absent or a rarity in the habitat. Rainfall occurs in winter and summer (cyclonic cold fronts and thunder showers), 200–300 mm per annum.

Altitude: 800–1200 m.

Associated vegetation: Gamka Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: Observations at Toorwaterspoort (west of Willowmore, Eastern Cape) include the following species: *Adromischus subdistichus*, *Bulbine* sp., *Carruanthus peersii*, *Cotyledon woodii*, *Crassula capitella* subsp. *thyrsiflora*, *C. cotyledonis*, *C. muscosa* var. *muscosa*, *C. pellucida* subsp. *marginalis*, *C. perfoliata* var. *minor*, *C. pubescens* var. *radicans*, *C. rupestris*, *C. velutina*, *Drimia uniflora*, *Haemanthus albiflos*, *H. decipiens* var. *decipiens*, *H. viscosa*, *Lampranthus affinis*, *Ornithogalum tortuosum* and *Senecio talinoides*.

Geology: Witteberg quartzite (Cape Supergroup).

DISTRIBUTION

Cyrtanthus inaequalis is restricted to the Groot Swartberg, from Buffelspoort near Ladismith (Western Cape) to Toorwaterspoort in the east (Eastern Cape).

RELATED SPECIES

Related to the non-cremnophytes *Cyrtanthus guthrieae* (Bredasdorp, Western Cape) and coastal *C. elatus* (George to Humansdorp, Eastern Cape) but differing from them by the glaucous, leathery leaves and zygomorphic flowers as well as its very prolific nature of forming basal bulbils. At once distinguished from *C. labiatus*, another obligate cremnophyte from the Kouga and Baviaanskloof, by its narrower, longer leaves, distinctly longer scape and larger flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with clusters of epigeous bulbs and spreading leaves, the latter retained in cultivation. A slow-growing, long-lived perennial.

Size and weight: Bulbs small, of medium weight. The small size suggests an adaptation to the limited growing conditions.

Roots: The slightly fleshy roots grow firmly wedged in crevices and soil pockets.

Bulb: The globose bulb is covered with dark, golden, papery tunics turning white with age and forming a protective cover over the fleshy bulbs and bulbils, thus reducing transpiration and penetration of light. Bulb photosynthetically active.

Leaves

Orientation: Ascending-spreading, apically grouped (2 or 3 per bulb).

Succulence: The fleshy leaves are an adaptation to its dry habitat.

Colour: Glaucous, purplish at the base, suggesting adaptations to the exposed, hot habitat.

Age and persistence: Becoming deciduous from the base.

Armament: The exposed bulbs and softer texture of the tunics suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the surrounding thorny but heavily grazed thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Flowers conspicuous, orange-red and with curved perianth tube, maximising pollination by sunbirds. Flowering time January–February.

Fruit/Seed

Size: Seed 15×5 mm including wing, actual seed 6×5 mm, relatively large size ensuring greater establishment on ledges and in crevices.

Dispersal: Seeds dispersed by wind, propeller action maximising its flying ability and ensuring a well-dispersed distance, settling in crevices.

Time: Seeds ripening in autumn and winter, coinciding with winter rainfall, an ideal time for seedling establishment and survival. Germination after 14–21 days.

Vegetative reproduction: *Cyrtanthus inaequalis* is prolific from the basal tunics, producing bulbils of about 12×11 mm. They will not easily roll off a ledge as they are oval-globose to angular and pointed to one side, ideal for establishment in crevices. The bulbils are covered with dark purplish tunics and their angular (not globose) shape provides maximum resistance and anchorage. This successful dispersal strategy ensures that ledges and crevices are continuously being populated with clones, important for long-term survival on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: *Cyrtanthus inaequalis* is a slow grower and thrives in dappled shade in cultivation. It is ideal for thicket gardens and plants are best grown in containers and on rockeries and window sills. It is also suitable for establishment in terraforce and gabions. Easily grown from bulbils, division or seed or grown as a specimen pot plant, not shy to flower. Outside its habitat it should preferably be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17415 (NBG).

ILLUSTRATIONS AND MAP

Figures 6a–6d, Map 6.

7. *Cyrtanthus junodii* P.Beauv. in Bulletin de l'Herbier Boissier, Ser. 2, 7: 437 (1907).

Cremonophyte growth form: Cluster-forming, epigeous, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:D:C:La (e) (vb)

Etymology: After Henri-Alexandre Junod (1863–1934), missionary and naturalist.

DESCRIPTION AND HABITAT

Deciduous, semi-epigeous to epigeous, cluster-forming geophytes, 200–450 mm in diameter. Bulbs ovoid, 30–70 × 30–60 mm, sprouting from base, tapering to a neck; tunics dense, reddish brown, membranous, becoming papery and greyish brown. Leaves 1–6, lorate, up to 250–380 × 20–28 mm, leathery, purplish at base, green distally, gently recurved, sometimes somewhat twisted sideways near apex; surface smooth, obscurely striate; apex acute. Scape 220–500 mm long, green; spathe valves 2, erect, ovate-lanceolate, 30–50 × 15–19 mm long, yellowish brown; pedicels variable in length, 15–40 mm long (shorter than spathe valves), ascending, reddish brown. Flowers 6–9, umbellate, horizontally presented, secund, subpendulous; perianth tubular, curved, dilating towards throat, 35–55 mm long; tube 4 mm wide at base, red, yellow at apex of lobes, 10–12 mm wide at base; lobes 8–12 × 4–6 mm long. Stamens biseriate, arising from throat, not exerted. Style yellowish, exerted; stigma trifid, lobes about 2 mm long. Capsule and seed not seen.

Phenology: Flowering time in summer (December).

Pollinators: Sunbirds.

Habitat and aspect: Vertical south-facing sandstone cliffs. Plants firmly rooted in crevices. The average daily maximum temperature is about 20°C and the average daily minimum about 10°C. Winters are colder with frost and with occasional snow. Rainfall mainly in summer, 1500–1750 mm per annum.

Altitude: 1500–200 m.

Associated vegetation: Strydpoort Summit Sourveld of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: At the Wolkberg in the Limpopo Province, *Cyrtanthus junodii* grows together with *Aloe thompsoniae*, *Crassula pellucida* subsp. *alsinoides*, *C. sarcocaulis*, *C. setulosa*, *Merwillia plumbea* and *Senecio oxyriifolius*.

Geology: Basalt.

DISTRIBUTION

Confined to the upper Wolkberg peaks in the Limpopo Province.

RELATED SPECIES

Cyrtanthus junodii is not closely related to other *Cyrtanthus* species. It is superficially similar to *C. flanaganii*, another cremnophyte from the Drakensberg midlands, with yellow flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming semi-epigeous to epigenous clusters up to 200–450 mm in diameter. The bulbs firmly wedged in crevices. A slow-growing, long-lived perennial.

Size and weight: Heads of medium weight.

Bulb: Semi-epigeous to epigeous, ovoid. The leathery, semisucculent leaves suggest an adaptation to the xeric habitat.

Leaves

Orientation: Ascending, appearing in spring and adjustable (phenotypic) according to the availability of light.

Succulence: Fleshy and adapted to its dry habitat.

Colour: Green.

Age and persistence: Deciduous, leaves withering in the autumn, maximising survival on the dry rock face.

Armament and camouflage: Lack of a camouflage defence strategy and the conspicuous clustered habit suggest an adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: Conspicuous, compact umbels of red flowers, pollinated by sunbirds.

Fruit/Seed

Size: Not seen.

Dispersal: Capsule dehiscent, seeds presumably flat and wind-dispersed.

Time: Summer.

Vegetative reproduction: Plants sprout from the base, forming clusters and ensuring long-term survival.

CONSERVATION STATUS

Cyrtanthus junodii is classified as vulnerable (Raimondo *et al.* 2009). Although it is known only from the Wolkberg in Limpopo Province, it is not threatened owing to the inaccessible cliff habitat.

ADDITIONAL NOTES

Horticulture: *Cyrtanthus junodii* is suited to temperate highveld gardens. It is best grown in a sandy mixture. Feed during spring and summer and apply a winter rest period. It can be propagated by division and does well in cultivation. Its very easy growing nature maximises its survival rate on the cliff face. It thrives in containers.

VOUCHER

Van Jaarsveld 16231 (NBG).

ILLUSTRATIONS AND MAP

Plate 7, Figures 7a–7e, Map 7.

8. *Cyrtanthus labiatus* R.A.Dyer in *Bothalia* 13: 135 (1980).

Cremonophyte growth form: Solitary to cluster-forming, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: Latin *labiatus*, lipped, referring to the two-lipped flowers, an adaptation to sunbird pollination.

DESCRIPTION AND HABITAT

Bulb epigeous, globose, 40–75 × 60–75 mm, purplish green, solitary or forming groups, bulbiferous from base; tunics withering papery brown. Leaves synanthous, evergreen, 2–4, glaucous, lorate-elliptic to strap-shaped, 180–300 × 14–20 mm; apex obtuse. Scape 120–300 × 23 mm, glaucous, up to 8-flowered; bracts 50 × 5 mm, triangular-lanceolate, soon withering; pedicels 20–25 mm long. Perianth red, zygomorphic, labiate, 50–60 mm long, tubular, curved; tube 10 mm long, infundibuliform; upper lobes 4, linear-oblong, forming a hood, lower lobes 2. Stamens fused to tepals, free for 10 mm; anthers yellow, 3 mm long, oblong. Style 40 mm long, 3-lobed; ovary oblong-triangular, 6 × 4 mm. Capsule 20–25 mm long. Seed black, 15 × 5 mm.

Phenology: Flowering from midsummer to autumn (December–January). Seeds wind-dispersed.

Habitat and aspect: Mainly ledges of vertical south- and east-facing quartzitic sandstone cliffs. Plants grow on narrow to larger inaccessible rocky ledges. The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Winters are cooler but frost is a rarity or absent. Rainfall in summer and winter, 400–500 mm per annum (cyclonic winter rainfall and thunder showers in summer).

Altitude: 300–900 m.

Associated vegetation: Mainly Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: Other cremonophytes observed at the Kouga Dam include: *Adromischus cristatus* var. *zeyheri*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula rupestris* subsp. *rupestris* ‘Kouga form’, *Gasteria glomerata*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna triplinervia* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). Substrate with many ledges, crevices and fissures, sufficient for establishment.

DISTRIBUTION

Cyrtanthus labiatus is restricted to the Baviaanskloof Mountains and Kouga Dam region west of Hankey, limited to river valleys of the Cape Fold Belt mountains.

RELATED SPECIES

Related to the non-cremnophytes *Cyrtanthus guthrieae* (Bredasdorp, Western Cape) and coastal *C. elatus* (George to Humansdorp, Eastern Cape) but differing from them by its glaucous, leathery leaves and zygomorphic flowers as well as its very prolific nature of basal bulbils. Differs from *C. inaequalis* by its smaller, broader leaves as well as the longer perianth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with clusters of epigeous bulbs and spreading leaves, the latter retained in cultivation. A slow-growing, long-lived perennial.

Size and weight: Bulbs small, of medium weight. Small size suggests an adaptation to the limited growing conditions.

Roots: The slightly fleshy roots grow firmly wedged in crevices and soil pockets.

Bulb: The globose bulb is covered with dark, golden, papery tunics turning white with age and forming a protective cover over the fleshy bulbs and bulbils, thus reducing transpiration and penetration of light. Bulb photosynthetically active.

Leaves

Orientation: Ascending-spreading, apically grouped (2 per bulb).

Succulence: The fleshy leaves are an adaptation to its dry habitat.

Colour: Glaucous, purplish at the base, suggesting adaptation to the exposed, hot habitat.

Age and persistence: Becoming deciduous from the base.

Armament: The exposed bulbs and softer texture of the tunics suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the surrounding thorny but heavily grazed thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Flowers red and conspicuous, with curved perianth tube, maximising pollination by sunbirds. Flowering time January–February.

Fruit/Seed

Size: Seed 15×5 mm including wing, actual seed 6×5 mm, relatively large size ensuring greater establishment on ledges and in crevices.

Dispersal: Seeds dispersed by wind, propeller action maximising its flying ability and ensuring a well-dispersed distance, settling in crevices.

Time: Seeds ripening in autumn and winter, coinciding with winter rainfall, an ideal time for seedling establishment and survival. Germination after 14–21 days.

Vegetative reproduction: *Cyrtanthus labiatus* are prolific from the basal tunics, producing bulbils of about 12×11 mm. They will not easily roll off a ledge as they are oval-globose to angular and pointed to one side, ideal for establishment in crevices. The bulbils are covered with dark purplish tunics and their angular (not globose) shape provides maximum resistance and anchorage. This successful dispersal strategy ensures that ledges and crevices are continuously being populated with clones, important for long-term survival on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: *Cyrtanthus labiatus* is a slow grower and thrives in dappled shade in cultivation. It is ideal for thicket gardens and plants are best grown in containers and on rockeries and window sills. It is also suitable for establishment in terraforce and gabions. Plants easily grown from bulbils, division or seed or as specimen pot plants, not shy to flower. Outside its habitat it should preferably be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 11070 (NBG).

ILLUSTRATIONS AND MAP

Plate 8, Figures 8a–8c, Map 8.

9. *Cyrtanthus montanus* R.A.Dyer in *The Flowering Plants of Africa* 44: t. 1756 (1977).

Cremnophyte growth form: Solitary to cluster-forming, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: Latin *montanus*, mountain, referring to the mountainous habitat.

DESCRIPTION AND HABITAT

Bulb epigeous, globose, 65×70 mm, purplish greenish, solitary or forming groups, bulbiferous from base; papery tunics withering grey-brown. Leaves synanthous, evergreen, and 2–4 lorate-elliptic to 300×20 mm ascending, glaucous. Scape up to 100 mm long; bracts 2, linear-lanceolate, up to 50 mm long, with smaller bracteoles with flowers; umbels up to 10-flowered; pedicels up to 30 mm long. Perianth red, erect, up to 50 mm long; tube

infundibuliform, up to 15 mm long; outer tepals 3, linear-lanceolate, up to 9 mm wide, inner tepals up to 11 mm wide. Stamens 2-seriate; filaments 9–11 mm long. Ovary oblong, up to 6 mm long; stigma filiform, tricuspidate, Capsule oblong. Seeds compressed, black.

Phenology: Flowering in late summer and autumn (March). Seeds wind-dispersed.

Pollinators: Butterflies.

Habitat and aspect: Vertical south-facing quartzitic sandstone cliffs. Plants grow on narrow to larger inaccessible rocky ledges. The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Winters are cooler but frost is a rarity or absent. Rainfall occurs in winter and summer, 400–500 mm per annum (cyclonic winter rainfall and thunder showers in summer).

Altitude: 250–500 m.

Associated vegetation: Mainly Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Observations at the Kouga Dam include: *Adromischus cristatus* var. *zeyheri*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula rupestris* subsp. *rupestris* ‘Kouga form’, *Gasteria glomerata*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna triplinervia* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). Substrate with many ledges, crevices and fissures sufficient for establishment.

DISTRIBUTION

Cyrtanthus montanus is distributed from Ladismith (Western Cape) to Hankey in the Eastern Cape and is restricted to river valleys of the Cape Fold Belt mountains.

RELATED SPECIES

Related to the non-cremnophytes *Cyrtanthus guthrieae* (Bredasdorp, Western Cape) and coastal *C. elatus* (George to Humansdorp, Eastern Cape) but differing from them by its glaucous, leathery leaves and somewhat different flowers as well as its very prolific nature of basal bulbils.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with clusters of epigeous bulbs and spreading leaves, the latter retained in cultivation. A slow-growing, long-lived perennial.

Size and weight: Bulbs of medium weight.

Roots: The slightly fleshy roots grow firmly wedged in crevices and soil pockets.

Bulb: The globose bulb is covered with dark, golden, papery tunics turning white with age and forming a protective cover over the fleshy bulbs and bulblets, thus reducing transpiration and penetration of light. Bulb photosynthetically active.

Leaves

Orientation: Ascending-spreading, apically grouped (2 per bulb).

Succulence: The fleshy leaves are an adaptation to its dry habitat.

Colour: Glaucous, purplish at the base, suggesting adaptation to the exposed hot habitat.

Age and persistence: Becoming deciduous from the base.

Armament: The exposed bulbs and softer texture of the tunics suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the surrounding thorny but heavily grazed thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Flowers red and conspicuous, maximising visibility for pollination in the vertical cliff environment. Its open nature attracts butterflies, the main pollinating agents.

Fruit/Seed

Dispersal: Seed with solitary wing, wind-dispersed, propeller action maximising its flying ability and ensuring a well-dispersed distance, settling in crevices.

Time: Seeds ripening in autumn and winter, coinciding with winter rainfall, an ideal time for establishment of seedlings and for survival. Germination after 14–21 days.

Vegetative reproduction: *Cyrtanthus montanus* is very prolific from the basal tunics, producing bulbils of about 10×8 mm. They will not easily roll off a ledge as they are oval-angular and pointed to one side, ideal for establishment in crevices. The bulbils are covered with dark purplish tunics, their angular (not globose) shape providing maximum resistance and anchorage. This successful dispersal strategy ensures that ledges and crevices are continuously being populated with clones, important for long-term survival on the cliffs. (Birds breeding on cliff faces often also have eggs that are not round.)

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: *Cyrtanthus montanus* is a slow grower but does well in cultivation, best in dappled shade in thicket gardens (Van Jaarsveld 2000). It is ideal for containers, rockeries and window sills. It is also suitable for establishment in terraforce and gabions. Plants easily

grown from bulbils, division or seed or grown as specimen pot plants. Outside the habitat it should preferably be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 12144 (NBG).

ILLUSTRATIONS AND MAP

Figures 9a–9d, Map 9.

HAEMANTHUS L.

10. *Haemanthus albiflos* Jacq., *Plantarum rariorum Horti Caesarei Schoenbrunnensis descriptiones et icones* 1: 31, t. 59 (1797). (Kouga Dam cliff-face forms.)

Cremonophyte growth form: Cluster-forming, epigeous, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: Latin *albiflos* (*albus*, white, *flos*, flower), referring to the white flowers.

DESCRIPTION AND HABITAT

Evergreen bulbous geophytes. Bulbs ovoid to medianally compressed, up to 80 mm broad, sprouting from base, cluster-forming (up to 12 heads, rarely more), epigeous to half-hypogeous; tunics truncate at top, green when exposed to light. Leaves strap-shaped to elliptic, adpressed to ground or spreading, flat or canaliculate, smooth or rarely pubescent; margin ciliate; apex obtuse to acute. Inflorescence 50–350 mm high; scape compressed to 14 mm wide; umbel compact, compressed to 70 mm wide, with 4–8 spathe valves. Flowers up to 12, exceptionally up to 50, white; pedicels up to 10 mm long; perianth funnel-shaped, up to 23 mm long; tube up to 7 mm long, with spreading oblong segments 10–18 × 1.0–2.5 mm. Ovary spherical, up to 3 mm in diameter. Berry ovoid, up to 10 mm in diameter, white to red.

Phenology: Flowering mainly from January–October, but with a peak between April and August. Seeds dispersed by birds from autumn onwards.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs of dry river valleys or coastal cliffs (all aspects but more so on sheltered southern faces). The average daily maximum temperature varies from 22–24°C and average daily minimum from 12–14°C; extremes of up to 40°C have been recorded. Winters are cooler but frost is absent. Rainfall throughout the year, but with a peak in spring and summer, ranging from 300–1000 mm (thunder showers or cyclonic winter rain). Plants firmly rooted in crevices, size often depending on the growing space allowed by the crevice.

Altitude: 15–1500 m

Associated vegetation: Mainly Eastern Valley Bushveld of the Sub-Escarpment Savanna Bioregion (Savanna Biome), also Thicket, Grassland and Indian Ocean Coastal Belt, rarely Nama-Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: On the Suurberg (cliffs in the Witrivier) it is associated with *Bulbine latifolia*, *B. suurbergensis*, *Crassula intermedia*, *C. perfoliata* var. *minor*, *Haworthia angustifolia* var. *baylissii*, *Lampranthus affinis*, *Ornithogalum juncifolium* and *O. longibracteatum*.

Geology: Quartzitic sandstone, Witteberg and Table Mountain Groups (Cape Supergroup) and mudstone and shale rocks of the Beaufort Group (Cape Supergroup). Substrate with sufficient ledges, crevices and fissures for establishment of plants.

DISTRIBUTION

From Still Bay (Western Cape) in the west to Zululand in KwaZulu-Natal and inland to Graaff-Reinet and Queenstown. Mainly in regions below the escarpment and especially on coastal cliffs. Although *Haemanthus albiflos* is widespread, some forms appear to be obligate cremnophytes, such as those found at the Kouga Dam.

RELATED SPECIES

Haemanthus albiflos is closely related to *H. pauculifolius*, another cremnophyte (see further on) from Mpumalanga. They differ from the flat-ground species *H. deformis* (southern KwaZulu-Natal) by their smaller, round, epigeous, cluster-forming, photosynthetically active bulbs and softer leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming globose clusters, exploiting the vertical cliff-face habitat and absence of disturbance by larger herbivores. A fairly slow-growing, long-lived perennial.

Size and weight: Heads of medium weight.

Bulb: Epigeous, ovoid to medianally compressed, fleshy and tolerant of warm, dry, vertical conditions. It is epigeous and photosynthetically active, maximising light absorption. The succulent nature suggests an adaptation to the xeric habitat.

Leaves

Orientation: Distichous, spreading, ascending to recurved, maximising absorption of light. Leaf orientation varies according to the aspect and availability of light. The leaves are phenotypically adjustable to the vertical habitat and aspect. The tunics are fleshy and conserve water.

Succulence: Fleshy, often hairy, suggesting morphological adaptations to its dry habitat.

Colour and texture: Light green, without markings, with soft texture.

Age and persistence: Evergreen, reflecting the climatic pattern of year-round rainfall. Each bulb with up to 6 leaves (Snijman 1984), maximising absorption of light. Leaves persisting for up to three years. Bulblets often forming at base of damaged leaves, ideal for establishment in crevices or on ledges (see Vegetative reproduction below).

Armament and camouflage: The soft leaf texture suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed thicket and subtropical coastal vegetation. Lack of a camouflage defence strategy and the conspicuous clustered habit also reflect adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: Ascending, compact umbels of conspicuous whitish to white-pink flowers.

Fruit/Seed

Size: Berry, red to white, fleshy when ripe, 10 mm in diameter.

Dispersal: Fruits released when soft and white to reddish, dispersed by frugatory birds sitting rock ledges.

Time: Fruits ripening in summer and autumn, coinciding with the rainy season. Germination of seed up to about 21 days.

Vegetative reproduction: *Haemanthus albiflos* suckers from the base, forming dense clusters. The fleshy bulb scales will root when detached, forming bulblets. The bulblets or other fragments will root, establishing new colonies. The continual sprouting from the base and rooting of leaf fragments fallen into crevices represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants easily grown by division or from seed, thriving in cultivation. It is best suited to thicket and bushveld gardens and grows well on shady rockeries, embankments and gabions. It also does well as a pot plant. Water sparingly throughout the year and feed during spring and summer. Its very easy growing nature maximises survival rate on the cliff face. Its polymorphic nature (genetic variability and phenotypic plasticity) ensures adaptation to local conditions and it is dispersed over long distances by birds. It is well established in horticulture.

VOUCHER

Van Jaarsveld 16920 (NBG).

ILLUSTRATIONS AND MAP

Figures 10a–10c, Map 10.

11. *Haemanthus humilis* Jacq. subsp. *humilis*, Jacquin, Plantarum rariorum Horti Caesarei Schoenbrunnensis descriptiones et icones 4: 6, t. 411 (1804).

Cremonophyte growth form: Cluster-forming, epigeous, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:D:C:La (e) (vb)

Etymology: Latin *humilis*, humble, pertaining to the low growing habit.

DESCRIPTION AND HABITAT

(Based on obligate cliff-face forms at Tandjiesberg and the Valley of Desolation near Graaff-Reinet.) Deciduous, epigeous geophytes. Bulbs ovoid to medianally compressed, up to 80 mm broad, cluster-forming (up to 10 heads, rarely more), epigeous to half-hypogeous; tunics truncate at top, green when exposed to light. Leaves 2, strap-shaped to elliptic, ascending to recurved, becoming deciduous towards summer, glabrous, glaucous green; margin ciliate; apex obtuse to acute. Inflorescence 50–200 mm high; scape compressed to 14 mm wide; umbel compact, compressed to 70 mm wide, with 4–8 spathe valves. Flowers 15–50, dark rose-pink; pedicels up to 11 mm long; perianth funnel-shaped, up to 23 mm long; tube up to 5 mm long, with spreading oblong segments 10–18 × 1–2 mm. Ovary spherical, up to 2 mm in diameter. Berry ovoid, up to 10 mm in diameter, white.

Phenology: Flowering mainly in midsummer (November–February) when plant is deciduous.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs of mainly inland mountains, growing on all aspects but more so on south- and east-facing cliffs. The average daily maximum temperature is about 25°C and average daily minimum 10°C; extremes of up to 35°C have been recorded. Winters are cooler but frost is absent. Rainfall mainly in summer, 400–1000 mm per annum (thunder showers or rarely cyclonic winter rain). Plants firmly rooted in crevices, size often depending on the growing space allowed by the crevice.

Altitude: 460–1400 m.

Associated vegetation: Mainly Camdebo Escarpment Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: On the Tandjiesberg (near Graaff-Reinet), it is associated with *Adromischus fallax*, *Ceterach cordatum*, *Cotyledon orbiculata* var. *orbiculata*, *Crassula exilis* subsp. *cooperi*, *C. perforata*, *C. sarcocaulis*, *Litanthus pusillus*, *Ornithogalum* sp. and *Othonna capensis*.

Geology: Mudstone (Emakwezini Formation), Beaufort Group (Karoo Supergroup). Substrate with efficient ledges, crevices and fissures for establishment of plants.

DISTRIBUTION

Eastern Cape, cliffs on the southern escarpment mountains near Graaff-Reinet.

RELATED SPECIES

Haemanthus humilis subsp. *humilis* is closely related to *H. montanus*, a geophyte with subterranean bulbs and white flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming globose clusters, exploiting the vertical cliff-face habitat and absence of disturbance by larger herbivores. A fairly slow-growing, long-lived perennial.

Size and weight: Heads of medium weight.

Bulb: Epigeous, ovoid to medianally compressed, fleshy and tolerant of warm, dry, vertical conditions. It is epigeous and photosynthetically active, maximising light absorption. The succulent nature suggests an adaptation to the xeric habitat.

Leaves

Orientation: Leaves appearing soon after the flowers in February, distichous, spreading, ascending to recurved, maximising absorption of light. Orientation varying according to aspect and availability of light. The leaves are phenotypically adjustable to the vertical habitat and aspect.

Succulence: Fleshy with a hairy margin, suggesting morphological adaptations to the dry habitat.

Colour: Light grey-green, reflecting excessive light.

Age and persistence: Deciduous, leaves withering in spring and new ones appearing only in February, maximising survival on the arid rock face.

Armament and camouflage: The soft leaf texture suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed thicket and subtropical coastal vegetation. Lack of a camouflage defence strategy and the conspicuous clustered habit also reflect adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: Ascending, compact umbels of conspicuous dark rose-pink flowers.

Fruit/Seed

Size: Berry fleshy, orange to white, 5–10 mm in diameter, seed white, 5 mm in diameter.

Dispersal: Berries released when soft, dispersed by frugatory birds sitting on rock ledges.

Time: Berries ripening in summer and autumn, coinciding with the rainy season. Germination of seed up to about 21 days.

Vegetative reproduction: *Haemanthus humilis* suckers from the base, forming dense clusters. The fleshy bulb scales will root if they become detached, forming bulblets. The bulblets or other fragments will root and establish new colonies. The continual sprouting from the base and rooting of leaf fragments that have fallen into crevices are an efficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Easily grown by division or from seed, thriving in cultivation. Best for dry thicket gardens, grown on rockeries and in containers. Its very easy growing nature maximises survival rate on the cliff face. Its polymorphic nature (genetic variability and phenotypic plasticity) ensures adaptation to local conditions; birds ensure long-distance dispersal.

VOUCHER

Van Jaarsveld 16702 (NBG).

ILLUSTRATIONS AND MAP

Figures 11a–11c, Map 11.

12. *Haemanthus pauculifolius* Snijman & A.E.van Wyk in *South African Journal of Botany* 59,2: 247–250 (1993).

Cremonophyte growth form: Cluster-forming, epigeous, bulbous (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: Latin *pauculifolius* (*paucus*, few, *folium* leaf), referring to the usually single leaf produced per season.

DESCRIPTION AND HABITAT

Evergreen bulbous geophytes. Bulbs ovoid, 40–50 mm in diameter, sprouting from base, cluster-forming, epigeous to half-hypogeous, green, smooth. Leaves few, usually 1 (rarely 2), fleshy, strap-shaped to linear-lanceolate, canaliculate, tomentose, 70–120(–325) × 20–45 mm; apex acute. Inflorescence 50–190 mm high; scape compressed to 7 mm wide; umbel compact, compressed to 30 mm wide, with 4 spathe valves. Flowers up to 19, white; pedicels up to 3 mm long; perianth funnel-shaped, up to 35 mm long; tube up to 13 mm long, with spreading lanceolate segments 17–20 × 3–4 mm. Berry spherical, up to 15 mm in diameter, orange. Seed ovoid, 10 mm long.

Phenology: Flowering mainly from late autumn to winter. Seeds dispersed by birds in late winter and spring, in time for the spring rains.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs and steep rocky slopes of the escarpment and mountains, ranging from dry river valleys to mountain slopes, on all aspects but more so on south- and east-facing cliffs. Plants firmly rooted in crevices, size often depending on the growing space allowed by the crevice. The average daily maximum temperature varies from 26–28°C and average daily minimum from about 12–14°C; extremes of up to 45°C have been recorded. Winters are cooler but frost is absent. Rainfall occurs mainly in summer, 600–800 mm per annum (mainly thunder showers).

Altitude: 600–900 m.

Associated vegetation: Mainly Barberton Serpentine Sourveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Joes Luck Mine (Eureka City, Barberton), the plants grow with *Aloe spicata*, *Cotyledon orbiculata*, *Crassula sarcocaulis*, *Kalanchoe rotundifolia*, *Plectranthus neochilus* and *Sarcostemma viminalis*.

Geology: Mainly shale and lava (Barberton Supergroup), quartzitic sandstone of the Black Reef Formation (Transvaal Supergroup). Substrate with sufficient ledges, crevices and fissures for establishment of plants.

DISTRIBUTION

Mpumalanga, from Barberton in the south to Blyderivierspoort north of Graskop, below the escarpment and a locality in Swaziland to the south.

RELATED SPECIES

Haemanthus pauculifolius is closely related to *H. albiflos* and differences are discussed under that species.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming globose clusters, exploiting the vertical cliff-face habitat and absence of disturbance by larger herbivores. A fairly slow-growing, long-lived perennial.

Size and weight: Heads of medium weight.

Bulb: Epigeous, ovoid to medianally compressed, fleshy and tolerant of warm, dry, vertical conditions. It is epigeous and photosynthetically active, maximising light absorption. The succulent nature can be seen as a response to its xeric habitat.

Leaves

Orientation: Distichous and spreading, sometimes recurved, maximising absorption of light. Orientation varying according to aspect and availability of light. The leaves are phenotypically adjustable to the vertical habitat and aspect.

Succulence: Fleshy and hairy, suggesting morphological adaptation to the dry habitat.

Colour: Light green, without markings.

Age and persistence: Evergreen, the solitary (occasionally with a smaller one) leaf is annually replaced, the reduction in leaves interpreted as a response to conditions on the very dry, hot cliffs and as a shift to bulb succulence. The epigeous bulbs are green and photosynthetically active. *Haemanthus albiflos* is closely related, widespread and a facultative cremnophyte (except the Kouga cliff form).

Armament and camouflage: The soft leaf texture suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed thicket and bushveld. Lack of a camouflage defence strategy and the conspicuous clustered habit also reflect adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: Ascending, compact umbels of conspicuous white flowers.

Fruit/Seed

Size: Conspicuous red, fleshy berry up to 10 mm in diameter.

Dispersal: Berries released when fully ripe (becoming orange), dispersed by frugatory birds perching on the rocky ledges.

Time: Berries ripening in winter, dispersed in time for spring rain. Germination of seed within about 21 days.

Vegetative reproduction: Suckers from the base, forming dense clusters. The fleshy bulb scales will root when detached, forming bulblets. Bulblets or other fragments will root, forming new colonies. Continual sprouting from the base and rooting of fragments fallen into crevices represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for bushveld gardens and grown in partial shade. A slow grower that does well in cultivation (containers or rockeries) and plants are easily grown by division, from bulb scales or from seed. Outside its bushveld habitat is best grown under controlled conditions in a greenhouse. Its ease of growth maximises its survival rate on the cliff face.

VOUCHERS

Van Jaarsveld 19365, 19373 (NBG).

ILLUSTRATIONS AND MAP

Plate 12, Figures 12a & 12b, Map 12.

ASPHODELACEAE

Aloe L.

13. *A. arborescens* Mill. subsp. *mzimnyi* Van Jaarsv. & A.E.van Wyk
14. *A. catengiana* Reynolds
15. *A. challisii* Van Jaarsv. & A.E.van Wyk
16. *A. corallina* I.Verd.
17. *A. dabenorisana* Van Jaarsv.
18. *A. dewinteri* Giess
19. *A. haemanthifolia* A.Berger & Marloth
20. *A. hardyi* Glen
21. *A. kouebokkeveldensis* Van Jaarsv. & A.B.Low
22. *A. meyeri* Van Jaarsv.
23. *A. mutabilis* Pillans
24. *A. nubigena* Groenew.
25. *A. omavandae* Van Jaarsv.
26. *A. pavelkae* Van Jaarsv., Swanepoel, A.E.van Wyk & Lavranos
27. *A. pictifolia* D.S.Hardy
28. *A. reynoldsii* Letty
29. *A. soutpansbergensis* I. Verd.
30. *A. thompsoniae* Groenew.

Bulbine Wolf

31. *B. cremnophila* Van Jaarsv.
32. *B. latifolia* (L.f.) Schult. & Schult.f. var. *curvata* Van Jaarsv.
33. *B. meiringii* Van Jaarsv.
34. *B. natalensis* Baker
35. *B. pendens* G.Will. & Baijnath
36. *B. ramosa* Van Jaarsv.
37. *B. retinens* Van Jaarsv. & S.A.Hammer
38. *B. rupicola* G.Will.
39. *B. suurbergensis* Van Jaarsv. & A.E.van Wyk
40. *B. thomasiae* Van Jaarsv.

Gasteria Duval

41. *G. batesiana* G.D.Rowley var. *batesiana*
42. *G. batesiana* G.D.Rowley var. *dolomitica* Van Jaarsv. & A.E.van Wyk
43. *G. croucheri* (Hook.f.) Baker subsp. *pendulifolia* (Van Jaarsv.) Zonn.
44. *G. doreeniae* Van Jaarsv. & A.E.van Wyk
45. *G. glauca* Van Jaarsv.
46. *G. glomerata* Van Jaarsv.
47. *G. pillansii* Kensit var. *ernesti-ruschii* (Dinter & Poelln.) Van Jaarsv.
48. *G. rawlinsonii* Oberm.
49. *G. tukhelensis* Van Jaarsv.

Haworthia Duval

50. *H. angustifolia* Haw. var. *baylissii* (C.L.Scott) M.B.Bayer
51. *H. attenuata* Haw. (Haw.) var. *attenuata* (Enon form)
52. *H. cymbiformis* Haw. (Duval) var. *ramosa* (G.G.Sm.) M.B.Bayer

- 53. *H. cymbiformis* Haw. (Duval) var. *setulifera* (Poelln.) M.B.Bayer
- 54. *H. glabrata* (Salm-Dyck) Baker
- 55. *H. gracilis* Poelln. var. *picturata* M.B.Bayer
- 56. *H. marumiana* Uitewaal var. *batesiana* (Uitewaal) M.B.Bayer
- 57. *H. marumiana* Uitewaal var. *marumiana*
- 58. *H. mirabilis* Haw. (Haw.) var. *consanguinea* M.B.Bayer
- 59. *H. scabra* Haw. var. *starkiana* (Poelln.) M.B.Bayer
- 60. *H. turgida* Haw. var. *turgida*
- 61. *H. zantneriana* Poelln.

***Trachyandra* Kunth**

- 62. *T. tabularis* (Baker) Oberm.

ALOE L.

13. *Aloe arborescens* Mill. subsp. *mzimnyati* Van Jaarsv. & A.E. van Wyk in Aloe 42,3: 40–42 (2005a).

Cremonophyte growth form: Cluster-forming, subpendulous, branched (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:P:R:C:Ar (vb)

Etymology: After the Buffalo River (Zulu, *Mzimnyati*) in KwaZulu-Natal where the plants were collected.

DESCRIPTION AND HABITAT

Arborescent, much-branched, rounded shrubs up to 0.76 m high, about the same in diameter. Roots fleshy, 3 mm in diameter, pale, root tips yellow. Branches 5–7 mm in diameter, with leaves crowded in apical rosettes of about 200 mm in diameter. Leaves linear-lanceolate, 130–210 × 8–10 mm at base, spreading, green but turning reddish green in dry winter, apices recurved; margin armed with yellowish teeth 1–2 mm long. Inflorescence 240–330 mm long, bearing conical racemes 80–100 mm long. Perianth subclavate, 22–25 mm long, orange-red to yellow. Capsule 10–17 × 4–5 mm. Seeds 1.5–2.0 × 1 mm.

Phenology: Flowering mainly in midwinter (July–August). Seeds dispersed by wind in early spring (end of September), just before the spring rains.

Pollinators: Sunbirds.

Habitat and aspect: Known only from vertical quartzitic sandstone cliffs (east- and south-facing) along the lower Mzimnyati River (Buffalo River) near confluence with the Thukela River. Plants occur scattered in rock crevices and are difficult to reach where they are firmly rooted in spaces large enough to support the roots and stem clusters. Vegetation of the region is mainly savanna and grassland. Average summer temperature is about 26°C and for winter 14°C. Rainfall experienced mainly in summer, with averages of 800–1000 mm per annum.

Altitude: 700–1000 m.

Associated vegetation: Thukela Valley Bushveld of the Sub-Escarpment Savanna Bioregion of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens* subsp. *mzimnyati* grows in association with *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula orbicularis*, *Cyanotis speciosa*, *Plectranthus madagascariensis* and *Schizobasis angolensis*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup). Texture rough, with many fissures, ledges and crevices ideal for establishment of plants.

DISTRIBUTION

Aloe arborescens subsp. *mzimnyati* is known only from the Buffalo (Mzimnyati) River close to its confluence with the Thukela River, the largest river in KwaZulu-Natal.

RELATED SPECIES

Aloe arborescens subsp. *mzimnyati* differs from *Aloe arborescens* subsp. *arborescens* by its smaller stature and flowers which are 22–25 mm long, ranging from red to yellow.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with ascending to drooping stems and leaves. Long-lived perennial.

Size and weight: Heads medium-sized to large, of medium weight to heavy.

Stem: Branches grey, fibrous and firm.

Leaves

Orientation: Leaves ascending to becoming drooping.

Colour: Green, no powdery bloom, perhaps an adaptation to the shady, south-facing cliffs.

Age and persistence: Perennial, deciduous from the base, resulting in apical rosettes.

Armament: The soft teeth on the leaf margins of *Aloe arborescens*, and especially subsp. *mzimnyati*, compared to other non-cremnophilous aloes, suggest a reduction in armament due to a reduction in herbivory.

Sexual reproduction

Inflorescence and flowers: Young inflorescence ascending or drooping but curving up as it matures, presenting the raceme(s) in the typical erect position.

Fruit/Seed

Size: Seed 1.5–2.0 × 1 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in spring, coinciding with the start of the rainy season.
Germination within 14–21 days.

Vegetative reproduction: Plants sprout from the base and branches will root when finding a suitable crevice. Detached branches will also root. The succulent nature ensures long-term survival on the cliffs.

CONSERVATION STATUS

Although it is not well represented in herbaria, it is locally common and not threatened.

ADDITIONAL NOTES

Horticulture: *Aloe arborescens* subsp. *mzimnyati* is a worthwhile introduction to horticulture. Just as the typical *Aloe arborescens* subsp. *arborescens*, it is easily grown from cuttings or seed. Plants grown at Kirstenbosch will be released and introduced through the annual plant sale of the Botanical Society of South Africa. It is widely adaptable and can be grown in bushveld or subtropical coastal gardens.

VOUCHER

Van Jaarsveld 18211 (NBG).

ILLUSTRATIONS AND MAP

Plate 13, Figures 13a–13d, Map 13.

14. *Aloe catengiana* Reynolds in *Kirkia* 1: 160 (1961). (Omavanda form.)

Cremonophyte growth form: Cluster-forming, pendulous, branched (of medium weight to heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Rls (vb)

Etymology: After Catenga in Angola where the plants were first recorded.

DESCRIPTION AND HABITAT

Arborescent, much-branched, spreading, pendent shrubs up to 0.7 m wide. Roots fleshy. Branches 8–12 mm in diameter, with leaves tending to be crowded in apical rosettes of about 300 mm in diameter. Leaves linear-lanceolate, 130–160 × 25–30, spreading, green but turning reddish in dry season; upper surface flat to convex, lower surface convex, spotted in proximal half, striate towards base and stem; margin armed with yellowish teeth 2–4 mm long; apices recurved, acute. Inflorescence up to 400 mm long, branched in lower half, at first pendent and apices bending up, with conical cylindrical-acuminate racemes up to 160 mm long and 40 mm in diameter; pedicels 10 mm long; bracts ovate-acuminate scarious, up to 5 × 3 mm. Perianth

scarlet, cylindrical, slightly decurved, up to 28×7 mm; outer segments free for 10 mm, inner segments broader, apices obtuse. Anthers becoming shortly exerted. Stigma exerted to 2 mm. Seed not seen.

Phenology: Flowering mainly in autumn (April–May). Seeds dispersed by wind in winter, just before the spring rains.

Pollinators: Sunbirds.

Habitat and aspect: East-facing sandstone cliffs on the Omavanda escarpment margin. *Aloe catengiana* grows firmly wedged in crevices and the rosette becomes pendent from a young age. The plants are rare and restricted to inaccessible places. The vegetation in the region below is arid mopane savanna, with several species of *Commiphora* prominent. Omavanda is within the tropics, with hot summers and dry, warm winters without frost. Rainfall mainly in summer, 300–500 mm per annum.

Altitude: 1800–2000 m.

Associated vegetation: Dry savanna with main species: *Combretum apiculatum*, *Combretum zeyheri*, *Cyphostemma currorii*, *Entandrophragma spicatum*, *Kirkia acuminata* and *Mundulea sericea*.

Associated cremnophytes: *Cotyledon orbiculata*, *Cyphostemma currorii*, *Euphorbia subsalsa*, *E. monteiroi*, *Kalanchoe lanceolata* and *Sarcostemma viminale*. Other non-succulent species include: *Ficus glumosa*, *F. ilicina* and *Petalidium coccineum*. On wider ledges, species such as *Cussonia angolensis*, *Nicotiana africana* and *Nuxia congesta* are encountered.

Geology: Sandstone of the Damara Sequence. Substrate with many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

In Namibia *Aloe catengiana* is known only from the upper vertical, quartzitic sandstone cliffs (east- and south-facing) along the northeastern Baynes Mountains. It also occurs east of Catengue Railway Station in Angolan below the inland escarpment.

RELATED SPECIES

Aloe catengiana (Omavanda, Namibia) differs from typical *Aloe catengiana* (Catengue, Angola), in its smaller heads, pendent spreading growth as well as its inflorescence, which is only 2- or 3-branched.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: With spreading to drooping stems. A long-lived perennial with a medium growth rate.

Size and weight: Heads of medium weight, but plants becoming large and heavy.

Stem: Branches grey, fibrous and firm.

Leaves

Orientation: Ascending, recurved and occasionally becoming drooping.

Colour: Greyish green, turning reddish to yellowish in the dry season.

Age and persistence: Persisting, ultimately becoming deciduous from the base, resulting in apical rosettes.

Armament: The soft teeth on the leaf margins of *Aloe catengiana* suggest a reduction in armament due to a reduction in herbivory.

Sexual reproduction

Inflorescence and flowers: Young inflorescence drooping but the tips curved upwards.

Fruit/Seed

Size: Not seen.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in spring, coinciding with the start of the rainy season.

Vegetative reproduction: *Aloe catengiana* proliferates from the base, forming dense, drooping clusters. Stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual basal sprouting of new shoots and rooting of stems in new crevices by extended stem growth represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Rare, but not threatened.

ADDITIONAL NOTES

Horticulture: A worthwhile introduction to horticulture, best grown in dry savanna gardens (Van Jaarsveld 2010). It propagates readily from cuttings planted in a well-drained, sandy mixture and grows fairly fast. Plants thrive on steep embankments, in large hanging baskets or on window sills. Outside its habitat, it is best grown under controlled conditions in containers in a greenhouse. Plants grown at Kirstenbosch are being increased by vegetative means and will be released and introduced through the annual plant sale and from the nursery at Kirstenbosch.

VOUCHER

Van Jaarsveld 18805 (NBG).

ILLUSTRATIONS AND MAP

Figures 14a–14c, Map 14.

15. *Aloe challisii* Van Jaarsv. & A.E.van Wyk in Aloe 43,2 & 3; 36–39 (2006a).

Cremonophyte growth form: Cluster-forming, pendulous rosettes (light to medium weight, cliff hanger).

Growth form formula: F:P:R:C:Ar (vb) (eg)

Etymology: This aloe was first collected by Mr Chris Challis, aloe and succulent plant enthusiast, while exploring a hiking trail at Verlorenkloof, Mpumalanga.

DESCRIPTION AND HABITAT

Perennial succulent suckering from base and forming small, dense groups up to 200 mm in diameter. Roots fleshy. Branches pendent. Leaves soft, flaccid, rosulate, 4–7 per branch, linear-triangular, 100–200(–250) × 8–10(–20) mm, curved and pendent from rock faces, very fleshy especially in rainy season and becoming almost subterete and channelled in dry season, smooth, slightly glaucous, bluish green, white-spotted at base; abaxial side convex, adaxial side flat or slightly channelled in rainy season, becoming channelled in dry season, striate, purplish green towards base; margin serrate, semitranslucent, white, cartilaginous, up to 1.5 mm broad at base, 0.2 mm broad elsewhere; teeth 1 × 0.4 mm, 1–3 mm apart; apex acute to subacute, armed with 5 or 6 teeth. Inflorescence simple, decumbent, 140–160 mm tall; peduncle 100 mm long, 5–6 mm broad at base, biconvex and slightly flattened at base, terete upwards, with 4 sterile bracts 8–9 mm long and clasping up to 9 mm at base; raceme short, subcapitata, 40–45 mm long, up to 15-flowered; floral bracts scarious, deltoid, acuminate, 8–9 × 4 mm; pedicels 10–15 mm long, ascending, orange. Perianth subclavate, pendent, 25 mm long, bright orange-red; apices obtuse to subacute, yellow, green-tipped; tube cylindrical-triangular; segments with a median green stripe, free to base, outer three concave, 25 × 3 mm, widening to 6 mm, linear-oblong, canaliculate, inner three not as deeply canaliculate, widening to 6 mm; base 5 mm in diameter, widening to 7 mm up to halfway and then narrowing towards apex. Stamens yellowish, 20–22 mm long. Ovary oblong, 5–6 × 2 mm, grooved, brownish green; style 18 mm long. Capsule 16 × 5 mm. Seeds oblong, angular, 3–4 × 1.5 mm, grey-black.

Phenology: Flowering mainly in spring (October–November).

Pollinators: Sunbirds.

Habitat and aspect: *Aloe challisii* is known only from the upper vertical, quartzitic, sandstone cliffs (south- and southeast-facing) along the southern part of the Steenkampsberg, which is frequently covered in cloud. Plants occur scattered among moss in rock crevices and are difficult to reach, firmly rooted in crevices and on ledges large enough to support the roots and stem clusters. The average daily maximum temperature is about 20°C and the average daily minimum about 8°C. Rainfall is high, 1500–1750 mm per annum, and is experienced mainly in summer.

Altitude: 1800–2000 m.

Associated vegetation: Lydenburg Montane Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: The species is found in association with other temperate, high-altitude plants such as *Crassula pellucida* subsp. *brachypetala*, *C. sarcocaulis*, *C. setulosa* var. *rubra*, *C. setulosa* var. *setulosa*, *Elaphoglossum* sp., *Ledebouria saundersiae*, *Mohria caffrorum*, *Morella pilulifera*, *Rhodohypoxis baurii*, *Senecio orbicularis* and a species of *Streptocarpus*.

Geology: Quartzitic sandstone (Black Reef Formation, Transvaal Supergroup). Light-textured (grey), rough- to smooth-textured, with many fissures, ledges and crevices for establishment of plants.

DISTRIBUTION

Aloe challisii is as yet known only from the upper sandstone cliffs of the Steenkampsberg southwest of Lydenburg in Mpumalanga.

RELATED SPECIES

There are some 125 species of *Aloe* indigenous to South Africa and Namibia (Glen & Hardy 2000). *Aloe challisii* is the 17th species of *Aloe* (21%) and the fourth member of section *Leptoaloe* recorded as confined to sheer cliff faces in South Africa and Namibia. This section also includes *A. nubigena*, *A. thompsoniae* and *A. soutpansbergensis*, all of them with soft, flaccid leaves with small or no (*A. nubigena*) teeth on the leaf margins. *Aloe nubigena* and *A. soutpansbergensis* also have a pendent habit. *Aloe challisii* is at once distinguished from other cremnophilous species in section *Leptoaloe* by its downward curving leaves (epinastic growth), short, subcapitate inflorescence (140–160 mm long), subclavate perianth (25 mm long), pedicels (10–15 mm long) and small floral bracts (8–9 × 4 mm). It is further distinguished by its bluish green, subterete leaves. It is closest to *A. soutpansbergensis*, which has an inflorescence 180–200 mm long and horizontally orientated racemes with forward projected flowers 27 mm long (pedicels 25 mm long, floral bracts 17 × 5 mm and leaves green, dorsiventrally flattened). *Aloe challisii* is also distinguished by its spring flowering season while the others in section *Leptoaloe* flower in summer or autumn.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming clusters among moss and other cremnophytes occupying smaller crevices and ledges.

Size and weight: Of light to medium weight.

Stem: Caulescent, grey, spreading, subpendulous to pendulous.

Leaves

Orientation: Rosulate, subterete, curving downwards owing to epinastic growth and pendent (positively geotropic).

Succulence: Very fleshy, becoming very succulent in summer, an adaptation to the dry winters when the cliffs become very dry.

Colour: Bluish green.

Age and persistence: Fairly fast-growing, long-lived, perennial, deciduous from the base.

Armament: Leaf margin serrate, semitranslucent, white, cartilaginous, up to 1.5 mm broad at base, 0.2 mm broad elsewhere; teeth 1 × 0.4 mm, 1–3 mm apart. The teeth are soft, providing little armament in response to the safe cliff-face habitat (inaccessible to larger herbivores).

Sexual reproduction

Inflorescence and flowers: Young inflorescence curving upwards as it matures, presenting the racemes in the typical erect position.

Fruit/Seed

Size: Seed 3–4 × 1.5 mm, an ideal size for establishment in crevices.

Dispersal: Light, greyish black, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in winter and autumn, ready for the early spring and summer rains. Germination in about 14–21 days.

Vegetative reproduction: Plants prolific from the base, forming dense clusters in rock crevices among tufts of grass or other cremnophytes. This continuous vegetative renewal ensures a long-term foothold.

CONSERVATION STATUS

Although this small aloe is confined to the Steenkampsberg, it is locally abundant and protected by the inaccessible habitat and therefore not threatened. Its status has been determined as VU D2 (Raimondo *et al.* 2009).

ADDITIONAL NOTES

Horticulture: Best grown in afroalpine or summer-rainfall grassland gardens in a slightly acid peat and sand mixture (Van Jaarsveld 2006b, 2010). Feed regularly in spring and summer. An easily and fast-growing species. Away from its habitat it is best kept in a greenhouse and kept moist and cool in summer. *Aloe challisii* is prolific from the base, soon becoming cluster-forming. The drooping nature of the soft, flaccid leaves is retained in cultivation.

VOUCHER

Van Jaarsveld & Challis 19801 (NBG).

ILLUSTRATIONS AND MAP

Plate 15, Figures 15a–15c, Map 15.

16. *Aloe corallina* I. Verd. in The Flowering Plants of Africa 45: t. 1788 (1979).

Cremnophyte growth form: Cluster-forming, pendulous rosettes (of medium weight to heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb) (eg)

Etymology: The epithet *corallina* refers to the coral-red flowers.

DESCRIPTION AND HABITAT

Plants slow-growing, pendulous, with leaves in apical rosettes, dividing and forming small pendent clusters (up to 6 heads) up to 600 mm in diameter and on stems up to 700 mm long. Roots up to 3 mm in diameter. Stems up to 700 mm long, up to 80 mm in diameter. Leaves firm, densely rosulate (rosettes up to 600 mm in diameter in solitary specimens), drawn together in a mitre-shaped head (dry season), lanceolate-acuminate, up to 500 × 110 mm; surface firm, leathery, grey-green; margin entire to slightly denticulate; apex acute. Inflorescence 600–700 mm long, branched in distal half, with up to 13 racemes forming a loose panicle, rarely solitary; scape curving upwards from pendulous rosettes, exposing ascending racemes; racemes elongate; pedicels up to 12 mm long. Perianth subpendulous, coral-red, 32 × 7 mm. Fruiting capsule oblong, 10–14 × 5–7 mm. Seeds angular, 3 × 1.5 mm, dark brown, angular.

Phenology: Flowering mainly in winter (May–June).

Pollinators: Sunbirds.

Habitat and aspect: Dolomite cliffs, on all aspects, but usually on the shady south-facing slopes. Temperatures in the Cunene Valley are high throughout the year, especially in summer. Plants are firmly rooted in crevices and on ledges large enough to support the roots and stem clusters. Rainfall occurs mainly in summer, ranging from 75–150 mm per annum.

Altitude: 400–1200 m.

Associated vegetation: Arid savanna.

Associated cremnophytes: *Ceraria longipedunculata*, *Ficus cordata*, *F. glumosa*, *F. ilicina*, *Kalanchoe laciniata*, *K. lanceolata*, *Plectranthus hereroensis* and *Sterculia rogersii*.

Geology: Dark Proterozoic Namibian dolomite (Otavi Group, Damara Sequence). The dolomite substrate is dark and rough in texture, with many fissures and crevices.

DISTRIBUTION

A dolomite endemic, confined to sheer cliff faces of the Baynes Mountains in the Cunene River Valley of northern Namibia as well as southern Angola. Plants are often locally abundant.

RELATED SPECIES

Aloe corallina comes closest to *A. dewinteri*, a solitary, larger, also cremnophilous species from the dolomite cliffs near Sesfontein and the adjacent Khowarib Poort. The latter has

larger open rosettes, inflorescences that are branched low down and bicoloured flowers (yellow and red) and the leaves have slightly larger teeth. It is also related to *A. kaokoensis*, a larger robust species with open, spreading rosettes and large panicles. The small size of *A. corallina* can be viewed as an adaptation to its cliff environment.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with medium-sized caulescent clusters, occupying larger crevices and ledges. *Aloe corallina* is a slow grower and long-lived perennial. Where within reach, stems and leaves heavily grazed.

Size and weight: Heads medium-sized, of medium weight to heavy.

Stem: Caulescent, grey, pendulous stems and thus less investment in woody tissue.

Leaves

Orientation: Distinctly incurved, pendulous (positively geotropic).

Colour: Grey-green, without a powdery bloom, margins reddish. The grey colouring deflecting the rays of the sun.

Age and persistence: Long-lived, deciduous from the base.

Armament: Juvenile leaves are armed with brownish teeth of 1×1 mm (5–7 mm apart) but as the plant matures the teeth become smaller and sometimes disappear completely, suggesting a reduction in energy expenditure (production of teeth) but possibly also revealing the evolutionary history of plants evolving away from the cliff face.

Sexual reproduction

Inflorescence and flowers: Young inflorescence curving upwards as it matures, presenting the racemes in the typical erect position.

Fruit/Seed

Size: Seed 3×1.5 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in winter and autumn, ready for the early spring and summer rains. Germination in about 14–21 days.

Vegetative reproduction: *Aloe corallina* is prolific from the base, forming drooping clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Loots 2005). Although confined to dolomite cliffs along the lower Cunene River, plants grow in abundance and are therefore not threatened.

ADDITIONAL NOTES

Horticulture: Best for dry, sunny, subtropical savanna and desert gardens. An easily grown species but outside its habitat it is best grown in a greenhouse where environmental conditions can be controlled. Although it is a dolomite endemic, it adapts well to acidic soils. Plants react well to summer feeding with an organic fertiliser (Van Jaarsveld 2006b, 2010).

VOUCHER

Van Jaarsveld 16482 (NBG).

ILLUSTRATIONS AND MAP

Plate 16, Figures 16a–16c, Map 16.

17. *Aloe dabenorisana* Van Jaarsv. in *Journal of South African Botany* 48,3: 419–424 (1982b).

Cremonophyte growth form: Pendent, capitate, cluster-forming, recurved, leafy, branched (of medium weight to heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb) (eg)

Etymology: After the Dabenoris Mountain (Bushmanland, Northern Cape) where the plants were discovered by Mr A.R. Mitchell, a British citizen.

DESCRIPTION AND HABITAT

Plants slow-growing, long-lived, perennial (from seed 5–7 years), forming pendulous clusters (rarely solitary), branched from base, with short elongated stems up to 300 mm long. Roots slightly fleshy. Leaves in apical rosette up to 450 mm in diameter, narrowly lanceolate-acuminate, up to 240 mm long, 50 mm in diameter, recurved, sometimes deflexed; surface green tinged red; margin green to reddish, armed with small deltoid teeth. Inflorescence 2–4-branched, pendulous, recurved, up to 300 mm long; racemes capitate to pointed. Flowers subpendent. Perianth orange-red, green-tipped, 25 mm long. Fruiting capsule ascending-spreading. Seed not seen.

Phenology: Flowering mainly in midsummer (December–January).

Pollinators: Sunbirds.

Habitat and aspect: South-facing quartzitic sandstone cliffs. Plants are firmly rooted in crevices large enough to support the roots and stem clusters. The average daily maximum temperature is about 27°C and about 12°C in winter (in summer it can reach about 35–40°C).

The southern slopes are cooler and shady in the winter months and frost is absent. Rainfall occurs mainly from autumn (thunder showers) to spring and ranges from about 75–150 mm per annum.

Altitude: 700–1000 m.

Associated vegetation: Eastern Gariep Rocky Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus diabolicus*, *Conophytum fulleri*, *Crassula exilis* subsp. *sedifolia*, *C. garibina* and *Tylecodon sulphureus* var. *armianus*.

Geology: Light-coloured quartz of the Hom Formation (Bushmanland Group), with many ledges, fissures and crevices, ideal for establishment of plants

DISTRIBUTION

Aloe dabenorisana is confined to the sheer south-facing cliffs of the Dabenoris and Pellaberg Mountains.

RELATED SPECIES

Aloe dabenorisana is related to *A. pearsonii*, which is a much larger, erect species (smaller heads) of the Northern Cape. *Aloe dabenorisana* differs in its larger apical rosettes, pendulous nature, green leaf surface and lack of short, biconvex, reddish grey-green, persistent leaves along the erect stems. *Aloe dabenorisana* differs from *A. pavelkae* in its much shorter stems and leaves that are distinctly recurved.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with drooping stems and recurved leaves. A slow grower, long-lived perennial with a sturdy leaves.

Size and weight: Its larger size ensures its survival under very high summer temperatures and maximises moisture retention by the leaves.

Stem: Branches pendulous and fibrous, thus less investment in woody tissue.

Leaves

Orientation: Open rosettes of recurved leaves maximise exposure to the open shade.

Colour: Green, turning reddish when under moisture stress.

Age and persistence: Persistent and often remaining functional for many years, thus acting as a water resource and staying photosynthetically functional.

Armament: The smaller teeth on the leaf margins suggest a reduction in armament as a direct result of the reduction in herbivory.

Sexual reproduction

Inflorescence and flowers: Young inflorescence drooping but curving up as it matures, presenting the raceme(s) in the typical erect position.

Fruit/Seed

Size: Seed not seen.

Dispersal: Light seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in autumn, coinciding with autumn rains and start of the winter rainy season.

Vegetative reproduction: *Aloe dabenorisana* is prolific from the base, forming drooping clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of shoots and rooting of stems in new crevices by extended stem growth represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Although rare, *Aloe dabenorisana* is not threatened (Hilton-Taylor 1996; Raimondo *et al.* 2009).

ADDITIONAL NOTES

Horticulture: Best for dry, subtropical desert gardens, grown on shady embankments, on the shady side of buildings or drooping from window sills (Van Jaarsveld 2006b, 2010). Outside its habitat, plants are difficult to grow and prone to fungal diseases such as crown rot and root rot (the latter due to a *Fusarium* sp.). Grow in a warm but shady position in a slightly acid soil. Water should be provided sparingly throughout the year. Propagation from stem cuttings, rooted in sandy soil in summer. Keep in light shade.

VOUCHERS

Van Jaarsveld & Kritzinger 6426, Van Jaarsveld & Patterson 6638 (NBG).

ILLUSTRATIONS AND MAP

Plate 17, Figures 17a–17d, Map 17.

18. *Aloe dewinteri* Giess in *Bothalia* 11: 120 (1973).

Cremonophyte growth form: Solitary, open, acaulescent or very shortly stemmed rosette (heavy, cliff squatter).

Growth form formula: A:S:Lper:R:So:La

Etymology: After Dr Bernard de Winter (1924–), Director of the former Botanical Research Institute in Pretoria.

DESCRIPTION AND HABITAT

Plants slow-growing, acaulescent or short-stemmed with leaves in horizontal exposed rosettes up to 800 mm in diameter. Stem up to 60 mm in diameter. Roots up to 3 mm in diameter. Leaves firm, densely rosulate, erect becoming spreading and recurved, lanceolate-acuminate, up to 560 × 100 mm; surface firm, leathery, grey-green; margin denticulate, bearing small yellowish brown teeth 2 mm long; apex acute. Inflorescence up to 900 mm long, branched in basal half, with up to 3 racemes, occasionally solitary; scape curving upwards from horizontal rosettes; racemes elongate; pedicels 5 mm long. Perianth subpendulous, 30 × 7 mm long, pink becoming cream-white as it matures. Fruiting capsule oblong, 15 × 8 mm. Seeds 3 × 1.5–2 mm, dark brown, angular.

Phenology: Flowering mainly in summer (December–January).

Pollinators: Sunbirds.

Habitat and aspect: Dolomite cliffs and has been recorded from most aspects, but more so from the shady south-facing slopes. Plants are firmly rooted in crevices and on ledges large enough to support the roots and stem clusters. Temperatures are high, especially in summer, with cooler but warm, dry winters. Rainfall occurs mainly in summer, ranging from 75–150 mm per annum.

Altitude: 600–1200 m.

Associated vegetation: Arid savanna and subtropical desert.

Associated cremnohytes: *Ceraria* sp., *Ficus cordata*, *F. ilicina*, *Kalanchoe laciniata*, *Plectranthus hereroensis*, *Sterculia rogersii* and *Urginea* sp.

Geology: Dark Proterozoic Namibian dolomite (Otavi Group, Damara Sequence), rough in texture and with many fissures.

DISTRIBUTION

Aloe dewinteri is a dolomite endemic, confined to the sheer cliff faces of the escarpment mountains east of Sesfontein (Kaokoland, Namibia) and plants are more often found on shady southern slopes where they are often locally abundant.

RELATED SPECIES

Aloe dewinteri comes closest to *A. corallina*; the differences are discussed under that species. It is also related to *A. kaokoensis*, the latter with much larger rosettes and a paniculate inflorescence. Its small size can be seen as an adaptation to its cliff-face environment.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with medium-sized to large acaulescent rosettes, occupying larger crevices and ledges. Growth is slow, but a long-lived perennial. Where within reach, stems and leaves heavily grazed.

Size and weight: Heads medium-sized, heavy.

Stem: Short, caulescent, grey, spreading to pendulous, thus less investment in woody tissue.

Leaves

Orientation: In an open rosette and recurved (negatively geotropic). Leaves with a firm but smooth texture, at first ascending-spreading and ultimately recurved, with maximum exposure to the open shade.

Colour and texture: Grey-green without a powdery bloom, margins reddish. The firm texture and colour in response to the very hot, dry desert environment.

Age and persistence: Long-lived, deciduous from the base.

Armament: Juvenile and mature leaves armed with brownish teeth 1 × 1 mm (5–7 mm apart).

Sexual reproduction

Inflorescence and flowers: Young inflorescence curving upwards as it matures, presenting the racemes in the typical erect position.

Fruit/Seed

Size: Seed 3 × 1.5–2 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in winter and autumn, ready for the early spring and summer rains. Germination in about 14–21 days.

Vegetative reproduction: Plants solitary but damaged heads will sprout as a vegetative backup.

CONSERVATION STATUS

Classified as rare (Loots 2005). Limited in distribution but often locally abundant and therefore not threatened.

ADDITIONAL NOTES

Horticulture: Best for dry, sunny, subtropical savanna and desert gardens (Van Jaarsveld 2006b, 2010). An easily grown species but outside its habitat it is best grown in a greenhouse

where environmental conditions can be controlled. Although it is a dolomite endemic, it adapts well to acidic soils. Plants react well to summer feeding with an organic fertiliser.

VOUCHER

Van Jaarsveld 16837 (NBG).

ILLUSTRATIONS AND MAP

Figures 18a–18c, Map 18.

19. *Aloe haemanthifolia* A.Berger & Marloth in *Botanische Jahrbücher* 38: 85 (1905).

Cremnophyte growth form: Cluster-forming (heavy, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After its habit and likeness to the genus *Haemanthus* (Amaryllidaceae).

DESCRIPTION AND HABITAT

Plants slow-growing, acaulescent, dividing forming large rounded clusters up to 1.5 m in diameter, 0.7 m high. Leaves distichous, ascending, broadly lorate, fibrous, green, up to 210 × 100 mm, lineate; margin reddish, minutely serrulata; apex rounded. Inflorescence simple, curving upwards, up to 650 mm tall; racemes capitate; pedicels up to 35 mm long. Perianth subpendulous, orange-red, up to 38 long; style and anthers included. Fruiting capsule conical, 30 × 17 mm. Seeds angular, 7 × 4 mm, dark grey.

Phenology: Flowering mainly in spring (October). Seeds dispersed by wind in summer and autumn, just before the spring rains.

Pollinators: Sunbirds.

Habitat and aspect: Sandstone cliffs on exposed north-, east-, west- and south-facing aspects. Plants firmly rooted in crevices and on ledges large enough to support the roots and stem clusters. Summers are cool, winters cooler with occasional snow. The average daily maximum temperature is about 18°C and the average daily minimum about 8°C. Rainfall occurs mainly in winter and ranges from 800–1000 mm per annum (cyclonic winter rainfall).

Altitude: 500–1675 m.

Associated vegetation: Western Altimontane Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus maculata*, *Crassula atropurpurea* var. *watermeyeri*, *C. obtusa*, *Ruschia drepanophylla* and restios (Restionaceae).

Geology: Quartzitic sandstone (Nardouw Subgroup, Table Mountain Group, Cape Supergroup). Light in colour and rough- to smooth-textured, with many ledges, fissures and crevices, ideal for establishment of plants.

DISTRIBUTION

Aloe haemanthifolia is a quartzitic sandstone endemic, confined to sheer cliff faces of the Hex River-Cold Bokkeveld and southern Cedarberg Mountains. Plants are often locally abundant.

RELATED SPECIES

Aloe haemanthifolia comes closest to *A. plicatilis*, an arborescent species from the Hex River Mountains with similar distichous leaves (margin denticulate, fibres lacking), corky bark and elongated racemes; it is also well adapted to fire. Apart from its small size, the heads of *A. haemanthifolia* are much larger and not glaucous green as in *A. plicatilis*. The seed pods are rounded in *A. plicatilis* but conical in *A. haemanthifolia*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with large acaulescent clusters, occupying larger crevices and ledges. *Aloe haemanthifolia* is a slow grower and long-lived perennial with distinctly fibrous leaves. Where within reach, plants heavily grazed (leaves lacking bitter substance), exposing the conspicuous fibrous leaves (Figure 19d).

Size and weight: Heads medium-sized, clusters heavy.

Stem: Acaulescent, thus less investment in woody tissue.

Leaves

Orientation: Ascending-spreading, distichous, becoming drawn together under dry conditions, the distichous orientation preventing full exposure to sunlight in dry, hot weather.

Colour: Green without a powdery bloom, becoming reddish in summer.

Age and persistence: Long-lived, deciduous from the base.

Armament: The smaller, softer, minutely serrulate leaf margins and lack of a bitter substance suggest a reduction in armament (mechanical and chemical) as a direct result of the reduction in herbivory.

Sexual reproduction

Inflorescence and flowers: Young inflorescence curving upwards as it matures, presenting the raceme(s) in the typical erect position.

Fruit/Seed

Size: Seed 7×4 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in summer and autumn, ready for the early autumn rains. Germination in about 14–21 days.

Vegetative reproduction: *Aloe haemanthifolia* is prolific from the base, forming dense clusters. The continual renewal of shoots (suckering from the base) is a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Aloe haemanthifolia has a fairly limited distribution but is often locally abundant and therefore not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: Best grown in warm temperate to cool fynbos gardens. Although seeds germinate easily, plants do not do well in a warm climate or in rich alkaline soil. They prefer mineral-poor, acid soil, a well-drained environment and cool conditions. Grown from seed, they take several years before flowering.

VOUCHER

Van Jaarsveld 16291 (NBG).

ILLUSTRATIONS AND MAP

Figures 19a–19d, Map 19.

20. *Aloe hardyi* Glen in *The Flowering Plants of Africa* 49: t. 1942 (1987).

Cremonophyte growth form: Cluster-forming, pendulous, branched, capitate, leafy (heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb) (eg)

Etymology: After Mr David Hardy (1931–1998), horticulturist at the former Botanical Research Institute in Pretoria.

DESCRIPTION AND HABITAT

Plants fast-growing, forming loose pendulous clusters, branched from base, with elongated stems up to 1 m long, occasionally solitary. Roots terete, up to 6 mm in diameter, dividing to form a network. Leaves in apical rosettes, deciduous towards base, up to 400–700 × 50–80 mm, flaccid and pendulous or curving down, becoming slightly spreading in rainy season, inwardly curved and becoming drawn together at apex; epidermis glaucous, with powdery bloom, reddish in dry season or during prolonged droughts. Juvenile leaves remaining distichous for up to 3 years. Inflorescence conspicuous, simple, pendulous, recurved, 450–700 mm long; racemes up to 200 mm long, conical. Perianth subpendulous, orange-red, green-tipped, 25–40 × 7 mm. Fruiting capsule ascending-spreading, 25 × 7 mm. Seeds angular, 3 × 2 mm, grey, about 55–70 per capsule.

Phenology: Flowering mainly in midwinter (July). Seeds dispersed by wind in early spring (end of September), just before the spring rains.

Pollinators: Sunbirds.

Habitat and aspect: Vertical cliffs on exposed northern and northwestern aspects, but also on southern and eastern slopes. Plants firmly rooted in crevices large enough to support the roots and stem clusters. Temperature is extremely high, especially on north-facing aspects in summer (35–45°C). Winters are mild and frost is absent. The average daily maximum temperature is about 28°C and the average daily minimum about 14°C. Rainfall occurs mainly in summer, 300–400 mm (thunder showers, October–May).

Altitude: 850–1350 m.

Associated vegetation: Origstad Mountain Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: Opportunistic species such as *Aloe sessiliflora*, *Commiphora marlothii*, *Euphorbia lydenburgensis*, *E. tirucalli*, *Ficus abutilifolia*, *Sarcostemma viminale*, *Sterculia rogersiae* and *Vellozia* sp.

Geology: Dolomite (dark-coloured and rough-textured), Chuniespoort Formation, Malmani Subgroup (Transvaal Supergroup). The rock is dark in colour and rough, with many ledges, fissures and crevices, ideal for establishment of plants.

DISTRIBUTION

Aloe hardyi is a dolomite endemic, confined to the Olifants River Valley between the Strydom Tunnel and Penge Asbestos Mine in the Limpopo Province and adjacent territory of the same geological formation.

RELATED SPECIES

Aloe hardyi belongs to series *Arborescens* and its closest relative is *A. arborescens*, a much-branched, rounded, shrubby species up to 1.5 m tall, from the nearby Drakensberg escarpment mountains. *Aloe hardyi* is also related to *A. mutabilis*, the latter another shrubby, branched cremnophyte with larger open heads. Apart from a slightly smaller size and the few pendulous branches of *A. hardyi*, the leaves in the apical rosette are drawn together, with a much more conspicuous powdery bloom and more glaucous appearance. The leaves of young plants of *A. hardyi* remain distichous for up to three years, but rapidly become rosulate in *A. arborescens*. The adult leaves of *A. hardyi* are furthermore flaccid and become pendent but remain sturdy in *A. arborescens* and *A. mutabilis*. Some forms of *A. arborescens* are glaucous, but not to the same extent as *A. hardyi*. Although some clones of *A. hardyi* are prolific from the base, others remain solitary.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with drooping stems and soft, flaccid leaves; even when grown in cultivation this habit is retained. *Aloe hardyi* is a rapid summer grower and long-lived perennial.

Size and weight: Heads medium-sized to large, heavy.

Stem: Branches grey, pendulous, fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Apart from curving down (positively geotropic), the leaves are drawn together in the apical rosette, becoming slightly spreading only in the rainy season, an adaptation to the extreme heat generated by the dark dolomitic rocks.

Colour: Glaucous (reflecting the light), with powdery bloom, becoming drawn together in the dry season and with a protective reddish coloration typical of most succulent plants under sunny conditions and water stress.

Age and persistence: Becoming deciduous from the base, resulting in apical rosettes. The large heads and stature can cope better with heat exposure in general and with the very warm conditions in lowveld savanna in summer.

Armament: The teeth on the leaf margins are soft, suggesting a reduction in armament as a direct result of the reduction in herbivory.

Sexual reproduction

Inflorescence and flowers: Young inflorescence drooping but curving up as it matures, presenting the raceme(s) in the typical erect position.

Fruit/Seed

Size: Seed 3×2 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in spring, coinciding with the start of the rainy season. Germination within 14–21 days.

Vegetative reproduction: Stems of *Aloe hardyi* root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of shoots of some prolific clones and the rooting of stems in new crevices by extended growth represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Although classified as rare (Raimondo *et al.* 2009), it is not threatened owing to the sheer cliff-face habitat.

ADDITIONAL NOTES

Horticulture: Plants easily grown from seed and as specimen pot collections (Van Jaarsveld 2006b, 2010). *Aloe hardyi* is best for dry savanna gardens. Plants thrive with regular feeding

in spring and summer. Although the soil in its native habitat is alkaline, it adapts well to neutral and acidic soils. Some clones are prolific from the base, forming clusters, while others remain solitary. This genetic variability suggests adaptive plasticity. *Aloe hardyi* is prone to fungal crown rot (not in *A. arborescens*). Excellent for balconies, sheer embankments or large hanging baskets. Keep dry in summer.

VOUCHER

Van Jaarsveld 16242 (NBG).

ILLUSTRATIONS AND MAP

Plate 20, Figures 20a–20c, Map 20.

21. *Aloe kouebokkeveldensis* Van Jaarsv. & A.B.Low, in Van Jaarsveld *et al.* in *Aloe* 41,2 & 3: 36–37 (2004a).

Cremonophyte growth form: Solitary rosettes (heavy, cliff squatter).

Growth form formula: A:S:Lper:R:So:La

Etymology: After its habitat, the Cold Bokkeveld (Koue Bokkeveld).

DESCRIPTION AND HABITAT

Plants decumbent to erect, acaulescent; rosettes usually solitary but occasionally dividing to form small groups of up to 3, approximately 0.5–1.0 m in diameter. Mature leaves 12–15, arcuate-ascending to ascending, lanceolate to somewhat acuminate, tapering to an acute, mucronate apex, 400–480 × 100–150 mm, flat above and slightly channelled toward apex, flat to convex below, fleshy and fairly soft in texture, easily bruised; leaf sap colourless, not bitter, becoming sulphur-yellow when dried; margin cartilaginous, with small pinkish white teeth 1 mm long; surface grey-white, often tinged bluish, becoming slightly reddish with drought stress, obscurely striate and irregularly spotted with pale, elongated H-shaped, confluent spots up to 5 mm long. Younger leaves with distinct bluish tinge, densely spotted. Inflorescence a branched corymbose panicle, 1.0–1.4 m tall, branching above the middle; peduncle basally biconvex, becoming subterete, 37 mm wide at base; racemes capitate, 80–100 mm long; bracts thin, scarious, deltoid-acuminate, lower bracts 4 mm wide at base, 8 mm long, distal bracts 2–3 mm wide at base, 5 mm long; pedicels 12–15 mm long. Perianth orange-red, 22–23 mm long, subpendulous, in bud horizontally spreading and slightly curved, base globose, 4–5 mm wide, abruptly narrowing to 3 mm and expanding to 5 mm near apex; outer segments orange, free for 7 mm, 3 mm wide, acute to subacute, apices very pale orange, inner segments free for 8 mm, white with median orange-red stripe, 4 mm wide, spreading, with obtuse apices. Stamens orange, just exerted at mouth. Ovary yellowish green, 6.5 × 3 mm. Style filiform, finally exerted for 3 mm; stigma capitate, minute. Capsules subglobose, 18–20 × 15–18 mm, green, becoming purplish green. Seeds grey-black, winged, 4 × 3 mm.

Phenology: Flowering mainly in spring (November–December). Seeds dispersed by wind in summer in the rainy season.

Pollinators: Sunbirds.

Habitat and aspect: *Aloe kouebokkeveldensis* grows in fully exposed or partially shaded cliff-face habitats, on rocky ledges and in crevices, in shallow soil. It occurs sympatric with *Aloe perfoliata*, which is common in the area. The sandy soil is derived from sandstone and is slightly acid. Summers are dry and hot. The average daily maximum temperature is about 23°C and the average daily minimum about 12°C. Rainfall occurs mainly in winter and ranges from 700–800 mm per annum.

Altitude: 400–600 m.

Associated vegetation: Cederberg Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe kouebokkeveldensis* shares its habitat with species such as *Diospyros glabra*, *Dodonaea angustifolia*, *Hymenolepis parviflora*, *Searsia undulata*, *Secamone alpini* and various members of the Restionaceae. Associated succulent species include *Adromischus hemisphaericus*, *Crassula dejecta*, *C. muscosa* var. *muscosa*, *C. rupestris*, *Oscularia lunata* and *Pelargonium alternans*.

Geology: Quartzitic Sandstone of the Table Mountain Group (Cape Supergroup). The rock substrate has many ledges, crevices and fissures and is ideal for establishment of plants.

DISTRIBUTION

Aloe kouebokkeveldensis is confined to the lower southern slopes of the Cold Bokkeveld Mountains southwest of Citrusdal (altitude 600–800 m above sea level) and is known only from a few small populations on north-facing quartzitic sandstone cliffs and steep slopes (Western Cape).

RELATED SPECIES

Aloe kouebokkeveldensis is the sixth member of *Aloe* series *Paniculatae* and the first recorded from fynbos vegetation. Members of the series are characterised by their entire or minutely dentate leaves and subcorymbose panicles, the flowers with a subglobose basal swelling and enlarging towards the throat. *Aloe kouebokkeveldensis* is at once distinguished from other members of this series by a combination of characters, the most conspicuous of these being its large, solitary rosettes of up to 1 m in diameter (occasionally dividing to form small groups) of grey-white, often bluish tinged leaves with elongated, confluent white spots and denticulate margins. Juvenile leaves are densely spotted, soft-textured, with margins that are often wrinkled. The inflorescences grow up to 1.4 m high, making them the largest in the *Paniculatae*. The small orange-red flowers are 22–23 mm long, and are followed by rounded fruiting capsules. A further diagnostic character is the leaf sap, which is not bitter. Plants growing in shade have leaves that are similar in colour to those of *A. reynoldsii*, the easternmost member of this group. *Aloe reynoldsii* occurs in riverine subtropical thicket vegetation and flowers in September and October. *Aloe striata* flowers in August and September and occurs mainly in Nama-Karoo vegetation. It is the most widespread member of the series. *Aloe karasbergensis*, the northernmost species in the group, is confined to Nama-Karoo and Succulent Karoo, but seems to favour winter-rainfall conditions and flowers in January and February. *Aloe buhrii* and *A. komaggasensis* grow in Succulent Karoo along

the western escarpment, their respective flowering periods being October–December and January. The distribution of *A. kouebokkeveldensis* falls between that of *A. buhrii* (Bokkeveld escarpment) in the north and *A. striata* in the east.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Large solitary rosettes. A fast winter grower and long-lived perennial with soft leaves.

Size and weight: Heads large and unusual for a general cremnophilous plant, heavy.

Stem: Plants acaulescent or with very short stem.

Leaves

Orientation: Ascending-spreading.

Colour: Grey-whitish green, often bluish tinged, becoming slightly reddish under drought stress, obscurely striate and irregularly spotted with pale, elongated, confluent, H-shaped spots.

Age and persistence: Long-lived, perennial.

Armament: The soft leaves with small teeth suggest a reduction in armament as a direct result of the reduction in herbivory. (*Aloe striata* has grey-white leaves with a smooth, but firm margin.)

Sexual reproduction

Inflorescence and flowers: Orange-red flowers conspicuous on the cliff face, attracting sunbirds.

Fruit/Seed

Size: Seed 4 × 3 mm, an ideal size for establishment in crevices.

Dispersal: Light, grey-black, winged, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed from late spring to summer, coinciding with the start of the rainy season. Germination can occur after 14–21 days.

Vegetative reproduction: Heads solitary and without an additional vegetative dispersal strategy. Damaged heads will divide and re-sprout.

CONSERVATION STATUS

Although classified as rare (Raimondo *et al.* 2009), it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Plants easily grown and best for fynbos and other summer-dry Mediterranean-type gardens (Van Jaarsveld 2006b, 2010). It is best planted on rockeries in full sun. Keep dry in summer and feed annually with compost. It is susceptible to aloe cancer mite, but easily treated with Karba paste painted onto the infected parts. Sow seed in autumn. Plants grow fairly fast and should flower after four years in cultivation.

VOUCHER

Van Jaarsveld & Ems 17744 (NBG).

ILLUSTRATIONS AND MAP

Figures 21a–21c, Map 21.

22. *Aloe meyeri* Van Jaarsv. in *Journal of South African Botany* 47,3: 567–571 (1981a).

Cremonophyte growth form: Cluster-forming, pendulous, leafy, branched (of medium weight to heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Rls (vb) (eg)

Etymology: After Mr Reverend G. Meyer (fl. 1929) who first collected this species in the Richtersveld (Northern Cape).

DESCRIPTION AND HABITAT

Plants slow-growing, long-lived, perennial (from seed 5–7 years), forming loose pendulous clusters, branched from base, with elongated stems up to 1 m long. Roots slightly fleshy. Branches leafy, becoming deciduous only from below or during severe drought. Leaves in an apical rosette up to 260 mm in diameter, spreading in rainy season, inwardly curved, becoming drawn together with a reddish colour in dry season or during prolonged drought, narrowly lanceolate-acuminate, up to 200 mm long, 35 mm in diameter. Inflorescence simple or branched, pendulous, recurved, up to 250 mm long; racemes capitate, not pointed. Flowers subsistent. Perianth orange-red, green-tipped, 20 mm long. Fruiting capsule 9–12 × 4 mm, ascending-spreading. Seeds grey, 3 × 2 mm.

Phenology: Flowering mainly in midsummer and autumn (December–April), but sporadically at other times as well.

Pollinators: Sunbirds.

Habitat and aspect: Vertical quartzitic sandstone cliffs. *Aloe meyeri* grows mainly on exposed northern and northwestern aspects, but also on southern and eastern slopes, the plants firmly rooted in crevices large enough to support the roots and stem clusters. The average daily maximum temperature is about 26°C and the average daily minimum about 14°C. The southern slopes are cooler with shady conditions. Winters are cool and subject to occasional

coastal fog from the west coast; frost is absent. Rainfall occurs mainly from autumn (thunder showers) to spring (cyclonic winter rain), ranging from 75–150 mm per annum.

Altitude: 300–1200 m.

Associated vegetation: Rosyntjieberg Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Conophytum taylorianum* subsp. *rosynense*, *Othonna cremnophila*, *Trachyandra aridimontana* and *Tylecodon ellaphieae*.

Geology: Quartzitic sandstone of the Rosyntjieberg Formation (Orange River Group). This rock formation has many fissures, ledges and crevices and is ideal for establishment of plants.

DISTRIBUTION

Aloe meyeri is confined to the upper slopes of the Rosyntjieberg and adjacent area of the same geological formation.

RELATED SPECIES

Its closest relative is *Aloe perfoliata* (formerly *A. mitriformis*, *A. comptonii*, *A. distans*), a much larger species from the Western Cape. It differs in a smaller general size of the plants and in armament (teeth small, white), and a lack of the white tubercles on the lower leaf surfaces found on *A. perfoliata*. The flowers are furthermore smaller and green-tipped, in fact the smallest of the subsection *Prolongatae* series *Mitriformis* (to which five species belong, mainly restricted to the winter-rainfall region). *Aloe perfoliata* is also an opportunistic cremnophyte but is usually associated with any quartzitic sandstone or shale outcrop (occasionally on the flats away from rocks), usually confined to exposed sunny positions. Differences with *A. pavelkae* and *A. dabenorisana* are discussed under the first named.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Pendent leafy stems and leaves, even when grown in cultivation. *Aloe meyeri* is a slow grower and long-lived perennial with a sturdy leaves.

Size and weight: Compared to related plants in subsection *Prolongatae* (Reynolds 1950), there is a general reduction in size (smallest in the subsection). Its smaller size also allows for more effective anchorage of the rootstock (coping with gravity). Plants of smaller size can cope better with heat absorption under cool growing conditions, a general trend among winter-active succulent plants.

Stem: Branches pendulous, fibrous.

Leaves

Orientation: In apical rosette.

Colour: Glaucous (reflecting light), with powdery bloom, becoming drawn together in the dry season and with a protective reddish coloration typical of most succulent plants under sunny conditions and water stress.

Age and persistence: Persistent and often remaining functional for many years, thus acting as a water resource. Leaves perennial and long-lived (photosynthetically functional), an adaptation to the extremely arid environment, maximising water storage. Replacement of leaves in a poor soil is costly, thus long-term leaves maximising water storage and remaining functional for a long period.

Armament: The smaller teeth on the leaf margins suggest a reduction in armament as a direct result of the reduction in herbivory.

Sexual reproduction

Inflorescence and flowers: Young inflorescence drooping but curving up as it matures, presenting the raceme(s) in the typical erect position.

Fruit/Seed

Size: Seed 3×2 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in autumn, coinciding with the start of the rainy season and period of greatest occurrence of rainfall.

Vegetative reproduction: *Aloe meyeri* is prolific from the base, forming drooping clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Hilton-Taylor 1996; Raimondo *et al.* 2009), but it is not threatened owing to its inaccessible cliff-face habitat.

ADDITIONAL NOTES

Horticulture: *Aloe meyeri* is best grown in succulent karoo gardens. It does best on sheer embankments or on a balcony (Van Jaarsveld 2006b). Plants are easily grown from seed or cuttings. It is best grown as a specimen pot collection outside its native habitat (Van Jaarsveld 1981a,b, 2006b, 2010). In moist environments, plants may become prone to fungal crown rot. It does well in a sandy, well-drained soil. Keep dry in summer.

VOUCHER

Van Jaarsveld 6137 (NBG).

ILLUSTRATIONS AND MAP

Plate 22, Figures 22a–22d, Map 22.

23. *Aloe mutabilis* Pillans in South African Gardening and Country Life, July: 168 (1933).

Cremnophyte growth form: Cluster-forming, subpendulous, branched, capitate, leafy (heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb)

Etymology: The epithet *mutabilis*, changeable, pertains to the nature of the species.

DESCRIPTION AND HABITAT

Plants fast-growing, caulescent, forming pendulous clusters, branches decumbent, branched from base, with elongated stems up to 1 m long and up to 150 mm in diameter, occasionally solitary. Roots terete, up to 6 mm in diameter, dividing to form a network. Leaves in apical rosettes, deciduous at base of plant, up to 700 × 90 mm, pendulous or curving down, becoming slightly spreading in rainy season, inwardly curved and becoming drawn together at apex; epidermis glaucous, with powdery bloom, reddish in dry season or during prolonged drought. Inflorescence conspicuous, simple, pendulous, recurved, to 1 m long; racemes densely flowered, conical. Perianth subpendulous, buds orange becoming greenish yellow when flower opens, 35 × 7 mm. Fruiting capsule ascending-spreading, 17–25 × 7 mm. Seeds angular, 3 × 2 mm, grey-black.

Phenology: Flowering mainly in midwinter (July). Seeds dispersed by wind in early spring (end of September), just before the spring rains.

Pollinators: Sunbirds.

Habitat and aspect: Mainly north- and northwest-facing cliffs, but also on southern and eastern slopes. Plants are firmly rooted in crevices large enough to support the roots and stem clusters. The average daily maximum temperature is about 24–25°C and the average daily minimum about 8–10°C. Winters are cool, with occasional light frost. Rainfall occurs mainly in summer and ranges from 700–800 mm (thunder showers, October–May).

Altitude: 800–1800 m.

Associated vegetation: Gold Reef Mountain Bushveld and Waterberg Mountain Bushveld of the Central Bushveld Bioregion, Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: Opportunistic species such as *Aloe sessiliflora*, *Cotyledon orbiculata*, *Crassula setulosa* var. *jenkinsii*, *C. swaziensis*, *Delosperma vogtsiae*, *Plectranthus ramosior* and *Sterculia rogersiae*.

Geology: Quartzite (Magaliesberg Group, Pretoria Formation of the Transvaal Supergroup), sandstone and conglomerate (Wilge River Formation, Waterberg Group). Substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Aloe mutabilis is quartzitic sandstone endemic, confined to cliffs in river valleys of Gauteng and Limpopo Province. Plants are commonly found at Chuniespoort near Polokwane.

RELATED SPECIES

Aloe mutabilis is closest to *A. hardyi*, the latter with unicoloured flowers and plants of the latter with positive geotropic growth. *Aloe mutabilis* retains a decumbent habit and has bicoloured flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with semidrooping stems and leaves, but mainly due to phenotypic plasticity as this character is not retained in cultivation. It is a rapid summer grower and long-lived perennial.

Size and weight: Heads large, heavy.

Stem: Branches grey, decumbent to subpendulous, fibrous and strong.

Leaves

Orientation: Ascending-spreading.

Colour: Glaucous (reflecting light), with powdery bloom.

Age and persistence: Becoming deciduous from the base, resulting in apical rosettes. The large heads and stature can cope better with heat exposure in general and with the very warm conditions in lowveld savanna in summer.

Armament: The leaves are soft but firm, with small teeth on the margins, suggesting a reduction in armament as a direct result of the reduction in herbivory. (*Aloe arborescens*, a close relative among slopes and boulders, has larger, closely spaced teeth.)

Sexual reproduction

Inflorescence and flowers: Young inflorescence drooping but curving up as it matures, presenting the raceme(s) in the typical erect position.

Fruit/Seed

Size: Seed 3×2 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in spring, coinciding with the start of the rainy season. Germination after 14–21 days.

Vegetative reproduction: *Aloe mutabilis* proliferates from the base, forming semidrooping shrubs. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of vegetative basal shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Rare, but not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: Best suited to bushveld (savanna) gardens (Van Jaarsveld 2010). Plants are easily grown and adaptable. Propagate from cuttings or seed in a sandy mixture. Fairly fast-growing and forming attractive shrubs, flowering in midwinter. It is ideal for steep embankments and larger window sills. An annual dressing of compost will benefit performance.

VOUCHER

Van Jaarsveld & Roux 17204 (NBG).

ILLUSTRATIONS AND MAP

Figures 23a & 23b, Map 23.

24. *Aloe nubigena* Groenew. in *Tydskrif vir Wetenskap en Kuns* 14: 3 (1936).

Cremonophyte growth form: Cluster-forming, pendulous rosettes (light to medium weight, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb) (eg)

Etymology: The epithet *nubigena* alludes to its cloud-borne habitat.

DESCRIPTION AND HABITAT

Plants with moderate growth rate to rapid-growing, caulescent, proliferating from base forming small clusters with soft functional leaves produced in apical rosette. Stem horizontal to horizontally pendulous to pendulous, up to 100 mm long, covered with old dried leaf remains. Leaves distichous, linear, pendulous, up to 600 × 20 mm; margin entire to denticulate in some populations, green; surface smooth. Inflorescence a simple spreading to spreading pendulous capitate raceme, up to 210 mm long; pedicels up to 30 mm long. Perianth subpendulous, orange-red, green-tipped, 27 × 7 mm. Fruiting capsule oblong-conical, 20 × 10 mm. Seeds 3 × 1.5 mm, dark brown, angular.

Phenology: Flowering mainly in summer (November–April) and sporadically at other times.

Pollinators: Sunbirds.

Habitat and aspect: Vertical quartzitic sandstone cliffs of the upper eastern escarpment margin. Plants grow firmly rooted in crevices and on ledges large enough to support the roots and stem clusters. The average daily maximum temperature is about 20°C and the average daily minimum about 5°C. It is cool throughout the year, with frequent fog in the summer rainy season. Rainfall occurs mainly in summer, ranging from 1500–2000 mm per annum.

Altitude: 1450–2100 m.

Associated vegetation: Northern Escarpment Quartzite Sourveld of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Crassula pellucida* subsp. *alsinoides*, *Drimia robusta*, *Scilla natalensis* and various moss species.

Geology: Quartzitic sandstone (Black Reef Formation, Transvaal Supergroup). Light-textured (grey), rough- to smooth-textured and with many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Aloe nubigena is a quartzitic sandstone endemic of the escarpment mountains near Graskop. It is confined to the moist and well-watered, sheer, east-facing cliffs. Plants are often locally abundant.

RELATED SPECIES

Aloe nubigena comes close to *A. thompsoniae* from the Wolkberg near Pietersburg in Limpopo Province. The latter has open, acaulescent rosettes, often recurved leaves and shorter inflorescences; it grows in a more exposed environment.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming clusters among moss and other cremnophytes occupying smaller crevices and ledges. Where within reach, stems and leaves heavily grazed.

Size and weight: Heads dwarf-sized, light to medium weight.

Stem: Caulescent, grey, spreading, subpendulous to pendulous.

Leaves

Orientation: Distichous, pendulous (positively geotropic), with soft texture and smooth epidermis in response to the moist, mild climate.

Colour: Green.

Age and persistence: Long-lived perennial with medium growth rate, leaves deciduous from the base.

Armament: Plants show variability in leaf armament from completely entire to denticulate in a small region.

Sexual reproduction

Inflorescence and flowers: Young inflorescence curving upwards as it matures, presenting the racemes in the typical erect position.

Fruit/Seed

Size: Seed 3×1.5 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in winter and autumn, ready for the early spring and summer rains. Germination in about 14–21 days.

Vegetative reproduction: *Aloe nubigena* is prolific from the base, forming small, drooping clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Although limited in distribution, it is often locally abundant and therefore not threatened.

ADDITIONAL NOTES

Horticulture: Best grown in afroalpine or summer-rainfall grassland gardens in a slightly acid peat and sand mixture. Feed regularly in spring and summer. Easy to grow, with a moderate growth rate. Away from its habitat it is best kept in a greenhouse and kept moist and cool in the summer months (Van Jaarsveld 2006b). Plants are prolific from the base, soon becoming cluster-forming.

VOUCHER

Van Jaarsveld 16215 (NBG).

ILLUSTRATIONS AND MAP

Plate 24, Figures 24a–24d, Map 24.

25. *Aloe omavandae* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Haseltonia* 10: 41–43 (2004b).

Cremonophyte life form: Solitary pendulous apical rosettes (heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb) (eg)

Etymology: After Omavanda, the eastern part of the Baynes Mountains in the Kaokoveld, northern Namibia.

DESCRIPTION AND HABITAT

Plants cremnophilous, usually solitary and pendent, weighing up to 4.5 kg when adult, stems up to 220 mm long, 35–55 mm thick; bark grey. Roots grey-brown, 3–4 mm thick. Leaves numerous (up to 25 functional), in a dense rosette, arcuate-pendent and becoming mitriform in dry season, triangular-lanceolate, 300–470 mm long, 65–85 mm in diameter at base; upper surface flat but becoming channelled in distal half, pale green to grey-green fading to pinkish green, sparsely white-spotted in basal third, lenticular spots irregularly arranged, lower surface flat to slightly convex at first, becoming convex and shortly keeled toward apex, copiously white-spotted, with the lenticular spots arranged in obscure white bands; margin armed with small, deltoid-acuminate, reddish brown teeth 1–1.5 mm long, 10–15 mm apart, projecting towards leaf apex and arising from the white cartilaginous margin; apex acute, mucronate. Inflorescence 1 or 2 per plant, 500–700 mm long, pendent, with 2–4 lateral branches in upper half, simple in young plants; racemes 250–300 mm long; scape biconvex, 300–450 mm long, purplish, 10–15 mm in diameter at base, with powdery bloom, flattened and marginiform at base for 30–70 mm; pedicels 8–10 mm long, lengthening to 12–14 mm in fruit; bracts 12×3 mm, ascending, navicular, linear-lanceolate, acuminate, whitish, thin, scarious, channelled. Perianth orange-red, grey-tipped in bud, cylindrical-trigonal, subclavate, 23–25 mm long, 5 mm in diameter. Capsule erect, $10\text{--}15 \times 6\text{--}10$ mm. Seeds angular, winged, grey-black, 3×2 mm.

Phenology: Flowering mainly in winter (May–June).

Pollinators: Sunbirds.

Habitat and aspect: Sandstone cliffs of the eastern, western and southern margin of the Omavanda plateau. Plants of *Aloe omavandae* grow firmly wedged in crevices and the rosette becomes pendent from a young age. The plants are often locally abundant, but are always restricted to inaccessible places. The vegetation in the region below is arid mopane savanna, with several species of *Commiphora* prominent. Summers are hot, winters mild and without frost. Rainfall mainly in summer, ranging from 300–500 mm per annum.

Altitude: 1600–1900 m.

Associated vegetation: Arid savanna. The vegetation at the top of the Omavanda escarpment adjacent to the cliffs consists of *Albizia antunesiana*, *A. tanganyicensis*, *Combretum apiculatum*, *C. zeyheri*, *Entandrophragma spicatum*, *Kirkia acuminata* and *Mundulea sericea*.

Associated cremnophytes: Associated succulent plants include *Cotyledon orbiculata*, *Sarcostemma viminalis* and *Kalanchoe lanceolata*. Other non-succulent cremnophilous plants on these cliffs include *Ficus bubu*, *F. glumosa*, *F. ilicina* and *Petalidium coccineum*. On wider ledges species such as *Cussonia angolensis*, *Nicotiana africana* and *Nuxia congesta* are encountered.

Geology: Sandstone of the Damara Sequence (Simplified Geological Map of Namibia, Geological Survey of Namibia 1980). Its substrate has many ledges, crevices and fissures and is ideal for establishment of plants.

DISTRIBUTION

Aloe omavandae is endemic to the eastern Baynes Mountains of the Kaokoveld, northern Namibia. It is restricted to sandstone cliffs of the escarpment margin, from just west of Epupa Falls in the north to Omavanda in the south and to Slangpoort in the west.

RELATED SPECIES

Aloe omavandae is at once distinguished by its pendent, solitary rosettes of grey-green, pendent, spreading leaves densely white-spotted on the upper surface and less so on the lower surface. The leaf margin is armed with deltoid-acuminate, small, reddish brown teeth and the pendent, branched inflorescence bears arcuate-ascending racemes of orange-red flowers 23–25 mm long. It is most closely related to *A. esculenta* from northeastern Namibia, grows on flat terrain. The latter has a prolific nature, forming dense groups. *Aloe esculenta* is at once distinguished by its erect growth and much larger teeth and paniculate inflorescences. It is also related to *A. corallina*, also a cremnophilous taxon with pendent leaf rosettes and whitish green leaves that are not spotted. *Aloe corallina* is confined to dolomite cliffs of the Otjhipa Mountains (western parts of the Baynes Mountains below altitudes of 1000 m). *Aloe corallina* proliferates from the base, forming small groups with firm, narrower, glaucous, acuminate, falcate leaves, almost without teeth and without any white spots. Its flowers are similar to those of *Aloe omavandae*, but larger (30–32 mm long). In vegetative characters, the leaves of *A. omavandae* reminds one of the widespread *A. littoralis* but here the resemblance ends, as *A. littoralis* is a much larger, robust, erect plant with different, larger teeth on the leaf margins and different floral features. It can also be related to *A. esculenta*, which has similar spotted leaves and is commonly found in Ovamboland, the latter an ascending species with short stems forming dense clusters (on flat terrain).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with medium-sized caulescent heads, occupying larger crevices and ledges. With medium growth rate, plants long-lived perennials.

Size and weight: Heads medium-sized, becoming heavy.

Stem: Caulescent, grey, pendulous and thus less investment in woody tissue.

Leaves

Orientation: Distinctly incurved, pendulous (positively geotropic). Texture firm, but smooth.

Colour: Green to grey-green, fading to pinkish green, sparsely white-spotted in basal third, the lenticular spots irregularly arranged; lower surface flat to slightly convex at first, becoming convex and shortly keeled toward apex. The grey-green colour deflects the rays of the sun, an adaptation to the bright sunlight.

Age and persistence: Long-lived, deciduous from the base.

Armament: Leaf margin armed with small, deltoid-acuminate, reddish brown teeth 1.0–1.5 mm long, 10–15 mm distant, projecting towards the leaf apex and arising from the white, cartilaginous margin; apex acute, mucronate. The teeth are larger in young plants, becoming smaller with age, perhaps an indication that its ancestors were probably not obligate cremnohytes and had larger teeth.

Sexual reproduction

Inflorescence and flowers: Young inflorescence curving upwards as it matures, presenting the racemes in the typical erect position.

Fruit/Seed

Size: Seed 3 × 2 mm.

Dispersal: Light, grey-black, angular, winged seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in winter and autumn, ready for the early spring and summer rains. Germination in about 14–21 days.

Vegetative reproduction: Usually with solitary drooping heads but damaged heads will re-sprout. Plants occasionally sprout from basal stolons. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. This acts as a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Aloe omavandae is restricted to the Omavanda Plateau, but it is locally abundant on the cliffs and therefore not threatened.

ADDITIONAL NOTES

Horticulture: *Aloe omavandae* is best for dry, sunny subtropical bushveld (savanna) gardens (Van Jaarsveld 2010). Keep dry during its resting phase in winter. An easily grown species, but outside its habitat it is best grown in a greenhouse where environmental conditions can be controlled. Plants react well to summer feeding with an organic fertiliser. Propagate from seed sown in spring or summer. Ideal for steep embankments (Van Jaarsveld *et al.* 2005a; Van Jaarsveld 2006b).

VOUCHER

Van Jaarsveld 17480 (NBG).

ILLUSTRATIONS AND MAP

Plate 25, Figures 25a & 25b, Map 25.

26. *Aloe pavelkae* Van Jaarsv., Swanepoel, A.E.van Wyk & Lavranos in *Aloe* 44,3: 75 (2007).

Cremonophyte growth form: Cluster-forming, pendulous, leafy, branched (heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb) (eg)

Etymology: After Mr Petr Pavelka who discovered this species on the Sonberg in southern Namibia.

DESCRIPTION AND HABITAT

Plants slow-growing, long-lived, perennial, forming loose pendulous clusters with up to 8 heads, branched from base, with elongated stems up to 1.5 m long. Roots slightly fleshy. Branches with persistent dry leaves, leaf bases becoming deciduous towards base of stem. Leaves in apical rosette up to 350–400 mm in diameter, spreading in rainy season, inwardly curved and becoming drawn together and reddish in dry season or during prolonged drought; 18–28 × 25–70 mm, linear-lanceolate, green, faintly striate; adaxial surface flat, channelled towards apex, abaxial surface convex; margin cartilaginous, white, serrate, teeth 1.5 × 1.5 mm, projected towards apex, 4–8 mm apart; apex acute. Inflorescence simple, rarely branched, up to 240–320 mm long, pendulous for 170–200 mm then recurved to erect position; scape biconvex at base, 6–8 mm in diameter, up to 180–220 long; raceme capitate, not pointed, 45–90 mm long; pedicels ascending-spreading, 20–28 mm long. Flowers subpendent, in a dense capitate raceme. Perianth orange-red, green-tipped, 20 mm long. Fruiting capsule 15–18 × 6–7 mm, ascending-spreading. Seeds blackish grey, 3.5 × 2 mm.

Phenology: Flowering mainly in midwinter (July–August).

Pollinators: Sunbirds.

Habitat and aspect: Vertical quartzitic sandstone cliffs. Plants are firmly rooted in crevices large enough to support the roots and stem clusters, mainly on southern and eastern aspects. The southern slopes are cooler, with shady conditions. Temperatures high during the day and the average daily summer temperature is about 26°C. Winters are cooler and are subject to regular coastal fog from the west coast; frost is absent. Rainfall occurs mainly from autumn (thunder showers) to spring (cyclonic winter rain), ranging from about 50–125 mm per annum.

Altitude: 700–800 m.

Associated vegetation: Succulent Karoo.

Associated cremonophytes: *Conophytum ricardianum*, *Crassula macowaniana*, *C. pseudohemisphaerica*, *C. sericea* var. *velutina*, *C. sladenii*, *Tylecodon bruynsii*, *T. buchholzianus* *T. racemosus* and *T. rubrovenosus*.

Geology: Sandstone of the Kuibis and Schwarzrand Subgroups (Nama Group). The cliff substrate is rough, with many ledges crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Aloe pavelkae is confined to the upper slopes of the southern mountain range adjacent to the Orange River and adjacent territory of the same geological formation. It mainly includes the Sonberg and Kuamsibberg.

RELATED SPECIES

Aloe pavelkae is related to both *A. meyeri*, a Rosyntjieberg endemic, and *A. dabenorisana* from the Dabenoris and Pellaberg along the South African side of the lower Orange River. It differs from *A. meyeri* in its larger rosettes, green leaves that are not biconvex and only the apical rosette with functional leaves. *Aloe meyeri* is smaller, with glaucous leaves that remain functional over a considerable part of the stem (leafy stems), and flowers in January and February. *Aloe dabenorisana* has similar green leaves but they are distinctly recurved.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Pendent, leafy stems and leaves, which it retains even when grown in cultivation. It is a slow grower and long-lived perennial.

Size and weight: There is a slight reduction in size compared to *Aloe perfoliata*, allowing for better anchorage of the rootstock (and coping with gravity). The smaller size also enables the plants to cope better with heat absorption under cool growing conditions, a general trend among winter-active succulents.

Stem: Pendulous, covered with old leaf remains, thus insulated from direct sunlight.

Leaves

Orientation: Apically produced in rosettes.

Colour: Green, without a powdery bloom, becoming drawn together in the dry season and with a protective reddish coloration as a result of the production of anthocyanins, typical of most succulent plants under sunny conditions and water stress.

Age and persistence: Fairly long-lived, becoming deciduous from the base.

Armament: The small teeth on the leaf margins suggest a reduction in armament as a direct result of the reduction in herbivory.

Sexual reproduction

Inflorescence and flowers: Young inflorescence drooping but curving up as it matures, presenting the raceme(s) in the typical erect position.

Fruit/Seed

Size: Seed 3.5×2 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in autumn, coinciding with the start of the rainy season and period of greatest occurrence of rainfall.

Vegetative reproduction: *Aloe pavelkae* is prolific from the base, forming drooping clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Rare, but not threatened.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens. It thrives on sheer embankments or balconies. Plants easily grown from seed or cuttings, and as specimen pot collections outside the native habitat. When grown outside its natural habitat it may become prone to fungal crown rot. Does well in a sandy, well-drained soil. Keep dry in summer.

VOUCHER

Van Jaarsveld 19919 (NBG).

ILLUSTRATIONS AND MAP

Plate 26, Figures 26a–26d, Map 26.

27. *Aloe pictifolia* D.S.Hardy in *Bothalia* 12: 62 (1976).

Cremonophyte growth form: Dwarf-sized globose cluster (of medium weight, cliff squatter).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: Latin *picti*, painted, and *folium*, leaf.

DESCRIPTION AND HABITAT

Plants dividing to form small clusters of up to 7 heads and up to 200 mm in diameter. Branches short, pendulous to erect. Leaves at first distichous, becoming rosulate, 80–150 × 10–20 mm, linear-lanceolate, incurved when grown erect, becoming recurved when pendulous, greyish green, becoming reddish green with drought stress, densely white-spotted; margin dentate; teeth small, reddish; apex acute, mucronate. Inflorescence an erectly spreading raceme, up to 350 mm long. Perianth 16 mm long, reddish pink, with yellow throat. Capsules 15 × 6 mm long, mostly pendulous to spreading. Seeds angular, grey-black, up to 4 × 2 mm.

Phenology: Flowering in winter and spring (October–November), but sporadically at other times as well. Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: Sandstone cliffs (all aspects) overlooking the Kouga River. The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Winters are cooler, but frost is a rarity or absent. Rainfall occurs in winter and summer, ranging from 400–500 mm per annum.

Altitude: 250–500 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus cristatus* var. *zeyheri*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula rupestris* subsp. *rupestris* ‘Kouga form’, *Cyrtanthus flammosus*, *C. montanus*, *Gasteria glomerata*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna lobata* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). The cliff substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Aloe pictifolia is restricted to cliff faces of the Kouga Dam and adjacent Baviaanskloof near Hankey in the Eastern Cape.

RELATED SPECIES

Aloe pictifolia is related to *A. humilis*, a non-cremnophilous species. The latter is a dense, cluster-forming species with grey leaves. It also superficially resembles *A. microstigma*, also a non-cremnophilous species, but much larger. The latter has ascending to incurved leaves, occurring in thicket and succulent karoo vegetation.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous rounded clusters. Its small size allows effective heat absorption and establishment in small crevices, the plants thus also coping better with gravity. In the dry season, the leaves become dorsiventrally flattened and reddish. This improves the ability of the plants to survive. The plants’ investment in vegetative output (dividing of heads) further enhances occupation of crevices and ultimate survival.

Size and weight: Heads small, of medium weight.

Leaves

Orientation: Adjustable compared to all other aloes. Becoming incurved when growing in full sun, but becoming distinctly recurved and often recurved-falcate in shady crevices (southern and sometimes east-facing slopes) and under overhangs, maximising absorption

of light. This character is retained in cultivation and can be viewed as an adaptation to the variable cliff-face environment.

Succulence: When turgid, the leaves are very fleshy and often biconvex, an adaptation to the dry vertical habitat.

Colour: Grey-green to grey-white, densely spotted, becoming reddish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis. The conspicuous white spotting is perhaps derived from a past camouflage character, now possibly an effective light-regulating tool and an adaptation to the cliff environment in the absence of herbivory.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, with leaves withering from the base.

Armament: The leaf margin is armed with small reddish teeth, much smaller than those of its flat-ground relative, this reduction in armament probably in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding thicket and succulent karoo vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending; flowers with conspicuous red-pink perianth.

Fruit/Seed

Size: Seed 4×2 mm, an ideal size for establishment in crevices.

Dispersal: Seed wind-dispersed as in other aloes.

Time: Seeds ripening in spring and summer, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: Plants divide, forming small, dense clusters. Stems root when finding a new crevice and fallen branches also when wedged in a suitable crevice. Continual dichotomous division of heads, the renewal of shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Aloe pictifolia has been classified as rare (Raimondo *et al.* 2009). In spite of its localised distribution, it is not threatened by collectors, and seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Horticulture: Best grown in thicket gardens (Van Jaarsveld 2010). It is an easy grower, propagated by division or from seed and thrives in small containers. This ease of cultivation

suggests a maximum survival reproductive output. Outside its native habitat it is best grown as a container subject under controlled environmental conditions in a greenhouse.

VOUCHER

Van Jaarsveld 11046 (NBG).

ILLUSTRATIONS AND MAP

Plate 27, Figures 27a–27d, Map 27.

28. *Aloe reynoldsii* Letty in *The Flowering Plants of South Africa* 14: t. 558 (1934).

Cremnophyte growth form: Cluster-forming (of medium weight to heavy, cliff squatter).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After Dr G.W. Reynolds (1895–1967), author of *The aloes of South Africa*, first published in 1950.

DESCRIPTION AND HABITAT

Plants rosulate, with moderate growth rate, almost acaulescent, dividing to form rounded clusters with up to 12 heads and up to 0.75 m in diameter, occasionally solitary. Roots terete. Stem up to 50 mm in diameter. Leaves ovate-lanceolate, acuminate, deciduous towards base of plant, up to 350 × 110 mm, spreading; epidermis glaucous, mottled; margin crenulate, with pinkish border. Inflorescence conspicuous, branched, a subcorymbose panicle, up to 600 mm high; racemes subcapitate. Perianth subpendulous, yellow, 28 × 7 mm. Fruiting capsule ascending-spreading, 22 × 10 mm. Seeds angular, 3 × 2 mm, grey.

Phenology: Flowering mainly in spring (September–October). Seeds dispersed by wind in summer in the rainy season.

Pollinators: Sunbirds.

Habitat and aspect: Shale and mudstone cliffs, on exposed northern and northwestern aspects, but also on southern and eastern slopes. Plants grow firmly rooted in crevices large enough to support the roots and stem clusters. Temperatures are high in summer, but mild in winter, the southern slopes cooler, with shady conditions. The average daily maximum temperature is about 20°C and the average daily minimum about 12°C. Rainfall occurs mainly in summer and ranges from 800–250 mm per annum (thunder showers from October–May).

Altitude: 150–1000 m.

Associated vegetation: Eastern Valley Bushveld of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Albuca batteniana*, *Aptenia cordifolia*, *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula cordata*, *C. lactea*, *C. perfoliata* var. *minor*, *C. perforata*,

Delosperma sp., *Drimia anomala*, *Haworthia cymbiformis*, *Ornithogalum longibracteatum* and a species of *Trichodiadema*.

Geology: Sandstone and mudstone of the Emakwezini Formation (Beaufort Group) of the Karoo Supergroup. Substrate has many ledges, crevices and fissures and ideal for establishment of plants.

DISTRIBUTION

Aloe reynoldsii is endemic to the dry Bashee River Valley, from Collywobbles in the north to near the river mouth at the coast.

RELATED SPECIES

Aloe reynoldsii is closest to *A. striata* from the southern Great Karoo regions. It differs from that species in its prolific dividing nature, smaller rosettes and softer, slightly mottled leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming rounded clusters, a medium summer grower and long-lived perennial with soft leaves.

Size and weight: Heads medium-sized, a reduction in size compared to non-cremnophilous members of this group.

Stem: Branches grey, fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Spreading to recurved.

Colour: Glaucous (reflecting light) and mottled.

Age and persistence: Becoming deciduous from the base, resulting in apical rosettes. The medium-sized heads and stature can cope better with heat exposure in general and with the very warm conditions in river valley thicket in summer.

Armament: The softer leaves with small teeth suggest a reduction in armament as a direct result of the reduction in herbivory. (*Aloe striata*, its closest relative, has grey-white leaves with a smooth but firm margin.)

Sexual reproduction

Inflorescence and flowers: Yellow flowers conspicuous on the cliff face, attracting sunbirds.

Fruit/Seed

Size: Seed 3×2 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed from late spring to summer, coinciding with the start of the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Aloe reynoldsii* divides, forming small, dense clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual dichotomous division of the heads, renewal of shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Rare, but not threatened (Hilton-Taylor 1996; Raimondo *et al.* 2009).

ADDITIONAL NOTES

Horticulture: *Aloe reynoldsii* is the easiest to grow of the five *Aloe* species belonging to series *Paniculatae* and widely adaptable in cultivation. It is best grown in thicket gardens (Van Jaarsveld 2010). It is easily propagated by division or from seed and does well in containers. This ease of cultivation suggests a maximum survival reproductive output. Outside its native habitat, in a colder climate, it is best grown as a container subject under controlled environmental conditions in a greenhouse.

VOUCHER

Van Jaarsveld 16907 (NBG).

ILLUSTRATIONS AND MAP

Plate 28, Figures 28a–28c, Map 28.

29. *Aloe soutpansbergensis* I. Verd. in *The Flowering Plants of Africa* 34: t. 1391 (1962).

Cremonophyte growth form: Cluster-forming, pendulous rosettes (of light weight, cliff hanger).

Growth form formula: S:Lper:R:C:Lp (vb) (eg)

Etymology: After the Soutpansberg, its habitat in the Limpopo Province.

DESCRIPTION AND HABITAT

Plants rapid-growing, shortly caulescent, proliferating from base, forming clusters up to 300 mm in diameter, bearing soft flaccid leaves. Stem horizontal to horizontally pendulous to pendulous, up to 50 mm long, covered with old dried leaf remains. Leaves at first distichous, becoming rosulate (up to 7), linear, pendulous, 120–460 × 7–9 mm, softly succulent; surface smooth, adaxial side flat to grooved, abaxial surface convex, purplish, spotted towards base; margin denticulate, green. Inflorescence simple, ascending-spreading, up to 200–380 mm

long; raceme 70–110 mm long, subcapitate, horizontally presented, flowers subsecundly and also horizontally presented, becoming subpendent; pedicels 15–20 mm long; bracts 25 × 12, whitish, acuminate, conspicuous, enclosing pedicels at first (longer than pedicels). Perianth orange-red, pale white-tipped, 27–32 mm long, broadest at base (7–8 mm in diameter), tapering to 4 mm wide close to apex, lobe apices becoming recurved. Fruiting capsule oblong-conical, 20 × 10 mm. Seeds small, grey-black.

Phenology: Flowering mainly in summer (December–February).

Pollinators: Sunbirds.

Habitat and aspect: Quartzitic sandstone cliffs, mainly on eastern and southern aspects. Plants are firmly rooted in crevices and on ledges large enough to support the roots and stem clusters. The temperature is moderate in summer, often cool with frequent fog, but with dry, cool winters. Rainfall occurs mainly in summer, ranging from 1500–2000 mm per annum.

Altitude: 1525–1750 m.

Associated vegetation: Soutpansberg Summit Sourveld (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Cotyledon barbeyi*, *Crassula pellucida* subsp. *alsinoides*, *C. setulosa*, *C. swaziensis* and *Thorncroftia succulenta*.

Geology: Quartzitic sandstone of the Wyllies Poort Formation (Soutpansberg Group). The sandstone rock substrate has many ledges, crevices and fissures and is ideal for establishment of plants.

DISTRIBUTION

Aloe soutpansbergensis is a quartzitic sandstone endemic of the Soutpansberg near Makhado in the Limpopo Province. Plants are often locally abundant.

RELATED SPECIES

The horizontally presented racemes and forward projected flowers are unique among the South African and Namibian cremnophilous aloes. The tapering perianth, 7–8 mm at the base and tapering to 4 mm, is also unique. *Aloe soutpansbergensis* is related to *A. challsii* and *A. nubigena*, the latter with ascending racemes, pendent flowers, and in *A. nubigena* the leaves usually remain distichous (often with an entire margin). *Aloe challsii* has almost terete, bluish green leaves with epinastic growth, resulting in the down-curving leaves. Differs from *A. woolliana* in its flaccid leaves and stems, probably an adaptation to its sheer cliff-face environment.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming clusters among moss and other cremnophytes occupying smaller crevices and ledges. Where within reach, stems and leaves are heavily grazed.

Size and weight: Heads small, of light weight.

Stem: Shortly caulescent, grey, spreading, subpendulous to pendulous.

Leaves

Orientation: Distichous at first, becoming rosulate and pendulous (positively geotropic), channelled.

Colour: Green, purplish at the base.

Age and persistence: Fairly fast grower and long-lived perennial, with leaves deciduous from the base.

Armament: Leaf margin sparsely denticulate.

Sexual reproduction

Inflorescence and flowers: Racemes simple, ascending-spreading (70–110 mm long), subcapitate, with horizontally presented flowers. Flowers subsecundly presented (and projected forward). This is an adaptation to the sheer habitat. The large floral bracts protect the flowers from damage by perching sunbirds. The orange-red perianth is also unique, broadest at the base (7–8 mm in diameter) and tapering to 4 mm (close to the apices).

Fruit/Seed

Size: Not seen.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in winter and autumn, ready for the early spring and summer rains.

Vegetative reproduction: *Aloe soutpansbergensis* proliferates from the base, forming small, dense clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual suckering from the base or renewal of shoots and rooting of stems is a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Although rare and limited in distribution, it is locally abundant and not threatened (Raimondo *et al.* 2009).

ADDITIONAL NOTES

Horticulture: Best grown in afroalpine or summer-rainfall grassland gardens in a slightly acid peat and sand mixture. Feed regularly in spring and summer. Easy to grow, with a medium growth rate. Away from its habitat, it is best kept in a greenhouse. Keep moist and cool during the summer months. Plants proliferate from the base, soon becoming cluster-forming. Keep partially shaded.

VOUCHER

Van Jaarsveld 19766 (NBG).

ILLUSTRATIONS AND MAP

Figures 29a–29d, Map 29.

30. *Aloe thompsoniae* Groenew. in *Tydskrif vir Wetenskap en Kuns* 14: 64 (1936).

Cremonophyte growth form: Cluster-forming, rosettes (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After Audrey Thompson, daughter of Sheila Thompson (fl. 1970), grower of indigenous plants at Magoebaskloof.

DESCRIPTION AND HABITAT

Plants with moderate growth rate to rapid-growing, acaulescent, rosulate, proliferating from base from subterranean stolons, forming small dense clusters up to 200 mm in diameter, with soft recurved leaves. Stem ascending to horizontal and pendulous on shady cliff faces. Leaves linear, softly succulent, ascending, becoming recurved at apex, pendulous, up to 50–200 × 5–15 mm; margin denticulate, green, mottled towards base; surface smooth; adaxial side channelled. Inflorescence simple, ascending to ascending-spreading, 200–300 mm long, bearing up to 5 sterile bracts; bracts scarious, pale pink, clasping stem, up to 18 mm long, acuminate; floral bracts clasping pedicels, gradually becoming smaller; raceme 50 mm long, capitate, with 12–16 flowers; pedicels up to 15–20 mm long. Perianth subpendulous orange-red, green-tipped, 27–30 × 6–7 mm. Fruiting capsule oblong-conical, 20 × 10 mm. Seeds angular, 3 × 1.5 mm, dark brown.

Phenology: Flowering mainly in summer (November–April) and sporadically at other times.

Pollinators: Sunbirds.

Habitat and aspect: Quartzitic sandstone cliffs and steep slopes (mainly on eastern and southern aspects and more so on the shady south-facing slopes). Plants are firmly rooted in crevices and on ledges large enough to support the roots and stem clusters. They are also found on the summit and boulders, and are not restricted to cliffs. Temperature moderate in summer, with frequent fog, but with dry, cool winters. Rainfall is about 1500–2000 mm per annum.

Altitude: 1650–2100.

Associated vegetation: Northern Escarpment Quartzite Sourveld of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Bulbine natalensis*, *Crassula pellucida* subsp. *alsinoides*, *C. setulosa*, *Cyrtanthus junodii*, *Drimia robusta*, *Merwillia plumbea* and various moss species.

Geology: Quartzitic sandstone (Black Reef Formation, Transvaal Supergroup). Light-textured (grey) rough- to smooth-textured, with many ledges, crevices and fissures and ideal for establishment of plants.

DISTRIBUTION

Aloe thompsoniae is a quartzitic sandstone endemic to the Wolkberg near Pietersburg. It is confined to the moist and well-watered, sheer, east-facing cliffs and crevices of large boulders. Plants are often locally abundant.

RELATED SPECIES

Aloe thompsoniae comes closest to *A. nubigena* from the east-facing escarpment mountains in Mpumalanga and differences are discussed under the latter.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Variability: Plants showing great phenotypic plasticity, adapting according to the situation on the cliffs.

Habit: Plants forming clusters among moss and other cremnophytes occupying smaller crevices and ledges. Where within reach, stems and leaves heavily grazed.

Size and weight: Heads dwarf-sized, of light to medium weight.

Stem: Acaulescent to shortly stemmed, ascending and subpendulous to pendulous when growing on shady cliff faces.

Leaves

Orientation: Rosulate, adaptable according to situation (phenotypic plasticity), pendulous and larger on shady cliffs, as opposed to ascending growth and smaller, recurved leaves in exposed situations.

Colour: Green, mottled towards the base.

Age and persistence: Long-lived perennial with medium growth rate, leaves deciduous from the base.

Armament: Leaf margin denticulate.

Sexual reproduction

Inflorescence and flowers: Young inflorescence curving upwards as it matures, presenting the racemes in the typical erect position.

Fruit/Seed

Size: Seed 3×1.5 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds dispersed in winter and autumn, ready for the early spring and summer rains. Germination within 14–21 days.

Vegetative reproduction: *Aloe thompsoniae* is prolific from the base, forming small, dense clusters. The stems root when finding a new crevice and fallen branches will also root when wedged in a suitable crevice. The continual renewal of shoots and rooting of stems in new crevices by extended stems represent a sufficient vegetative backup dispersal strategy for the harsh cliff-face environment.

CONSERVATION STATUS

Aloe thompsoniae is rare (Raimondo *et al.* 2009). It is confined to the Wolkberg (limited distribution), often locally abundant and not threatened. Well protected by the precipice and steep terrain.

ADDITIONAL NOTES

Horticulture: Best grown in afroalpine or summer-rainfall grassland gardens in a slightly acid peat and sand mixture (Van Jaarsveld 2010). Feed regularly in spring and summer. Easy to grow, with a medium growth rate. Away from its habitat it is best kept under cool, shady conditions in a greenhouse. Keep moist and cool during the summer months. Plants proliferate from the base, soon forming small clusters.

VOUCHER

Van Jaarsveld 16221 (NBG).

ILLUSTRATIONS AND MAP

Figures 30a–30e, Map 30.

BULBINE Wolf

31. *Bulbine cremnophila* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 36,4: 72 (1999).

Cremnophyte growth form: Cluster-forming, short pendent leaves (of light weight, cliff hanger).

Growth form formula: A:S:Lper:R:C:Lp (eg)

Etymology: Greek *kremnos*, cliff, and Greek *phileein*, to love, pertaining to its cliff habitat.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, clustering, up to 120 mm high, 100 mm in diameter, with 3–8 heads. Roots grey, terete. Leaves up to 7, in a rosette, drawn together but curving downwards, linear-lanceolate, 60–100 × 10–15 mm, channelled above, cymbiform below, glaucous and faintly translucent, covered with powdery bloom, apex acute-mucronate, reddish pink. Inflorescence 200–400(–450) mm long, 17–35-flowered in distal half; raceme 150–300 mm long; peduncle 2 mm in diameter at base, terete; bract deltoid-acuminate, 5 × 1 mm, clasping; pedicels 15–18 mm long. Perianth stellate, becoming reflexed, drooping, about 8–10 mm in diameter; tepals orange-yellow; outer tepals elliptic, 7 × 2 mm, inner tepals ovate to ovate-elliptic, 6 × 2.5 mm, obtuse. Stamens up to 5 mm long. Ovary globose, up to 1.5 mm in diameter. Fruit obovate, 3 × 2.5 mm. Seeds 2 mm in diameter, black.

Phenology: Flowering mainly from spring to early summer (peak end October). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs of narrow, shady kloofs (mainly eastern and western aspects). Plants are firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Temperatures are high on summer days (35–40°C). The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Winters are cooler, but frost is a rarity or absent. Rainfall throughout the year, but with a peak in spring and summer, ranging from 400–500 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 400–1000 m.

Associated vegetation: Gamtoos Thicket of the Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Albuca cremnophila*, *Cotyledon tomentosa* var. *tomentosa*, *Crassula perfoliata* var. *minor*, *C. perforata* and *Gasteria rawlinsonii*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). The quartzitic sandstone substrate is rich in ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Bulbine cremnophila is endemic to quartzitic sandstone, confined to the narrow kloofs (north-south orientation) of the Baviaanskloof Mountains of the Eastern Cape, west of Hankey.

RELATED SPECIES

Bulbine cremnophila is the smallest of the broad-leaved bulbines. It comes closest to *B. retinens*, another cremnophyte with erect, much longer leaves. *Bulbine rupicola* has short, erect leaves. *Bulbine natalensis* and *B. latifolia* are much larger, solitary species (widely distributed from the Eastern Cape to KwaZulu-Natal) often associated with cliff faces. Both have open rosettes of broad leaves and spreading flowers that are not drooping. *Bulbine latifolia* has firm leaves and *B. natalensis* has leaves with a ciliate margin.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with drooping leaves which are retained in cultivation. Rapid-growing, fairly long-lived perennials.

Size and weight: Heads small, of light weight.

Stem: The short branches (up to 40 mm) are grey and covered by persistent old leaves. They are fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Apart from curving down (positively geotropic), the leaves are drawn together in the apical rosette, becoming slightly spreading only in the rainy season, suggesting an adaptation to the extreme, dry habitat.

Succulence: The very fleshy leaves are soft, becoming turgid after rain, but are deeply channelled during dry periods, an adaptation to the extreme, dry habitat.

Colour: Glaucous (reflecting light), with powdery bloom. The slight translucent nature allows light to penetrate deeply, an adaptation to the shady cliff environment.

Age and persistence: Becoming deciduous from the base, resulting in apical rosettes.

Armament: The entire leaf margin and softer leaf texture suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; individual flowers subpendulous to pendulous. Initial orientation of the buds erect, but the flowers curving down as they mature. Orientation of the mature perianth (up to 9 flowers open at the same time) renders the flowers more conspicuous in the narrow, shady kloofs when viewed from below, an adaptation maximising visibility for pollination in the vertical cliff environment.

Fruit/Seed

Size: Seed 2 mm in diameter, an ideal size for establishment in crevices.

Dispersal: Light, black, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Bulbine cremnophila* divides, forming dense, rounded clusters. The continual division is an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Individual branches of the clusters will root under suitable conditions and continue to grow, resulting in survival of the clone. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: *Bulbine cremnophila* plants are easily grown from seed or division and thrive in cultivation. It is best grown as a pot plant in small containers simulating the small crevices of the cliff environment. The soil should be sandy and slightly acid, with ample feeding throughout the year. It rapidly becomes turgid after watering. Its very easy growing nature maximises its survival rate. Outside its subtropical thicket habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 7238 (NBG).

ILLUSTRATIONS AND MAP

Plate 31, Figures 31a–31d, Map 31.

32. *Bulbine latifolia* (L.f.) Schult. & Schult.f. var. *curvata* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 40,1: 4–5 (2003d).

Cremonophyte growth form: Solitary, pendulous rosette (of medium weight, cliff hanger).

Growth form formula: E:F:P:R:So:Lp (eg)

Etymology: The varietal epithet *curvata* refers to the curved leaves.

DESCRIPTION AND HABITAT

Plants solitary, with pendulous rosette 150 mm in diameter and 250 mm long from short branch 70 mm long. Stem 25 mm in diameter, covered with persistent leaf bases, the latter weathering and forming a fibrous network. Roots grey, fleshy, terete. Leaves 12–15 in a rosette, with firm texture, pendent or curving downwards, linear-lanceolate, 150–250 × 8–12 mm, flat above, rounded below, light green; margin entire; apex attenuate, mucronate. Inflorescence up to 420 mm long, densely flowered in distal third; raceme conical, 150 mm long; peduncle up to 7 mm in diameter at base, biconvex, green to reddish green; bracts deltoid, acuminate, 5 × 1 mm, clasping; pedicels 12 mm long. Perianth stellate, about 15 mm in diameter; tepals bright yellow with greenish yellow median stripes, outer tepals narrowly oblanceolate, 10 × 2 mm, inner tepals elliptic to elliptic-oblanceolate, 9 × 3 mm; apices obtuse to emarginate. Stamens 7 mm long, bearded in central part, 2.5–3 mm. Ovary globose, 1.5 mm in diameter; style erect, up to 7 mm long. Fruit obovate, 3 × 2.5 mm. Seeds 3 × 1.5 mm, black.

Phenology: Flowering mainly from late spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs, at an altitude of about 500 m above the Kouga River at the Kouga Dam (mainly eastern and western aspects). Plants are firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Temperature is high in summer (35–40°C). Winters are cooler, but frost is a rarity or absent. The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Rainfall occurs throughout the year but with a peak in spring and summer, ranging from 400–500 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 250–500 m.

Associated vegetation: Gamtoos Thicket (Mucina *et al.* 2005).

Associated cremnoophytes: *Bulbine latifolia* var. *curvata* is a rare species confined to quartzitic sandstone rock crevices, occurring in full sun or partial shade of rock ledges or other cremnophilous vegetation. It occurs solitary or together with *Albuca cremnophila*, *Aloe perfoliata*, *A. pictifolia*, *Cotyledon tomentosa*, *Crassula perfoliata* var. *minor*, *C. perforata*, *C. rupestris* subsp. *rupestris*, *C. socialis*, *Cyrtanthus montanus*, *Gasteria glomerata* and *Haworthia viscosa*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). The quartzitic sandstone substrate is rich in sufficient ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Bulbine latifolia var. *curvata* is confined to the Kouga Dam near Hankey (Eastern Cape).

RELATED SPECIES

Bulbine latifolia var. *curvata* is at once distinguished by its solitary, pendent habit of firm, linear-attenuate leaves (often becoming reddish in the dry season) from a short stem, the persistent leaf bases weathering to a fibrous, mat-like network. It is further distinguished by its dense flowering racemes. The leaves retain their drooping nature in cultivation. The plants occur on exposed, west-facing, quartzitic sandstone cliff faces. *Bulbine latifolia* var. *curvata* can immediately be distinguished from *B. latifolia* var. *latifolia* by its narrow, drooping leaves. *Bulbine latifolia* var. *curvata* superficially resembles *B. cremnophila*, another cremnophilous species from the same region and further westwards in the Baviaanskloof. The latter, however, is a smaller, cluster-forming species with soft, triangular-lanceolate, glaucous leaves with a distinctly ciliate margin, and lax racemes.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants conspicuous, with drooping stems and leaves, even when grown in cultivation. *Bulbine latifolia* var. *curvata* is a fairly long-lived perennial with a medium to slow growth rate. Its sluggish growth (compared to that of other *Bulbine* species) could perhaps be due to the mineral-deprived cliff habitat.

Size and weight: Heads of medium weight.

Stem: Short branches (up to 40 mm) are grey and covered by persistent old leaves. They are fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Apart from curving down (positively geotropic), the leaves are drawn together in the apical rosette, becoming slightly spreading only in the rainy season, suggesting an adaptation to the extreme dry habitat.

Succulence: The very fleshy leaves are firm, becoming turgid after rain.

Colour: Light green, becoming maroon under drought stress, an adaptation helping the plants to cope with the well-drained cliff environment.

Age and persistence: Long-lived, perennial, becoming deciduous from the base, resulting in apical rosettes.

Armament: The entire leaf margin and softer leaf texture suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence densely flowered and conspicuous, ascending to spreading; individual flowers spreading.

Fruit/Seed

Size: Seed 3×1.5 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Light, black, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season. Germination after 14–21 days.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Although rare, it is a local endemic that is not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine latifolia* var. *curvata* is easily grown from seed and does well in cultivation. It is best grown as a pot plant in containers, in full sun or partial shade. The soil should be sandy and slightly acid, with ample feeding throughout the year. Its very easy growing nature maximises its survival rate. Outside its subtropical thicket habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 13806 (NBG).

ILLUSTRATIONS AND MAP

Plate 32, Figures 32a–32c, Map 32.

33. *Bulbine meiringii* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 40,1: 5–6 (2003d).

Cremonphyte growth form: Cluster-forming (of light to medium weight, cliff squatter).

Growth form formula: A:S:Lper:R:C:Ts:Lp (eg) (vb)

Etymology: Named after Meiringspoort in the northeastern Little Karoo, the location where this species was discovered.

DESCRIPTION AND HABITAT

Dwarf-sized, rosulate succulents up to 100 mm high, dividing to form clusters about 200 mm in diameter, with up to 12 heads. Roots fleshy, terete, slightly fusiform, up to 3 mm in diameter, grey. Tuber oblong, terete, 20–35 × up to 10 mm, slightly thickening towards base, covered with persistent fibrous tunics. Leaves 4–7, curving downwards; lamina glaucous, linear-lanceolate, almost subterete when fully turgid, 80–210 × 6–8 mm; adaxial side flat to convex, abaxial side convex, striate; apex acute, margins denticulate. Inflorescence solitary, 210–260 mm tall, ascending to spreading; flowers lax, borne in distal third, about 14 mm in diameter, 4–6 mm apart; peduncle up to 3 mm wide at base, biconvex, terete distally; bracts deltoid-acuminate, 3–4 mm long, about 1 mm wide at base, membranous, clasping; pedicels 10–12 mm long. Perianth stellate, becoming reflexed; tepals pale yellow, outer tepals elliptic, up to 7 × 2 mm, apices obtuse, inner tepals ovate to ovate-elliptic, up to 6 × 2.5–3.0, apices obtuse. Stamens up to 5 mm long; anthers yellow, oblong, dorsifixed. Ovary globose, up to 1.5 mm in diameter; style erect, up to 5 mm long; stigma capitate. Capsule ovoid, up to 3 × 4 mm. Seeds up to 1.5 × 1 mm, grey-black. Flowering in spring.

Phenology: Flowering in spring (September–October).

Pollinators: Insects.

Habitat and aspect: Plants of *Bulbine meiringii* occur on sheer south-facing quartzitic sandstone cliff faces where they form small clusters. The average daily maximum temperature is about 26°C and the average annual minimum about 9°C. Rainfall occurs in winter and summer, ranging from 200–300 mm per annum.

Altitude: 500–800 m.

Associated vegetation: Western Gwarrieveld of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Adromischus triflorus*, *Crassula perforata*, *C. rupestris*, *Haworthia* sp., *Senecio ficoides* and *S. muirii*.

Geology: Sandstone rock ledges of Peninsula Formation, Table Mountain Group (Cape Super-group). Cliff substrate with many fissures, ledges and crevices, ideal for establishment of plants.

DISTRIBUTION

It is known only from Meiringspoort, near De Rust in the Little Karoo, Western Cape.

RELATED SPECIES

Bulbine meiringii is characterised by its oblong tubers with slightly fusiform roots and by the slender, linear-lanceolate, glaucous leaves. In contrast, *B. cremnophila* has shorter, much fleshier leaves and lacks the oblong tuber and fusiform roots. *Bulbine meiringii* is also closely related to *B. rupicola* occurring towards Klipplaat in the northeast. The latter has ovoid tubers and short, ascending, green, somewhat channelled leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants growing in clusters. This is a rapid-growing, fairly long-lived perennial.

Size and weight: Heads small, of medium weight.

Stem: Branches short.

Leaves

Orientation: Clustered or grouped. Drooping, leaning from the cliff face, and of a softer, fragile texture.

Succulence: Fleshy.

Colour: Greyish green.

Age and persistence: Becoming very turgid after rain, an adaptation to the extreme, dry habitat.

Armament: Leaf margin entire without armament, suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, maximising visibility to possible insect pollinators.

Fruit/Seed

Size: Seed 1.5×1 mm, an ideal size for establishment in crevices.

Dispersal: Light, grey-black seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer, coinciding with the rainfall. Germination within 14–21 days.

Vegetative reproduction: *Bulbine meiringii* divides, forming dense clusters. The continual division and filling of crevices represent an efficient vegetative backup dispersal strategy. Individual branches of the clusters will root and continue to grow, maximising survival (vegetative backup). Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine meiringii* is easily grown by division and thrives in cultivation. It is best grown as a pot plant in containers, in partial shade or full sun. The soil should be sandy and slightly acid, with ample watering and feeding throughout the year. Its very easy growing nature maximises its survival rate. Outside its succulent karoo habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld, Vlok & Nanni 12762 (NBG).

ILLUSTRATIONS AND MAP

Plate 33, Figures 33a–33c, Map 33.

34. *Bulbine natalensis* Baker in *Flora capensis* 6: 366 (1896). (Soft, translucent, cliff-face form bearing ciliate leaves.)

Cremonophyte growth form: Solitary to cluster-forming (of light to medium weight, cliff squatter).

Growth form formula: A:S:Lper:R:So:La

Etymology: After KwaZulu-Natal in South Africa.

DESCRIPTION AND HABITAT

Plants solitary or forming small clusters, evergreen, rosulate, with short stem. Roots yellow, fleshy, terete. Leaves 10–14, triangular-lanceolate, grey-green, striate, soft, spreading, 85–130 × 35–45 mm, flat to broadly channelled above, flat to rounded below; margin densely ciliate; cilia 2 mm long; apex acuminate. Inflorescence 1–3, densely flowered, up to 550 mm tall; peduncle flattened at base, 6–7 mm in diameter; bracts linear-lanceolate, 10 × 1 mm; pedicels 9–11 mm. Flowers spreading; perianth stellate, up to 15 mm in diameter, yellow; outer tepals

lanceolate, 6×3 mm, inner tepals 6×4 mm; apices obtuse. Stamens 5 mm long. Ovary globose, 1.5 mm in diameter. Style 6 mm long; stigma capitate. Capsule rounded, 3×3 mm. Seeds 1.5 mm in diameter, grey-black, elliptic.

Phenology: Flowering mainly from spring to early summer (peak end October). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs of narrow shady kloofs (mainly eastern and southern aspects) where plants are firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Temperature is high in summer (28–34°C). Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Rainfall throughout the year, but with a peak in spring and summer, ranging from 400–500 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 35–600 m.

Associated vegetation: Mainly Indian Ocean Coastal Belt, Albany Thicket and dry Fynbos (Mucina *et al.* 2005).

Associated cremnophytes: *Albuca cremnophila*, *Bulbine cremnophila*, *Cotyledon tomentosa*, *Crassula perforata*, *C. perfoliata* var. *minor* (Baviaanskloof) and *Gasteria rawlinsonii*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Bulbine natalensis has a wide distribution from the Baviaanskloof and Kouga northeastwards to KwaZulu-Natal, confined to kloofs and narrow, shady cliff faces.

RELATED SPECIES

Bulbine natalensis comes closest to *B. latifolia*, a much larger, solitary species (widely distributed from the Eastern Cape to KwaZulu-Natal) from the flats but also sometimes associated with cliff faces. Both have open rosettes of broad leaves and dense, conical racemes of spreading flowers. *Bulbine latifolia* has firm leaves and *B. natalensis* has leaves with a ciliate margin.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with small, spreading to drooping rosettes. *Bulbine natalensis* is a rapid-growing, fairly long-lived perennial.

Size and weight: Heads are small to medium-sized, of light to medium weight (fully turgid adult plants).

Stem: Plants with short, grey stems covered by persistent old leaves. They are fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Patent to recurved, exposing maximum foliage to open shade, becoming channelled only under dry conditions.

Succulence: Leaves fleshy and soft, becoming turgid after rain but channelled during dry periods, an adaptation to the extreme, dry habitat.

Colour: Glauous (reflecting the light); epidermis with powdery bloom. The slight translucent nature allows light to penetrate deeply, an adaptation helping the plants to cope with the shady cliff environment.

Age and persistence: Leaves are very soft, withering from the base.

Armament: Compared to the related *Bulbine latifolia*, the leaf texture is markedly softer, with a fragile, ciliate margin. This reduction in armament can possibly be viewed as a response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket, savanna (*B. latifolia*) or grassland vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence conical and densely flowered, thus conspicuous in the narrow, shady kloofs, maximising visibility for pollination on the vertical cliffs.

Fruit/Seed

Size: Seed 2 mm in diameter, an ideal size for establishment in crevices.

Dispersal: Light, black, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season. Germination after 14–21 days.

Vegetative reproduction: Absent.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996). Plants are popular in traditional medicine (Nguni people) and are often sold at muti markets.

ADDITIONAL NOTES

Horticulture: Easily grown from seed and thrives in cultivation. It is best grown as a pot plant in containers, in partial shade. The soil should be sandy and slightly acid, with ample feeding throughout the year. Its very easy growing nature maximises its survival rate. Outside its subtropical thicket habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17566 (NBG).

ILLUSTRATIONS AND MAP

Figures 34a & 34b, Map 34.

35. *Bulbine pendens* G.Will. & Baijnath in South African Journal of Botany 61,6: 316 (1995).

Cremonophyte growth form: Solitary with pendent leaves type (of light weight, cliff hanger).

Growth form formula: A:B:D:C:Lp:(vb) (eg)

Etymology: The epithet *pendens* pertains to the pendent leaves.

DESCRIPTION AND HABITAT

Plants dwarf-sized, solitary, acaulescent, single or twin-headed geophytes, pendent from cliff faces. Tuber oblong, 30 × 15 mm, stellate, lobes tapering to roots. Leaves 1 or 2, pendent, amplexicaul, with basal sheath 10–20 long, linear, terete, striate, 15–18 × 2–5 mm. Inflorescence solitary, erect, 80–180 mm long, up to 4-flowered; peduncle 1 mm wide at base, terete; bracts deltoid-acuminate, 3–4 × 1 mm, clasping; pedicels up to 25 mm long. Perianth stellate, spreading, about 18 mm in diameter; tepals yellow, outer tepals 8 × 3 mm; inner tepals ovate to ovate-elliptic, 8 × 4 mm; apices obtuse to subacute. Stamens 5 mm long; filaments bearded. Ovary globose, 1.5–2.0 mm in diameter; style erect, 5 mm long; stigma capitate. Capsule obovoid, 3 mm in diameter. Seeds cubical, with elongate apex 1.7 × 0.7 mm, tuberculate, blackish brown.

Phenology: Flowering in spring. Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs of narrow shady kloof (mainly western and southwestern aspects). Plants firmly rooted in crevices. Temperature is high in summer (35–40°C). Winters are cooler but frost is absent. Rainfall in winter, ranging from 75–150 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 300–800 m.

Associated vegetation: Rosyntjieberg Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Aloe meyeri*, *Bulbinella gracilis*, *Conophytum angelicae*, *C. wettsteinii*, *Cyrtanthus herrei*, *Trachyandra aridimontana* and *Tylecodon ellaphieae* (Rosyntjieberg).

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Rosyntjieberg Formation (Orange River Group). Substrate with many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

A quartzitic sandstone endemic, confined to the narrow kloofs and cliff faces of the Rosyntjieberg and Oemsberg of the Richtersveld Transfrontier National Park. It was recently also found on cliffs along the Skaaprivierspoort northwest of Springbok.

RELATED SPECIES

Bulbine pendens is related to other two-leaved *Bulbine* sp. (*B. vitrea*, *B. diphylla*, *B. francescae*) but is immediately separated by its linear, almost terete, pendent leaves. The others are all chasmophytes.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants solitary, tuber often horizontal owing to cracks, with 1 or 2 drooping leaves up to 150 mm long. Plants become deciduous in summer, like other geophytes in the region coping with the long, dry summers.

Size and weight: Heads small, of light weight.

Stem: Plants acaulescent, with short, oblong tubers for summer dormancy.

Leaves

Orientation: The leaves are pendent (positively geotropic), withering after spring, an adaptation to the extreme, dry summer habitat.

Colour: Dull green and pellucid, maximising light in the shady environment. The translucent nature allows light to penetrate deeply, an adaptation helping the plants to cope with the shady cliff environment.

Age and persistence: Becoming deciduous in late spring.

Armament: The leaves are very soft and fleshy, thus fragile and without armour, suggesting adaptation to the undisturbed cliff habitat.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading, but individual flowers semi-reflexed and orientated towards the light source, maximising visibility to pollinators.

Fruit/Seed

Size: Seed 1.7 mm in diameter, the tuberculate surface and angular shape maximising establishment in crevices.

Dispersal: Light, dark, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening and dispersed in late spring and summer. Germination within 14–21 days.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Although regarded as a critically rare species (Raimondo *et al.* 2009), it has been found by the author at a second location as Skaaprivierspoort northeast of Springbok. The plants are locally abundant in parts of the Rosyntjieberg as well as at Skaaprivierspoort. It is not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine pendens* is easily grown from seed or division and does well in cultivation. It is best grown in a shady position as a pot plant in small containers simulating the small crevices of the cliff environment. The soil should be sandy and slightly acid, with ample feeding during autumn and winter. The plant should be allowed to dry out completely for its long summer dormancy. It grows fairly easily, maximising its survival rate. Outside its dry, winter-rainfall habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 2118 (NBG).

ILLUSTRATIONS AND MAP

Plate 35, Figures 35a–35d, Map 35.

36. *Bulbine ramosa* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 40,1: 6–7 (2003d).

Cremonophyte growth form: Cluster-forming (of medium weight, cliff squatter).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: Latin *ramus*, a branch, after its branching nature.

DESCRIPTION AND HABITAT

Plants rosulate, heads continuously dividing to form clusters up to 120 mm in diameter. Roots fleshy, terete, 3–5 mm in diameter. Stem short, 20–50 mm long, 15–25 mm in diameter, with globose, tuberous basal swelling 5–30 mm in diameter, tunicate; tunics golden brown, only slightly fibrous. Leaves rosulate, 6–8; older leaves spreading, firm, persistent; lamina linear to triangular-lanceolate, 80–110(–220) × (7–)10–15(–23) mm, ascending to slightly falcate, adaxial side flat, sometimes convex when fully turgid, or concave or slightly channelled during dry periods, abaxial side convex; surface smooth, bright green, obscurely striate, soft; leaf sap clear, not a lubricant; apex acute, mucronate; margin entire. Inflorescence 1 or 2, 300–470 mm tall, laxly flowered; flowers 20–35, borne in distal third of inflorescence, slightly drooping, 12–20 mm apart; peduncle flattened, 3–4 mm wide at base, terete distally, tapering up to 2 mm; bracts membranous, withering, lower bracts triangular, acuminate, 2–3 × up to 1 mm; pedicels terete, 11–15 mm long. Perianth yellow, stellate, 18 mm in diameter; outer tepals elliptic, up to 9 × 3 mm, apex obtuse, inner tepals up to 9 × 6 mm, apex obtuse.

Stamens up to 6 mm long; anthers oblong, up to 1 mm long, yellow. Ovary globose, up to 1.5 mm in diameter; style erect, terete, up to 6.5 mm long, yellow; stigma capitate. Capsule rounded, up to 4 × 3 mm. Seeds elliptic, oblong, up to 1.5 mm long, grey-black.

Phenology: Flowering in November.

Pollinators: Insects.

Habitat and aspect: *Bulbine ramosa* occurs on sheer south-facing quartzitic sandstone cliff faces. The average daily maximum temperature is about 26°C and the average daily minimum about 9°C. Rainfall in winter and summer, ranging from 200–300 mm per annum.

Altitude: 400–600 m.

Associated vegetation: Western Gwarrieveld of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Adromischus triflorus*, *Crassula badspootense*, *C. perforata*, *C. rupestris*, *Haworthia* sp., *Senecio ficoides*, *Tridentea choanantha* and *Tylecodon leucothrix*.

Geology: Bokkeveld Group (Cape Supergroup). The quartzitic sandstone substrate has many fissures, ledges and crevices, ideal for establishment of plants.

DISTRIBUTION

Bulbine ramosa is known only from Badspoot near Calitzdorp in the Western Cape.

RELATED SPECIES

Bulbine ramosa is at once distinguished by its bright green dividing rosettes forming small clusters. Its globose tubers and thick roots up to 5 mm in diameter are also distinct. Unlike the juice of many other *Bulbine* species, the leaf sap of this species is not a lubricant. *Bulbine frutescens* has aerial branches and roots without a tuberous base or swollen roots, and the leaf sap is a good lubricant.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants growing in clusters. A rapid-growing, fairly long-lived perennial.

Size and weight: Heads small and of average weight in fully turgid plants.

Stem: Short branches (up to 40 mm) grey and covered by persistent old leaves. They are fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Clustered or grouped, ascending.

Succulence: Very fleshy, of a firm texture.

Colour: Bright green.

Age and persistence: Leaves becoming turgid after rain, an adaptation to the extreme, dry habitat.

Armament: Leaf margin entire without armament, suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, maximising visibility to possible insect pollinators.

Fruit/Seed

Size: Seed 1.5 mm in diameter, an ideal size for establishment in crevices.

Dispersal: Light, grey-black seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer, coinciding with the rainfall. Germination within 14–21 days.

Vegetative reproduction: *Bulbine ramosa* divides, forming dense clusters. The continual division and filling of crevices represent an efficient vegetative backup dispersal strategy. Individual branches of the clusters will root and continue to grow, maximising survival (vegetative backup). Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine ramosa* is easily grown by division and thrives in cultivation. It is best grown as a pot plant in containers, in partial shade. The soil should be sandy and slightly acid, with ample watering and feeding throughout the year. Its very easy growing nature maximises its survival rate. Outside its succulent karoo habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 16120 (NBG).

ILLUSTRATIONS AND MAP

Plate 36, Figures 36a–36c, Map 36.

37. *Bulbine retinens* Van Jaarsv. & S.A.Hammer, in Van Jaarsveld *et al.* in Aloe 42,1 & 2: 14–15 (2005b).

Cremnophyte growth form: Cluster-forming (of light to medium weight, cliff squatter).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The epithet *retinens* pertains to the capsules retaining and not immediately releasing the seed.

DESCRIPTION AND HABITAT

Plants rosulate, cluster-forming, small, up to 90 mm high (without flowers), 90 mm in diameter, bearing 3–9 rosettes. Tubers ovate, 12–20 × 10–15 mm, covered with dry remains of amplexicaul leaf bases which weather to a fibrous network; flesh yellow. Roots grey, fleshy, terete, stubby, 1.5 mm in diameter. Leaves 5–7, in apical rosette, forming short neck at base up to 7 mm long, erect, soft-textured, linear, subterete, adaxial side becoming flat towards base, 50–80 × 5–7 mm; surface smooth, grey-green to bluish owing to dense powdery bloom, obscurely striate; apex acute, apiculate. Inflorescence up to 350–490 mm long, erect, 17–35-flowered in distal half; raceme 230–310 mm long; peduncle 2–3 mm in diameter at base, terete; bracts deltoid, acuminate, 2 × 1 mm, clasping; pedicels 14–17 mm long. Perianth stellate, becoming reflexed, drooping, about 15–20 mm diameter; tepals pale orange-yellow, outer tepals elliptic, 11 × 3 mm, inner tepals ovate to ovate-elliptic, 12 × 5 mm, obtuse. Stamens 8 mm long. Ovary globose, 1.5 mm in diameter; style erect, up to 6 mm long. Fruit obovate, up to 6 mm long, 2 mm thick, pendulous, orange when ripe, splitting at carpels but retaining seeds for 1–3 days. Seeds 10–30 per fruit, 2.2 × 1.2 × 0.9 mm, indistinctly angular, dull brownish black, finely pitted.

Phenology: In habitat *Bulbine retinens* flowers in spring and summer. Under cultivation its season is extended. Flowers open midmorning, are sweetly scented and deliquesce by dusk. As is normal in the genus, *Bulbine retinens* is not self-fertile. Seed is dispersed by wind.

Pollinators: Insects.

Habitat and aspect: *Bulbine retinens* is known only from the quartzitic sandstone cliffs along the Kouga River between Haarlem and Joubertina in the Hoeree and Skrikrivier tributaries of the Kouga River, where it is locally abundant. Plants grow in clusters, firmly rooted in crevices, and size often depends on the growing space allowed by the crevice. Temperature is high in summer (30–35°C). Winters are cooler but frost is absent. The average daily maximum temperature is about 24°C and the average daily minimum 10°C. Rainfall occurs throughout the year but more so in summer, ranging from 300–400 mm per annum.

Altitude: 500–800 m.

Associated vegetation: Gamtoos Thicket and dry Fynbos at higher altitudes (Mucina *et al.* 2005).

Associated cremnophytes: Locally common, it grows on sheer rock faces in crevices in shade or sun, solitary or together with other succulents such as *Crassula rupestris* subsp.

rupestris, *Cyrtanthus montanus*, *Haemanthus albiflos*, *Haworthia translucens*, *Ornithogalum longibracteatum*, *Othonna capensis*, *Senecio scaposus* and *Veltheimia capensis*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). The cliff substrate has many fissures, ledges and crevices, ideal for establishment of plants.

DISTRIBUTION

Known only from the Kouga River (Hoeree and Skrikrivier) in the southwestern part of the Eastern Cape.

RELATED SPECIES

Bulbine retinens is at once distinguished from the other dwarf-sized, cluster-forming, cremnophilous *Bulbine* species by its erect, linear leaves arising from a short neck, its ovate tubers covered with fibrous, reticulate remains of leaf bases, and its peculiar mode of seed retention. *Bulbine retinens* comes closest to *B. cremnophila* of the Baviaanskloof to the north of Hoeree, and the widespread *B. rupicola* of the Kouga Mountains to the east (see Van Jaarsveld & Van Wyk 1999). *Bulbine cremnophila* has distinctly curved, linear-lanceolate leaves, similar in colour and texture to those of *B. retinens*, but the plants tend to be more robust and form smaller clusters. *Bulbine rupicola* is a dwarf-sized species with short, erect, lanceolate, green leaves up to 60 mm long and with ciliate margins.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with tight clusters. It is a rapid-growing, fairly long-lived perennial.

Size and weight: Heads small, of light to average weight (fully grown and turgid).

Tubers: The short tubers are grey and covered by persistent old leaves. They are fleshy, maximising water storage in the dry habitat.

Leaves

Orientation: Ascending, linear.

Succulence: Fleshy.

Colour: Glaucous (reflecting the light), with powdery bloom. The slight translucent nature allows light to penetrate deeply, an adaptation helping the plants to cope with the shady cliff environment.

Age and persistence: The leaves are soft, becoming turgid after rain, but reddish and somewhat channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The entire leaf margin and softer leaf texture suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Fruit/Seed

Size: Seed $2.2 \times 1.2 \times 0.9$ mm, 10–30 per fruit.

Dispersal: The invariably pendulous fruits start to swell a few days after pollination and ripen within two weeks. The carpel seams begin to split but the indistinctly angular, dull brownish black, finely pitted seeds are retained within the barely intact fruits for one to three days, unless they are strongly shaken (presumably done by wind in the habitat). All other *Bulbine* species shed their seeds immediately. Unlike many species, *Bulbine retinens* has no well-defined dormancy and is never leafless, although it looks drab in winter.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Bulbine retinens* divides, forming dense clusters. Branches (or broken branches) will root in suitable crevices. The continual division and filling of crevices represent an efficient vegetative backup dispersal strategy. Broken branches or detached heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine retinens* is easily grown by division, doing well in cultivation. It is best grown as a pot plant in containers, in partial shade or full sun. The soil should be sandy and slightly acid, with ample watering and feeding throughout the year. Its very easy growing nature maximises its survival rate. Outside its thicket habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 15747 (NBG).

ILLUSTRATIONS AND MAP

Figures 37a–37c, Map 37.

38. *Bulbine rupicola* G.Will. in *Bradleya* 18: 36 (2000).

Cremonophyte growth form: Cluster-forming mats (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The epithet *rupicola* pertains to its rock-dwelling habitat.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, forming dense clusters up to 80 mm in diameter and with many heads from oblong to oblong-ovoid tubers (yellow flesh), only one to two heads flowering per cluster. Tubers up to 10–12 × 5–8 mm, grey, covered with fibrous remains of leaves. Roots yellowish, terete to 1 mm in diameter. Leaves up to 3–7, in a rosette, ascending, linear to linear-lanceolate, 15–30 × 6–10 mm, triangular-lanceolate to subterete, green, with soft texture, becoming reddish under dry conditions; upper side flat to convex becoming channelled during dry season, cymbiform below, green and slightly glaucous and faintly translucent, striate, covered with powdery bloom; margin entire; apex acute-mucronate. Inflorescence 50–120 mm long, 3–8-flowered in distal quarter; peduncle 1 mm in diameter at base, terete, reddish; bracts deltoid-acuminate, 1.5 × 1 mm, clasping; pedicels 7 mm long. Perianth stellate, becoming reflexed, slightly drooping to drooping, about 8–14 mm in diameter; tepals yellow with darker brownish central stripe in each tepal, outer tepals obovate-elliptic, 7 × 3 mm, channelled, inner tepals ovate to ovate-elliptic, 6 × 4 mm, obtuse. Stamens up to 5 mm long, bearded. Ovary oblong-globose, up to 1.2 × 2 mm. Fruit a rounded capsule, up to 2.5–3 mm in diameter. Seeds angular, black, 2 × 1 mm, minutely wrinkled.

Phenology: Flowering mainly early November–January. Seeds dispersed by wind in summer.

Pollinators: Insects.

Habitat and aspect: Cliffs of narrow shady kloofs (all aspects). Plants are firmly rooted in crevices, their size often depending on the growing space allowed by the crevice. Temperature is high in summer (30–35°C). Winters are cooler but frost is absent. Rainfall occurs throughout the year, but with a peak in spring and summer, 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 500–800 m.

Associated vegetation: Gamtoos Thicket and dry Fynbos at higher altitudes (Mucina *et al.* 2005).

Associated cremnophytes: *Albuca cremnophila*, *Crassula perfoliata* var. *minor*, *C. perforata* and *Gasteria glauca*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). Cliff substrate with many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Bulbine rupicola is a quartzitic sandstone endemic, confined to the narrow kloofs (north-south orientation) of the Kouga River Mountains of the Eastern Cape, west of Hankey.

RELATED SPECIES

Bulbine rupicola comes closest to *B. retinens*, which is larger, with long, linear leaves and fruit that retain the seed for some time. It differs further in its flowering time in December. Both have a prolific nature.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants growing in tight clusters. It is a rapid-growing, fairly long-lived perennial.

Size and weight: Heads dwarf-sized, of light weight.

Tubers: The short, oblong tubers are grey and covered by persistent old leaves. They are fleshy, maximising water storage in the dry habitat.

Leaves

Orientation: Drawn together in the apical rosette, becoming slightly spreading only in the rainy season, an adaptation to the extreme, dry habitat.

Succulence: Very fleshy.

Colour: Green to slightly glaucous (reflecting the light), with powdery bloom. The slight translucent nature allows light to penetrate deeply, an adaptation helping the plants to cope with the shady cliff environment.

Age and persistence: Becoming deciduous from the base, resulting in apical rosettes. Leaves are soft, becoming turgid after rain, but reddish and somewhat channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The entire leaf margin and softer leaf texture suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading but with only one or two developing from a cluster, the few individual flowers subpendulous. Initial orientation of the buds is erect but the flowers curve down as they mature. The subpendulous orientation of the perianth renders the flowers more conspicuous in the narrow, shady kloofs when viewed from below, thus an adaptation maximising visibility for pollination in the vertical cliff environment. The prolific nature maximises survival and compensates for reduced sexual output (fewer inflorescences and flowers).

Fruit/Seed

Size: Seed 2×1 mm, a relatively ideal size for establishment in crevices.

Dispersal: Angular, black seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season. Germination usually after 14–21 days.

Vegetative reproduction: Plants divide, forming dense clusters. Continual division and filling of crevices represent an efficient vegetative backup dispersal strategy in the harsh cliff-face environment. Individual branches of clusters will root and establish many clones,

continuing growth and maximising survival (vegetative backup). Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine rupicola* is easily grown from seed or division, thriving in cultivation. It is best grown as a pot plant in partial shade and kept in small containers simulating the small crevices of the cliff environment. The soil should be sandy and slightly acid, with ample feeding throughout the year. Its very easy growing nature maximises its survival rate. Outside its subtropical thicket habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17378 (NBG).

ILLUSTRATIONS AND MAP

Figures 38a–38c, Map 38.

39. *Bulbine suurbergensis* Van Jaarsv. & A.E.van Wyk in *Aloe* 42,3: 48–49 (2005b).

Cremonphyte growth form: Pendent rosettes (of medium weight, cliff hanger).

Growth form formula: E:F:P:R:C:Ar (vb)

Etymology: After the Suurberg, its habitat.

DESCRIPTION AND HABITAT

Plants at first solitary, dividing and becoming branched. Rosettes pendent, up to 150 mm in diameter, 250 mm long, characteristically curving upwards at apices. Stems pendent, up to 700 × 15 mm, characteristically orange-brown when cut, covered with persistent leaf bases, weathering to form a fibrous network; basal part often becoming glabrous, grey-brown, smooth, with aerial roots. Roots grey-brown, fleshy, terete, about 1.5–2.0 mm in diameter. Leaves 6–10 per rosette, ascending to ascending-spreading, linear-lanceolate, 70–170 × 12–18 mm; apex acute, mucronate; lamina flat above, convex to rounded below, becoming channelled during drought, soft-textured, pale green, smooth, obscurely striate; margin entire. Inflorescence 110–350 mm long, sparsely flowered (20–30 flowers) in distal third; raceme up to 100–153 mm long; peduncle up to 5 mm in diameter at base, biconvex, green; bracts deltoid, up to 3 × 0.5 mm, acuminate, clasping; pedicels 8–10 mm long. Perianth stellate, about 13 mm in diameter; tepals bright yellow with greenish yellow median stripes, apices obtuse to emarginate, outer tepals narrowly oblanceolate, up to 7–9 × 1.5–2 mm, inner tepals elliptic to elliptic-oblanceolate, up to 7–8 × 2.5–3 mm. Stamens up to 7 mm long, bearded in central part, with hairs 1–2 mm long. Ovary obovoid, up to 1 mm in diameter; style erect, up to 4.5 mm long. Capsule obovate, up to 3 × 2.5 mm, ascending. Seeds 3 × 1.5 mm, black. Flowering from August to November (Figure 39a).

Phenology: Flowering mainly in spring (August–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs about above the Witterivier (mainly southern, eastern and western aspects). Plants are firmly rooted in crevices, and size often depends on the growing space allowed by the crevice. Temperature is high in summer (35°C). Winters are cooler but frost is absent. Rainfall throughout the year, but with a peak in spring and summer, ranging from 400–500 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 400–600 m.

Associated vegetation: Sundays Noorsveld of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Bulbine frutescens*, *Chlorophytum comosum*, *Crassula lactea*, *Delosperma truteri*, *Haworthia angustifolia* var. *baylissii*, *H. glauca*, *Ledebouria concolor*, *Litanthus pusillus* and *Ornithogalum longibracteatum*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Witteberg Group (Cape Supergroup). The quartzitic sandstone substrate has many fissures, ledges and crevices, ideal for establishment of plants.

DISTRIBUTION

Bulbine suurbergensis is confined to the Suurberg, north of Port Elizabeth (Eastern Cape).

RELATED SPECIES

Bulbine suurbergensis differs from other cremnophilous species by its long, pendent, dichotomous, sparsely branched stems up to 700 mm long, characteristically curving upwards and by its soft, linear-lanceolate leaves. It shares these features as well as the persistent leaf bases weathering to a mat-like, fibrous network with *B. latifolia* var. *latifolia* and var. *curvata*. But here the resemblance ends. Both varieties of *B. latifolia* usually grow solitary, var. *curvata* bearing firm, falcate leaves whereas those of var. *latifolia* are soft and fragile. The latter is usually acaulescent.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with long, drooping stems and this habit retained in cultivation. A fairly long-lived perennial with a slow to medium growth rate. The slow growth could perhaps be due to the mineral-deprived cliff habitat.

Size and weight: Heads of medium weight.

Stem: The long, leafless branches are grey and covered by a persistent fibrous network of old leaves. They are fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Leaves ascending to spreading in apical rosettes.

Succulence: Very fleshy, firm, becoming turgid after rain.

Colour: Light green, coping with the well-drained cliff environment.

Age and persistence: Long-lived, perennial, becoming deciduous from the base, resulting in apical rosettes.

Armament: The entire leaf margin and softer leaf texture suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence densely flowered, conspicuous, ascending to spreading; individual flowers spreading.

Fruit/Seed

Size: Seed 3×1.5 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Light, black, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season. Germination after 14–21 days.

Vegetative reproduction: *Bulbine suurbergensis* divides dichotomously, forming loose clusters. Branches (or broken branches) will root in suitable crevices. The continual division (and lengthening of branches) represent an efficient vegetative backup dispersal strategy. Broken branches or detached heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic well protected by the sheer habitat and not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine suurbergensis* is easily grown from cuttings or division and thrives in cultivation. It is best grown as a pot plant in containers, in partial shade. The soil should be sandy and slightly acid, with ample watering and feeding throughout the year. Its very easy growing nature maximises its survival rate. Outside its thicket habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 19228 (NBG).

ILLUSTRATIONS AND MAP

Plate 39, Figures 39a–39c, Map 39.

40. *Bulbine thomasiae* Van Jaarsv., in Van Jaarsveld & Van Wyk in Aloe 40,1: 5–6 (2003d).

Cremonophyte growth form: Cluster-forming, short pendent leaves (of medium weight, cliff squatter).

Growth form formula: A:S:Lper:R:C:Lp (eg) (vb)

Etymology: After Vicki Thomas, in recognition of her work as botanical artist.

DESCRIPTION AND HABITAT

Plants short-stemmed, with pendent dividing rosettes forming clusters of up to 8 heads. Rosettes up to 150 mm long and high, 150 mm in diameter. Tuber ovoid, up to 20 × 18 mm, tapering slightly towards neck, sparsely covered with few soft fibres. Roots terete, up to 2 mm in diameter, grey-brown. Leaves very soft, up to 7, drawn together, pendent or curving downwards, linear-lanceolate to triangular-lanceolate, 80–170 × 14–20(–30) mm; base clasping; lamina with few soft fibres, channelled to flattened above, rounded below, glaucous, becoming reddish pink during dry winters, faintly translucent and striate, covered with short pointed papillae; apex acute, mucronate; margins acute, translucent, minutely ciliate. Inflorescence 250–290 mm long; racemes subcapitate, 40–80 mm long, pointed, densely flowered; flowers secundly arranged; peduncle flattened at base, 4–6 mm in diameter, basal half biconvex, minutely ciliate, subterete distally; bracts deltoid-ovate, cymbiform, 4–5 × up to 3 mm, apex acuminate, keel and margins minutely ciliate, clasping; pedicels 15–20 mm. Perianth becoming reflexed, spreading, about 15 mm in diameter when fully expanded, stellate; tepals orange-yellow, slightly channelled and incurved at tips, outer tepals oblong-obovate, up to 8 × 3 mm, inner tepals ovate-lanceolate, up to 7.5 × 2 mm, obtuse. Stamens up to 6 mm long, bearded in distal quarter; anthers versatile, up to 1 × 0.8 mm. Ovary globose, up to 1.5 mm long. Capsule obovoid, up to 5 × 4 mm, pendent. Seeds up to 2 mm in diameter, angular, black.

Phenology: Flowering mainly from midwinter to spring. Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: South-facing cliffs, on upper slopes of escarpment. Temperatures are high in summer and mild in winter. The average daily maximum temperature is about 21°C and average daily minimum about 12°C. Rainfall occurs mainly in summer and ranges from 500–600 mm per annum (thunder showers, October–May).

Altitude: 200–800 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Albuca cremnophila*, *Aloe reynoldsii*, *Cotyledon orbiculata*, *Crassula orbicularis*, *Delosperma* sp., *Haemanthus albiflos* *Haworthia cymbiformis* var. *setulifer* and *Ornithogalum juncifolium*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). The shale substrate has many fissures, ledges and crevices, ideal for the establishment of plants.

DISTRIBUTION

Bulbine thomasiae is known only from the Bashee River in the Transkei, from Collywobbles to near the river mouth (Eastern Cape).

RELATED SPECIES

Bulbine thomasiae belongs to the broad-leaved *Bulbine* species. It is closest to *B. natalensis* and *B. cremnophila*, both of which are also cremnophilous. It is at once distinguished from these species by its subcapitate, acuminate inflorescence. The first named is a much larger, solitary species with broad, spreading leaves (widely distributed from the Eastern Cape to KwaZulu-Natal) and the second a smaller species with glaucous, glabrous leaves. Both related species have elongated racemes.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with drooping stems and leaves, even when grown in cultivation. Growth rate of *Bulbine thomasiae* is rapid. It is a fairly long-lived perennial.

Size and weight: Heads small, of average weight (fully turgid adult clusters).

Stem: Short branches (up to 40 mm) are grey and covered by persistent old leaves. They are fibrous and strong, thus less investment in woody tissue.

Leaves

Orientation: Apart from curving down (positively geotropic), the leaves are drawn together in the apical rosette, becoming slightly spreading only in the rainy season, an adaptation to the extreme, dry habitat.

Succulence: Very fleshy, soft and fragile.

Colour: Glaucous (reflecting the light), sparsely but regularly tuberculate. The slight translucent nature allows light to penetrate deeply, an adaptation helping the plants to cope with the shady cliff environment.

Age and persistence: Becoming deciduous from the base, resulting in apical rosettes. Becoming very turgid after rain, but deeply channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The entire, minutely ciliate margin and soft, fragile leaf texture suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence drooping but the subcapitate racemes turning upwards; flowers spreading and secundly arranged, pointing away from the cliff face and thus maximising visibility to possible insect pollinators.

Fruit/Seed

Size: Seed 2 mm in diameter, an ideal size for establishment in crevices.

Dispersal: Light, black, angular seeds are shaken from the capsules and dispersed by the wind.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season. Germination after 14–21 days.

Vegetative reproduction: *Bulbine thomasiae* divides, forming dense clusters. The continual division and filling of crevices represents an efficient vegetative backup dispersal strategy. Individual branches of the clusters will root and continue to grow, maximising survival (vegetative backup). Detached clusters or heads will also root if they fall into a new crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Bulbine thomasiae* is easily grown from seed or division and does well in cultivation. It is best grown as a pot plant in containers, in partial shade. The soil should be sandy and slightly acid, with ample feeding during spring and summer. Its very easy growing nature maximises survival rate. Outside its subtropical thicket habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 16893 (NBG).

ILLUSTRATIONS AND MAP

Plate 40, Figures 40a–40c, Map 40.

GASTERIA Duval

41. *Gasteria batesiana* G.D.Rowley var. *batesiana*, Rowley in National Cactus and Succulent Journal 10: 32 (1955).

Crempnophyte growth form: Dwarf-sized rosulate cluster (of medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: Named for J.T. Bates, British trolley bus conductor and succulent plant collector.

DESCRIPTION AND HABITAT

Acaulescent, decumbent to erect, 30–100 × 80–300 mm, proliferating from base to form small to large groups, rarely solitary. Roots terete. Leaves distichous at first, becoming rosulate, 50–180 × 15–40 mm, triangular-lanceolate to linear, erectly spreading, becoming recurved; surface dark green with dense white spots arranged in transverse bands, densely rugulose-tuberculate; margin cartilaginous, serrulate, rarely denticulate; apex acute, rarely obtuse, mucronate. Juvenile leaves lorate, densely tuberculate; apex obtuse, mucronate. Inflorescence racemose, 300–450 mm long; bracts 6–12 × 2–5 mm; pedicels 9 mm long. Perianth 35–40 mm long, stipitate for 3–5 mm, gasteriform basally (narrowly elliptic) over half perianth length, gasteriform portion 6–9 mm in diameter (often triangular in cross section), light pink, distal half white with green striations, inflated to the same diameter as proximal portion (with slight constriction in middle); apices erect, becoming erectly spreading, obtuse, white with green median stripes. Ovary 7 × 3 mm, style 15 mm long, stigma included or exerted for up to 5 mm. Capsule 16–20 mm long. Seeds 4–6 × 2–3 mm.

Phenology: Flowering in spring (September–October), but sporadically at other times as well. Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: South-facing cliffs of the northeastern parts of South Africa (northern KwaZulu-Natal and Mpumalanga) where the plants grow in crevices and on ledges in inaccessible places. Temperature is high in summer. Winters are cooler but frost is a rarity or absent. The daily average maximum temperature is about 28°C and the average daily minimum about 13°C. Rainfall mainly in spring and summer, 500–600 mm per annum.

Altitude: 300–1000 m.

Associated vegetation: KwaZulu-Natal Coastal Belt and Barberton Serpentine Sourveld of the Savanna Biome (Mucina *et al.* 2005).

Associated crempnophytes: *Aeollanthus parvifolius*, *Crassula orbicularis*, *C. perfoliata* var. *perfoliata*, *Delosperma tradescantioides*, *Peperomia blanda*, *Plectranthus cylindraceus*, *P. spicatus* and *P. verticillatus*.

Geology: It has been recorded as occurring on rock formations of the following formations: Mesozoic rhyolite (Jozini Formation) of the Lebombo Group, Palaeozoic sandstone and shale

(Madzaringwe Formation) of the Karoo Sequence and quartzitic sandstone (Mozaan Formation) of the Pongola Sequence. The quartzitic sandstone substrate has sufficient ledges, crevices and fissures for establishment of plants.

DISTRIBUTION

Gasteria batesiana var. *batesiana* has been recorded from the Buffalo (Mzimnyati) River in the south (KwaZulu-Natal) to Barberton in Mpumalanga in the north. The var. *dolomitica* is known only from south-facing dolomite cliffs of the Olifants River near Penge in the Limpopo Province (see under that variety).

RELATED SPECIES

Gasteria batesiana var. *batesiana* is at once distinguished by its triangular, spreading to recurved, linear leaves. *Gasteria batesiana* var. *dolomitica* has subterete, linear leaves. *Gasteria batesiana* is closely related to *G. tukhelensis* from cliffs along the Thukela Valley. The latter is much larger, with smooth-textured leaves and a divided inflorescence, the flowers with longer pedicels.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: *Gasteria batesiana* proliferates from the base, forming small clusters. Its small size allows effective heat absorption and establishment in crevices, the plants thus also coping better with gravity. During the dry season the leaves become dorsiventrally flattened and reddish tinged, the production of anthocyanins further enhancing the ability of the plants to survive.

Size and weight: Heads small, of medium weight.

Leaves

Orientation: Spreading to recurved, maximising absorption of light on the south-facing cliffs.

Colour: Dark green and varying from almost unspotted blackish green to mottled green, becoming reddish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis. The reduction of camouflage in some forms (compared to non-cremnophilous species of *Gasteria*) can be seen as an adaptation to the absence of herbivory in the cliff environment.

Presentation: Conspicuous clusters.

Age and persistence: Plants very slow-growing, long-lived, with leaves withering from the base.

Armament: The leaf margin is cartilaginous and serrulate, the leaves mucronate at the apex, but in comparison with other flat-ground species it represents a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding savanna vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending; perianth large, conspicuous, red-pink, green-tipped, suggesting adaptation maximising attraction of pollinators.

Fruit/Seed

Size: Seed 3×2 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Dispersed by wind.

Time: Germination within 14–21 days.

Vegetative reproduction: *Gasteria batesiana* var. *batesiana* suckers from the base, forming small, dense clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Continual sprouting from the base and rooting of leaves or fragments that have fallen into crevices represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

Classified as near threatened (Raimondo *et al.* 2009). Threatened by medicinal plant collectors. In spite of its localised distribution, seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Horticulture: Ideal for subtropical bushveld (savanna) gardens (Van Jaarsveld 2010). Plants are best grown in rockeries, dry stone walls or containers, in shade, and are easily grown by division, from leaf cuttings or seed. It does best in pot collections. Keep in partial shade and dry during its winter resting phase. The ease of cultivation suggests a maximum survival reproductive output. Outside its native habitat, it is best grown indoors, protected from the sun and from frost in winter. Well established as a house plant (in cultivation, locally and abroad).

VOUCHER

Van Jaarsveld 22362 (NBG).

ILLUSTRATIONS AND MAP

Plate 41, Figures 41a–41e, Map 41.

42. *Gasteria batesiana* G.D.Rowley var. *dolomitica* Van Jaarsv. & A.E.van Wyk in *Aloe* 36,4: 74 (1999).

Cremonophyte growth form: Dwarf-sized globose cluster (of medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: Named for J.T. Bates, British trolley bus conductor and succulent plant collector.

DESCRIPTION AND HABITAT

Acaulescent, decumbent to erect, 30–100 × 80–300 mm, proliferating from base forming small to large groups. Roots terete. Leaves distichous at first, becoming rosulate, 50–180 × 15–40 mm, linear to linear lanceolate, almost terete when turgid, ascending-spreading, becoming recurved; surface dark green, with dense white spots arranged in transverse bands, densely rugulose tuberculate; margin cartilaginous, serrulate, rarely denticulate; apex acute, rarely obtuse, mucronate. Juvenile leaves lorate, densely tuberculate; apex obtuse, mucronate. Inflorescence racemose, 300–450 mm long; bracts 6–12 × 2–5 mm; pedicels 9 mm long. Perianth 35–40 mm long, stipitate for 3–5 mm, gasteriform basally (narrowly elliptic) over half perianth length, gasteriform portion 6–9 mm in diameter (often triangular in cross section), light pink, distal half white with green striations, inflated to the same diameter as proximal portion (with slight constriction in middle); apices erect, becoming erectly spreading, obtuse, white with green median stripes. Ovary 7 × 3 mm, style 15 mm long, stigma included or exerted for up to 5 mm. Capsule 16–20 mm long. Seeds 4–6 × 2–3 mm.

Phenology: Flowering in spring (September–October), but sporadically at other times as well. Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: South-facing cliffs of the northeastern parts of South Africa (Mpumalanga and Limpopo Province). Plants grow in crevices and on ledges in inaccessible places. Winters are cool but frost is a rarity or absent. The average daily maximum temperature is about 28°C and the average daily minimum about 12°C. Rainfall mainly in spring and summer, and varying from 400–600 mm per annum.

Altitude: 450–600 m.

Associated vegetation: Mainly Bushveld and recorded from Pong Dolomite Mountain Bushveld (Mucina *et al.* 2005).

Associated cremnophytes: *Aeollanthus parvifolius*, *Crassula expansa* subsp. *fragilis*, *Delosperma vandermerwei*, *Orbea hardyi*, *Plectranthus dolomiticus*, *P. spicatus* and *P. verticillatus*.

Geology: Dolomite (ancient Vaalian dolomites of the Chuniespoort Group, Malmani Subgroup, Transvaal Supergroup). The dolomite substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Gasteria batesiana var. *dolomitica* has so far been recorded only from the Olifantsrivier Gorge near Penge (Mpumalanga and Limpopo Provinces).

RELATED SPECIES

At once distinguished by its linear, almost terete leaves (when fully turgid). The var. *batesiana* has triangular leaves. *Gasteria batesiana* is closely related to *G. tukhelensis* from

cliffs along the Thukela Valley. *Gasteria tukhelensis* is much larger, with smooth-textured leaves and a divided inflorescence, the flowers with longer pedicels.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: It proliferates from the base, forming small clusters. Its small size allows effective heat absorption and establishment in crevices, the plants thus also coping better with gravity. During the dry season the leaves become dorsiventrally flattened and reddish tinged. This production of anthocyanins improves the ability of the plants to survive. The plants' investment in vegetative output (vigorous prolific nature) further enhances occupation of crevices and ultimate survival.

Size and weight: Heads small, of medium weight.

Leaves

Orientation: Spreading to recurved, maximising absorption of light on the south-facing cliffs.

Colour: Dark green, and varying from almost unspotted blackish green to mottled green, becoming reddish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis. The reduction of camouflage in some forms (compared to non-cremophilous species of *Gasteria*) can be seen as an adaptation to the absence of herbivory in cliff environment.

Presentation: Conspicuous clusters.

Age and persistence: Plants very slow-growing, long-lived, with leaves withering from the base. When turgid, the leaves are very fleshy and subterete or biconvex in the var. *dolomitica*, an adaptation to the dry cliff-face habitat.

Armament: The leaf margin is cartilaginous and serrulate, the leaves mucronate at the apex, but in comparison with other flat-ground species it represents a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding savanna vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending; perianth large, conspicuous, red-pink, green-tipped, suggesting adaptation maximising attraction of pollinators.

Fruit/Seed

Size: Seed 3×2 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Wind-dispersed.

Time: Germination within 14–21 days.

Vegetative reproduction: *Gasteria batesiana* var. *dolomitica* suckers from the base, forming small, dense clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Another unique feature of *Gasteria batesiana* var. *dolomitica* is the leaves, which bend backwards and spontaneously form vegetative propagules, rooting in crevices or on ledges. Continual sprouting from the base, rooting of leaves or fragments that have fallen into a crevice and leaf propagules represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009). In spite of its localised distribution, it is not threatened and seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Horticulture: Ideal for subtropical bushveld (savanna) garden (Van Jaarsveld 2010). Plants are best grown in rockeries, dry stone walls or containers, in shade, and are easily grown by division, from leaf cuttings or seed, as specimen pot collections. Keep in partial shade and dry during its winter resting phase. This ease of cultivation suggests a maximum survival reproductive output. Outside its native habitat, it is best grown indoors where it can be protected from the sun and from frost in winter. *Gasteria batesiana* var. *dolomitica* is well established in cultivation, locally and abroad.

VOUCHER

Van Jaarsveld & Hankey 15081 (NBG).

ILLUSTRATIONS AND MAP

Plate 42, Figures 42a–42c, Map 42.

43. *Gasteria croucheri* (Hook.f.) Baker subsp. *pendulifolia* (Van Jaarsv.) Zonn. in *Plant Systematics and Evolution* 251: 217–227 (2005).

Cremonophyte growth form: Cluster-forming, pendent leaves (of medium weight to heavy, cliff hanger).

Growth form formula: A:S:Lper:R:C:La (vb) (eg)

Etymology: The epithet *pendulifolia* (*penduli*, pendulous, and *folium*, leaf) pertains to the pendulous leaves.

DESCRIPTION AND HABITAT

Acaulescent, forming small but dense clusters (off-shooting from base), up to 300 mm in diameter, bearing pendulous leaves in rosettes. Roots slightly fleshy. Leaves spreading-pendulous, linear-lanceolate, up to 470 × 45 mm, without armament, with purplish tinge during dry winter or prolonged drought. Inflorescence conspicuous, simple or branched, up to

500 mm long, pendulous-ascending, tips drooping. Perianth pink, distal half white with green striations to 40 mm long. Fruiting capsule 18–25 mm long, ascending when dry. Seeds black, 3–4 × 2–3 mm.

Phenology: Flowering in spring and summer (October–February), but sporadically at other times as well. Seeds dispersed by wind in summer and autumn (in the wet season).

Pollinators: Sunbirds.

Habitat and aspect: Shady quartzitic sandstone cliffs (southern aspects) overlooking the Umgeni River and adjacent river valleys. The southern slopes are cooler, with shady conditions. Plants are firmly rooted in crevices and on rock ledges large enough to support the roots and stem clusters. Winters are cool but frost is a rarity or absent. The average daily maximum temperature is 27°C. Rainfall occurs mainly from spring to autumn, about 1000–1250 mm per annum (thunder showers), but occasionally also in winter.

Altitude: 100–400 m.

Associated vegetation: KwaZulu-Natal Coastal Belt of the Indian Ocean Coastal Belt (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Aptenia cordifolia*, *Cotyledon orbiculata* var. *oblonga*, *Crassula flanaganii*, *C. multicava*, *C. perfoliata* var. *perfoliata*, *Delosperma tradescantioides*, *Petopentia natalensis*, *Plectranthus hadiensis* var. *tomentosus*, *P. purpuratus*, *Portulacaria afra*, *Rhipsalis baccifera* and *Sarcostemma viminale*.

Geology: Natal Group (Cape Supergroup). The sandstone substrate is rich in ledges, crevices and fissures and is ideal for establishment of plants.

DISTRIBUTION

Gasteria croucheri subsp. *pendulifolia* is restricted to cliff faces at Shongweni and Mamba Valley, Durban.

RELATED SPECIES

It differs from *Gasteria croucheri* subsp. *croucheri* in its pendent, linear-lanceolate leaves. When growing in full sun, the leaves are glaucous and compact, without the pendent nature. It differs in the reduction in the general size of the plants and the absence of armament (along the leaf margins) as well as in its inflorescence which is reduced to a simple raceme or occasionally divided from the base.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Clustering, with pendent leaves, suggesting an adaptation of maximising light absorption in the shady environment. This form proliferates from basal stolons, forming dense clusters. During the dry season, the leaves become deeply channelled, with a purplish tinge. Its prolific nature compensates for a reduction in floral output. The plant thus invests in vegetative output occupying a rock crevice. The plants are smaller than those of the typical subspecies, this reduction in size allowing them to cope better with gravity.

Size and weight: Heads of medium size and weight.

Leaves

Orientation: Flattened, long-linear, becoming drooping and faintly spotted, an adaptation enabling the plants to maximise absorption of light.

Colour: Slightly glaucous, faintly spotted, becoming purplish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, with leaves withering from the base. The fleshy leaves becoming turgid after rain, but channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The leaf margin is entirely smooth, suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, with pendulous apices; corolla pink, attracting sunbirds.

Fruit/Seed

Size: Seed 3–4 × 2–3 mm, an ideal size for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Gasteria croucheri* subsp. *pendulifolia* suckers from the base, forming dense clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Continual sprouting from the base and rooting of leaf fragments that have fallen into a crevice represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

Classified as vulnerable (Raimondo *et al.* 2009). Threatened and over-exploited. This is a popular item in the medicinal plant trade (Scott-Shaw 1999; Crouch *et al.* 2000).

ADDITIONAL NOTES

Horticulture: *Gasteria croucheri* subsp. *pendulifolia* is a worthwhile introduction to horticulture. It is best grown in moist savanna gardens (Van Jaarsveld & Van Wyk 2001b,

Van Jaarsveld 2006b, 2010). It propagates readily from leaf cuttings planted in a well-drained, sandy mixture and is fairly fast-growing. Plants can also be divided or grown from stolons. Sow seed in spring or summer in a warm, shady position in a sandy, slightly acidic soil and keep moist. *Gasteria croucheri* subsp. *pendulifolia* does well on steep embankments. It is also ideal for large hanging baskets and window sills. Outside its habitat, it is best grown in containers under controlled conditions in a greenhouse. Plants grown at Kirstenbosch are being increased by vegetative means and will be released and introduced through its annual plant sale and from the nursery at Kirstenbosch in future.

VOUCHER

Van Jaarsveld, Baijnath & Heigeldorf 9838 (NBG).

ILLUSTRATIONS AND MAP

Plates 43 & 43a, Figures 43a–43c, Map 43.

44. *Gasteria doreniae* Van Jaarsv. & A.E.van Wyk in *Aloe* 41,4: 81–83 (2004a).

Crempnophyte growth form: Dwarf-sized globose cluster (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After Mrs Doreen Court, botanist and author.

DESCRIPTION AND HABITAT

Plants acaulescent, decumbent to erect, 50–80 mm tall, up to 120 mm in diameter, proliferating from base to form dense clusters up to 150 mm in diameter. Roots fleshy, up to 3 mm in diameter. Leaves distichous, lorate, 35–80 mm long, 14–25 mm in diameter at base, erectly spreading, often becoming patent (apices incurved during dry season); surface minutely asperulous, mottled with dark green and white spots, adaxial surface plane to convex, abaxial side convex; margin tuberculate towards obtuse or acute, mucronate apex. Juvenile leaves distichous, lorate, patent to ascending, similar in texture and colouring to adult leaves. Inflorescence a simple raceme, 120–400 mm long. Scape 3–4 mm broad and flattened at base; floral bracts 5–7 × 2–3 mm, piliferous; pedicels 3–4 mm long, pink. Perianth 15–17 mm long, stipitate for 2–3 mm, globose to globose-ovoid for about a third of perianth length, gasteriform basal portion 6–8 mm wide, pink, distal third pale pink to almost white with green striations, 4 mm in diameter; segments free, apices obtuse, erect becoming erectly spreading. Stamens 10–14 mm long; anthers 2.0–2.5 × 1 mm, included. Ovary 6–7 mm long, green; style 6 mm long; stigma included or just exerted, minute, curved upwards. Capsule 18 mm long, obtuse at apex. Seeds 3–4 × 2–3 mm, black.

Phenology: Flowering in spring (October–November), but sporadically at other times as well. Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: Cliffs in the Swartwaterspoort, more so on southern faces. The Swartwatersberg Mountains consist of hard quartzites (Witteberg Group, Cape Supergroup) and are situated 40 km northeast of the location of *Gasteria baylissiana* on the Suurberg (Farm Oudekraal, Witrivier). The average annual daily maximum temperature is about 24°C and the average daily minimum about 11°C. They range from about 600–800 m in altitude, with typical thicket vegetation on the lower slopes and in the poort. Rainfall in the habitat occurs mainly in summer and ranges from 400–500 mm per annum.

Altitude: 350–500 m.

Associated vegetation. Kowie Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Gasteria doreeniae* shares its cliff-face habitat with the following succulent and bulbous species: *Crassula intermedia*, *C. lactea*, *C. orbicularis*, *C. pellucida* subsp. *marginalis*, *C. perforata*, *Delosperma laxipetalum*, *Haemanthus albiflos* and *Ornithogalum longibracteatum*.

Geology: Witteberg quartzite (Cape Supergroup). The quartzitic sandstone substrate has many ledges, crevices and fissures and is ideal for the establishment of plants.

DISTRIBUTION

Gasteria doreeniae is restricted to cliff faces of Swartwaterspoort in the Eastern Cape.

RELATED SPECIES

Gasteria doreeniae is closely related to the variable *G. bicolor* (non-cremnophyte), but is at once distinguished by its compact growth (plants very shortly stemmed) and short, broad leaves. Superficially not unlike *G. baylissiana* of the adjacent Suurberg, another small, rounded, cluster-forming species. The latter has distinctly tuberculate leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters of distichous heads. It proliferates profusely from the base. Its small size allows effective heat absorption and establishment in crevices, the plants thus also coping better with gravity. During the dry season, the leaves become dorsiventrally flattened and reddish tinged. This improves its ability to survive. The plants' investment in vegetative output (vigorous prolific nature) further enhances occupation of crevices and ultimate survival.

Size and weight: Heads of light to medium weight.

Leaves

Orientation: Distichous, spreading to recurved, maximising absorption of light on the south-facing cliffs.

Colour: Mottled, dull green, becoming reddish in dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, leaves withering from the base. When turgid, the leaves are very fleshy and often biconvex, an adaptation to the dry vertical habitat.

Armament: The leaf margin is smooth (only slightly crenate-tuberculate at the apex), suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending; perianth pink, conspicuous.

Fruit/Seed

Size: Seed 3–4 × 2–3 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Capsules ascending and seed released only during strong winds, ensuring a sufficient dispersal distance.

Time: Germination after about 14–21 days.

Vegetative reproduction: *Gasteria doreeniae* suckers freely from the base, forming dense clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Continual sprouting from the base and rooting of leaf fragments that have fallen into a crevice represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment. Leaves that drop from the cliff face at Swartwaterspoort often root under shrublets, forming small scattered groups—explaining its occurrence in only a narrow strip near the base of the cliffs. Swartwaterspoort is about 15 km west of Riebeeck East in the Eastern Cape and forms part of the Swartwatersberg Mountains (*swart water* means black water, pertaining to the dark but clear water, the dark colour due to the high organic content).

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009). In spite of its localised distribution, it is not threatened and seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Variability: The species varies genetically considerably in a small area (size, shape and texture of leaves, shape of perianth), suggesting adaptable plasticity.

Horticulture: Ideal for thicket gardens. Plants are easily grown by division, from leaf cuttings or seed. It does well in small containers as a specimen pot collection. It should be shaded. This ease of cultivation suggests a maximum survival reproductive output.

VOUCHER

Van Jaarsveld 18763 (NBG).

ILLUSTRATIONS AND MAP

Plate 44, Figures 44a–44c, Map 44.

45. *Gasteria glauca* Van Jaarsv. in *Cactus and Succulent Journal (U.S.)* 70,2: 65–66 (1998).

Cremonophyte growth form: Dwarf-sized globose cluster (of medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb) (rd)

Etymology: Latin *glauca*, pertaining to the glaucous leaf colour.

DESCRIPTION AND HABITAT

Plants proliferating from base to form dense globose clusters up to 250 mm in diameter. Roots up to 2 mm in diameter. Leaves at first distichous, becoming rosulate, 50–70 × 15–18 mm, firm, lorate-lanceolate and falcate to straight, the inner erectly spreading, the outer patent; adaxial surface slightly canaliculate, flat in distal half; abaxial surface convex, with a distinct eccentric keel, both surfaces glaucous; epidermis tuberculate-asperulous; margin tuberculate-denticulate; apex acute, mucronate. Inflorescence racemose, up to 250 mm long; pedicels up to 7 mm long. Perianth 30–43 mm long, gasteriform basally for half of its length or shorter, gasteriform portion reddish pink, variable, up to 10 mm in diameter (globose-elliptic), thence constricted into a tube 4 mm wide. Stamens 25–32 mm long, 3 lengthening in advance; anthers 3 × 1.5 mm long, oblong, included. Ovary 6–2.5 mm long; style 22 mm long; stigma minute. Capsule oblong, 20 × 8 mm. Seed 3 × 2 mm.

Phenology: Flowering in summer (December–January), but sporadically at other times as well. Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: Quartzitic sandstone cliffs (east-facing) overlooking the Kouga River (in altitude). Plants grow in crevices and soil pockets (inaccessible rocky ledges). Winters are cool but frost is a rarity or absent. The average daily maximum temperature is about 26°C and the average daily minimum about 11°C. Rainfall in winter (cyclonic) and summer (mainly thunder showers), about 500–600 mm per annum.

Altitude: 400–800 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Crassula lactea*, *Cyrtanthus montanus*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Lampranthus affinis*, *Othonna triplinervia* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). The substrate has many ledges, crevices and fissures and is ideal for establishment of plants.

DISTRIBUTION

Gasteria glauca is restricted to cliff faces of the Kouga River region just west of Guerna Kop.

RELATED SPECIES

Gasteria glauca is related to *G. ellaphieae*, a typically well-camouflaged chasmophyte of the Kouga Dam to the east. The latter has a darker mottled epidermis, with slender, less conspicuous flowers and erect fruiting capsules. With its mottled leaves, *G. ellaphieae* is difficult to spot in its natural habitat. However, although *G. glauca* is conspicuous, on the cliffs it is safe from predation by larger herbivores. It is also related to *G. glomerata* but immediately distinguished by the spirally arranged leaves and flowering time from December–January; *G. glomerata* flowers in October.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Genetic variability: Plants vary in leaf and perianth size and shape, characters retained in cultivation at Kirstenbosch. This variability in a small population suggests genotypic plasticity.

Habit: It profusely proliferates from the base, forming small, dense clusters. Its small size allows effective heat absorption and establishment in crevices, the plants thus also coping better with gravity. During the dry season, the leaves become dorsiventrally flattened and reddish tinged. This improves its ability to survive. The plants' investment in vegetative output (vigorous prolific nature) further enhances occupation of crevices and ultimate survival.

Size and weight: Heads small.

Leaves

Orientation: Spreading to recurved, maximising light absorption on the east-facing cliffs.

Colour: Grey-green, unspotted, becoming reddish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis. The reduction of camouflage in comparison to non-cremophilous species of *Gasteria* can be seen as an adaptation to the absence of herbivory in the cliff environment.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, leaves withering from the base. When turgid, the leaves are very fleshy and often biconvex, an adaptation to the dry vertical habitat.

Armament: The leaf margin is tuberculate-dentate, the leaves mucronate at the apex, but in comparison with flat-ground species it represents a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending; perianth red-pink, large and conspicuous compared to that of the chasmophytic species *Gasteria baylissiana* and *G. ellaphieae*, suggesting an adaptation maximising attraction of pollinators.

Fruit/Seed

Size: Seed about 3×2 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Another unique feature is the capsules that remain pendulous or become spreading (only occasionally erect). The capsules of all other *Gasteria* species (except *G. glomerata*) become distinctly erect. This feature (retained in cultivation) suggests a local dispersal strategy, the seeds dropping when the capsules ripen and not dependent on wind dispersal to the same extent as in other species. This corresponds to the very localised distribution on a few cliff faces. The spreading to erect capsules suggest wind dispersal, but to a lesser degree.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Gasteria glauca* suckers from the base, forming dense clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Continual sprouting from the base and rooting of leaf fragments that have fallen into crevices represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

Although classified as critically rare (Raimondo *et al.* 2009), it is not threatened and seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Horticulture: *Gasteria glauca* is a worthwhile introduction to horticulture. It is best grown in thicket gardens (Van Jaarsveld 2010). It propagates readily from leaf cuttings planted in a well-drained, sandy mixture and is fairly fast-growing. Plants can also be divided or grown from stolons. Sow seed in spring or summer in a warm, shady position in a sandy, slightly acidic soil and keep moist. *Gasteria glauca* is excellent for containers and miniature rock gardens. Outside its habitat, it is best grown in containers under controlled conditions in a greenhouse. Plants grown at Kirstenbosch are being continuously increased and made available to the general public. This ease of cultivation suggests a maximum survival reproductive output.

VOUCHER

Van Jaarsveld & Welsh 14760 (NBG).

ILLUSTRATIONS AND MAP

Figures 45a–45d, Map 45.

46. *Gasteria glomerata* Van Jaarsv. in Bradleya 9: 100 (1991a).

Cremonophyte growth form: Dwarf-sized globose cluster (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb) (rd)

Etymology: Latin *glomerata*, closely together in a head, alluding to the growth habit.

DESCRIPTION AND HABITAT

Plants proliferating from base to form dense globose clusters up to 200 mm in diameter. Roots up to 2 mm in diameter. Leaves distichous, 15–50 × 15–25 mm, lorate to widely ovate, the inner erectly spreading, the outer patent or recurved, biconvex in cross section to almost terete, becoming dorsiventrally flattened during dry season; both surfaces glaucous, immaculate; epidermis minutely tuberculate-asperulous; margin entire, minutely crenulate-tuberculate in distal quarter; apex truncate or obtuse, mucronate. Inflorescence an erectly spreading raceme, 120–200 mm long. Perianth 20–27 mm long, gasteriform basally for slightly more than half of the perianth length, gasteriform portion reddish pink, variable, 6–9(–10) mm in diameter (globose-elliptic to globose), thence constricted into a tube 4 mm wide. Stamens 18–20 mm long, 3 lengthening in advance; anthers 2 mm long, oblong, included. Ovary 4–5 mm long, 2 mm in diameter. Style 10–11 mm long; stigma minute. Capsules 14–16 × 8 mm long, mostly pendulous to spreading. Seeds 3 × 2 mm, black.

Phenology: Flowering in spring (October–November), but sporadically at other times as well. Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: Mainly south-facing quartzitic sandstone cliff faces overlooking the Kouga River, the plants growing in crevices and soil pockets of inaccessible rocky ledges. Summers are hot and dry. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is about 27°C and the average daily minimum about 12°C. Rainfall occurs mainly in summer and winter, about 300–400 mm per annum.

Altitude: 400–700 m

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Adromischus cristatus* var. *zeyheri*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula rupestris* subsp. *rupestris* 'Kouga form', *Cyrtanthus flammosus*, *Gasteria glomerata*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna lobata* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). Substrate with many ledges, crevices and fissures ideal for establishment of plants.

DISTRIBUTION

Restricted to cliff faces of the Kouga Dam in the lower reaches of the Kouga River region.

RELATED SPECIES

Gasteria glomerata is related to *G. baylissiana*, a typically well camouflaged chasmophyte of the Witteberg north of Port Elizabeth. The latter has a darker mottled epidermis, with smaller, less conspicuous flowers and erect fruiting capsules. With its mottled leaves, *G. baylissiana* is difficult to spot in its natural habitat.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters of distichous heads. It proliferates profusely from the base. Its small size allows effective heat absorption and establishment in crevices, the plants thus also coping better with gravity. During the dry season, the leaves become dorsiventrally flattened and reddish tinged. This improves its ability to survive. The investment in vegetative output (vigorous prolific nature) further enhances occupation of crevices and ultimate survival.

Size and weight: Heads small, of light to medium weight.

Leaves

Orientation: Distichous, spreading to recurved, maximising absorption of light on the south-facing cliffs.

Colour: Grey-green, unspotted, becoming reddish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis. The reduction of camouflage in comparison to non-cremophilous species of *Gasteria* can be seen as an adaptation to the absence of larger herbivores in the cliff environment.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, leaves withering from the base. When turgid, the leaves are very fleshy and often biconvex, an adaptation to the dry vertical habitat.

Armament: The leaf margin is smooth (only slightly crenate-tuberculate at the apex), suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending; perianth red-pink, conspicuous, its large size compared to that of chasmophytes such as *Gasteria baylissiana* and *G. ellaphieae* suggesting an adaptation maximising attraction of pollinators.

Fruit/Seed

Size: Seed 3×2 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Another unique feature is the capsules, some remaining pendulous and others becoming spreading or erect. The capsules of all other *Gasteria* species (except *G. glauca*) become distinctly erect. This feature (retained in cultivation) suggests a local

dispersal strategy, the seeds dropping when the capsules ripen and not dependent on wind dispersal to the same extent as in other species. This corresponds to the very localised distribution consisting of six to eight closely spaced cliff faces in the Kouga Dam region. The spreading to erect capsules suggest wind dispersal, but with a reduced role.

Time: Seeds ripening in late spring, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Gasteria glomerata* suckers from the base, forming dense, rounded clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Continual sprouting from the base and rooting of leaf fragments that have fallen into a crevice represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

Although it is classified as critically rare (Raimondo *et al.* 2009), it is not threatened and seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Variability: The species varies genetically considerably in a small area (size, shape and texture of leaves, shape of perianth), suggesting adaptable plasticity.

Horticulture: A worthwhile introduction to horticulture, especially the house plant trade (Van Jaarsveld 2010). It can also be grown out of doors in partial shade in rock crevices in rockeries. It is, however, best grown in thicket gardens. It propagates readily from leaf cuttings planted in a well-drained, sandy mixture and is fairly fast-growing. Plants can also be divided or grown from stolons. Sow seed in spring or summer in a warm, shady position in a sandy, slightly acidic soil and keep moist. *Gasteria glomerata* grows well in miniature rock gardens. Outside its habitat, it is best grown in containers under controlled conditions in a greenhouse. Plants grown at Kirstenbosch are being continuously increased and made available to the general public. Today it is well established in ornamental horticulture throughout the world. This ease of cultivation suggests a maximum survival reproductive output.

VOUCHER

Van Jaarsveld & Sardien 11054 (NBG).

ILLUSTRATIONS AND MAP

Plate 46, Figures 46a–46c, Map 46.

47. *Gasteria pillansii* Kensit var. *ernesti-ruschii* (Dinter & Poelln.) Van Jaarsv. in Aloe 29,1: 17 (1992a).

Cremonophyte growth form: Dwarf-sized mat-forming cluster (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The specific epithet commemorates Mr N.S. Pillans (1884–1964), a botanist at the Bolus Herbarium who collected plants near Clanwilliam and grew this plant in his garden in Rosebank, Cape Town. The variety is named for Ernst Rusch (1867–1957), a Namibian farmer who collected plants in southern Namibia.

DESCRIPTION AND HABITAT

Plants proliferating from base to form dense mats up to 300 mm in diameter. Roots up to 2 mm in diameter. Leaves distichous, 20–70 × 15–30 mm, lorate to widely ovate, spreading, patent, dorsiventrally compressed, becoming turgid during moist winters; both surfaces mottled dull green; epidermis minutely asperulous; margin entire, minutely crenulate-tuberculate; apex truncate or obtuse, mucronate. Inflorescence an erectly spreading raceme, 60–300– mm long. Perianth 25–30 mm long, reddish pink, gasteriform shortly at base, thence constricted into a tube 5–6 mm wide. Stamens with anthers included or shortly exposed. Ovary 4–5 mm long; 2 mm in diameter; style about 25 mm long; stigma minute. Capsule 14–16 × 8 mm long, becoming erect. Seeds 3 × 2 mm, black.

Phenology: Flowering in summer (December–January). Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: An obligate cremnophyte of the lower Orange River Valley of the Lorelei, Sonberg and Kuamsibberg Mountains. Plants are confined to sheer south-facing aspects, growing in crevices and soil pockets of inaccessible rocky ledges that are in permanent shade in the winter months. Summers are hot and dry. Winters are cooler and frost is absent. The average daily maximum temperature is about 27°C and the average daily minimum about 10°C. Rainfall mainly in winter, about 50–100 mm per annum.

Altitude: 400–700 m.

Associated vegetation: Succulent Karoo.

Associated cremnophytes: *Aloe pavelkae*, *Conophytum ricardianum*, *Crassula pseudohemisphaerica*, *C. sericea* var. *sericea*, *Cyrtanthus herrei*, *Tylecodon bruynsii*, *T. buchholzianus* subsp. *buchholzianus* and *T. racemosus*.

Geology: Quartzitic sandstone (light-coloured to reddish and smooth-textured), Nama Group Karoo Supergroup). Substrate with many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Gasteria pillansii var. *ernesti-ruschii* is restricted to cliff faces of southern Namibia and is mainly confined to the Ai-Ais Richtersveld Transfrontier National Park, which is in the lower reaches of the Orange River and just east of Rosh Pinah.

RELATED SPECIES

Gasteria pillansii var. *ernesti-ruschii* is related to the var. *pillansii*, a very variable taxon to the south. The latter is immediately differentiated by its much larger and longer, ascending-spreading, lorate leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dense, mat-forming clusters of distichous, patent leaves. It profusely proliferates from the base. Its small size allows effective heat absorption and establishment in crevices, the plants thus also coping better with gravity. During the dry season, the leaves become reddish and flattened. This improves its ability to survive. The plants' investment in vegetative output (vigorous prolific nature) further enhances occupation of crevices and ultimate survival.

Size and weight: Heads small, of light to medium weight.

Leaves

Orientation: Distichous, patent, maximising absorption of light on the shady south-facing cliffs.

Colour: Dull mottled green, spotted, becoming reddish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, leaves withering from the base. When turgid, the leaves are very fleshy.

Armament: The leaf margin is smooth (only slightly crenate-tuberculate at the apex), suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding succulent karoo.

Sexual reproduction

Inflorescence and flowers: Compared to solitary *Gasteria* species such as *G. excelsa*, which forms a large paniculate inflorescence, *G. pillansii* var. *ernesti-ruschii* has a smaller, spreading inflorescence (and only a very limited number per clone). This suggests an effective vegetative backup associated with so many cremophilous succulent plants. The inflorescence is ascending-spreading, the perianth red-pink and conspicuous. The large perianth size compared to that of chasmophytes such as *G. baylissiana* and *G. ellaphieae* suggests rich flowering, an adaptation maximising attraction of pollinators on the cliff face.

Fruit/Seed

Size: Seed 3 × 2 mm, a relatively small size ideal for establishment in crevices.

Dispersal: Capsules becoming erect after fertilisation, the erect capsules suggesting wind dispersal. Strong gusts of wind, common to the cliff habitat, will lift the seeds from the capsules and disperse them.

Time: Seeds ripening in late spring, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Gasteria pillansii* var. *ernesti-ruschii* suckers from the base, forming dense, rounded clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Continual sprouting from the base and rooting of leaf fragments that have fallen into a crevice represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

In spite of its localised distribution, it is not threatened and seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Horticulture: *Gasteria pillansii* var. *ernesti-ruschii* thrives in cultivation. Outside its habitat, it is best grown in small containers under greenhouse conditions where moisture can be controlled. Plants can also be divided or grown from stolons. Sow seed in autumn in a warm, shady position in a sandy, slightly acidic soil and keep moist. Excellent for miniature rock gardens. The ease of cultivation suggests a maximum survival reproductive output.

VOUCHER

Van Jaarsveld 21065 (NBG).

ILLUSTRATIONS AND MAP

Plate 47, Figures 47a & 47b, Map 47.

48. *Gasteria rawlinsonii* Oberm. in *The Flowering Plants of Africa* 43: t. 1701 (1976).

Cremnophyte growth form: Leafy pendent stems, clusters (of medium weight to heavy, cliff hanger).

Growth form formula: E:F:P:R:C:Rls (eg)

Etymology: Named for S.I. Rawlinson, South African collector and grower of succulent plants.

DESCRIPTION AND HABITAT

Plants caulescent, pendulous, prolific from base, with long pendent stems up to 1 m long. Stems foliate, occasionally branched; internodes 10–20 mm apart. Roots succulent, up to 3 mm in diameter. Leaves distichous or spirally arranged, linear, lorate, slightly falcate, 30–80

× 10–25 mm; both surfaces green, not spotted, or with faint white spots, abaxial surface convex, without a keel; epidermis asperulous; margin sparsely denticulate, sometimes unarmed; prickles turning black with age; apex recurved obtuse, mucronate. Inflorescence racemose, 100–500 mm long; bracts 5 mm long, 2 mm broad at base. Perianth reddish pink, variable, 16–25 mm long, stipitate for 1–3 mm, gasteriform basally over more than half the perianth length (globose-elliptic or globose), thence constricted to a tube 4–6 mm in diameter, gasteriform portion pink, 6–9 mm in diameter; tube pink or white, occasionally with green striations. Stamens 17 mm long; anthers 2 mm long. Ovary oblong-ovoid, 5 × 2–3 mm; style 11–12 mm long. Capsule 18 mm long, oblong-ovoid. Seeds 3–4 mm wide.

Phenology: Flowering in spring (October–November), but sporadically at other times as well. Seed wind-dispersed.

Pollinators: Sunbirds.

Habitat and aspect: Quartzitic sandstone cliffs in kloofs of the Baviaanskloof and Kouga Mountains, on all aspects but more so on south-facing ones. These kloofs are often very narrow and shady. It is hot in summer, mild to warm in winter and frost is absent from the habitat. Average daily maximum temperature is about 25°C and the average daily minimum about 9°C. Rainfall mainly in winter and summer, an average of about 200–300 mm per annum.

Altitude: 300–700 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus cristatus* var. *zeyheri*, *Albuca cremnophila*, *Cotyledon tomentosa* subsp. *tomentosa*, *Cyrtanthus montanus*, *C. labiatus*, *Delosperma esterhuyseniae*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna lobata* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone, Peninsula Formation (Cape Supergroup). The quartzitic sandstone substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Gasteria rawlinsonii is restricted to the Baviaanskloof Mountains, occurring in sheer, narrow, often shady north-south-running kloofs.

RELATED SPECIES

Gasteria rawlinsonii with its long, pendent stems is unique in the genus. *Gasteria bicolor* of the thickets to the east is the only other *Gasteria* with leafy stems. That species has very different mottled leaves (well camouflaged in its habitat), smaller and pinkish flowers and a decumbent habit. When detached as a result of disturbance, the leaves proliferate and form new plantlets.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous clusters of pendent, leafy stems. It profusely proliferates from the base, forming clusters. It occupies larger to smaller ledges. The plants' investment in vegetative output (vigorous prolific nature) further enhances occupation of crevices and ultimate survival.

Size and weight: Heads medium-sized, adult specimens of medium weight to heavy.

Stems: Fibrous and very tough, not brittle, suggesting an adaptation coping with gravity.

Leaves

Orientation: Distichous (more exposed, xeric habitats) or spirally distichous (shady places), spreading and becoming slightly recurved, the spirally distichous type maximising absorption of light. This distichous form grows along the western, drier part of the range.

Colour: Dull brownish green to reddish green, faintly mottled in the spirally distichous types. The reduction of camouflage in comparison to non-cremnophilous species of *Gasteria* can be seen as an adaptation to the cliff environment.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, with long leafy stems (covered with perennial and functional leaves withering from the base). When turgid, the leaves are very fleshy and often biconvex, thus with enough water stored for existence in the dry, cliff-face habitat.

Armament: The leaf margin is almost smooth in the distichous form (only slightly crenate-tuberculate at the apex), suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding thicket vegetation. The spirally distichous form occurs in regions to the east where the rainfall is slightly higher and the kloofs narrower and shadier, the unique black prickles perhaps an adaptation that deters the often cremnophilous (and roosting place at night) chacma baboon (*Papio ursinus*). Other plants, such as *Ficus* species with long aerial roots and hanging branches, enable primates (baboons and monkeys) to reach this form.

Sexual reproduction

Inflorescence and flowers: Inflorescence drooping; perianth red-pink, conspicuous. It does not flower from all stems, compensating by its prolific vegetative output. The large perianth size compared to that of other thicket species suggests an adaptation maximising attraction of pollinators.

Fruit/Seed

Size: Seed 4×3 mm, a relatively small size ideal for establishment in crevices.

Dispersal: As in other species of *Gasteria*, the spreading to erect capsules suggest wind dispersal.

Time: Seeds ripening in late spring, coinciding with the rainy season. Germination after 14–21 days.

Vegetative reproduction: *Gasteria rawlinsonii* suckers freely from the base, forming dense hanging clusters. Continual sprouting from the base and rooting of stems that have fallen into a crevice act as a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment. Unlike in other *Gasteria* species, the leaves are not brittle, and do not proliferate

when detached (in rare cases plants might proliferate), suggesting a loss of this ability due to its cliff habitat.

CONSERVATION STATUS

In spite of its localised distribution and rare status (Raimondo *et al.* 2009), it is not threatened and seed from a cultivated source has been distributed to nurseries and botanical gardens in various parts of the world.

ADDITIONAL NOTES

Variability: The species varies genetically considerably within a small area (size, shape and texture of leaves, shape of perianth), suggesting adaptable plasticity. It is a slow-growing cremnophyte with two forms grading into each other, the first with leaves remaining distichous and with a short inflorescence; the second with spirally arranged leaves and longer inflorescences, the gasteriform portion of the perianth globose.

Horticulture: *Gasteria rawlinsonii* is a worthwhile introduction to horticulture. It is best grown in thicket gardens (Van Jaarsveld 2006b, 2010). It is ideal for embankments, large hanging baskets and balconies in shady positions and excellent for growing in containers and miniature rock gardens. Best propagated by division, from stem cuttings or seed, grown as a specimen pot collection. Sow seed in spring or summer in a warm, shady position in a sandy, slightly acidic soil and keep moist. Outside its habitat, it is best grown in containers under controlled conditions in a greenhouse. Plants grown at Kirstenbosch are being continuously increased and made available to the general public. Today it is well established in ornamental horticulture throughout the world. The ease of cultivation suggests a maximum survival reproductive output.

VOUCHER

Van Jaarsveld 7134 (NBG).

ILLUSTRATIONS AND MAP

Plate 48, Figures 48a–48c, Map 48.

49. *Gasteria tukhelensis* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Bothalia* 35,2: 164–166 (2005c).

Cremonophyte growth form: Cluster (of medium weight to heavy, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: From the Thukela River, KwaZulu-Natal.

DESCRIPTION AND HABITAT

Plants acaulescent, decumbent, 250 mm high, up to 700 mm in diameter, proliferating from base, cluster-forming (3–8 heads). Roots succulent, up to 5 mm in diameter. Leaves rosulate, 120–250 mm long, up to 30–50 mm broad at base, triangular-lanceolate, falcate and curving

upwards, sometimes becoming recurved; adaxial surface deeply canaliculate, plane towards apex, faintly white-spotted; abaxial surface somewhat convex with distinct eccentric keel and faintly spotted; spots arranged in obscure transverse bands; both surfaces shiny dark green with smooth epidermis; margin minutely denticulate to almost entire; apex obtuse or acute, often acuminate, mucronate. Juvenile leaves distichous, lorate, patent to ascending; epidermis tuberculate, densely white-spotted, spots arranged in transverse bands; apex obtuse, mucronate.

Inflorescence racemose, up to 560 mm long, with 2 side branches; racemes horizontally spreading, up to 300 mm long; scape 4–5 mm broad at base, flattened; floral bracts 7×2 mm, piliferous; pedicels 17 mm long, pink. Perianth 40–43 mm long (up to 11 flowers open at the same time), stipitate for 3–4 mm, gasteriform basally (narrowly elliptic) over half perianth length, gasteriform portion 6 mm wide (subcylindrical), pink, distal half white with green striations, inflated to the same diameter as basal portion (with slight constriction in middle); apices erect, becoming erectly spreading, obtuse; margins of inner segments free, channelled at base for 10–12 mm, margins diverging gradually towards apex. Stamens 34–37 mm long; anthers 3×1.5 mm, included or shortly exerted. Ovary 8 mm long, 3 mm in diameter, green; style 31 mm long, stigma included or shortly exerted, curved upwards, minute. Capsule 23–32 mm long, clavate, triangular in cross section, obtuse at apex, 6–8 mm in diameter. Seeds $5-7 \times 2-3$ mm, black.

Phenology: Flowering in late spring and summer (November, December) but sporadically at other times as well. Seeds dispersed by wind in summer and autumn (during the wet season).

Pollinators: Sunbirds.

Habitat and aspect: Cliff faces above the Thukela River. It grows in crevices in humus-rich ledges on shale and mudstone rocks in dry savanna (succulent thickets). The rosettes grow in crevices, in the shade of succulent thicket consisting of *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula nudicaulis*, *C. orbicularis*, *C. perfoliata* var. *perfoliata*, *Delosperma lebomboensis*, *Gerrardanthus macrorrhizus*, *Petopentia natalensis* and *Plectranthus hadiensis* var. *tomentosus*. Although the vegetation of the KwaZulu-Natal region is well known, the flora of the sheer cliff faces in the Thukela region is still poorly known and likely to yield more new species. The Thukela Valley has a dry subtropical climate and is situated in a rain shadow. Summers are very hot, temperatures frequently above 30°C. The average daily maximum temperature is about 27°C and the average daily minimum about 14°C. Winters are mild, frost is absent or very light. Rainfall occurs mainly in summer, ranging from 500–700 mm per annum.

Altitude: 350–400 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: Taller shrubs are *Aloe arborescens*, *A. rupestris*, *Commiphora harveyi*, *Euphorbia tirucalli*, *E. evansii*, *Ficus ingens* and *Portulacaria afra*. The small species include *Aptenia cordifolia*, *Crassula multicava*, *C. perfoliata* var. *perfoliata*, *Delosperma tradescantioides*, *Petopentia natalensis*, *Rhipsalis baccifera* and *Sarcostemma viminalis*.

Geology: Mudstone of the Vryheid Formation (Ecca Group) of the Karoo Supergroup.

DISTRIBUTION

Gasteria tukhelensis is known only from the lower Thukela Valley near Kranskop, and as yet only from the type collection, but probably occurs elsewhere along the river, in similar habitats.

RELATED SPECIES

Gasteria tukhelensis is at once distinguished from *G. batesiana* by its much larger rosettes of falcate, dark green leaves, often becoming recurved and with a shiny, faintly spotted surface. The leaf margin is minutely denticulate to almost entire. The inflorescence can be a simple raceme (with up to 11 flowers open at the same time), but in adult plants with a pair of side branches. It is prolific from the base, forming clusters on the sheer southwest-facing cliffs above the northern bank of the Thukela River, east of Ngubevu near Kranskop. It is at once distinguished from *G. pendulifolia* by the shiny leaf surface, slightly tuberculate when young. Floristically it can be placed within *Gasteria* series *Longifoliae*. The long, slender perianth comes closest to that of *G. acinacifolia* of the coastal Eastern Cape and eastern extreme of the Western Cape. In *G. tukhelensis* the perianth is 42 mm long and only gently bent, not as markedly as in *G. batesiana*. The perianth in *G. batesiana* is usually shorter, 35–40 mm. The long, slender pedicels are 17 mm long, compared to 6–12 mm in *G. batesiana*. The fruiting capsules also differ from those of *G. batesiana*, being more slender and 23–32 mm long compared to 16–20 mm in *G. batesiana*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Clustering, with ascending rosettes suggesting an adaptation to maximise light absorption in its shady environment. *Gasteria tukhelensis* proliferates from basal stolons, forming dense clusters.

Size and weight: Heads of medium weight to heavy in large clusters.

Leaves

Orientation: Ascending-spreading.

Colour: Mottled green, faintly spotted, becoming purplish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous clusters.

Age and persistence: Plants long-lived, leaves withering from the base.

Armament: Leaf margin minutely denticulate to almost entire.

Sexual reproduction

Inflorescence and flowers: Inflorescence spreading, with pendulous apices; corolla pink, attracting sunbirds.

Fruit/Seed

Size: Seed 5–7 × 2–3 mm, a size sufficient for establishment in crevices.

Dispersal: Angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.
Germination within 14–21 days.

Vegetative reproduction: *Gasteria tukhelensis* suckers from the base, forming dense clusters. The leaves are brittle and will root if they become detached and fall into a crevice, establishing new colonies. Continual sprouting from the base and rooting of leaf fragments that have fallen into crevices represent a sufficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

Although classified as rare (Raimondo *et al.* 2009), it is not threatened owing to the safe cliff-face habitat.

ADDITIONAL NOTES

Variability: The species varies genetically considerably within a small area (size, shape and texture of leaves, shape of perianth), suggesting adaptable plasticity.

Horticulture: Ideal for bushveld and subtropical coastal gardens (Van Jaarsveld 2010), but should preferably be planted in partial shade. Plants are easily grown by division, from leaf cuttings or seed. It does well in containers as a specimen pot collection. This ease of cultivation suggests a maximum survival reproductive output.

VOUCHER

Van Jaarsveld 17996 (NBG).

ILLUSTRATIONS AND MAP

Plate 49, Figures 49a–49e, Map 49.

HAWORTHIA Duval

50. *Haworthia angustifolia* Haw. var. *baylissii* (C.L.Scott) M.B.Bayer in *Aloe* 36, 4: 72 (1999).

Cremonophyte growth form: Cluster-forming, recurved leaves (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After Roy Bayliss (1909–1994), enthusiastic collector of succulent plants.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, prolific from base, forming semiglobose clusters up to 60 mm high, up to 120 mm in diameter and consisting of up to 12 heads. Rosettes about 55 mm in diameter. Roots grey, terete. Leaves triangular-lanceolate, up to 20, in a rosette, erect at first,

becoming spreading and recurved; upper side flat to slightly channelled, cymbiform below; surface smooth, green, becoming purplish during dry periods; margin ciliate, apex acute, aristate. Inflorescence racemose, 130–250 mm long, 8–15-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels 1.5 mm long. Perianth tubular, curved, ascending-spreading, 15–18 mm long, white with green midstripe. Ovary tubular, 2 × 1.5 mm, green; stigma 1 mm long, widening and truncate at apex.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs of narrow shady kloof aspects. Plants firmly rooted in crevices, and size often depending on the growing space allowed by the crevice. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. Rainfall throughout the year but with a peak in spring and summer, ranging from 400–500 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 400–500 m.

Associated vegetation: Mainly Sundays Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnohytes: *Bulbine latifolia*, *Crassula intermedia*, *C. perfoliata* var. *minor*, *Haworthia glauca*, *Lampranthus affinis*, *Ledebouria concolor* and *Ornithogalum juncifolium*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Witteberg Group, Witpoort Formation (Cape Supergroup). Substrate with many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Haworthia angustifolia var. *baylissii* is a quartzitic sandstone endemic, confined to the narrow gorge cut by the Witrivier through the Suurberg Mountains of the Eastern Cape.

RELATED SPECIES

Haworthia angustifolia var. *baylissii* is related to the var. *angustifolia*, a chasmophyte occurring on exposed rocky outcrops in grassy fynbos. The latter has narrow, lanceolate, acuminate leaves and is sufficiently camouflaged.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Globose clusters in shady cliffs.

Size and weight: Heads small, of light weight.

Leaves

Orientation: Flattened, becoming recurved, an adaptation maximising absorption of light in the shady environment.

Colour: Green, becoming purplish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous globose clusters.

Age and persistence: Plants long-lived, soft leaves withering from the base. The very fleshy leaves are soft, becoming turgid after rain but channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The soft leaf texture and entire margin (occasionally ciliate) suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect in summer (December–February).

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in late summer and autumn, coinciding with the autumn rains. Germination within 14–21 days.

Vegetative reproduction: *Haworthia angustifolia* var. *baylissii* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best grown in a sandy, slightly acid soil mixture. Feed in spring and summer and keep dry in winter. Plants easily grown by division, thriving in cultivation but in shady places. Outside its thicket habitat, is best grown under controlled conditions in a greenhouse. Plants rapidly dividing, forming clusters. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 16038 (NBG).

ILLUSTRATIONS AND MAP

Figures 50a & 50b, Map 50.

51. *Haworthia attenuata* (Haw.) Haw. var. *attenuata*, Haworth, Synopsis plantarum succulentarum: 92 (1812). (Enon form.)

Cremnophyte growth form: Cluster-forming, rosulate (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The epithet *attenuata*, tapering, pertains to the tapering leaves.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, prolific from base, forming rounded clusters up to 200 mm in diameter and 70 mm high consisting of many heads. Rosettes 80–100 mm in diameter. Roots grey, terete. Leaves firm, light to dark green, often reddish, triangular-lanceolate, 40–50 × 15–18 mm, erect at first becoming spreading and somewhat recurved under shady conditions; upper side flat, convex to slightly channelled depending on moisture state, smooth or with few white cartilaginous tubercles, lower surface convex, distinctly keeled towards apex, rarely densely tuberculate; tubercles cartilaginous, often in white horizontal bars; margin tuberculate, tubercles about 3 mm apart; apex acute, aristate. Inflorescence racemose, up to 300 mm long, occasionally branched in distal half, 12–18-flowered in distal half; bracts 3 mm long, clasping, ovate-acuminate; pedicels 2–7 mm long. Perianth tubular, curved, ascending-spreading, 14–18 mm long, white with purplish green midstripe. Capsule 12–14 × 3–4 mm. Seed 3 × 1–2 mm, greyish black, angular.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: South-facing cliffs, the plants firmly rooted in crevices, and size often depending on the growing space allowed by the crevice. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. Rainfall throughout the year but mostly in summer, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 400 m.

Associated vegetation: Sundays Thicket of the Albany Thicket Biome (Mucina *et al.* 2005)

Associated cremnophytes: *Adromischus sphenophyllus*, *Anacampseros arachnoidea*, *Crassula cultrata*, *C. lactea* and *C. perforata*.

Geology: Enon Conglomerate cliffs. The cliff substrate has sufficient crevices and fissures and is ideal for the establishment of plants.

DISTRIBUTION

This cremnophilous form of *Haworthia attenuata* is confined to the Enon Conglomerate cliffs near the town of Enon in the Eastern Cape.

RELATED SPECIES

Related to *Haworthia glabrata* which occurs on cliffs to the east and lacks the distinct large, white tubercles in horizontal bars of *H. attenuata*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit and presentation: Conspicuous compact, globose clusters, suggesting a xeromorphic adaptation, maximising tolerance to drought.

Size and weight: Plants dwarf-sized with small rosettes, of light weight.

Leaves

Orientation: Ascending-spreading, becoming somewhat recurved, an adaptation maximising light absorption on the shady cliff face.

Colour: Green, becoming reddish owing to production of anthocyanins during dry periods, reducing photosynthesis.

Age and persistence: Plants slow-growing, long-lived, with firm leaves withering from the base. The fleshy leaves becoming turgid after rain, but channelled during dry periods, an adaptation to the dry habitat. The slow growth rate and long-lived leaves can be viewed as an adaptation to mineral-poor soil.

Armament: The leaves of this Enon form of *Haworthia attenuata* are more triangular and shorter, with a reduction in tubercles and often with a smooth surface, adaptations to the shady south-facing cliff environment.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small and angular, ideal for establishment in crevices.

Dispersal: Light seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination after 14–21 days.

Vegetative reproduction: *Haworthia attenuata* (Enon Form) suckers freely from the base, forming dense clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment.

CONSERVATION STATUS

Classified as endangered (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for thicket gardens and plants are easily grown by division, doing well in cultivation. Plants can be grown in rockeries, in a shady corner, but also thrive in small containers (Van Jaarsveld 2010). It is best kept in partial shade in a sandy, well-drained mixture. Plants rapidly divide, forming mats or rounded clusters. Sow seed in summer or autumn.

VOUCHER

Van Jaarsveld 17833 (NBG).

ILLUSTRATIONS AND MAP

Plate 51, Figures 51a–51c, Map 51.

52. *Haworthia cymbiformis* (Haw.) Duval var. *ramosa* (G.G.Sm.) M.B.Bayer, *Haworthia* revisited: 60 (1999).

Cremonophyte growth form: Cluster-forming, rosulate (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The name *cymbiformis*, boat-shaped, pertains to the leaves; *ramosa*, bearing branches.

DESCRIPTION AND HABITAT

Plants dwarf-sized, neatly rosulate, prolific from base, forming small rounded clusters up to 80 mm in diameter and consisting of up to and more than 25 heads and bearing leafy branches up to 150 mm long; branches grey, up to 7 mm in diameter. Rosettes 40–130 mm in diameter. Roots grey, terete, up to 4 mm in diameter. Leaves up to 25, soft, broadly ovate to oblanceolate, amplexicaul at base and partly imbricate, patent with spreading to incurved translucent and striate apices; upper side flat to channelled or slightly convex, lower side cymbiform; surface smooth, green, becoming pinkish green to yellowish during dry periods; margin entire or with soft teeth; apex obtuse or acute, mucronate. Inflorescence racemose, up to 250 mm long, 10–20-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels 2 mm long. Perianth tubular, curved, ascending-spreading, 15 mm long, white with purplish green midstripe. Capsule 5 × 2 mm. Seed 2.5 × 1.5 mm.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs (all aspects but more so on open, shady, south-facing aspects). Plants are rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (28–40°C). Winters are cooler but frost is absent. Rainfall occurs throughout the year but with a peak in spring and summer, ranging from 250–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 400–500 m.

Associated vegetation: Great Fish Thicket of the Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Bulbine natalensis*, *Crassula cordata*, *C. intermedia*, *C. muscosa*, *C. perfoliata* var. *minor*, *C. spathulata*, *Ornithogalum longibracteatum* and *Plectranthus verticillatus*.

Geology: Plants are found on sandstone and mudstone cliffs (Adelaide Subgroup) of the Karoo Supergroup. The cliff substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Haworthia cymbiformis var. *ramosa* is confined to a cliff near Wooldridge (Peddie district) in the Eastern Cape.

RELATED SPECIES

Haworthia cymbiformis var. *ramosa* is distinguished mainly by the formation of short stems. However, as Bayer (1999) stated, the plants are variable and some populations do not have stems. Related to *H. cooperi* and *H. retusa*, both usually flat-ground species, well camouflaged, with a sunken growth and difficult to detect. They often occur under the protection of thorny nurse shrubs. Their leaves generally have a firmer texture.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters, the plants often bearing short, flaccid, leafy stems, suggesting an adaptation to maximise light absorption in its environment.

Size and weight: Rosettes small and light, but large clusters of medium weight.

Leaves

Orientation: Very fleshy, soft, in dense leafy stems and rosettes, the leaves spreading as an adaptation to regulate excessive absorption of light. The leaves are amplexicaul at the base and partly imbricate, the arrangement minimising water loss and exposure to excessive radiation on the exposed cliff faces.

Colour: Green, becoming yellowish to pinkish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous globose clusters.

Age and persistence: Plants long-lived, with soft leaves withering from the base. The very fleshy leaves are soft, becoming turgid after rain, but channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament and camouflage: Leaves soft, the margin varying from entire to softly dentate. Compared to their relatives, there is a reduction in armament and camouflage in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Haworthia cymbiformis* var. *ramosa* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Variability: *Haworthia cymbiformis* var. *ramosa* is one of seven recognised varieties (Bayer 1999). They include *H. cymbiformis* var. *cymbiformis*, var. *incurvula*, var. *obtusata*, var. *ramosa*, var. *reddii*, var. *setulifera* and var. *transiens*. The genetic variability or plasticity reflects its ability to adapt to local conditions and colonisation, should the opportunity of new habitats arise. Most varieties are found predominantly on cliffs but *H. cymbiformis* var. *ramosa* and var. *setulifera* are strictly confined to cliff faces.

Horticulture: Plants doing well in cultivation and are best for containers and miniature succulent gardens (Van Jaarsveld 2010). This is an adaptable plant, suitable for thicket and subtropical coastal gardens. Its very easy growing nature maximises survival rate. Plants are rapid-growing and respond well to watering and feeding, soon filling a container. Water can be given throughout the year, but sparingly in winter.

VOUCHER

Van Jaarsveld 16829 (NBG).

ILLUSTRATIONS AND MAP

Figures 52a & 52b, Map 52.

53. *Haworthia cymbiformis* (Haw.) Duval var. *setulifera* (Poelln.) M.B.Bayer, *Haworthia* revisited: 62 (1999).

Cremonophyte growth form: Cluster-forming, rosulate (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The epithet *setulifera* refers to small bristles on the leaf margins.

DESCRIPTION AND HABITAT

Plants dwarf-sized, neatly rosulate, prolific from base, forming small rounded clusters up to 80 mm in diameter and consisting of up to 25 heads. Rosettes about 45 mm in diameter. Roots grey, terete, up to 4 mm in diameter. Leaves up to 25, soft, oblanceolate, patent with spreading to incurved translucent and striate apices; upper side flat to channelled or slightly convex, lower surface cymbiform; surface smooth, green, becoming pinkish green during dry periods; margin with soft bristle-like teeth; apex obtuse or acute, mucronate. Inflorescence racemose, 170 mm long, 12–20-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels 2 mm long. Perianth tubular, curved, ascending-spreading, 15 mm long, white with purplish green midstripe. Capsule 8 × 3 mm. Seed 2.5 × 1.5 mm, angular, grey-black.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: South-facing cliffs on the upper portion of the cliff face. Plants are firmly rooted in crevices. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. Rainfall occurs mainly in summer and ranges from 800–1250 mm per annum (thunder showers or cyclonic winter rain) towards the east, with rain almost absent in winter.

Altitude: 400–1500 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Albuca batteniana*, *Aptenia cordifolia*, *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula cordata*, *C. lactea*, *C. perfoliata* var. *minor*, *C. perforata*, *Delosperma* sp., *Ornithogalum longibracteatum* and *Trichodiadema* sp.

Geology: Sandstone and mudstone of the Emakwezini Formation (Beaufort Group) of the Karoo Supergroup. Substrate has many ledges, crevices and fissures that are ideal for establishment of plants.

DISTRIBUTION

Haworthia cymbiformis var. *setulifera* is a quartzitic sandstone endemic, confined to the coastal river valleys in the Transkei region of the Eastern Cape, from the Bashee River in the north to the Kei River in the south.

RELATED SPECIES

Related to *Haworthia retusa* and *H. arachnoidea*, which are flat-ground species with firmer leaves, well sunken into the ground and well camouflaged in their habitats.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Globose clusters on shady cliffs, suggesting an adaptation to maximise light absorption in its environment.

Size and weight: Heads small, of light to medium weight (fully grown, globose, turgid clusters).

Leaves

Orientation: Flattened and distinctly incurved, an adaptation to the dry cliff habitat and also regulating excessive absorption of light.

Colour: Green, becoming pinkish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous globose clusters.

Age and persistence: Plants long-lived, with soft leaves withering from the base. The very fleshy leaves are soft, becoming turgid after rain, but channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The soft leaf texture and soft teeth on the margins suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Haworthia cymbiformis* var. *setulifera* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Variability: *Haworthia cymbiformis* var. *setulifera* is one of seven recognised varieties (Bayer 1999). They include *H. cymbiformis* var. *cymbiformis*, var. *incurvula*, var. *obtusata*, var. *ramosa*, var. *reddii*, var. *setulifera* and var. *transiens*. The genetic variability or plasticity reflects its ability to adapt to local conditions and colonisation, should the opportunity of new habitats arise. Most varieties are found predominantly on cliffs but *H. cymbiformis* var. *ramosa* and var. *setulifera* are strictly confined to cliff faces.

Horticulture: Plants do well in cultivation and are best for containers and miniature succulent gardens. It is best kept in partial shade. It is a rapid grower, soon filling its container and forming rounded clusters. It responds rapidly to watering and feeding. It is adaptable but best suited as a pot plant. It is ideal for thicket and subtropical coastal gardens (Van Jaarsveld 2010). It grows easily, maximising its survival rate.

VOUCHER

Van Jaarsveld 17578 (NBG).

ILLUSTRATIONS AND MAP

Figures 53a–53c, Map 53.

54. *Haworthia glabrata* (Salm-Dyck) Baker in Journal of the Linnean Society, Botany 18: 206 (1880).

Cremonophyte growth form: Cluster-forming, rosulate (mainly of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The epithet *glabrata* refers to the smooth leaves.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, prolific from base, forming rounded clusters up to 220 mm in diameter and up to a 100 mm high, consisting of many heads. Rosettes 50–120 mm in diameter. Roots grey, terete. Leaves firm, triangular-lanceolate to attenuate, 75 × 20 mm, erect at first becoming spreading and recurved under shady conditions; upper side flat, convex to slightly channelled depending on moisture state, lower surface convex, keeled towards apex; surface scabrid, green, becoming purplish green during dry periods; margin entire; apex acute, aristate. Inflorescence racemose, 340–400 mm long, occasionally branched from base, 18–25-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels up to 5 mm long. Perianth tubular, curved, ascending-spreading, 18 mm long, white with purplish green midstripe.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Vertical north-facing cliffs, plants firmly rooted in crevices. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. Rainfall mainly in spring and summer, ranging from 800–1250 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 500–1000 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe reynoldsii*, *Crassula lactea*, *C. perfoliata* var. *minor*, *C. planifolia*, *Ophioglossum* sp. and *Ornithogalum juncifolium*.

Geology: Shale cliffs of the Beaufort Group, Adelaide Subgroup (Karoo Supergroup). The cliff substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Haworthia glabrata is confined to the southern Transkei (northern Eastern Cape), from the Bashee River in the south to near Mthatha in central Transkei (Eastern Cape).

RELATED SPECIES

Haworthia glabrata is related to *H. radula* and *H. attenuata*, which occur further west in a mosaic of Thicket (*H. radula*), Nama-Karoo and grassy Fynbos (*H. attenuata*). Both have distinct white tubercles and grow on undulating to flat terrain.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit and presentation: Conspicuous globose clusters on sunny north-facing slopes, the firm thick epidermis suggesting adaptation to the hot, dry, exposed, sunny habitat. By contrast, *H. cymbiformis* var. *setulifera* occurs on cliffs on south-facing slopes, the leaves soft and with a more translucent appearance, maximising light absorption in the shady environment.

Size and weight: Heads small, of light to medium weight.

Leaves

Orientation: Ascending, triangular-lanceolate, an adaptation to the exposed, sunny situation.

Colour: Green, becoming purplish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Age and persistence: Plants long-lived with a firm texture, leaves withering from the base. The fleshy leaves become turgid after rain, but channelled during dry periods, an adaptation to the dry habitat.

Armament: The leaf colour (in contrast to that of related species) is uniform, the leaves with a scabrid texture and entire margin, suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Haworthia glabrata* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

Classified as vulnerable (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Although rare in its native habitat, it is one of the many examples of cremnophytes well established in cultivation. Plants thrive in cultivation (containers, miniature succulent gardens), are very easily grown and are best propagated by division (Van Jaarsveld 2010). Owing to its ease of growth and ornamental features, it is probably one of the most widely cultivated succulents in the world today, a great survivor. This ease of cultivation reflects its shale cliff habitat where plants may fall and re-root in crevices.

VOUCHER

Van Jaarsveld 16840 (NBG).

ILLUSTRATIONS AND MAP

Figures 54a & 54b, Map 54.

55. *Haworthia gracilis* Poelln. var. *picturata* M.B.Bayer, *Haworthia revisited*: 78 (1999).

Creemnophyte growth form: Cluster-forming, rosulate (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The epithet *picturata* pertains to the leaf ornamentation.

DESCRIPTION AND HABITAT

Plants dwarf-sized, neatly rosulate, prolific from base, forming small rounded clusters up to 80 mm in diameter and consisting of up to 12 heads. Rosettes about 35 mm in diameter. Roots grey, terete, up to 4 mm in diameter. Leaves up to 25, soft, oblanceolate, ascending-spreading; apices translucent, striate, obtuse or acute, mucronate; upper side flat to channelled or slightly convex, lower surface cymbiform; surface smooth, green, becoming pinkish green during dry periods; margin entire. Inflorescence racemose, 150–350 mm long, 8–12-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels 2 mm long. Perianth tubular, curved, ascending-spreading, 15 mm long, white purplish with green midstripe. Fruit 8×2.5 mm. Seed oblong, 2×1 mm, grey brown.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Mainly south-facing cliffs. Plants are firmly rooted in crevices and their growth size often depends on the growing space allowed by the crevice. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. The average daily maximum temperature is about 27°C and the average daily minimum is about 12°C. Rainfall occurs throughout the year but with a peak in spring and summer, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 400–1000 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Albuca batteniana*, *Bulbine cremnophila*, *Cotyledon tomentosa*, *Crassula perfoliata* var. *minor*, *C. perforata*, *Cyrtanthus labiatus*, *C. montanus* and *Gasteria rawlinsonii*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). Substrate has sufficient ledges, crevices and fissures and is ideal for establishment of plants.

DISTRIBUTION

Haworthia gracilis var. *picturata* is a quartzitic sandstone endemic, confined to the Baviaanskloof and surrounding region of the Eastern Cape.

RELATED SPECIES

Haworthia gracilis var. *picturata* is related to the *H. retusa*, an often a well-camouflaged geophyte or chasmophyte occurring in conglomerate and soil.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Globose clusters in shady cliffs, suggesting an adaptation to maximise light absorption in its shady environment.

Size and weight: Rosettes small, of light weight.

Leaves

Orientation: Flattened, compact and distinctly incurved, an adaptation to the semi-arid environment and also regulating excessive absorption of light.

Colour: Green, becoming purplish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis. The windows on the leaf surface allow for penetration of light to the inner tissue, aiding in effective photosynthesis in the shady cliff environment.

Presentation: Conspicuous globose clusters.

Age and persistence: Long-lived, succulent, with a soft texture, withering from the base. After rain, the leaves becoming turgid, but channelled during dry periods, an adaptation to the extreme dry habitat.

Armament: The soft leaf texture and entire margin (occasionally ciliate) suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Haworthia gracilis* var. *picturata* suckers freely from the base, forming dense clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Heads blown from the cliff will root where they land.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Haworthia gracilis* var. *picturata* is easily grown by division and thrives in cultivation (Van Jaarsveld 2010). Suitable for small containers (full sun or partial shade). Outside its habitat it is best grown under controlled conditions in a greenhouse. Its very easy growing nature maximises survival rate. It is best grown in sandy, well-drained soil. Plants rapidly enlarge and will soon fill their container. Feed in spring and summer. Popular in cultivation and cultivated worldwide.

VOUCHER

Van Jaarsveld 17101 (NBG).

ILLUSTRATIONS AND MAP

Figures 55a & 55b, Map 55.

56. *Haworthia marumiana* Uitewaal var. *batesiana* (Uitewaal) M.B.Bayer, *Haworthia* revisited: 105 (1999).

Cremnophyte growth form: Cluster-forming, rosulate (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After J.T. Bates, London trolley bus conductor and collector of succulent plants.

DESCRIPTION AND HABITAT

Plants stemless, rosulate succulents up to 45 mm in diameter, proliferating from base to form large clusters. Leaves up to 23 × 6 mm, ascending (outer spreading and incurved), green, incurved, flattened, lanceolata to ovate lanceolate; upper surface flat to subconvex, lower surface convex, with centric keel towards tip, both surfaces with 6–8 pellucid longitudinal lines; margin entire; apex acuminate-aristate. Inflorescence an erect raceme up to about 310 mm long. Flowers about 12; pedicels up to 4 mm long, erect; perianth white, up to 11 mm long; tube compressed at base, 4 mm in diameter, curved, funnel-shaped; segments free, with green keels, bilabiate, posterior segments erect, slightly recurved. Stamens 7–8 mm long. Ovary 5 × 2 mm; style 1,5 mm long, capitate.

Phenology: Flowering mainly from spring (September–October). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Vertical south-facing cliffs. Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (35–40°C). Winters are cooler but frost is absent or limited to flat terrain. The average annual daily maximum temperature is about 24°C and the average annual daily minimum temperature about 9°C. Rainfall occurs mainly in summer, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 500–1500 m.

Associated vegetation: Camdebo Escarpment Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Observations at the Valley of Desolation include the following species: *Cotyledon orbiculata* var. *orbiculata*, *Crassula exilis* subsp. *cooperi*, *C. lanceolata* subsp. *lanceolata*, *C. nemorosa*, *C. perforata*, *Delosperma* spp., *Drimia uniflora* and *Haemanthus humilis* subsp. *hirsutus*.

Geology: Beaufort shales, Adelaide Subgroup (Karoo Supergroup). Substrate with many ledges, crevices and fissures and ideal for establishment of plants.

DISTRIBUTION

Haworthia marumiana var. *batesiana* is endemic to the higher-lying cliff faces around Graaff-Reinet (Eastern Cape).

RELATED SPECIES

Haworthia marumiana var. *batesiana* is related to *H. arachnoidea*, a well-camouflaged succulent plant or chasmophyte of the flats that grows in various soil types under karoo shrubs in Succulent Karoo. The latter has firm leaves with dense marginal cilia and dry tips, providing camouflage and protection from the sun.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Globose clusters in shady cliffs, suggesting an adaptation to maximise light absorption in its shady environment.

Size and weight: Rosettes small, of light weight.

Leaves

Orientation: In tight rosettes, becoming incurved under dry conditions. This is an adaptation to the semi-arid environment and also helps with adjustment to the available light.

Colour: Green, becoming purplish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous globose clusters.

Age and persistence: Plants long-lived, with soft leaves withering from the base. The very fleshy leaves are soft, becoming turgid after rain, but channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The soft leaf texture and entire margin suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding Nama-Karoo vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination after 14–21 days.

Vegetative reproduction: *Haworthia marumiana* var. *batesiana* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Haworthia marumiana* var. *batesiana* is easily grown by division and does well in cultivation. It should preferably be kept in a partially shady place. Feed in spring and summer. Its ease of growth maximises its survival rate. Best for dry summer-rainfall karoo gardens grown as a pot plant. Keep dry during the winter months. Outside its habitat it should be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 16590 (NBG).

ILLUSTRATIONS AND MAP

Figure 56a, Map 56.

57. *Haworthia marumiana* Uitewaal var. *marumiana*, Uitewaal in Cactussen en Vetplanten 6: 33 (1940).

Cremonophyte growth form: Cluster-forming, rosulate (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After Dr N. van Marum, collector of succulent plants.

DESCRIPTION AND HABITAT

Plants stemless, rosulate succulents up to 30 mm in diameter, proliferating from base to form large clusters. Leaves up to 20 × 8 mm, ascending (outer spreading), light top dark to brownish-green, flattened, ovate-lanceolate; upper surface flat to subconvex, lower surface convex, with centric keel towards tip, both surfaces with 3–6 pellucid longitudinal lines; margin and keel with soft spines; apex acuminate-aristate. Inflorescence an erect raceme up to about 230 mm long. Flowers about 10; pedicels up to 3 mm long, erect; perianth white, up to 11 mm long; tube compressed at base, 4 mm long, curved, funnel-shaped; segments free, with green keels, bilabiate, posterior segments erect, slightly recurved. Stamens 7–8 mm long. Ovary 4 mm long; style 1 mm long, white, not capitate.

Phenology: Flowering mainly during summer (January-February). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Mainly south-facing cliffs. Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (35–40°C). Winters are cooler but frost is absent or limited to flat terrain. The average annual daily maximum temperature is about 24°C and the average annual daily minimum temperature about 10°C. Rainfall throughout the year but with a peak in spring and summer, 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 1300–2000 m.

Associated vegetation: Grootrivier Quartzite Fynbos of the Fynbos Biome as well as Camdeboo Escarpment Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnoophytes: The following species occur at Aasvoëlberg, northwest of Willowmore where the plants are very common: *Adromischus subdistichus*, *Cotyledon orbiculata* var. *orbiculata*, *Crassula montana* subsp. *quadrangularis*, *C. orbicularis*, *C. pellucida* subsp. *marginalis*, *C. perforata* and *Delosperma esterhuyseniae*.

Geology: Quartzitic sandstone (Witteberg quartzite) and Beaufort shales, Adelaide Subgroup (Karoo Supergroup). Substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Widely distributed, from the escarpment mountains near Graaff-Reinet to Queenstown in the east, and southwards to Willowmore and westwards to Beaufort West.

RELATED SPECIES

Haworthia marumiana var. *marumiana* is related to *H. arachnoidea*, a well-camouflaged succulent plant or chasmophyte of the flats that grows in various soil types under karoo shrubs in Succulent Karoo. The latter has firm leaves with dense marginal cilia and dry tips, providing camouflage and protection from the sun. *Haworthia marumiana* var. *batesiana* does not have soft spines on the leaf margins.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Globose clusters in shady cliffs, suggesting an adaptation to maximise light absorption in its shady environment.

Size and weight: Rosettes small, of light weight.

Leaves

Orientation: In tight rosettes, but becoming incurved in under dry conditions. This is an adaptation to the semi-arid environment and also helps with adjustment to the available light.

Colour: Dark to lighter green, becoming purplish during dry periods as the plants aestivate, blocking out excessive light and reducing photosynthesis.

Presentation: Conspicuous globose clusters.

Age and persistence: Plants long-lived, with soft leaves withering from the base. The very fleshy leaves are soft, becoming turgid after rain, but channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The soft leaf texture and soft spines on the keel and margin suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding Nama-Karoo vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination after 14–21 days.

Vegetative reproduction: *Haworthia marumiana* var. *marumiana* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants are easily grown by division and do well in cultivation, but rather in small containers kept in partial shade. Plants rapidly proliferate and are best propagated by division. Feed in spring and summer and water sparingly in winter. Outside its habitat, it is best suited to a greenhouse where conditions can be controlled. Its very easy growing, adaptable nature maximises its survival rate.

VOUCHER

Van Jaarsveld 20050 (NBG).

ILLUSTRATIONS AND MAP

Figures 57a & 57b, Map 57.

58. *Haworthia mirabilis* (Haw.) Haw. var. *consanguinea* M.B.Bayer, *Haworthia revisited*: 111 (1999).

Cremnophyte growth form: Cluster-forming, rosulate (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: Latin *consanguinea*, kindred or related to, pertains to its superficial likeness to the small mountain form of *Haworthia turgida*.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, prolific from base, forming small rounded clusters up to 50 mm in diameter and consisting of up to 12 heads. Rosettes 30–50 mm in diameter. Roots grey, terete. Leaves up to 35, soft, triangular, ascending-spreading to patent, with translucent linear markings; upper surface rounded, lower surface cymbiform, surface smooth, green, becoming brownish red during dry periods; margin entire; apex acute to acuminate, mucronate (shiny and pellucid). Inflorescence racemose, up to 150 mm long, 10-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels 2 mm long. Perianth tubular, curved, ascending-spreading, 15 mm long, white with purplish green midstripe.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Mainly south-facing cliffs. Plants are rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (28–34°C). Winters are cooler but frost is absent. Rainfall occurs throughout the year but mainly in winter, ranging from 600–800 mm per annum (cyclonic winter rain or thunder showers).

Altitude: 1000–1500 m.

Associated vegetation: North Sonderend Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Cotyledon orbiculata*, *Crassula dejecta*, *C. nudicaulis* and *C. perforata*.

Geology: Plants are found on quartzitic sandstone, Peninsula Formation (Cape Supergroup), but also on shale (Bokkeveld Group, Ceres Subgroup of the Cape Supergroup). The rocky cliff substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Confined to the mountains near McGregor and Greyton (Western Cape).

RELATED SPECIES

Haworthia mirabilis var. *consanguinea* differs from the other four level-ground varieties in its softer, less retuse leaves. The others are well camouflaged, with a sunken growth and are difficult to detect. They often occur under the protection of thorny nurse shrubs.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small globose clusters on shady cliffs.

Size and weight: Rosettes small, of light weight.

Leaves

Orientation: In dense rosettes, spreading, maximising absorption of light.

Colour: Green, becoming brownish red during dry periods, reducing absorption of light. Windows on upper leaf surface allowing deep penetration of light. Compared to its inconspicuous relatives, these plants occur as conspicuous globose clusters on the cliff face.

Age and persistence: Plants long-lived, with soft leaves withering from the base. The very fleshy leaves are soft, becoming turgid after rain, but channelled during dry periods, an adaptation to the extreme dry habitat.

Armament and camouflage: The leaves have a soft texture and entire margin. Compared to their relatives, there is a reduction in armament and camouflage in response to the undisturbed cliff habitat in contrast to accessible fynbos and thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination within 14–21 days.

Vegetative reproduction: *Haworthia mirabilis* var. *consanguinea* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base is an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Variability: This variety belongs to a genotypically extremely variable complex of *Haworthia mirabilis* with many local variants. Bayer (1999) recognises five varieties, the other all level-ground taxa. The genetic variability or plasticity reflects its ability to adapt to local conditions and colonisation, should the opportunity of new habitats arise.

Horticulture: Best suited to fynbos gardens. Grow in small containers in slightly acidic, sandy soil and feed in autumn. Keep in dappled shade. Plants are easily propagated by division, doing well in cultivation. Water should be provided throughout the year, but sparingly in summer. A rapidly dividing plant, forming clusters.

VOUCHER

Van Jaarsveld 18443 (NBG).

ILLUSTRATIONS AND MAP

Figures 58a–58c, Map 58.

59. *Haworthia scabra* Haw. var. *starkiana* (Poelln.) M.B.Bayer in *Haworthia revisited*: 197 (1999).

Crempnophyte growth form: Cluster-forming, rosulate (of medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: In honour of Professor Peter Stark.

DESCRIPTION AND HABITAT

Plants rosulate, prolific from base, forming rounded clusters up to 500 mm in diameter and consisting of up to 10 heads. Rosettes up to 150 mm in diameter. Roots grey, terete. Leaves up to 30, firm, falcate, ovate to triangular-lanceolate, attenuate, ascending-spreading, laterally

incurved (towards apex), up to 70 × 20 mm; surface yellowish green, smooth, shiny green; apex mucronate. Inflorescence racemose, up to 370 mm long, 18-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels 2 mm long. Perianth tubular, 14–15 mm long, curved, ascending-spreading, white with purplish green midstripe.

Phenology: Flowering mainly from early autumn (March–April). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Mainly north-facing cliffs. Plants are rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (28–38°C). Winters are cooler but frost is absent. The average daily maximum temperature is about 25°C and the annual daily minimum about 8°C. Rainfall occurs throughout the year, ranging from 200–300 mm per annum (cyclonic winter rain or thunder showers).

Altitude: 500–1500 m.

Associated vegetation: Gamka Thicket of the Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Cotyledon orbiculata*, *Crassula perforata* and *Portulacaria afra*.

Geology: Plants are found on quartzitic sandstone, Peninsula Formation (Cape Supergroup). Substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Haworthia scabra var. *starkiana* is confined to the northern Little Karoo adjacent to the Groot Swartberg Mountains, from Cango to near De Rust (Western Cape).

RELATED SPECIES

Haworthia scabra var. *starkiana* differs from *H. scabra* var. *scabra* (level-ground species) in its conspicuous, smooth, yellowish green leaves. *Haworthia scabra* var. *scabra* has rough (scabrid), dark green leaves and is well camouflaged.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Large conspicuous clusters on exposed cliffs.

Size and weight: Heads medium-sized, of medium weight in fully turgid adult plants.

Leaves

Orientation: Spirally twisted, shading out copious amounts of sunlight from the inner parts.

Colour: Conspicuous, yellowish green. The leaves of its relative, *Haworthia scabra* var. *scabra*, are dark, with a rough texture.

Age and persistence: Plants long-lived, with hard, firm leaves withering from the base. The fleshy leaves become turgid after rain, storing sufficient moisture for dry periods, an adaptation to the extreme, dry habitat.

Armament and camouflage: The leaves have an entire leaf margin, ending in a hard point that would deter cliff-adapted animals such as the rock dassie (*Procavia capensis*) and chacma baboon (*Papio ursinus*). Compared to *Haworthia scabra* var. *scabra*, there is some reduction in armament (conspicuous clusters, glabrous leaves, entire margin) and camouflage (the non-cremophilous *H. scabra* is well camouflaged) in response to the undisturbed cliff habitat in contrast to accessible fynbos and succulent karoo vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in winter, coinciding with the cool period of winter rains, a good time for effective establishment. Germination after 14–21 days.

Vegetative reproduction: *Haworthia scabra* var. *starkiana* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

Classified as vulnerable (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Variability: Although it has a limited distribution, *Haworthia scabra* var. *starkiana* is very variable, with local forms and showing genotypic plasticity. This is reflected in the work of Bayer (1999) who recognises four varieties of a variable *H. scabra* (*H. scabra* var. *scabra*, var. *morrisiae*, var. *lateganiae* and var. *starkiana*). *Haworthia scabra* var. *scabra* is not a cremnophyte and the others are regarded here as local variants of *H. scabra* var. *starkiana*. This genetic variability reflects its evolutionary ability to adapt to local conditions and colonisation of new habitats, should the opportunity arise. However, plants are not as easily grown as other *Haworthia* species, reflecting the narrow adaptation to the extreme, exposed conditions.

Horticulture: It is best grown in dry succulent karoo and thicket gardens, in full sun or partial shade and propagated from seed or division. Outside its habitat, it should preferably be grown under controlled conditions in a greenhouse. Plants should be watered sparingly in winter and summer.

VOUCHER

Van Jaarsveld 16720 (NBG).

ILLUSTRATIONS AND MAP

Figures 59a & 59b, Map 59.

60. *Haworthia turgida* Haw. var. *turgida*, Haworth, Supplementum plantarum succulentarum: 52 (1819).

Cremonophyte growth form: Cluster-forming, rosulate (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: The epithet *turgida*, swollen, pertains to the leaves.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, prolific from base, forming dense rounded clusters up to 15 mm in diameter and consisting of up to and more than 25 heads. Rosettes 20–30(–80) mm in diameter. Roots grey, terete. Leaves up to 40, soft, oblanceolate, somewhat retuse at apices, somewhat recurved, turgid, ascending-spreading, with somewhat translucent reticulation; upper side flat to convex, lower surface rounded, surface smooth, bright green, becoming pinkish green to purplish green during dry periods; margin entire or with soft sparse teeth; apex obtuse or acute (shiny and pellucid), mucronate. Inflorescence racemose, up to 200 mm long, 10–20-flowered in distal half; bracts white, clasping, up to 3 mm long, ovate-acuminate; pedicels 2 mm long. Perianth tubular, curved, ascending-spreading, 15 mm long, white with purplish green midstripe.

Phenology: Flowering mainly from in summer and early autumn (February–April). Seeds dispersed by wind in autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs and all aspects, but more on open, shady, south-facing aspects. Plants are rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (28–40°C). Winters are cooler but frost is absent. Rainfall occurs throughout the year but more so in winter, 250–500 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 500–1500 m.

Associated vegetation: South Langeberg Sandstone Fynbos and southern Cape Valley Thicket of the Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Cotyledon eliseae*, *C. orbiculata*, *Crassula perforata*, *C. rupestris*, *Drimia anomala* and *Ornithogalum longibracteatum*.

Geology: Plants are found on quartzitic sandstone of the Peninsula Formation (Cape Supergroup), but also on shale and mudstone (Ceres Group, Bokkeveld Formation) of the same supergroup. Substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Haworthia turgida is a Western Cape endemic confined to an area from Mossel Bay in the east to the mountains north of Bredasdorp in the west.

RELATED SPECIES

Haworthia turgida var. *turgida* is related to *H. mirabilis*, *H. magnifica*, *H. retusa*, *H. reticulata* and *H. herbacea*, all of them usually flat-ground species, well camouflaged, with a sunken growth and inconspicuous. They often occur under the protection of thorny nurse shrubs and their leaves have a firmer texture. *Haworthia turgida* var. *suberecta* does not occur in cliff habitats and has distinctly retuse leaves with markings. *Haworthia turgida* var. *longibracteata* is much larger, occurring on steep, rocky slopes near Still Bay.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters, in contrast to the cryptic sunken habit of its relatives.

Size and weight: Rosettes small, of light weight.

Leaves

Orientation: In dense rosettes, ascending-spreading to almost recurved, with slightly retuse but pellucid to distinctly translucent apices. This appears to be an adaptation to maximise distribution of light within the leaf tissue on the shady cliff face. The very swollen nature of the leaves reflects their ability to store moisture on the extreme, well-drained cliffs.

Colour: Bright to greyish green, becoming pinkish to purplish green under dry conditions, minimising absorption of light under dry conditions.

Presentation: Conspicuous clusters. Leaves tightly arranged, ascending-spreading and can be almost recurved compared to those of its relatives, which are inconspicuous in their habitat.

Age and persistence: Long-lived, with soft leaves withering from the base. The very fleshy leaves becoming turgid after rain, but less so during dry periods, an adaptation to the extreme, dry habitat.

Armament and camouflage: The leaves are unarmed or have a soft texture, the margin varying from entire to softly dentate. Compared to their relatives, there is a reduction in armament and camouflage in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.
Germination within 14–21 days.

Vegetative reproduction: *Haworthia turgida* var. *turgida* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Variability: This is an extremely variable taxon (genotypic variation), with many local variants. Bayer (1999) recognises three varieties, var. *turgida*, var. *longibracteata* and var. *suberecta*, reflecting its variability. The genetic variability or plasticity reflects its ability to adapt to local conditions and colonisation, should the opportunity of new habitats arise.

Horticulture: Plants are easily grown from stolons or division and thrive in cultivation. It is best grown in partial shade in a sandy, well-drained soil in succulent karoo gardens. Plants rapidly respond to water, becoming turgid, and should be fed with an organic fertiliser sparingly throughout the year. Its very easy growing nature maximises its survival rate. Well-established in cultivation throughout the world. Plants do well in containers.

VOUCHER

Van Jaarsveld 17715 (NBG).

ILLUSTRATIONS AND MAP

Figures 60a–60c, Map 60.

61. *Haworthia zantneriana* Poelln. in *Cactus Journal*, British 5: 35 (1936).

Cremonophyte growth form: Cluster, mat-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: After a Major Alfred Zantner (?–1953).

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, prolific from base, forming clusters up to 60 mm in diameter and consisting of up to 12 heads. Rosettes about 30 mm in diameter. Roots grey, terete. Leaves up to 40, triangular to linear-lanceolate, attenuate, soft, with entire white margin, at first erect becoming ascending-spreading; abaxial surface keeled, green becoming purplish during dry periods; apex mucronate. Inflorescence racemose, up to 250 mm long; 17–35-flowered in distal half. Perianth tubular, curved, ascending-spreading, 15–18 mm long, white with green midstripe. Ovary tubular, 2 × 1.5 mm, green; stigma 1 mm long, widening and truncate at apex.

Phenology: Flowering mainly from spring to early summer (October–November). Seeds dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs of narrow shady kloofs, mainly on southern aspects. Plants firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. Rainfall throughout the year, ranging from 250–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 600–1500 m.

Associated vegetation: Mainly Groot Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnohytes: *Bulbine latifolia*, *Crassula perfoliata* var. *minor*, *Haworthia glauca*, *Lampranthus affinis*, *Ledebouria ensifolia* and *Ornithogalum juncifolium*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Witteberg Group, Witpoort Formation (Cape Supergroup). Cliff substrate has many ledges, crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Haworthia zantneriana appears to be a quartzitic sandstone endemic, confined to the mountains north of the Little Karoo, from Willowmore in the west to Camphor's Poort in the east (Eastern Cape). The plants are chasmophytes, occurring on rock slabs and inaccessible vertical cliff faces.

RELATED SPECIES

Its soft leaves with an entire margin separate it from related flat-ground *Haworthia* species, the latter with firm leaves and some densely covered with hairs, suggesting some herbivory defence strategies.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small clusters in shady cliffs, suggesting an adaptation to maximise light absorption in its shady environment.

Size and weight: Rosettes dwarf-sized, of light weight.

Leaves

Orientation: Flattened, becoming more spreading in shadier environments, an adaptation to maximise absorption of light.

Colour: Green, becoming purplish during dry periods, reducing absorption of light and slowing down photosynthesis.

Presentation: Fairly inconspicuous clusters.

Age and persistence: Plants long-lived, with soft leaves withering from the base. The very fleshy leaves are soft, becoming turgid after rain, but channelled during dry periods, an adaptation to the extreme dry habitat.

Armament: The soft leaf texture and entire margin suggest a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; corolla white, attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed small, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in early autumn (March, April), coinciding with the cooler winter-rainfall season, a good time for successful establishment. Germination within 14–21 days.

Vegetative reproduction: *Haworthia zantneriana* suckers freely from the base, forming dense, rounded clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this harsh cliff-face environment. Detached clusters or heads will also root if they fall into a crevice.

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: It is best grown in dry thicket gardens. The soil should be sandy and slightly acid, the plants kept in small containers in partial shade. Plants are easily grown by division and thrive in cultivation. Its very easy growing nature maximises survival rate. Plants within

reach of herbivores such as the rock dassie (*Procavia capensis*) are grazed in habitat, as seen at Camphor's Poort.

VOUCHER

Van Jaarsveld 16596 (NBG).

ILLUSTRATIONS AND MAP

Figures 61a–61c, Map 61.

TRACHYANDRA Kunth

62. *Trachyandra tabularis* (Baker) Oberm. in *Bothalia* 7: 730 (1962). (Table Mountain cliff-face form.)

Cremonophyte growth form: Cluster-forming, long pendent leaves (of medium weight, cliff hanger).

Growth form formula: A:B:Lper:C:Lp (e) (vb)

Etymology: The epithet *tabularis*, flat-topped, from Table Mountain, pertains to its mountain habitat.

DESCRIPTION AND HABITAT

Plants at first solitary, dividing to form dense clusters. Rhizome herbaceous, subterranean, wiry, up to 300 mm long. Roots yellow. Leaves 1–5, succulent, pendent, terete in young plants, becoming flat in mature plants, $750 \times 2.5\text{--}7.0$ mm, drooping from basal rosette; surface smooth, faintly striate, slightly translucent; margin entire to obscurely denticulate. Inflorescence solitary, few-branched to simple; scape arcuate, up to 0.5 m long, curved upwards; pedicels 5–7 mm long. Perianth white, sweetly scented, segments 14 mm long. Capsule globose, 5 mm in diameter. Seed black, angular, 2.5–3.0 mm in diameter.

Phenology: Flowering in summer, capsule ripening from March–April. Perianth opening in the late morning, sweetly scented, attracting insect pollinators.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs, at altitudes of about 500–1000 m, in narrow, shady kloofs (mainly southern and eastern aspects) and where temperatures are mild. Plants are firmly rooted among moss in crevices. Winters are cool, with occasional snow. Rainfall mainly in autumn, winter and spring, 2000–3000 mm per annum (cyclonic winter rain).

Altitude: 500–1000 m.

Associated vegetation: Peninsula Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Window Gorge, plants grow with *Crassula atropurpurea* var. *anomala*, *C. coccinea*, *C. nudicaulis*, *Disa uniflora*, *Elaphoglossum* sp. and species of moss. On the back table of Table Mountain, *Trachyandra tabularis* shares its habitat with *Cotyledon orbiculata* var. *orbiculata*, *Crassula nudicaulis*, *C. pellucida* subsp. *alsinoides*, *Erepsia falciformis* and *Ornithogalum juncifolium*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). Substrate has sufficient fissures, ledges and crevices, ideal for establishment of plants.

DISTRIBUTION

Trachyandra tabularis is a quartzitic sandstone endemic, confined to the narrow kloofs and sheer south-facing rock faces of Table Mountain and adjacent areas.

RELATED SPECIES

Trachyandra tabularis is related to *T. hirsuta*, a species with firm leaves, a hairy, woody inflorescence and occurring on mountain slopes and flats.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with drooping, subterete to dorsiventrally flattened leaves.

Size and weight: Plants cluster-forming, of medium weight.

Stem: Short subterranean rhizome.

Leaves

Orientation: Pendulous (positively geotropic).

Colour and texture: Dark to light green, with a soft texture. The slight translucent nature allows light to penetrate deeply, an adaptation helping the plants to cope with the shady cliff environment.

Age and persistence: Plants evergreen, leaves persistent, long-lived.

Armament: The entire to minutely denticulate margin and softer leaf texture suggest a reduction in armament in response to the undisturbed cliff habitat.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading; flowers scented, conspicuous, white, attracting insects.

Fruit/Seed

Size: Seed small.

Dispersal: Angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in autumn, coinciding with the start of the rainy season.

Vegetative reproduction: Plants divide, forming dense clusters. Continual sprouting from the base represents an efficient vegetative backup dispersal strategy for this cliff-face environment.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Cremnophilous *Trachyandra*: This is the only known member of *Trachyandra* that grows only on cliffs. Plants are locally abundant but confined to moist southern and southeastern cliffs. On Table Mountain, plants have been observed on the lower and upper cliffs above 'The Aloes'.

Horticulture: Plants require cool, moist conditions throughout the year. Best grown in a warm temperate climate, under cool, moist conditions. Propagation is by seed or division.

VOUCHER

Van Jaarsveld 22891 (NBG).

ILLUSTRATIONS AND MAP

Plate 62, Figures 62a & 62b, Map 62.

HYACINTHACEAE

Albuca L.

- 63. *A. batteniana* Hilliard & B.L.Burt
- 64. *A. cremnophila* Van Jaarsv. & A.E.van Wyk
- 65. *A. crudenii* Archibald
- 66. *A. kirstenii* (J.C.Manning & Goldblatt) J.C.Manning & Goldblatt
- 67. *A. shawii* Baker
- 68. *A. thermarum* Van Jaarsv.

Drimia Jacq.

- 69. *D. cremnophila* Van Jaarsv.
- 70. *D. flagellaris* T.J.Edwards, D.Styles & N.R.Crouch
- 71. *D. loedolffiae* Van Jaarsv.
- 72. *D. mzimvubuensis* Van Jaarsv.
- 73. *D. uniflora* J.C.Manning & Goldblatt

Ledebouria Roth

- 74. *L. concolor* (Baker) Jessop
- 75. *L. cremnophila* S.Venter & Van Jaarsv.
- 76. *L. venteri* Van Jaarsv. & A.E.van Wyk

Ornithogalum L.

- 77. *O. juncifolium* Jacq. var. *emsii* Van Jaarsv. & A.E.van Wyk
- 78. *O. longibracteatum* Jacq.
- 79. *O. pendens* Van Jaarsv.

Schizobasis Baker

- 80. *S. intricata* (Baker) Baker

ALBUCA L.

63. *Albuca batteniana* Hilliard & B.L.Burt in Notes from the Royal Botanical Garden Edinburgh 42,2: 247–249 (1985).

Cremonphyte growth form: Cluster-forming geophyte, with rosulate subpendent leaves (of medium weight to heavy, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb) (r)

Etymology: After Auriol Batten (née Taylor) (1918–), well-known South African botanical artist and teacher.

DESCRIPTION AND HABITAT

Plants cluster-forming, glabrous, evergreen and bulbous. Bulbs epigeous, ovoid to 50 × 30 mm; tunics fleshy, imbricate, truncate at top, green. Roots fleshy, white, up to 2 mm diameter. Leaves

10–70 × 20–30 mm, in apical rosette, soft to firm, oblong, canaliculate, linear-attenuate, faintly lineate; apex acute. Inflorescence a spreading raceme, up to 800 mm long; scape 6–10 mm in diameter at base; peduncle up to 250 mm long; pedicels erect, up to 120 mm long at base, becoming smaller distally, up to 35 mm long near tip. Flowers erect, white with green median stripe; outer tepals 30–42 × 7 mm, oblong, green with white margins, apex cucullate, inner tepals 25–30 × 7 mm, oblong, green with white margins, apex cucullate. Filaments 15–20, white, flattened at base; anthers oblong, versatile, outer 4 × 1 mm, inner 7 × 2.5 mm. Ovary 8–12 mm long, obtuse-trigonous; style 10–13 mm long; stigma trilobate, white. Capsule ovoid, 20 × 14 mm. Seed flat, 5 mm long.

Phenology: Flowering in winter (July–August). Seed released in spring (September–November).

Pollinators: Insects.

Habitat and aspect: Sea-facing coastal cliffs where plants are firmly rooted in crevices on the cliff faces and on the talus slopes below. Winters are cool but frost is absent. Average daily maximum temperature is about 23°C, but daily temperatures can reach 35°C under hot berg wind conditions. Rainfall mainly in summer and winter, ranging from 700–800 mm per annum (thunder showers and cyclonic winter rain).

Altitude: 25–800 m.

Associated vegetation: Albany Coastal Belt of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Aptenia cordifolia*, *Bulbine natalensis*, *Crassula multicava*, *C. orbicularis*, *C. pellucida* subsp. *marginalis*, *Gasteria excelsa* and *Haemanthus albiflos*.

Geology: Mudstone, Emakwezini Formation, Adelaide Subgroup (Beaufort Group of the Karoo Supergroup).

DISTRIBUTION

Albuca batteniana is distributed along the coastal region from Oribi Gorge in southern KwaZulu-Natal to the Bashee River and East London in the southwest (Eastern Cape).

RELATED SPECIES

Related to *A. cremnophila*, both species with imbricate leaf bases and similar secundly arranged flowers. The flowers of *A. cremnophila* are smaller and more densely arranged and yellow-tipped. *Albuca cremnophila* differs further in its larger, very firm, drooping, canaliculate leaves up to 1 m and drooping inflorescence up to 2 m long. *Albuca batteniana* has a rosette of recurved leaves, with a more robust inflorescence and larger flowers (30–42 mm long), which are not yellow-tipped. It is winter-flowering while *A. cremnophila* flowers in spring (October–November). Both are related to *A. nelsonii*, a non-cremnophilous species with soft, erect leaves and inflorescence.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming clusters of epigeous bulbs with rosulate, spreading, recurved to subpendulous leaves and ascending-spreading inflorescence.

Size and weight: Bulbs medium-sized, of medium weight to heavy in large clusters.

Bulb: Bulbs epigeous, forming dense clusters, tunics succulent, imbricate and an adaptation to the dry cliff environment.

Leaves

Orientation: In apical rosette, recurved to spreading, pendulous.

Colour and texture: Dark green, with soft to firm texture.

Age and persistence: Evergreen, long-lived, with basal abscission layer.

Armament: Leaves channelled and without obvious armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence horizontally presented, the conspicuous white flowers attracting insects.

Fruit/Seed

Size: Seed flat, shiny, 5 mm in diameter, an ideal size for establishment in crevices.

Dispersal: Seeds shaken or blown from the erect capsules and dispersed by wind.

Time: Seeds ripening at the end of December and dispersed in summer and autumn, coinciding with autumn rains. Germination after 21 days.

Vegetative reproduction: *Albuca batteniana* proliferates from the base, forming dense clusters. When bulbs become detached, they will re-root and continue growth. This vegetative regeneration can be seen as a backup ensuring survival in the harsh cliff-face environment.

CONSERVATION STATUS

Local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: *Albuca batteniana* is an ornamental species best for subtropical coastal gardens. Ideal for embankments, gabions or terraforce walls, also well suited to hanging baskets and large containers. Plants can be grown in full sun or partial shade and should be well watered during their summer growing season. Plants easily grown from seed or division and thrive in cultivation. Its very easy growing nature maximises survival rate.

VOUCHERS

Van Jaarsveld 16617, 16815, 16885 (NBG).

ILLUSTRATIONS AND MAP

Plate 63, Figures 63a–63d, Map 63.

64. *Albuca cremnophila* Van Jaarsv. & A.E.van Wyk in *Aloe* 36,4: 71–74 (1999).

Crempnophyte growth form: Cluster-forming geophyte, with rosulate pendent leaves (of medium weight to heavy, cliff hanger).

Growth form formula: A:B:Lper:C:La (e) (vb) (r)

Etymology: Greek *kremnos*, cliff, and Greek *phileein*, to love, pertaining to its cliff habitat.

DESCRIPTION AND HABITAT

Evergreen, epigeous (rarely hypogeous), bulbous plants, solitary or dichotomously dividing forming small, dense clusters. Bulb ovoid, 90 × 50–60 mm; tunics fleshy, imbricate, truncate at top, green-grey. Roots fleshy, white, up to 3 mm in diameter. Leaves 30–70 × 20–30 mm, in apical rosette, firm, oblong, canaliculate, linear-attenuate, drooping, succulent, dark green, glabrous, becoming terete towards tip; apex acute. Inflorescence a spreading to pendulous raceme, up to 2 m long; peduncle up to 250 mm long; bracts acuminate, membranous, margin translucent, basal bracts up to 110 × 13 mm, gradually becoming smaller distally; pedicels erect, 35–50(–80) mm long (exceptionally 120 mm), becoming shorter distally (35 mm). Flowers secundly arranged, 20–25 mm long, dense, erect, white with green median stripe; outer tepals linear-obovate, 20–25 × 7–8 mm, green with green median portion, inner tepals 18–20 × 8–10 mm, ovate with hooded yellowish apex. Filaments 13 mm long, 2.5 mm in diameter at base. Ovary stipitate for 1 mm, 6 mm long, 4 mm in diameter at base, narrowing to 3 mm, 3-angular, basally each angle with raised twin tubercles; stigma linear-trigonous, 10 × 2 mm. Capsule 15 × 9 mm. Seed flat, 4 × 3 mm.

Phenology: Flowering in spring (October–November) or after sufficient rainfall. Seed released towards end of November, early December.

Pollinators: Insects.

Habitat and aspect: Cliffs in dry river valleys and dark, narrow kloofs at all aspects but more on the cooler south-facing ones. Plants firmly rooted in crevices. Winters are cool but frost is a rarity or absent. Average daily maximum temperature is about 27°C and the average daily minimum about 9°C. Rainfall mainly in summer and winter, ranging from 200–300 mm per annum (thunder showers and cyclonic winter rain).

Altitude: 300–600 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated crempnophytes: *Adromischus cristatus* var. *zeyheri*, *Cotyledon tomentosa* subsp. *tomentosa*, *Cyrtanthus flammosus*, *C. labiatus*, *C. montanus*, *Delosperma elsieae*, *Gasteria*

rawlinsonii, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna lobata* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone, Peninsula Formation (Cape Supergroup). Substrate with sufficient ledges and crevices for establishment of plants.

DISTRIBUTION

Albuca cremnophila is distributed in Baviaanskloof and the Kouga Dam region west of Hankey (Eastern Cape).

RELATED SPECIES

Albuca cremnophila is related to *A. batteniana*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants solitary or forming small clusters of epigeous bulbs with pendulous leaves up to 1 m long and a pendulous inflorescence up to 2 m long. The pendent nature and epinastic growth are retained in cultivation, an adaptation related to its cliff habit. The bulbs are succulent, with truncate tunics.

Size and weight: Heads of medium weight but heavy in large clusters.

Bulb: Bulb solitary or dividing dichotomously, forming small, dense clusters. Tunics fleshy, green, an adaptation to the dry cliff environment.

Leaves

Orientation: In apical rosette, pendulous, with positive geotropic growth.

Colour and texture: Dark green. The firm, succulent texture and terete apices can be seen as an adaptation to the dry habitat.

Age and persistence: Leaves evergreen, long-lived.

Armament: Leaves channelled and without obvious armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence pendulous to horizontally presented, the conspicuous, erect, white flowers attracting insects.

Fruit/Seed

Size: Seed flat, shiny, 3 × 4 mm, an ideal size for establishment in crevices.

Dispersal: Seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening at the end of December and dispersed in summer and autumn, coinciding with autumn rains. Germination after 21 days.

Vegetative reproduction: *Albuca cremnophila* sometimes divides dichotomously to form small, dense clusters. When bulbs become detached, they will re-root and continue growth. This vegetative regeneration can be seen as a backup ensuring survival in the harsh cliff-face environment.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: *Albuca cremnophila* is easily grown from seed or division and does well in cultivation. It is best grown in thicket gardens and is suited to sheer embankments, gabions and rockeries. It can be grown in dappled shade or full sun. Its very easy growing nature maximises its survival rate. The plants retain their pendent growth in cultivation and plants in the Botanical Society conservatory at Kirstenbosch have positively geotropic rosettes.

VOUCHER

Van Jaarsveld 12171 (NBG).

ILLUSTRATIONS AND MAP

Plate 64, Figures 64a–64c, Map 64.

65. *Albuca crudenii* Archibald in *Bothalia* 6: 542–544 (1956).

Cremonophyte growth form: Cluster-forming bulbous plant, with linear drooping leaves (of light weight, cliff hugger).

Growth form formula: A:B:D:C:Lp (e) (vb) (eg)

Etymology: After Frank Cruden (date of birth and death unknown), schoolmaster at Grahamstown in the Eastern Cape during the 1920s and collector of plants who collected this species near Alicedale in September 1917.

DESCRIPTION AND HABITAT

Summer-deciduous, semi-epigeous (rarely hypogeous), glabrous, bulbous plants, sprouting from base, forming small clusters up to 80 mm in diameter. Bulb globose, up to 30 mm in diameter; scales tunicate, outer tunics thin, papery, grey-green, clasping, withering and exposing green tissue. Roots white, 0.5 mm in diameter, fibrous. Leaves 1, rarely 2, green, flaccid, slightly fleshy, linear-lanceolate; surface flat to channelled, up to 450 × 19 mm, striate; tip subulate in young leaf; margin with single row of minute, glandular, transparent, erect hairs. Inflorescence lax, secund, racemose, up to 450 mm long; scape up to 260 × 3 mm; surface minutely sparsely glandular hairy; raceme up to 70 mm long; bracts puberulous, deltoid, apiculate, up to 9 mm

long, 8 mm broad at base, membranous, translucent; pedicels cernuous, becoming erect after fruiting. Flowers 3–10, pendulous, with faint vanilla scent; outer tepals 15×6 mm, patent, oblong, with very slightly cucullate apex, bright yellow, with narrow green median stripe, inner segments up to 12×5 mm, erect, connivent, ovate, pale yellow, with narrow green median stripe, apex cucullate, 1 mm long. Androecium of 3 sterile and 3 fertile stamens; outer filaments ovate-lanceolate, 9×1.5 mm, mucronate, with sterile tip, inner filaments spade-shaped, basal part 1.5×1.5 mm, distal part 5.5×1 mm; anthers 4 mm long, apex rectangular, base spreading. Gynoecium glabrous; ovary ellipsoidal; style oblong, slightly narrower in distal third, triquetrous, 5×1 mm, yellow; stigma convex, 3-lobed, lobes simple, each with row of minute papillae, green. Fruit a trilocular capsule, 13 mm long. Seed flat, 3×1.5 mm, black.

Phenology: Flowering from end of October–November. Seed released in summer.

Pollinators: Insects.

Habitat and aspect: South-facing sandstone cliffs. Plants rooted in crevices and on ledges. The average daily maximum temperature is about 24°C and average daily minimum about 10°C . Rainfall in summer and winter, ranging from 400–600 mm per annum (mainly thunder showers and cyclonic winter rain).

Altitude: 350–400 m.

Associated vegetation: Bisho Thornveld of the Sub-Escarpment Savanna Bioregion of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Bowiea volubilis*, *Bulbine natalensis*, *Crassula orbicularis*, *C. perforata*, *Ophioglossum nudicaule* and *Plectranthus strigosus*.

Geology: Witteberg quartzite (Cape Supergroup). Substrate with sufficient ledges and crevices for establishment of plants.

DISTRIBUTION

Albuca crudenii is known only from the Grahamstown district (Eastern Cape).

RELATED SPECIES

Albuca crudenii is related to *A. glandulosa*, immediately distinguished by its more than one leaf and white flowers with glandular hairs on the perianth segments.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants form small clusters of epigeous bulbs, with narrow, flaccid, drooping leaves.

Size and weight: Clusters small, of light weight.

Bulb: The bulbs are photosynthetically functional. The small clusters of epigeous succulent bulbs are an adaptation to the dry vertical habitat. Its prolific vegetative reproductive nature (sprouting bulbils) from the base acts as a backup and ensures small mats. Deciduous during the summer months.

Leaves

Orientation: Soft flaccid, drooping, grooved on upper surface, suggesting adaptation to the sheer cliff habitat.

Colour and texture: Light green. Texture succulent, flaccid and channelled at the base, suggesting xeromorphic adaptation to the dry vertical habitat.

Age and persistence: Plants evergreen and leaves gradually replaced.

Armament: Leaves without obvious armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, the conspicuous yellow flowers attracting insects.

Fruit/Seed

Size: Seed 3×1.5 mm.

Dispersal: Flat, black seeds shaken or blown from the erect, dehiscent capsules and dispersed by wind.

Time: Seeds ripening in the summer, coinciding with summer rains.

Vegetative reproduction: *Albuca crudenii* proliferates, forming small, dense clusters. When bulbs become detached, they will re-root and continue growth. This vegetative regeneration can be seen as a backup ensuring survival in the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants of *Albuca crudenii* are easily grown by division or from seed. However, owing to their small stature and little appeal, they are not grown much. Best for containers, in a sandy mixture and in dappled shade. Outside its habitat, it is best grown under controlled conditions in a greenhouse. It is not shy to flower.

VOUCHER

Cruden 14a (ALB).

ILLUSTRATIONS AND MAP

Plate 65, Figures 65a & 65b, Map 65.

66. *Albuca kirstenii* (J.C.Manning & Goldblatt) J.C.Manning & Goldblatt in *Taxon* 58: 97 (2009).

Cremonophyte growth form: Cluster-forming geophyte, with terete leaves (of light weight, cliff hugger).

Growth form formula: A:B:D:C:Lp (e) (vb)

Etymology: After the late Kirsten Louw.

DESCRIPTION AND HABITAT

Summer-deciduous, epigeous (rarely hypogeous), bulbous plants forming small clusters up to 80 mm in diameter. Bulb globose to ovoid, up to 20 × 18 mm; outer tunics thin, papery, grey-green, clasping, withering, exposing green tissue. Roots white, 0.5 mm in diameter, fleshy. Leaves 1 or 2, linear, succulent, inrolled with margins often touching and appearing terete, 50–100 × 1.5–2.0 mm; surface smooth, glaucous; margin entire: apex acute. Inflorescence ascending, up to 140 mm high, enclosed in basal half of youngest leaf; peduncle smooth, glaucous, 0.8 mm in diameter at base, enlarging to 1.5 mm in diameter in distal half; raceme up to 50 mm long; bracts ovate-acuminate, thin, papery, 7 × 3 mm, base clasping; pedicels 3 mm long, bending down. Flowers yellow with green median stripe, 30 mm in diameter; outer tepals spreading, linear-obovate, 12 × 3 mm, pale yellow with green median portion, inner tepals 11 × 5 mm, ovate, with hooded apex. Filaments 9 mm long, 1 mm in diameter, canaliculate at base, white; anthers 1.5 mm long, oblong, white; pollen yellowish. Ovary stipitate for 1 mm, 4–6 mm long, 2–3 mm in diameter, green, grooved, 3-angular; style trigonous, 6 × 1 mm, yellowish; stigma capitate. Capsule dehiscent, 12 × 6 mm. Seed black, flattish 3 × 2 mm.

Phenology: Flowering in autumn (end March–April). Seed released towards end of April.

Pollinators: Insects.

Habitat and aspect: Southeast-facing cliffs overlooking Gourits River. Plants rooted in crevices and on ledges. On hot days with berg wind conditions, temperatures can go up to 40°C. Average daily maximum about 23°C, average daily minimum about 11°C. Rainfall mainly in winter and in summer, 300–400 mm per annum (thunder showers and cyclonic winter rain).

Altitude: 200–300 m.

Associated vegetation: Southern Cape Valley Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Cotyledon elisae*, *Crassula atropurpurea*, *C. lactea* and *Haworthia turgida*.

Geology: Quartzitic sandstone, Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Albuca kirstenii is known only from the Breede and lower Gourits Rivers in the Western Cape.

RELATED SPECIES

Albuca kirstenii is related to *A. crudenii*, the latter with a solitary dorsiventrally flattened leaf.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants form small clusters of epigeous bulbs, with ascending, narrow leaves. The bulbs are photosynthetically functional.

Size and weight: Clusters small, of light to medium weight in large clusters.

Bulb: The small clusters of epigeous succulent bulbs are an adaptation to the dry vertical habitat.

Leaves

Orientation: Ascending, only 1 or 2 terete leaves, blocking out minimum light from the photo-active bulbs.

Colour and texture: Glaucous. Texture succulent and channelled, suggesting xeromorphic adaptation to the dry vertical habitat.

Age and persistence: Plants becoming deciduous in summer.

Armament: Leaves without obvious armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, conspicuous yellow flowers attracting insects.

Fruit/Seed

Size: Seed small and light.

Dispersal: Seeds blown and shaken from the erect capsules and dispersed by wind.

Time: Seeds ripening and dispersed at end of autumn, coinciding with first winter rains.

Vegetative reproduction: *Albuca kirstenii* proliferates, forming small, dense clusters. When bulbs become detached, they will re-root and continue growth. This vegetative regeneration can be seen as a backup ensuring survival in the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Easily grown by division or from seed. However, owing to their small stature and little appeal, they are not grown much. Best for containers, in a sandy mixture and in dappled shade. Outside its habitat, it is best grown under controlled greenhouse conditions.

VOUCHER

Van Jaarsveld 16718 (NBG).

ILLUSTRATIONS AND MAP

Figures 66a & 66b, Map 66.

67. *Albuca shawii* Baker in Journal of Botany 12: 367 (1874). (Cliff-face form.)

Cremonophyte growth form: Cluster-forming geophyte, with linear drooping leaves (of light weight, cliff hanger).

Growth form formula: A:B:Lper:C:Lp (vb) (eg)

Etymology: After John Shaw (1837–1890), Scotsman, geologist and naturalist.

DESCRIPTION AND HABITAT

Evergreen, hypogeous, bulbous plants proliferating from base, forming small clusters up to 120 mm in diameter. Bulb globose to ovoid, up to 20 × 18 mm; outer tunics thin, papery, grey-green, clasping, withering, exposing green tissue. Roots white, 0.5 mm in diameter, fleshy. Leaves up to 12, in a rosette, often drooping from cliff face, linear-lanceolate, succulent, 150–400 × 1.5–6.0 mm; surface slightly hairy, green; margin ciliate; apex acuminate; young leaves terete. Inflorescence ascending, racemose, 200 mm high; surface beset with short translucent hairs; peduncle 3 mm in diameter at base, green; raceme up to 80–100 mm long; bracts ovate-acuminate, thin, papery, 16 × 4 mm, base clasping; pedicels 20 mm long, ascending. Flowers nodding, yellow with green median stripe, 18 mm in diameter; outer tepals spreading, linear-lanceolate, 7 × 3.5 mm, pale yellow with green median portion, apices obtuse, incurved, inner tepals 11 × 4 mm, linear-ovate, with hooded incurved apex. Filaments 9 mm long, 1 mm in diameter, outer 1.5 mm in diameter at base, hyaline, abruptly constricted, canaliculate at base, white. Anthers 15 × 1 mm, oblong, white; pollen yellowish. Ovary stipitate for 1 mm, 4 mm long, 2 mm in diameter, green, grooved, 3-angular. Style 5 mm long, 1 mm in diameter expanding to 2 mm, yellow; stigma 3-lobed, truncate. Capsule and seed not seen.

Phenology: Flowering in spring (October–November). Seed released towards summer and early autumn.

Pollinators: Insects.

Habitat and aspect: South- and southeast-facing quartzitic sandstone cliffs or large boulders. Plants rooted in crevices and on ledges. Average daily maximum temperature is about 23°C and average daily minimum 12°C. Rainfall occurs mainly in summer, ranging from 800–1500 mm per annum (thunder showers).

Altitude: 533–2400 m.

Associated vegetation: Zululand Lowveld of the Savanna Biome as well as many regions within the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: Along the White Mfolozi, it shares its habitat with *Aloe arborescens*, *Crassula orbicularis*, *C. expansa* subsp. *fragilis* and *Delosperma lebomboensis*.

Geology: Varied, but mainly sandstone such as quartzitic sandstone of the Moodies Group (Barberton Supergroup) (Keyser 1997).

DISTRIBUTION

Albuca shawii is widely distributed from the Eastern Cape to Limpopo Province in the north, confined to mountain slopes and river valleys. This cliff-face form appears to be confined to the White Mfolozi.

RELATED SPECIES

Albuca shawii is related to *A. crudenii* but is immediately distinguished by its much narrower leaves in a central rosette.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small clusters of hypogeous bulbs, with drooping linear-lanceolate leaves. The succulent leaves are an adaptation to dry conditions in the vertical habitat.

Size and weight: Clusters of light to medium weight in large clusters.

Bulb: Hypogeous, prolific from the base and forming dense clusters.

Leaves

Orientation: Drooping, up to 12, canaliculate; young leaves terete.

Colour and texture: Light to dark green. Texture succulent and channelled, suggesting xeromorphic adaptation to the dry vertical habitat.

Age and persistence: Plants evergreen, leaves seasonally replaced.

Armament: Leaves soft and without obvious armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, nodding yellow flowers attracting insects.

Fruit/Seed

Size: Not seen.

Dispersal: Seeds shaken from the erectly orientated capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn and dispersed in late autumn, coinciding with the first winter rains.

Vegetative reproduction: *Albuca shawii* proliferates, forming small, dense clusters. When bulbs become detached, they will re-root and continue growth. This vegetative regeneration can be seen as a backup ensuring survival in the harsh cliff-face environment.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

General: *Albuca shawii* is not an obligate cremnophyte and has many forms. This form from the White Mfolozi River appears to be obligate.

Horticulture: Plants of *Albuca shawii* are easily grown by division or from seed and thrive in cultivation. It is best for bushveld and subtropical coastal gardens, grown in dappled shade. Water well in summer and feed with an organic fertiliser. It does well in rockeries and containers. Its very easy growing nature maximises its survival rate.

VOUCHERS

Van Jaarsveld 18708, 19379 (NBG).

ILLUSTRATIONS AND MAP

Figures 67a–67c, Map 67.

68. *Albuca thermarum* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Bothalia* 33,1: 116 (2003e).

Cremonophyte growth form: Solitary geophyte, with pendent leaves (of medium weight, cliff hanger).

Growth form formula: A:B:Lper:C:Lp (e) (vb) (eg)

Etymology: After the thermal springs at Calitzdorp.

DESCRIPTION AND HABITAT

Evergreen, hypogeous (rarely epigeous), solitary, bulbous plants. Bulb ovoid, 70 × 55 mm; tunics fleshy, imbricate, persistent, drying grey and with fibrous network. Roots fleshy, white, up to 3 mm in diameter. Leaves oblong, linear-attenuate, 300–550 × 20–30 mm, in apical rosette, drooping, succulent, firm, dark green, glabrous, channelled for most of their length; apex acute. Inflorescence a spreading to pendulous raceme, 400–600 mm long; peduncle up to 260 mm long; bracts acuminate, 45 × 8 mm, green with white translucent margin; scape 8–10 mm in diameter at base; pedicels ascending to erect, up to 105 mm long at base, becoming

shorter, up to 35 mm long near tip. Flowers erect; tepals yellowish green, tips yellow to yellowish green, becoming white proximally but with distinct green midstripe (about 3 mm wide), outer tepals 25×7 mm, strap-shaped, apex cucullate, inner tepals ovate, 20–12 mm long. Stamens: filaments 15 mm long, 2 mm in diameter at base (flattened); inner 13 mm long, with distinct short channelled constriction 4.5 mm from base, basal third broadly triangular-ovate (3mm wide at base), margin membranous, apices of both inner and outer filaments projected forward and adpressed against style; anthers oblong, versatile, outer 2.5×1.5 mm, inner 3.5×2.5 mm. Ovary oblong, 3-angled, 7×4 mm, stipitate for 1.5 mm, each angle with raised emarginate base; style linear-trigonous, clavate, 9×2 mm; stigma yellowish green. Capsule 18×10 mm, grey-brown, valves splitting in distal quarter. Seeds flat, 6×3 mm, angular, distinctly wrinkled, blackish brown.

Phenology: Flowering October–November. Seed released towards end of November, early December.

Pollinators: Insects.

Habitat and aspect: South- and east-facing cliffs at altitude of about 500–1000 m (Badspoot, Olifantsrivier in the southern Little Karoo) near Calitzdorp. Plants firmly rooted in crevices. Temperature high in summer, 28–38°C. Winters are cooler but frost is absent. The average daily maximum temperature is about 26°C and the average daily minimum about 9°C. Rainfall occurs in summer and winter, ranging from 200–300 mm per annum (thunder showers and cyclonic winter rain).

Altitude: 400–800 m.

Associated vegetation: Western Gwarrieveld of the Rainshadow Valley Karoo Bioregion, Succulent Karoo (Mucina *et al.* 2005).

Associated cremnoophytes: Associated species include *Aloe comptonii*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula badspootense*, *C. perforata*, *C. rupestris*, *Haworthia integra* var. *rycroftiana* and *Senecio ficoides*.

Geology: Quartzitic sandstone of the Nardouw Subgroup, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Albuca thermarum is a quartzitic sandstone endemic, confined to the mountains of the southern Little Karoo at Calitzdorp Spa.

RELATED SPECIES

Albuca thermarum is related to *A. papyracea*, both with fibrous sheaths but the latter with shorter leaves that are not drooping.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with drooping leaves and inflorescence.

Size and weight: Heads medium-sized, of medium weight.

Bulb: Hypogeous, tunics fleshy, imbricate, persistent.

Leaves

Orientation: Pendulous (positively geotropic).

Colour and texture: Dark green, with a firm texture.

Armament: Leaves without obvious armament.

Sexual reproduction

Inflorescence, flowers and fruit: Inflorescence horizontally presented to drooping, the conspicuous white flowers attracting insects. Fruit a dehiscent capsule becoming erect once fertilised.

Fruit/Seed

Size: Seed 6×3 mm, an ideal size for establishment in crevices.

Dispersal: Seed blown and shaken from the erect infructescence and dispersed by wind.

Time: Seeds ripening at the end of December and dispersed in summer and autumn, coinciding with autumn rains. Germination after 21 days.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants of *Albuca thermarum* are easily grown from seed, doing well in cultivation. Its very easy growing nature maximises its survival rate. It is best grown in succulent karoo gardens. Water sparingly throughout the year. Suitable for embankments. Also thriving in containers.

VOUCHER

Van Jaarsveld 14152 (NBG).

ILLUSTRATIONS AND MAP

Plate 68, Figures 68a–68e, Map 68.

DRIMIA Jacq.

69. Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 42,4: 53–55 (2005d).

Cremonophyte growth form: Cluster-forming, epigeous bulbs (of medium weight, cliff hanger).

Growth form formula: A:B:Lper:C:Lp (e) (vb)

Etymology: Greek *kremnos*, cliff, and Greek *phileein*, to love, pertaining to its cliff habitat.

DESCRIPTION AND HABITAT

Semi-evergreen, epigeous, bulbous geophytes. Roots white, fleshy, 2 mm in diameter. Bulbs ovoid, up to 30 mm high, forming loose clusters of up to 4 heads and about 80 mm in diameter; tunics (scales) loose, thick, succulent, oblong-clavate, 15–45 × 5–12 mm; stalk flattened, up to 20 mm long, up to 4 mm in diameter; distal part of tunic oval-depressed; adaxial side flat, grooved to convex, abaxial side cymbiform to convex; apex truncate to obtuse; surface dark purplish. Leaves linear, amplexicaul at base, 100–200 × 3–8 mm, dark green; petiole short, indistinct, purplish; adaxial surface with 3–5 shallow grooves, abaxial surface with distinct midrib; margin entire. Inflorescence spreading, ascending, racemose, 250–300 mm long; scape 1.5 mm in diameter, dark green, terete, glabrous; racemes 50–80 mm long, bearing 4–8 pendent flowers; pedicels 7–8 mm long, curving down; bracts 3.5–4.0 mm long, white, linear-lanceolate, ascending, not clasping; spur 6 mm long, linear-lanceolate, adpressed to peduncle. Perianth white, 15–16 mm in diameter, opening in the morning; tepals oblanceolate-oblong, 7 × 2 mm, white with dull purplish centric stripes, apices obtuse to acute. Stamens adpressed to ovary into an erect cone-like structure, 11 mm high, with an acute apex; filaments short, 1.5 mm long, flattened at base (diameter of about 0.5 mm), tapering to 0.25 mm, white, translucent; anthers linear-lanceolate, 6 mm long, introrse, erectly projected, apex acute, opening by means of an apical pore. Ovary ovoid, 3.5 × 1.8 mm, 6-grooved, green, shortly stipitate; stipe black; style 3 mm long; stigma capitate.

Phenology: Flowering mainly in early summer (December–January). Seeds dispersed by wind from summer onwards. Flowers opening acroptally from below, promoting cross pollination, in the morning and lasting for two days.

Pollinators: Insects, pollen released by vibration of insect wings.

Habitat and aspect: Shale cliffs, mainly on shady south-facing ones. Plants firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Winters are cool but frost is absent. The average daily maximum temperature is about 23°C and average daily minimum 14°C, but extremes of up to 40°C have been recorded in the region. Rainfall mainly in summer, ranging from 800–1000 mm per annum (thunder showers or cyclonic winter rain), occasionally in winter.

Altitude: 50–600 m.

Associated vegetation: Eastern Valley Bushveld of the Sub-Escarpment Savanna Bioregion, Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: Near Ludonga (Mzimvubu River) it is associated with *Adromischus cristatus* var. *mzimvubuensis*, *Bulbine natalensis*, *Crassula cordata*, *C. cultrata*, *C. multicava* subsp. *floribunda*, *C. orbicularis*, *Cyanotis speciosa*, *Ornithogalum longibracteatum*, *Peperomia blanda* and *Plectranthus mzimvubuensis*.

Geology: Ecca shale (Karoo Supergroup).

DISTRIBUTION

From the lower Mzimvubu River (Transkei, Eastern Cape) and also on cliffs from the Kei Mouth. The plants occur mainly on south-facing shale cliffs.

RELATED SPECIES

Drimia cremnophila is related to *D. haworthioides* of the Eastern Cape from East London westwards, which has similar loose, bulbous scales but that is where the resemblance ends. The leaves of *D. haworthioides* have a ciliate margin, the flowers are spreading and not pendent and the plants occur in thicket among rocks, usually not on cliffs. It also resembles *D. mzimvubuensis* but the latter has terete leaves and a distinct staminal column in the flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming loose, globose clusters, exploiting the vertical cliff-face habitat and absence of disturbance by larger herbivores. A fairly slow-growing, long-lived perennial.

Size and weight: Heads of medium and average weight.

Bulb: Bulb epigeous with loose, fleshy, club-shaped scales, slightly compressed and tolerant of warm, dry, vertical conditions. It is photosynthetically active, maximising absorption of light. The succulent nature suggests an adaptation to the xeric habitat.

Leaves

Orientation: Mainly drooping, but varying according the crevice location. Long, flat, pendent, not shading out the bulb.

Succulence: The succulent bulb scales well adapted to the dry habitat. The succulent nature of the leaves is an adaptation to the xeric cliff-face habitat.

Colour: Dark green, immaculate.

Age and persistence: Semi-evergreen species, reflecting the climatic pattern of almost year-round rainfall.

Armament and camouflage: Lack of a camouflage defence strategy and the conspicuous clustered habit suggest adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: Inflorescence spreading-ascending, racemose, with conspicuous, drooping, white flowers, maximising visibility from below, an adaptation to the cliff-face dwelling.

Fruit/Seed

Size: Not seen.

Dispersal: Capsules ripening in summer, the flat, winged seeds wind-dispersed.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.

Vegetative reproduction: Plants proliferate, forming clusters. The vegetative clusters actively occupy crevices by growth and should any bulb or bulb scale become dislodged and fall onto ledges below, it will root—a prolific vegetative dispersal strategy ensuring long-term survival on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants easily grown by division, from bulb scales or from seed, doing well in cultivation. Its very easy growing nature maximises survival rate on the cliff face. It is best for thicket and subtropical gardens, suitable for rockeries and containers.

VOUCHER

Van Jaarsveld, Xaba & Harrower 97 (NBG).

ILLUSTRATIONS AND MAP

Plate 69, Figures 69a–69c, Map 69.

70. *Drimia flagellaris* T.J.Edwards, D.Styles & N.R.Crouch in *South African Journal of Botany* 71,1: 122–126 (2005).

Cremonophyte growth form: Cluster-forming (hugging), epigeous bulbs, with spreading to pendent linear-terete leaves (of medium weight, cliff hanger).

Growth form formula: A:B:Lper:C:Lp (e) (vb)

Etymology: The epithet *flagellaris*, like a flagellum, pertains to the leaves.

DESCRIPTION AND HABITAT

Plants evergreen, with epigeous bulbs proliferating from base, forming tight round clusters up to 100 mm in diameter and consisting of up to 14 bulbs. Bulbs ovoid, up to 20–30 × 15–20 mm, each with a solitary leaf; tunics grey-brown, leathery, exposing green to purplish green lower tissue. Leaf synanthous, 100–250 × 2 mm, linear, filiform, tapering towards apex, withering from tip, green. Inflorescence 10–25-flowered, 18–250 mm high; scape terete, erect; racemes 80–90 mm long; bracts deltoid-cymbiform, 1 × 1 mm, white, slightly translucent, basal bracts spurred, up to 3.5 mm long; pedicels (8–)10–12 mm long. Perianth stellate, up to 14 mm in diameter, white; outer tepals linear-obovate, 5–8 × 1.8–3.0 mm, acute, inner tepals narrowly elliptic, 5–8 × 2–3 mm, obtuse, white with red-brown keel. Stamens 4.5 mm long; filaments linear, inner slightly shorter; anthers 0.7 mm long, versatile; pollen yellow. Ovary ovoid, tapering towards apex, 2.2 × 1.8 mm, green, shortly stipitate; style erect, 3 mm long. Capsule obovoid, 4 mm long. Seed oblong, angular, 3.5–4.0 × 1 mm, black.

Phenology: Flowering mainly from early spring to spring (end July–October). Seeds dispersed by wind in summer.

Pollinators: Insects.

Habitat and aspect: South- and east-facing cliffs. Plants firmly rooted in crevices. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. The average daily maximum temperature is about 24°C and the average daily minimum about 16°C. Rainfall occurs mainly in summer and ranges from 1000–1250 mm per annum.

Altitude: 250–800 m.

Associated vegetation: Mainly KwaZulu-Natal Coastal Belt of the Indian Ocean Coastal Belt (Mucina *et al.* 2005). The local vegetation consists of short forest, thicket and grassland and margin of grassland.

Associated cremnophytes: *Aloe arborescens*, *Bulbine natalensis*, *Crassula perfoliata* var. *minor*, *Gasteria pendulifolia*, *Peperomia blanda* and *Plectranthus purpuratus*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Natal Group (Cape Supergroup).

DISTRIBUTION

Drimia flagellaris is confined to quartzitic sandstone gorges from Durban (KwaZulu-Natal) to Fraser Gorge in the Eastern Cape.

RELATED SPECIES

Related to both *Drimia loedolffiae* and *D. anomala*. *Drimia loedolffiae* has yellowish green flowers and the bulbs are not angular (also see under *D. loedolffiae*). *Drimia anomala* is a widespread species that occurs on shale or sandstone; the solitary plants are much larger and robust, each with a single terete leaf.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, globose, often pendent to vertically orientated clusters of green (photosynthetically active) bulbs, each with spreading-ascending to pendent, filiform leaves, suggesting an adaptation to shady cliffs and the thin leaves allowing optimum penetration of light to the bulbs in this environment.

Size and weight: Heads in clusters of medium weight.

Bulb: Bulb epigeous, succulent, proliferating from base, forming tight clusters, an adaptation to the xeric environment.

Leaves

Orientation and presentation: Spreading, becoming pendent from cliff face, numerous, filiform (2 mm), an adaptation to the dry cliff conditions.

Colour: Green, withering from the apices during dry periods, the bulbs enveloped in grey tunics blocking much light.

Age and persistence: Plants long-lived, with the dry leaves persistent, withering from the base.

Armament and camouflage: Clusters conspicuous and without any obvious armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence spreading-ascending, the white corolla attracting the right pollinating flying insect. The inflorescence remains persistent, green and alive for some time after flowering, thus contributing to photosynthesis on the shady southern aspects, suggesting an adaptation to the harsh environment.

Fruit/Seed

Size: Seed 4×1 mm, ideal for establishment in crevices.

Dispersal: Light, black, angular, oblong seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer, which coincides with the rainy season.

Vegetative reproduction: Plants proliferate, forming dense clusters. The vegetative clusters actively occupy crevices by growth and should any bulb or bulb scale become dislodged and fall onto ledges below, it will root—a prolific vegetative dispersal strategy ensuring long-term survival on the cliffs. Plants of the Fraser Falls collection (*Van Jaarsveld, Bellstedt & Dekker 16371*) are smaller, producing basal stolons and bulbils, very much in the same manner as *Ornithogalum longibracteatum*, but to a lesser degree. It can be seen as a vegetative backup dispersal method often associated with succulent cremnophilous bulbs and succulent plants.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens and ideal for steep embankments. It also thrives in containers. It is best grown by division and does well in cultivation. Its very easy growing nature maximises its survival rate.

VOUCHERS

Van Jaarsveld 16731, 17456 (NBG).

ILLUSTRATIONS AND MAP

Figures 70a–70f, Map 70.

71. *Drimia loedolffiae* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 43,2 & 3: 49–51 (2006b).

Cremonophyte growth form: Cluster-forming, epigeous bulbs, with spreading to pendent linear-terete leaves (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:Lp (e) (vb)

Etymology: Named after Jeanette Loedolff, botanical artist at the former National Botanical Institute for 20 years (1982–2002).

DESCRIPTION AND HABITAT

Evergreen plants forming tight, round clusters up to 150 mm in diameter and consisting of up to 15 bulbs. Bulbs epigeous, ovoid to globose, 40–45 × 25–50 mm, each bulb with up to 3 or 4 leaves; outer tunics greyish white, papery, exposing purplish green inner tunics. Leaves flaccid, linear, terete, tapering towards apex, 200–260 × 1–4 mm, surface striate, bright green, withering from tip. Inflorescence racemose, 350–400 mm long, initially erect, becoming decumbent; flowers 1–3 mm apart, densely arranged in distal quarter; scape erect, terete, 200–270 mm long, 1.5 mm in diameter; racemes 60–65-flowered, 120–150 mm long; bracts deltoid-cymbiform, 2 × 0.5 mm, purplish white, slightly translucent, basal bracts caudate, spur up to 4 × 1 mm, distal bracts becoming smaller; pedicels 1.5–2.5 mm long, enlarging to 4–5 mm in fruit. Perianth rotate, cream-coloured, up to 12 mm in diameter; tepals linear-elliptic to linear-obovate, inner 5 × 1.5 mm, outer 5.5 × 1.75 mm, with dark brownish median stripe on abaxial surface. Stamens 2.5 mm long; filaments linear, inner slightly shorter; anthers 1 mm long, versatile; pollen yellow. Ovary ovoid, 3-lobed, tapering towards apex, 1.5–2.0 × 1.5 mm, green, shortly stipitate; style erect, 2 mm long; stigma minute, truncate. Capsule ovoid, 5 × 2.5–4 mm. Seed flattened, sickle-shaped, 2.5–3.0 × 1.0–1.8 mm, black.

Phenology: Flowering October–February, flowers opening late in the afternoon.

Pollinators: Insects.

Habitat and aspect: South- and east-facing cliffs. Plants firmly rooted in crevices. Winters are cool but frost is absent. Average daily maximum temperature is about 22°C and the average minimum about 14°C. Rainfall occurs mainly in summer, but some also occurs in the winter months. It ranges from 600–1250 mm per annum.

Altitude: 300–500 m.

Associated vegetation: Mainly subtropical short forest, thicket and grassland vegetation, and on the margin of grassland.

Associated cremnophytes: *Cotyledon orbiculata*, *Crassula cultrata*, *C. orbicularis*, *C. perforata*, *Gasteria excelsa*, *Ornithogalum juncifolium*, *Peperomia blanda*, *Plectranthus spicatus*, *P. strigosus*, *Pyrrhosia africana* and *Senecio aizoides*.

Geology: Mainly Beaufort shales of the Emakwezini Formation (Beaufort Group, Karoo Supergroup). Also on dolerite cliffs (intrusions).

DISTRIBUTION

Drimia loedolffiae has been found only in Buffels Thicket of the Albany Thicket Biome (Mucina *et al.* 2005), on sheer shale or rarely dolerite cliffs of dry river valleys. At the type locality near the Kei River, it grows in clusters on exposed south-facing aspects.

RELATED SPECIES

Both *Drimia loedolffiae* and *D. flagellaris* are cluster-forming, with semi-epigeous, somewhat similar bulbs and pendent, terete leaves. However, that is where the resemblance ends as *D. loedolffiae* is at once distinguished by its floral features and shape of the seeds. In *D. loedolffiae* the bulb is ovoid to globose, never angular as in *D. flagellaris*. *Drimia loedolffiae* has densely arranged, cream-coloured flowers (distal quarter of inflorescence) on short pedicels (1.5–2.5 mm) and ovoid capsules 5 × 2.5 mm, with sickle-shaped seeds 2–3 × 1.0–1.8 mm. The inflorescence is not persistent and soon withers after the capsules have dried. *Drimia flagellaris* has laxly arranged, white flowers (distal half of inflorescence) on longer pedicels (17–25 mm). Its slender seeds are 3–5 mm long, a distinctive character. The somewhat persistent inflorescence remains alive and green after the capsules have been shed.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, globose, often pendent to vertically orientated clusters of green (photosynthetically active) bulbs, each with spreading-ascending to pendent filiform leaves, suggesting an adaptation to shady cliffs and the thin leaves allowing optimum light exposure of the bulbs in this environment.

Size and weight: Heads small, of light weight.

Bulb: Bulbs epigeous, succulent, forming tight clusters and an adaptation to the dry cliff environment.

Leaves

Orientation and presentation: Spreading, becoming pendent from cliff face, numerous, filiform (2 mm), an adaptation to the dry cliff conditions.

Colour: Green, withering from the apices during dry periods, bulbs enveloped in grey tunics blocking much light.

Age and persistence: Plants long-lived, dry leaves persisting and withering from the base.

Armament and camouflage: Conspicuous clusters lacking in armament and camouflage characters. They are less firm than those of the typical chasmophytic relatives, suggesting a reduction in armament in response to the less disturbed environment.

Sexual reproduction

Inflorescence and flowers: The solitary inflorescence is spreading-ascending, the cream-coloured corolla attracting the right pollinating flying insect. Flowers open in succession from below (acropetally), with only a few flowers on an inflorescence open at the same time, thus promoting cross pollination.

Fruit/Seed

Size: Seed 2.5–3.0 mm long, ideal for establishment in crevices.

Dispersal: Light, black, angular, sickle-shaped seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer, which coincides with the rainy season.

Vegetative reproduction: Plants proliferate, forming clusters. The vegetative clusters actively occupy crevices by growth and should any bulb become dislodged and fall onto ledges below, it will root—a prolific vegetative dispersal strategy ensuring long-term survival on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants of both *Drimia loedolffiae* and *D. flagellaris* have been grown at Kirstenbosch for a number of years and both are easily propagated by division and thrive in cultivation. They are slow-growing and divide to form dense, small clusters. It is best for thicket gardens and ideal for steep embankments. *Drimia loedolffiae* flowers from the end of October to January (February) while *D. flagellaris* flowers from the end of July to October.

VOUCHER

Van Jaarsveld & Voigt 17914 (NBG).

ILLUSTRATIONS AND MAP

Plate 71, Figures 71a–71e, Map 71.

72. *Drimia mzimvubuensis* Van Jaarsv. in *Aloe* 42,4: 53–55 (2005d).

Cremonophyte growth form: Cluster-forming (hugging) epigeous bulbs, with drooping leaves (of medium weight, cliff hanger).

Growth form formula: A:B:Lper:C:Lp (e) (vb)

Etymology: After the Mzimvubu River in the Eastern Cape Province.

DESCRIPTION AND HABITAT

Evergreen, bulbous geophytes. Roots white, fleshy, 2 mm in diameter. Bulbs epigeous, ovoid, up to 50 mm high, forming loose clusters of up to 6 heads and about 100 mm in diameter; tunics (scales) loose, club-shaped, 18–30 × 15–23 mm, thick and succulent, maroon-brown, stalked, apex obtuse; stalk flattened, up to 4 mm in diameter, maroon-brown. Leaves linear, subterete, amplexicaul at base, 47–50 × 5–3 mm, leathery, dark green; adaxial surface shallowly channelled, abaxial surface 12–14-grooved, minutely ciliate on angles (short translucent hairs). Inflorescence spreading, ascending, racemose, 340–380 mm long; scape 3 mm in diameter, dark green, terete, glabrous; racemes 60–120 mm long, bearing 20–30 pendent flowers; pedicels 15–18 mm long, curving down; bracts 8 mm long, white, linear-lanceolate, ascending, not clasping; spur 10 mm long, linear-lanceolate, adpressed to peduncle. Perianth white, 22–24 mm in diameter, opening at noon; tepals white with green centric stripes, 9 × 3 mm, lanceolate to strap-shaped, green at base; apices obtuse. Anthers 3 mm long, erectly projected, sagittate; filaments fused into a central cylindrical staminal column 2.5 mm high and 2 mm wide; apices free, triangular, 1 × 1 mm, together tapering into a cone-like structure consisting of acute adpressed introrse anthers and exposing centric white stigma for 0.5 mm. Ovary green, ovate-tapering, 6-grooved, 3 × 1.5 mm; style 4.5 mm long, white; stigma capitate. Capsule 3-locular, 10 × 7.5 mm, loculicidal. Seed 7 × 3 mm, oblong, flat, surface angular, black.

Phenology: Flowering mainly in early summer (end of November–December). Flowers open in succession acropetally from below, encouraging cross pollination. Seeds dispersed by wind from summer onwards.

Pollinators: Insects.

Habitat and aspect: Shale cliffs, mainly shady south-facing aspects. Plants firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Temperature in summer may go up to 40°C. Winters are cooler but frost is absent. The average daily maximum temperature is about 23°C and the average daily minimum about 15°C. Rainfall occurs mainly in summer, ranging from 600–1250 mm per annum (thunder showers or occasional cyclonic winter rain), occasionally in winter.

Altitude: 300–500 m.

Associated vegetation: Eastern Valley Bushveld of the Sub-Escarpment Savanna Bioregion, Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: Near Lutengele (Mzimvubu River) it is associated with *Adromischus cristatus*, *Bulbine natalensis*, *Crassula multicava*, *C. perforata*, *C. spathulata*, *Ornithogalum longibracteatum* and *Peperomia blanda*.

Geology: Ecce shale (Karoo Supergroup). Substrate with ledges, crevices and fissures ideal for establishment of plants.

DISTRIBUTION

Known only from the lower Mzimvubu River (Transkei, Eastern Cape). Mainly shale cliffs along river.

RELATED SPECIES

Drimia mzimvubuensis is related to *D. cremnophila* of the same river system in the Eastern Cape from East London westwards, which has similar loose bulbous scales but the leaves of *D. cremnophila* are dorsiventrally compressed, not terete.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming loose, globose clusters, thus exploiting the vertical cliff-face habitat and the absence of disturbance by larger herbivores. It is a fairly slow-growing, long-lived perennial.

Size and weight: Heads of medium weight.

Bulb: Bulb epigeous with loose, fleshy, club-shaped scales slightly compressed and tolerant of warm, dry, vertical conditions. Bulb scales are purplish green and photosynthetically active, optimising absorption of light. The succulent nature suggests an adaptation to the xeric habitat.

Leaves

Orientation: Mainly spreading to drooping but varying according the crevice location. Extended terete nature minimising transpiration.

Succulence: Fleshy, grooved, an adaptation to the xeric cliff-face habitat.

Colour: Dark green, without markings.

Age and persistence: Evergreen condition reflecting the climatic pattern of almost year-round rainfall. Evergreen and persistent leaves maximising absorption of light.

Armament and camouflage: Lack of a camouflage defence strategy and the conspicuous clustered growth suggest adaptation to the safe cliff habitat in the absence of disturbances.

Sexual reproduction

Inflorescence and flowers: Inflorescence spreading-ascending, racemose, the conspicuous, drooping, white flowers maximising visibility from below, an adaptation to the cliff-face dwelling.

Fruit/Seed

Size: Capsule 3-locular, 10×7.5 mm, loculicidal. Seed 7×3 mm, oblong.

Dispersal: Capsules ripening in summer and the flat, black, angular, winged seeds dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.

Vegetative reproduction: Plants proliferate, forming small clusters. The vegetative clusters actively occupy crevices by growth and should any bulb or bulb scale become dislodged and fall onto ledges below, it will root—a prolific vegetative dispersal strategy ensuring long-term survival on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Drimia mzimvubuensis* is easily grown and thrives in cultivation, but requires well-drained soil and is best for containers. Feed in spring and keep dry for its winter resting season. It is best grown in partial shade. Plants easily grown by division, from bulb scales or from seed. Its very easy growing nature maximises its survival rate on the cliff face.

VOUCHER

Van Jaarsveld, Xaba, Harrower & Styles 58 (NBG).

ILLUSTRATIONS AND MAP

Plate 72, Figures 72a–72c, Map 72.

73. *Drimia uniflora* J.C.Manning & Goldblatt in *Strelitzia* 9: 712 (2000) (= *Litanthus pusillus*)

Cremnophyte growth form: Cluster-forming, miniature bulbs (of light weight, cliff hugger, in fact, the smallest of all cremnophytes and the smallest bulb in the world!).

Growth form formula: A:Lper:C:La (vb)

Etymology: The epithet *uniflora* pertains to the solitary flower. The older Greek generic name *Litanthus* is derived from *litos*, plain or simple, and *anthos*, flower (Jackson 1971); *pusillus*, very small, refers to its small stature.

DESCRIPTION AND HABITAT

Plants bulbous (epigeous to hypogeous), forming inconspicuous dwarf-sized clusters up to 25 mm in diameter. Bulbs up to 13 mm in diameter, globose-conical; outer tunics imbricate, grey. Roots fibrous. Leaves 1–3, hysteranthous, filiform, up to 70 mm long, ascending to spreading, pendulous. Inflorescence reduced to a 1 (rarely 2)-flowered raceme, up to 17–55 mm long; bracts 2, up to 1 mm long, spurred. Perianth pendulous, white to pink, tubular, up to 4 × 2 mm; lobes fused for two thirds. Stamens fused to perianth tube; anthers dorsifixed. Ovary sessile, ellipsoid. Capsule loculicidal, 3 × 2.5 mm, slightly transparent. Seeds angular, up to 1 × 0.4 mm, flattened, black.

Phenology: Flowering summer and midsummer. Perianth opening day and night, attracting insect pollinators.

Pollinators: Insects.

Habitat and aspect: Cliffs, in rock crevices at altitudes of about 500–3000 m in exposed to sheltered kloofs (all aspects). Plants are rooted among moss and other succulent plants in crevices. Temperature warm to cool. Winters are cool, with frost at higher altitudes. Rainfall occurs at any time of the year in the south, but mainly in summer in the northeast, ranging from 100–1250 mm per annum.

Altitude: 650–3000 m.

Associated vegetation: Mainly Fynbos, Albany Thicket, Nama-Karoo and Succulent Karoo Biomes and afroalpine vegetation (Mucina *et al.* 2005).

Associated cremnophytes: *Cotyledon orbiculata* var. *orbiculata*, *Crassula nemorosa*, *C. nudicaulis*, *C. pellucida* subsp. *marginalis* and *Ornithogalum juncifolium*.

Geology: Shale (Phanerozoic Emakwezini Formation) or quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Drimia uniflora is widespread throughout South Africa, occurring on vertical cliffs and rock crevices.

RELATED SPECIES

Without any close relatives. The smallest bulbous plant in South Africa. Easily overlooked.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dwarf-sized cluster form with ascending to drooping, filiform leaves.

Size and weight: Plants miniature, small and of light weight.

Bulb: Bulbs succulent, proliferating and forming clusters, an adaptation to the dry cliff habitat.

Leaves

Orientation: Ascending or subpendulous, orientation maximising absorption of light.

Colour and texture: Dark green, with a soft texture. The slight translucent nature allows light to penetrate deeply, an adaptation helping plants to cope with the shady to sunny cliff environment.

Age and persistence: Plants evergreen, leaves continuously replaced.

Armament: The filiform leaves without any armament, perhaps a response to the undisturbed cliff habitat.

Sexual reproduction

Inflorescence, flowers and fruit: Raceme ascending and the small, white, pendulous perianth attracting insects. Fruit becoming erect.

Fruit/Seed

Size: Seed 1×0.4 mm, an ideal size for establishment in crevices.

Dispersal: Seed blown or shaken from the erect capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn.

Vegetative reproduction: *Drimia uniflora* proliferates from the base, forming small, dense clusters. When bulbs become detached, they will re-root and continue growth. This vegetative regeneration can be seen as a backup ensuring survival in the harsh cliff-face environment.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

General: Plants very small and easily overlooked.

Horticulture: Best grown in small containers. Not popular owing to its minute size. Plants easily grown from seed or division, doing well in cultivation. Its very easy growing nature maximises survival rate. Plants are often unwittingly or accidentally introduced with other bulb or succulent clusters and are often found among clusters of *Conophytum* or other succulents.

VOUCHER

Van Jaarsveld & Nordenstam 20041 (NBG).

ILLUSTRATIONS AND MAP

Plate 73, Figures 73a–73d, Map 73.

LEDEBOURIA Roth

74. *Ledebouria concolor* (Baker) Jessop in Journal of South African Botany 36: 254 (1970). (Suurberg cliff form.)

Cremnophyte growth form: Cluster-forming, epigeous bulbs, rosulate leaves (of medium weight, cliff hugger).

Growth form formula: B:Lper:C:La (e) (vb) (rd)

Etymology: The epithet *concolor*, uniform in colour, refers to the uniform leaf colour in contrast to most other *Ledebouria* species which have characteristic leaf markings.

DESCRIPTION AND HABITAT

Epigeous, cluster-forming, bulbous plants. Roots succulent, 2 mm in diameter. Bulb conical to 40–60 × 55 mm, purplish green, proliferating from base, forming rounded clusters on cliffs; tunics tight, withering grey. Leaves 5–10 per plant, ovate-lanceolate to ovate, 80–110 × 45–60 mm, green, fleshy, not spotted, obscurely striate, younger leaves ascending, older drooping. Inflorescence up to 200 mm long, ascending; raceme 140 mm long; peduncle 3–4 mm long; bracts small, ovate. Perianth, cup-shaped, greenish white, 5 mm in diameter, 3 mm deep, becoming purplish, drooping; pedicels white, up to 7 mm long, becoming purple; tepals greenish, with broad white margins, outer surface purplish at base, 6 × 2.5 mm. Ovary globose, 6-lobed. Stamens 6 mm long; filaments white, collected into a cone; anthers 0.5 long, oblong, versatile. Stigma 3 mm long, lengthening to 5 mm at maturity, subulate, white. Fruit and seed not seen.

Phenology: Flowering mainly from end of October–November.

Pollinators: Insects.

Habitat and aspect: Mainly south-facing cliffs in protected river gorges. Plants firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Summers are hot and temperatures of up to 35°C are not uncommon. Winters are cooler but frost is absent. The average daily maximum temperature is about 22°C and average daily minimum about 12°C. Rainfall can occur throughout the year, but with a peak in spring and summer, ranging from 300–500 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 300–800 m.

Associated vegetation: Sundays Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Bulbine latifolia*, *Crassula intermedia*, *C. perfoliata* var. *minor*, *Haworthia angustifolia* var. *baylissii*, *Lampranthus affinis*, *Ornithogalum juncifolium* and *O. longibracteatum*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Witteberg Group, Witpoort Formation (Cape Supergroup).

DISTRIBUTION

Ledebouria concolor is confined to the Eastern Cape, and this form is endemic to the narrow kloofs of the Witrivier in the Suurberg. Larger forms of the same species occur on the flats near Uitenhage and Port Elizabeth.

RELATED SPECIES

Ledebouria concolor is one of the larger *Ledebouria* species and is without leaf markings. It is related to *L. socialis*, another species with epigeous bulbs but with silvery green, mottled leaves occurring in shade of thickets.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming globose clusters, exploiting the vertical cliff-face habitat. A fairly rapid-growing, fairly long-lived perennial.

Size and weight: Heads of medium weight.

Bulb: Bulb globose, fleshy and tolerant of warm, dry, vertical conditions.

Leaves

Orientation: Spreading, in an apical rosette, maximising absorption of light

Succulence: Fleshy, tolerant of the dry habitat.

Colour: Light to dark green. Unlike leaves of most *Ledebouria* species in which the mottling provides the ideal camouflage, leaves of this species are without leaf spots, suggesting an adaptation to the absence of herbivory.

Age and persistence: Evergreen condition reflecting the rainfall patterns.

Armament and camouflage: Lack of a camouflage defence strategy suggests adaptation to the safe cliff habitat.

Sexual reproduction

Inflorescence and flowers: Ascending racemes of whitish green flowers.

Fruit/Seed

Size: Fruit and seed not seen.

Dispersal: Seeds locally dispersed.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.

Vegetative reproduction: Plants proliferate, forming clusters. The vegetative clusters actively occupy crevices by growth and should any bulb become dislodged and fall onto ledges below, it will root—a prolific vegetative dispersal strategy ensuring long-term survival on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Ledebouria concolor* is easily propagated by division. Plants are best grown on steep embankments, gabions, rockeries or terraforce and can be grown in full sun or dappled shade. They require a well-drained soil. They also thrive in containers. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 19229 (NBG).

ILLUSTRATIONS AND MAP

Figures 74a–74c, Map 74.

75. *Ledebouria cremnophila* S.Venter & Van Jaarsv., in Venter *et al.* in *Aloe* 43,4: 78–79 (2007).

Cremnophyte growth form: Cluster-forming, epigeous bulbs, rosulate leaves (of medium weight, cliff hugger).

Growth form formula: B:Lper:C:La (e) (vb) (rd)

Etymology: Greek *kremnos*, cliff, and Greek *phileein*, to love, pertaining to its cliff habitat.

DESCRIPTION AND HABITAT

Plants solitary. Bulb epigeous to semi-epigeous, 90–120 × 30–40 mm, cylindrical; dry bulb scales dark brown and hard, live bulb scales tightly arranged with visible threads when torn. Leaves 6–8, fully emerged at anthesis, spreading, lanceolate, 80–130 × 20–40 mm, with threads when torn, fleshy; surfaces dull green with purple blotches, venation sunken on adaxial surface; margin smooth but wavy; leaf base shallowly canaliculate; apex acute. Inflorescence 1, rarely 2, flaccid, lax, 50–120-flowered, longer than leaves, with a pronounced coma when young; peduncle terete at base, green fused purple, glabrous, 50–110 mm long; rachis shallowly ridged, 80–140 mm long; raceme lax, oblong, 130–250 × 20–30 mm; bracts and bracteoles always present, membranous, 5–8 × 0.25–0.50 mm, linear, white; pedicels

spreading, 8–12 mm long, pink turning olive-green. Tepals initially spreading then strongly recurved, equal, linear-oblong, 5–6 × 1.5 mm, olive-green on abaxial surface, green fused purple on adaxial surface; apex acute. Stamens erect, 3–4 mm long; filaments pink with white base, epitepalous; anthers 0.75 mm long, orange-yellow. Ovary depressed, ovate, 6-lobed, 1 × 2 mm; lobes obtusely deltate, apical shoulders not raised, basal lobes absent; style 2.5–3.0 mm long, terete, pink with white apex and base; stipe 0.25 × 0.25 mm. Capsule clavate, base tapering. Seed not seen

Phenology: Flowering November–January.

Pollinators: Insects.

Habitat and aspect: Wooded shady south-facing cliffs. Plants are firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Summers are hot, with temperatures up to 35°C. Winters are cooler but frost is absent. Temperatures are high in summer, the average daily temperature in summer is about 27°C and average daily minimum about 13°C. Rainfall mainly in summer, 500–700 mm per annum (mainly thunder showers).

Altitude: 400–600 m.

Associated vegetation: Barberton Serpentine Sourveld of the Lowveld Bioregion, Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Cotyledon barbeyi*, *Crassula perfoliata*, *Cyanotis speciosus*, *Delosperma lebomboensis*, *Haemanthus paucifolius*, *Plectranthus verticillatus* and *Portulacaria afra*.

Geology: Quartzitic sandstone, Moodies Group (Barberton Supergroup).

DISTRIBUTION

Ledebouria cremnophila appears to be confined to the mountains along the Honeybird Creek (Noordkaap east of Barberton) in Mpumalanga. It occurs on high quartzite cliffs in humus-filled rock cracks, but sometimes in humus-rich lithosols.

RELATED SPECIES

Ledebouria cremnophila is related to the widespread *L. revoluta*, but it is at once distinguished by three prominent features. Firstly, the bulbs are cylindrical, with hard, dark brown bulb scales. Secondly, the bulbs are semi-epigeous to epigeous. The third feature is the filiform floral bracts that form a distinct coma, which is very prominent in the young inflorescence.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming epigeous clusters, exploiting the vertical cliff-face habitat. A fairly rapid-growing, fairly long-lived perennial.

Size and weight: Heads of medium weight.

Bulb: Bulb cylindrical, oblong, fleshy, photosynthetically active and tolerant of warm, dry, vertical conditions.

Leaves

Orientation: Spreading, in apical rosette, maximising absorption of light.

Succulence: Fleshy, tolerant of the dry habitat.

Colour: Dull green, with purple blotches.

Age and persistence: Evergreen condition reflecting the warm climate.

Camouflage: *Ledebouria cremnophila* is well camouflaged, perhaps indicating that it is a recent cliff neo-endemic.

Sexual reproduction

Inflorescence and flowers: Spreading to pendent racemes.

Fruit/Seed

Size: Fruit and seed not seen.

Dispersal: Seeds are released and then presumably locally dispersed when the capsules split open.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.

Vegetative reproduction: Plants proliferate, forming clusters. The vegetative clusters actively occupy crevices by growth and should any bulb become dislodged and fall onto ledges below, it will root—a prolific vegetative dispersal strategy ensuring long-term survival on the cliffs.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). A local endemic, not threatened.

ADDITIONAL NOTES

General: *Ledebouria cremnophila* is one of four species commonly associated with cliff faces. The others are *L. concolor*, *L. ensifolia* and *L. venterii*. All of them have bulbs that are epigeously produced. *Ledebouria concolor* and *L. venterii* have spreading, fleshy leaves without spots and are cluster-forming, while *L. ensifolia* and *L. cremnophila* have spotted leaves. *Ledebouria ensifolia* is also cluster-forming, the smallest of the group. The epigeous nature makes them vulnerable to fire, a character perhaps adopted as a result of to the safer, fire-free cliff-face environment. The fleshy leaves are an efficient adaptation to the dry conditions on the cliff face.

Horticulture: *Ledebouria cremnophila* is best grown in bushveld gardens, on steep embankments in dappled shade. It also does well in containers. Keep dry in winter and feed in spring. Plants are easily propagated by division or from seed and thrive in cultivation. Its very easy growing nature maximises its survival rate.

VOUCHER

Van Jaarsveld 19372 (NBG).

ILLUSTRATIONS AND MAP

Plate 75, Figures 75a–75c, Map 75.

76. *Ledebouria venteri* Van Jaarsv. & A.E.van Wyk in *Aloe* 43,4: 75–77 (2007b).

Cremnophyte growth form: Cluster-forming, epigeous bulbs, rosulate leaves (of medium weight, cliff hugger).

Growth form formula: B:Lper:C:La (e) (vb) (rd)

Etymology: After Stefanus Venter (1953–) botanist formerly at the University of the North who revised the genus *Ledebouria*.

DESCRIPTION AND HABITAT

Bulbs globose, up to 50 × 45 mm, at first solitary, becoming small, epigeous or semi-epigeous clusters of up to 14 individuals, 220 mm in diameter, covered in dense, dry tunic remains; tunics thin, papery, brownish, translucent, with indistinct, transverse abscission layer. Roots fleshy, up to 1.5 mm long. Leaves succulent, 6–12, spreading, linear-lanceolate to ovate-lanceolate, 55–100 × 15–35 mm, green, glabrous, obscurely striate, with thread-like strings when severed; abaxial surface suffused with purple streaks in centre and towards base; apex acute, becoming slightly channelled; base amplexicaul; margin white, minutely denticulate. Inflorescence 70–100 mm long; scape terete, 50 mm long, 3 mm in diameter at base; raceme 40–50 mm long, with up to 14 flowers open at the same time; rachis angular; bracts small, subulate, curving upwards, up to 1 × 0.3 mm, base ending in a decurrent ridge and resulting in angular floral axis. Flowers spreading, nodding; stalks 14–15 mm long, maroon-mottled; tepals triangular-ovate, 5 × 1.5 mm, purplish green, soon becoming reflexed, apices acute. Stamens 3.0–3.5 mm long, purplish, base green; anthers 0.75 mm long; pollen yellowish. Ovary 1 × 2.5 mm, 6-lobed, grooved, green, stipitate for 0.5 mm. Capsule obovoid, 6 mm long. Seed obovoid-oblong, 5 × 2.5 mm.

Phenology: Flowering November–December.

Pollinators: Insects.

Habitat and aspect: Cliffs, at altitudes of about 300 m. Plants firmly rooted in crevices, size often depending on the growing space allowed by the crevice. Summers are hot, with temperatures up to 35°C. Winters are cooler but frost is absent. The average maximum

temperature is about 24°C and average minimum about 12°C. Rainfall throughout the year, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 600–800 m.

Associated vegetation: North Langeberg Sandstone Fynbos and Southern Cape Valley Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Albuca tortuosa*, *Bulbine aloides*, *Crassula orbicularis*, *C. perforata*, *C. rupestris*, *Haworthia chloracantha* var. *chloracantha*, *Litanthus pusillus*, *Ornithogalum longibracteatum*, *Othonna carnosa* and *Scopelogena verruculata*.

Geology: Quartzitic sandstone, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Ledebouria venterii is at present known only from between the Gourits River Poort and near the Gourits Bridge (N2 between Albertinia and Mossel Bay) where it grows on ledges of east-facing cliffs and steep embankments. The Langeberg habitat consists of dry fynbos and at the confluence with the Vals River it grows in thicket vegetation with a high proportion of succulent plants.

RELATED SPECIES

Ledebouria venterii is related to *L. concolor*. Both are evergreen species, with epigeous bulbs and fleshy leaves without spots, usually confined to cliff faces and steep slopes. *Ledebouria venterii* is at once distinguished by its succulent, unspotted, linear-lanceolate leaves with a white, minutely denticulate margin and tepals that are free and fully reflexed. The flowers are much smaller than those of *L. concolor* and the flower stalks, stamens and stigma are distinctly maroon-red. *Ledebouria concolor*, in contrast, is a much larger species, the leaves are ovate-lanceolate, with a distinctly undulating margin, and the tepals are much larger, fused at the base.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming globose clusters, exploiting the vertical cliff-face habitat. A slow-growing fairly long-lived perennial.

Size and weight: Heads of medium and average weight.

Bulb: Bulb globose, fleshy and tolerant of warm, dry, vertical conditions.

Leaves

Orientation: Spreading, in apical rosette, maximising absorption of light.

Succulence: Fleshy, tolerant of the dry habitat.

Colour: Light to dark green. Unlike leaves of most *Ledebouria* species in which the mottling provides the ideal camouflage, leaves of this species are without leaf spots, suggesting an adaptation to the absence of herbivory.

Age and persistence: Evergreen condition reflecting the rainfall patterns.

Armament and camouflage: Lack of a camouflage defence strategy suggests an adaptation to the safe cliff habitat.

Sexual reproduction

Inflorescence and flowers: Ascending racemes of whitish green flowers.

Fruit/Seed

Size: Capsule obovoid, 6 mm long. Seed obovoid-oblong, 5 × 2.5 mm.

Dispersal: Seeds released and locally dispersed when the capsules split open.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.

Vegetative reproduction: Plants proliferate, forming clusters. The vegetative clusters actively occupy crevices by growth and should any bulb or bulb scale become dislodged and fall onto ledges below, it will root—a prolific vegetative dispersal strategy ensuring long-term survival on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants of *Ledebouria venterii* are best suited to fynbos and thicket gardens and are ideal for dry rockeries or containers. They are best grown in well-drained soil with ample compost added. The plants can be propagated by division and can be grown in full sun or light shade.

VOUCHERS

Harrower 2115, Van Jaarsveld 17633, 19247 (NBG).

ILLUSTRATIONS AND MAP

Plate 76, Figure 76a, Map 76.

ORNITHOGALUM L.

77. *Ornithogalum juncifolium* Jacq. var. *emsii* Van Jaarsv. & A.E.van Wyk in *Bothalia* 35,1: 82–84 (2005e).

Cremonophyte growth form: Cluster-forming, epigeous bulbs, with spreading linear leaves (of light weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: After Paul Ems, botanist, who first noticed the population on the cliff face.

DESCRIPTION AND HABITAT

Plants bulbous, epigeous, forming round clusters up to 100 mm in diameter and consisting of many bulbs and bulbils. Bulbs globose, 15–20 mm in diameter and high; tunics grey, papery, exposing green live tissue, basal part of bulb continuously proliferating, forming many ovate to rounded bulbils up to 5 mm in diameter. Leaves 2 or 3, synanthous, linear, half-terete, 95–150 × 1.5 mm; apex acute, dark green; adaxial surface shallowly canaliculate, abaxial surface rounded; base sheathing, tubular, with short membranous neck 5–8 mm long, 2–3 mm in diameter; margin minutely ciliolate. Raceme 100–200 mm long, 8–12-flowered; scape terete, erect; bracts deltoid-cuspidate, auriculate, up to 6 × 2 mm; pedicel up to 4–5 mm long, lengthening to up to 6–7 mm in fruit. Perianth stellate, white, up to 20–24 mm in diameter; tepals linear-lanceolate, 3 inner 10.0–12.0 × 3.0–3.5 mm, white, with green median stripe. Stamens 5 mm long; outer filaments flattened, linear-acuminate, 1 mm in diameter at base, inner filaments shorter, ovate-triangular, up to 1.5 mm long; anthers 0.8 mm long, yellow. Ovary ovate, 3 × 2 mm, green, shortly stipitate; style erect, 4 mm long; stigma capitate. Capsule ovoid, 5–7 × 3–4 mm. Seeds 24 per capsule, triangular-ovate, 1.5 × 0.8 mm, black, denticulate.

Phenology: Flowering mainly in summer (from early December–January). Seeds dispersed by wind in summer and early autumn (October onwards).

Pollinators: Insects.

Habitat and aspect: Mainly south-facing shale cliffs. Plants firmly rooted in crevices. Temperature high in summer (35–40°C). Winters are cooler but frost is absent. Rainfall throughout the year but with a peak in spring and summer, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 500–600 m.

Associated vegetation: Mainly Great Fish Noorsveld of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: The plants at the type locality share their habitat with others such as *Bulbine latifolia*, *Crassula cultrata*, *C. perfoliata* var. *minor*, *C. socialis*, *Haworthia angustifolia* var. *baylissii* and *Ledebouria concolor*.

Geology: Dark-coloured and smooth-textured Ecce shale (Fort Brown Formation) of the Karoo Supergroup. Substrate with sufficient ledges, crevices and fissures for establishment of plants.

DISTRIBUTION

Ornithogalum juncifolium var. *emsii* is a shale endemic, confined to the Kei River (north of Grahamstown) Eastern Cape.

RELATED SPECIES

Related to *Ornithogalum juncifolium* var. *juncifolium*, which is also encountered on cliffs but does not have the prolific nature of producing small bulblets.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, globose clusters of green (photosynthetically active) and (2 or 3 active) spreading, pendulous, linear leaves, an adaptation to shady cliffs and the thin leaves allowing optimum absorption of light by the bulbs in this environment.

Size and weight: Bulbs small, of light weight, cliff hugger.

Bulb: Bulb tunics becoming dry and grey, protecting the bulb from excessive light.

Leaves

Orientation and presentation: Grouped and bundled together at base, very thin, allowing maximum light reaching the bulbs. The leaves are spreading, becoming subpendent.

Colour: Dark green.

Age and persistence: Plants long-lived, with dry leaves persistent, withering from the base.

Armament: Without obvious defence characters.

Sexual reproduction

Inflorescence and flowers: Inflorescence spreading, the apices drooping and the white corolla attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed 1.5×0.8 mm, 24 per capsule.

Dispersal: Seeds light, triangular-ovate, denticulate, ideal for dispersal by wind and easily becoming stuck in crevices after release from the capsules.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season.

Vegetative reproduction: Plants continuously forming bulbils at the base of the mother bulb and these spilling over, filling crevices and thus maximising survival. It is a prolific vegetative dispersal strategy that ensures continued existence on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants best grown in small containers and miniature succulent gardens. It is easily propagated by division, thriving in cultivation. Outside the thicket habitat it is best grown under controlled conditions in a greenhouse. Its very easy growing nature maximises its survival rate.

VOUCHER

Van Jaarsveld 16808 (NBG).

ILLUSTRATIONS AND MAP

Figures 77a & 77b, Map 77.

78. *Ornithogalum longibracteatum* Jacq., Hortus botanicus vindobonensis 3: t. 29 (1776). (Bashee form.)

Cremonophyte growth form: Cluster-forming, epigeous bulbs, with recurved spreading subpendent leaves (of medium weight, cliff hugger).

Growth form formula: A:B:Lper:C:La (e) (vb)

Etymology: Latin *longi*, long, and *bracteatum*, bract, referring to the long bracts on the inflorescence.

DESCRIPTION AND HABITAT

Plants glabrous, bulbous, epigeous and cluster-forming. Bulbs globose, up to 80 mm in diameter, bulbiferous; tunics succulent, green, withering grey, exposing green live tissue; vegetative bulbils 6–8 × 6–7 mm, grey-green. Roots white, terete, succulent. Leaves synanthous, 200–1000 × 20–50 mm, rosulate, flaccid, ascending to curving, linear, succulent, channelled, withering from apex. Raceme up to 1 m high, densely flowered; scape terete, erect; bracts filiform, broadening at base to 40 mm long; pedicels up to 5 mm long, lengthening to 15 mm in fruit. Perianth stellate; tepals linear-elliptic, 9 × 2.5 mm, green with white margins. Ovary spherical. Capsule trigonous, 10 × 6 mm. Seeds oblong, angular, 4 × 1.5 mm, black.

Phenology: Flowering mainly from spring to early summer but in some populations to autumn, and occasionally throughout the year. Seeds are dispersed by wind in summer and early autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs and steep slopes, often south-facing but also in other habitats. Plants firmly rooted in crevices. Temperature moderate to high in summer. Winters are cooler but frost is absent. Average daily maximum temperature about 24°C and average daily minimum about 11°C. Rainfall throughout the year but with a peak in spring and summer, ranging from 300–1000 mm per annum (thunder showers or cyclonic winter rain). In the north the rainfall occurs mainly in summer, with dry winters.

Altitude: 300–500 m.

Associated vegetation: Mainly thicket and subtropical coast vegetation.

Associated cremnophytes: On the Suurberg, the following plants grow with *Ornithogalum longibracteatum*: *Bulbine latifolia*, *Crassula intermedia*, *C. perfoliata* var. *minor*, *Haworthia angustifolia* var. *baylissii*, *H. glauca*, *Lampranthus affinis* and *Ledebouria concolor*.

Geology: Occurs on various rock formations such as shale, mudstone, sandstone and quartzitic sandstone belonging to the Karoo and Cape Supergroup.

DISTRIBUTION

Ornithogalum longibracteatum is widely distributed from Mossel Bay in the Western Cape to southeastern Africa. The Bashee form is confined to the lower Bashee River.

RELATED SPECIES

Not closely related to other species of *Ornithogalum*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Globose clusters of epigeous bulbs.

Size and weight: Heads of medium weight.

Bulb: Bulbs green (photosynthetically active), an adaptation to shady cliffs and exposing the surface to the light source.

Leaves

Orientation and presentation: Rosulate, flaccid and recurved, exposing maximum surface for absorption of light during the rainy season. Leaves are spreading, fleshy and sometimes pendulous. Apices are terete, an adaptation to the dry cliff face. Forms from the lower Bashee cliffs with much-reduced, narrow, almost terete leaves.

Colour: Light green and smooth, becoming dry during dry periods, the bulbs enveloped in grey tunics protecting them from excessive rays of the sun.

Age and persistence: Plants long-lived, evergreen leaves withering from below.

Armament and camouflage: Clusters conspicuous, less firm than those of the typical chasmophytic relatives, suggesting a reduction in armament in response to the less disturbed environment. Leaf sap causing tremendous itching and hence the Afrikaans name *jeukbol*. The leopard tortoise (*Testudo pardalis*) is very fond of the leaves and bulbs, and whenever the plants occur in accessible areas they are immediately demolished.

Sexual reproduction

Inflorescence and flowers: Inflorescence spreading, the apices drooping, the white corolla attracting the right pollinating flying insect.

Fruit/Seed

Size: Seed 4×1 mm, an ideal size for establishment in crevices.

Dispersal: Light, black, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn, coinciding with the rainy season. Germination after 21 days.

Vegetative reproduction: The very prolific nature of continuous production of bulbils has led to the common name ‘pregnant onions’. This prolific vegetative reproductive strategy ensures long-term survival and represents adaptation to the cliff environment. Bulbils are continuously dispersed and will root if they fall into a crevice. The grey-green bulbils are $6\text{--}8 \times 6\text{--}7$ mm and brittle and are therefore easily detached, a vegetative reproductive backup ensuring a hold on the cliff face.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: *Ornithogalum longibracteatum*, also known as ‘pregnant onions’, is one of the most commonly grown *Ornithogalum* species, popular as a pot plant worldwide. It is mainly grown for its ornamental green, photosynthetically active bulbs. It will do best in thicket gardens, on steep embankments, gabions or terraforce concrete walls. It thrives in dappled shade but also in full sun. It is easily propagated by division or seed and does well in cultivation. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 16636 (NBG).

ILLUSTRATIONS AND MAP

Plate 78, Figures 78a–78c, Map 78.

79. *Ornithogalum pendens* Van Jaarsv., in Van Jaarsveld & Van Wyk in Aloe 46,2: 30–32 (2009a).

Cremonophyte growth form: Cluster-forming, hypogeous bulbs, with pendent linear leaves (of light weight, cliff hanger).

Growth form formula: A:B:D:C:Lp (vb)

Etymology: The epithet *pendens* refers to the pendent leaves.

DESCRIPTION AND HABITAT

Plants bulbous, hypogeous, forming dense clusters up to 100 mm in diameter and consisting of many bulbs and bulbils. Bulbs globose-ovoid, up to 5–10 × 5–8 mm; tunics white, lightly translucent. Roots whitish, less than 1 mm in diameter. Leaves 2, synanthous, 50–100 × 10–16 mm, pendent, linear, fleshy, channelled; surface glaucous, somewhat translucent, smooth, striate, lower surface with slight keel; margin entire. Inflorescence 1 per plant; 50–70 mm long; raceme subcorymbose, 25–30 mm long, 3–6-flowered; scape terete, 1 mm in diameter at base, erect, same colour as leaves; bracts ascending, lanceolate to linear-lanceolate, cymbiform, same colour as leaves, clasping pedicel, channelled, 10–14 × 2–4 mm, becoming smaller distally; pedicel up to 12–20 × 0.5–0.7 mm. Perianth stellate, white, 15–18 mm in diameter; tepals white, ovate-elliptic, 7–12 × 3–4 mm. Stamens 4–7 mm long; filaments white, linear, inner flattened, up to 1 mm in diameter at base; anthers 1.4 mm long. Ovary oblong, abruptly tapering at apex, 3.5 × 2 mm, green, 3-ridged, sessile; style erect, 1.2 mm long, yellowish; stigma capitate. Capsule and seed not seen.

Phenology: Flowering in spring (September). Seeds dispersed by wind in summer.

Pollinators: Insects.

Habitat and aspect: South-facing quartzitic sandstone cliffs. Plants occur in crevices, on ledges and in shady rock veins on southern aspects. Summers are warm to hot, winters are cooler but frost is absent. The average daily maximum temperature ranges from 22–24°C and the average daily minimum for the region is between 10–12°C. Rainfall mainly in winter and autumn, 100–250 mm per annum (mainly cyclonic winter rain). Occasional fog provides extra moisture.

Altitude: 400–600 m.

Associated vegetation: Namaqualand Shale Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Bulbine pendens*, *Colpias molle*, *Ornithogalum pendens* and *Ornithogalum* sp.

Geology: Quartzitic sandstone cliffs (Kuibus Formation) of the Nama Group.

DISTRIBUTION

Ornithogalum pendens is known only from the Skaaprivierspoort northwest of Springbok (Northern Cape).

RELATED SPECIES

Related to *Ornithogalum puberulum*, differs from that species by its glabrous leaves. *Ornithogalum pendens* is at once distinguished by its proliferous production of bulbils at the base of the bulb, by the two distichous, succulent, grey-green leaves becoming pendent and by the subcorymbose racemes of white flowers. The plants grow in dense clusters. It belongs to subgenus *Aspasia* characterised by leafy cymbiform bracts and a style as long as or shorter than the ovary (Obermeyer 1978).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, dense clusters of grey-green (photosynthetically active) and (2 active) pendulous linear leaves. Plants become deciduous after flowering in spring.

Size and weight: Heads small, of light weight.

Bulb: Hypogeous and prolific from the base, filling crevices.

Leaves

Orientation and presentation: Dense owing to the clustered growth, channelled and slightly translucent, allowing maximum penetration of light. Leaves soon becoming pendent.

Colour and texture: Grey-green, succulent, soft-textured.

Age and persistence: Plants long-lived perennials, becoming deciduous in late spring.

Armament: Without obvious defence characters.

Sexual reproduction

Inflorescence and flowers: Ascending subcorymbose raceme.

Fruit/Seed

Size: Seed not seen.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by wind.

Time: Seeds ripening in summer and autumn.

Vegetative reproduction: Plants continuously form bulbils at the base of the mother bulb, these spilling over and filling crevices, thus maximising survival. It is a prolific vegetative dispersal strategy ensuring continued existence on the cliffs.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants best grown in small containers and miniature succulent gardens. It is easily propagated by division, thriving in cultivation. Outside its succulent karoo habitat, it is best grown under controlled conditions in a greenhouse. It grows very easily, maximising survival rate.

VOUCHER

Van Jaarsveld 21108 (NBG).

ILLUSTRATIONS AND MAP

Plate 79, Figures 79a–79c, Map 79.

SCHIZOBASIS Baker

80. *Schizobasis intricata* (Baker) Baker in Journal of Botany, British and Foreign 12: 368 (1874).

Cremonophyte growth form: Solitary, bulbous (of light to medium weight, cliff hugger).

Growth form formula: A:B:D:C:La (e) (vb)

Etymology: The epithet *intricata* pertains to the ‘intricate’ inflorescence.

DESCRIPTION AND HABITAT

Bulb solitary or dividing to form small groups, epigeous, pear-shaped, 50–70 × 40–60 mm; tunics fleshy, reddish to greyish green, soft. Leaf rudimentary, filiform, soon deciduous. Inflorescence (stem) erect to spreading, up to 300 mm long, leafless, persistent, green (functioning as assimilating organ), forming loose panicles up to 150 × 150 mm; scape 120–150 mm × 1.5 mm at base; bracts 2 × 1 mm, triangular, soon withering, acute, spurred at base; spur 2.5 mm long; pedicels 2 mm long. Perianth campanulate, drooping, yellowish cream to greenish, 6 × 3 mm; segments 6, subequal, 1-nerved. Stamens arising from base of segments; anthers oblong, dorsifixed. Ovary sessile, subglobose, 1.5 mm in diameter, 3-celled. Capsule membranous, loculicidal, 3-valved. Seed 1–3 per locule, turgid, black.

Phenology: Flowering in October–November. Seed released towards end of November, early December.

Pollinators: Insects.

Habitat and aspect: *Schizobasis intricata* is grows on quartzitic sandstone cliffs (east- and south-facing). Along the lower Mzimnyati River (Buffalo River) it was collected at an altitude of about 500 m, near the confluence with the Thukela River. Plants are difficult to reach where they are firmly rooted in crevices large enough to support the roots and stem clusters

scattered in rock crevices. Average summer temperature is about 26°C and for winter 14°C. Rainfall is experienced mainly in summer, with averages of 800–1000 mm per annum.

Altitude: 250–2000 m.

Associated vegetation: Thukela Valley Bushveld of the Sub-Escarpment Savanna Bioregion of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Schizobasis intricata* grows in association with *Aloe arborescens*, *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula orbicularis*, *Cyanotis speciosa* and *Plectranthus madagascariensis*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup).

DISTRIBUTION

Schizobasis intricata is widespread in the eastern parts of South Africa, occurring on cliff faces in dry savanna.

RELATED SPECIES

Differs from *Bowiea* by its firm, non-climbing inflorescence.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants solitary or in small groups, with epigeous, photosynthetically active bulbs and persistent, ascending-spreading inflorescence. Plants grow in nutrient-poor sandstone soil and have a slow metabolism. Long-lived perennials.

Size and weight: Heads small to medium-sized.

Bulb: Succulent, solitary or dividing to form epigeous clusters.

Leaves

Orientation: Rudimentary.

Colour: Green.

Age and persistence: Soon deciduous.

Armament: Soft edible bulb scales suggest a reduction in armament as a direct result of reduced herbivory.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending or drooping, persistent and photosynthetically active (having taken over the function of the leaves), even after flowering. This is a xeromorphic adaptation of reducing water loss through reduced leaf surface and a photosynthetically functional inflorescence.

Fruit/Seed

Size: Seed black, angular-rounded, ideal for establishment in crevices.

Dispersal: Light, angular seeds shaken from the capsules and dispersed by gravity to crevices below.

Time: Seed dispersal coincides with the rainy season.

Vegetative reproduction: Bulbs are often cluster-forming, filling crevices. Young bulbs root and increase their numbers further, thus an efficient vegetative expansion and a backup ensuring survival under the harsh conditions on the cliff.

CONSERVATION STATUS

A species seldom encountered, not threatened.

ADDITIONAL NOTES

Horticulture: *Schizobasis intricata* is easy to grow and makes an interesting specimen plant for the specialist plant lover. It is best grown in bushveld gardens, in containers and in a sandy, well-drained mixture. Keep dry during winter for its resting phase and place in a warm, partially shady situation.

VOUCHER

Van Jaarsveld 18213 (NBG).

ILLUSTRATIONS AND MAP

Figures 80a–80c, Map 80.

Dicotyledons

ASCLEPIADACEAE

Huernia R.Br.

81. *H. pendula* E.A.Bruce

Lavrania Plowes

82. *L. haagnerae* Plowes

Tromotriche Haw.

83. *T. baylissii* (L.C.Leach) Bruyns
84. *T. choanantha* (Lavranos & H.Hall) Bruyns

HUERNIA R.Br.

81. *Huernia pendula* E.A.Bruce in The Flowering Plants of Africa 28: t. 1108 (1951).

Cremonophyte growth form: Pendulous stem, cluster, succulent (of light to medium weight, cliff hanger).

Growth form formula: E:Ex:P:Ss (vb) (eg)

Etymology: Greek *pendula*, pendulum, pertaining to its hanging nature.

DESCRIPTION AND HABITAT

Plants sparsely branched, pendent from rock faces, often filling crevices and rooting where stems touch the ground. Branches initially erect or flat, becoming pendulous from ledges, up to 900 mm long. Stems very obscurely 4-angled, cylindrical, 5–8 mm in diameter, green sometimes purplish mottled, becoming greyish green, articulated at nodes. Inflorescence 3- or 4-flowered subsessile cymes towards base of stem and lateral branches. Flowers pendulous, opening successively; pedicels short, up to 8 mm long. Corolla bowl-shaped 10-15 x 8-10 mm, lobes ascending to spreading, up to 5-7 mm in diameter, 5-6 mm long, dark maroon on inside, densely papillate. Fruit paired fusiform follicles.

Phenology: Flowering from spring to midsummer. Flowers with scent of decaying meat. Seeds wind-dispersed.

Pollinators: Probably flies and bluebottles.

Habitat and aspect: Cliffs overlooking the Kei River where the plants grow on ledges, in crevices and fissures, sharing the habitat with other succulent cremonophytes. Summers are hot, winters cooler. The average daily maximum temperature is 28°C and average daily minimum 12°C. Rainfall occurs mainly in summer (thunder showers), 300–800 mm per annum.

Altitude: 400–800 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other cremnophytes at Collywobbles: *Albuca batteniana*, *Aloe reynoldsii*, *Bulbine natalensis*, *Cotyledon orbiculata* and *Haworthia cymbiformis* var. *setulifera*.

Geology: Shale of the Emakwezini Formation (Beaufort Group, Karoo Supergroup).

DISTRIBUTION

Confined to cliffs of east-flowing river valleys between Kei and Bashee Rivers (Eastern Cape).

RELATED SPECIES

Distinguished from related (not cremnophilous) *Huernia* species by its long, subterete stems and pendulous nature. The other species are cluster-forming, usually square-stemmed and well-camouflaged, while the pendulous stems of *H. pendula* are exposed on the cliffs.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Pendulous, sparsely branched (leafless) but conspicuous succulent branches up to 900 mm long. Branches rooting on ledges.

Size and weight: Of light to medium weight.

Stem: Subterete to almost terete, succulent, obscurely 4-angled (5–8 mm in diameter), with obscure shallow grooves along the angles, leaf tubercles decussately arranged, 6–7 mm apart. Side branches articulated at the attachment or base and spreading at right angles, rooting where touching the ground; epidermis smooth. The subterete stems are an adaptation to the hot xeric conditions of the vertical habitat, the branch ramification pattern, rooting where it touches the soil, also ensuring optimum vegetative establishment.

Leaves

Orientation: Rudimentary, reduced to inconspicuous scales.

Colour: Green, occasionally purplish mottled, becoming grey-green, the latter an adaptation to the xeric habitat.

Age and persistence: Slow-growing, long-lived perennials.

Armament: Conspicuous armament lacking.

Sexual reproduction

Inflorescence and flowers: Subsessile cymes towards base of stem and lateral branches, with pendulous, bowl-shaped flowers. This arrangement suggests a specific pollinator. Flowers dark maroon, pendulous, the size in comparison to the small stems maximising visibility from the bottom of the cliff, an adaptation to the cliff environment.

Fruit/Seed

Size: Follicles paired, fusiform.

Dispersal: Flattened seeds dispersed by wind.

Time: Seeds released in summer and autumn, maximising establishment of seedlings during the rainy season.

Vegetative reproduction: Stems actively growing and lengthening and will occupy new crevices or fissures (when finding new ground), establishing new clusters—an efficient backup for survival in this dry, hostile environment.

CONSERVATION STATUS

Although *Huernia pendula* is not very common (classified as rare), it is not threatened owing to the sheer, safe habitat.

ADDITIONAL NOTES

Horticulture: Easily grown from cuttings, thriving in a sandy, humus-rich soil in cultivation. It is one of the easiest stapeliads to grow. This growth vigour maximises survival. Like other indigenous cremnophilous stapeliads, it has subterete stems as opposed to the cluster-forming and square-stemmed taxa normally growing on level ground. Best grown on steep embankments, in hanging baskets or on rockeries in thicket and bushveld gardens (Van Jaarsveld 2010).

VOUCHER

Van Jaarsveld 17861 (NBG).

ILLUSTRATIONS AND MAP

Figures 81a–81e, Map 81.

LAVRANIA Plowes

82. *Lavrania haagnerae* Plowes in *Cactus and Succulent Journal* (U.S.) 58: 123 (1986).

Cremonophyte growth form: Stem succulent, cluster (of medium weight to heavy, cliff hugger).

Growth form formula: E:Ex:De:St (vb)

Etymology: After Mrs C.H. Haagner who first collected this species.

DESCRIPTION AND HABITAT

Cluster-forming, up to 150 mm high, shallow-rooted, branched from base, bearing 20–100 grey-green stems; growth decumbent or semiplagiotropic, not pendulous. Stems cylindrical,

cactoid in appearance, 20–30 mm in diameter, with 10–12 regular rows of parallel, neatly arranged, flattened, polygonal tubercles each bearing a small, persistent, conical leaf. Inflorescence reduced on basal half of stem on secondary shoots; primary shoot sterile. Flowers in groups of 3–15 arising from peduncular patches near base, opening in succession. Corolla 13–16 mm in diameter, whitish green on outside, regularly red-mottled on inside; tube shallowly cup-shaped. Fruit a follicle, up to 70 × 3–4 mm, diverging 30–60°. Seed 7 mm long, flat, grey, circular, with pale cream border.

Phenology: Flowering in spring (October). Seeds wind-dispersed.

Pollinators: Probably flies. Bruyns (1993) reports ‘the flowers of *L. haagnerae* are notable for their intense and regular mottling with red spots and their unusually strong odour reminiscent of rock-rabbit dung and urine (*Procavia capensis*)’.

Habitat and aspect: Mainly south-facing cliffs and ledges, but also on other aspects. Temperature (within the subtropics), very hot in summer. The average daily maximum of about 30°C and average daily minimum temperature about 17°C. Winters are cooler but frost absent. Rainfall occurs in summer months, ranging from 50 and 150 mm per annum. Plants grow on medium to small inaccessible rocky ledges and can fill a horizontal crevice up to a meter long (Bruyns 1993).

Altitude: 700–900 m.

Associated vegetation: Mosaic of arid mopane savanna (*Colophospermum mopane* dominant) and Namib Desert vegetation.

Associated cremnophytes: About 12 km east of Sesfontein, *Lavrania haagnerae* shares its habitat with the following cliff dwellers: *Aloe dewinteri*, *Ceraria* sp., *Commiphora multijuga*, *Cyphostemma uter*, *Drimia* sp., *Ornithogalum* sp., *Oxalis* sp., *Petalidium* sp. and *Sterculia africana*.

Geology: Proterozoic dolomite cliffs (Damara Sequence).

DISTRIBUTION

East of Sesfontein, Kaokoveld (Namibia), growing on the western fringe of the dolomite escarpment and river valley cliff faces (Khowarib Poort). *Lavrania haagnerae* is known only from two sites (Bruyns 1993) about 40 km apart, always confined to inaccessible, vertical dolomite cliff faces on the escarpment edge of the Namib Desert.

RELATED SPECIES

Related to the other *Lavrania* species but at once distinguished by its dense clusters of decumbent to semiplagiotropic, succulent stems. The stems have regular rows (irregular in all other *Lavrania* species) of neatly arranged, parallel, flattened, polygonal tubercles, each with a small, conical, persistent leaf. There are also differences in the inflorescence, with markedly fewer inflorescences arising on secondary shoots in the basal parts of the stem. In the other four *Lavrania* species (non-cremnophytes) the inflorescences are apically produced. Although the inflorescences in *L. haagnerae* are initially produced on the apical part of the secondary stems, their growth is suppressed until the stems have lengthened and they subsequently then

occur on the basal portion of the stem. The flowers of *L. haagnerae* are larger (compared to those of the other *Lavrania* species) and more conspicuous. The seeds are the largest in the genus *Lavrania* (Bruyns 1993).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: *Lavrania haagnerae* differs from the other four *Lavrania* species in its dense conspicuous clusters of up to 100 stems. The decumbent or semiplagiotropic growth is ideal for exploiting rocky ledges, with very little competition and in the absence of large herbivores. The regularly arranged tubercles make the plants conspicuous.

Size and weight: Clusters often large, of medium weight to heavy.

Stem: Stems with regularly arranged tubercles, rooting at nodes. The regularly arranged tubercles are more conspicuous, suggesting less investment in camouflage mechanisms.

Leaves

Orientation: Reduced and rudimentary (see above).

Colour: Glaucous.

Age and persistence: Slow-growing, long-lived perennial.

Armament and camouflage: Without conspicuous armament or camouflage properties.

Sexual reproduction

Inflorescence and flowers: With fewer, but larger and thus more conspicuous flowers, produced at the base of the stems, not apically as in the other species. This arrangement suggests a specific pollinator.

Fruit/Seed

Size: Seed about 7 mm in diameter, the largest in the genus.

Dispersal: The large, flat seeds suggest dispersal by wind on the cliffs.

Time: Seeds released during the rainy season in late spring and summer.

Vegetative reproduction: With an expanding habit, rooting where stems touch the ground, exploiting available space by active vegetative growth, very unlike its non-cremophilous relatives. Other *Lavrania* species grow on hilly to flat, rocky terrain with either solitary or fewer stems, less conspicuous owing to fewer, cryptic stems (irregularly arranged tubercles) and adapted to a habitat frequently disturbed by large herbivores and with competition from other plants. These other species grow cryptically and are never common.

CONSERVATION STATUS

Classified as rare (Loots 2005). Endemic to the dolomite region east of Sesfontein. Despite a restricted distribution, it is not threatened as it is well protected by the sheer cliff-face habitat.

ADDITIONAL NOTES

General: *Lavrania haagnerae* was first collected and recorded by Clem and Peggy Haagner in August 1969 (Plowes 1986).

Horticulture: Best for dry subtropical desert gardens. Plants can be grown in full sun or partial shade and are ideal for steep embankments or rockeries. Outside the native habitat it is best grown under controlled conditions in a greenhouse. Keep completely dry in winter. Feed in late spring and water sparingly in the summer. The soil should be sandy and preferably slightly alkaline. Add dolomitic lime when necessary. Plants easily grown from stem cuttings or division.

VOUCHER

Van Jaarsveld 19879 (NBG, WIND).

ILLUSTRATIONS AND MAP

Plate 82, Figures 82a–82c, Map 82.

TROMOTRICHE Haw.

83. *Tromotriche baylissii* (L.C.Leach) Bruyns in South African Journal of Botany 61,4: 206 (1995).

Cremonophyte growth form: Pendulous stem, cluster, succulent (of medium weight, cliff hanger).

Growth form formula: E:Ex:P:Ss (vb) (eg)

Etymology: After Mr Roy Bayliss (1909–1994), succulent plant enthusiast and the first collector of this species.

DESCRIPTION AND HABITAT

Plants sparsely branched from base, pendent from rock faces, often filling crevices and some stems becoming subterranean and rooting. Stems obtusely 4-angled, sulcate along sides, tubercle-toothed; older branches becoming smooth and rounded; arboreal stems hanging from ledges, up to 1.5 m long. Leaves rudimentary, inconspicuous. Inflorescence produced at tips of branches, shortly pedunculate, produced repeatedly from apices of growing stems. Flowers opening successively; pedicels short, up to 13 mm long. Corolla 5-angled, tubular-campanulate, up to 15 mm long, 13 mm wide, red-purple on inside; surface satin-like; lobe margins sometimes with vibratile clavate cilia. Fruit paired fusiform follicles up to 60 mm long.

Phenology: Flowering from spring to midsummer. Flowers with scent of decaying meat, thus attracting pollinators. Seeds wind-dispersed.

Pollinators: Probably flies and bluebottles.

Habitat and aspect: Southern and eastern aspects of sheer cliff faces, growing in ledges, fissures and crevices (300–600 m in altitude). Temperature in summer hot, cooler in winter with the occasional cold fronts. Average daily maximum temperature is about 26°C and average daily minimum about 10°C. Rainfall (cyclonic winter rainfall and summer thunder showers) is in summer and winter and range from 200–300 mm per annum.

Altitude: 400–600 m.

Associated vegetation: Gamka Thicket of the Albany Thicket Biome (Mucina *et al.* 2005). Thicket Biome with elements of the Succulent Karoo Biome.

Associated cremnophytes: At Geelhoutboskloof, the following species have been observed in association with our species: *Adromischus cristatus* var. *zeyheri*, *Albuca cremnophila*, *Cotyledon tomentosa* subsp. *tomentosa*, *Cyrtanthus labiatus*, *C. montanus*, *Delosperma elsiae*, *Gasteria rawlinsonii*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna lobata* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone of the Nardouw Subgroup (Table Mountain Formation, Cape Supergroup), on south-facing cliffs.

DISTRIBUTION

Confined to tributaries of the Gamtoos, Kouga and Baviaanskloof Rivers and Grootrivier where they flow through the Cape Fold Belt mountains (from east of Willowmore to just west of Hankey).

RELATED SPECIES

Distinguished from related level-ground *Tromotriche* species by its long subterete stems, pendulous nature and pendulous spreading campanulate flowers. The other species are cluster-forming and well camouflaged. Its closest relative is *T. choanantha*, another cremnophyte very similar in vegetative features, but with a slightly longer corolla and with flowers produced at the base of the long stems.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Pendulous, sparsely branched (leafless) but conspicuous succulent branches up to 1.5 m long. Branches on ledges rooting and often becoming subterranean.

Size and weight: Clusters of medium weight.

Stem: Stems obscurely 4-angled (7–12 mm in diameter) to almost terete, with shallow grooves along the angles, tessellate, tubercle-toothed, becoming rounded with age, rooting where touching the ground. These subterete, rope-like stems are a response to the very xeric and exposed cliff environment.

Leaves

Orientation: Reduced and rudimentary (see above).

Colour: Stems dark bluish green.

Age and persistence: Plants slow-growing, long-lived perennials.

Armament and camouflage: Plants without conspicuous armament or camouflage properties.

Sexual reproduction

Inflorescence and flowers: Inflorescences apically and successively produced along the sides of the young stems. This arrangement suggests a specific pollinator. Flowers campanulate, pendulous, spreading, thus maximising visibility from the bottom of the cliff.

Fruit/Seed

Dispersal: Flattened seeds released from the follicles and then dispersed by wind.

Time: Seeds released in summer and autumn, maximising establishment of seedlings during the rainy season.

Vegetative reproduction: Stems often negatively phototropic, growing into the soil or crevices and establishing new clusters. Stems lengthen and will root where they find new ledges or crevices, forming new colonies. This active vegetative growth and establishment of new colonies represent an efficient backup ensuring survival in this dry, hostile environment.

CONSERVATION STATUS

Little-known species, not threatened owing to the sheer cliff-face habitat.

ADDITIONAL NOTES

Horticulture: Plants of *Tromotriche baylissii* are easily propagated by division or from seed and are best grown as specimen pot plants. It is best suited to dry thicket and succulent karoo gardens, suitable for growing in dappled shade on steep embankments. Water sparingly throughout the year and renew soil every second year. Feed in spring. Outside its habitat, it is best suited to containers in a greenhouse where conditions can be controlled.

VOUCHER

Van Jaarsveld 17717 (NBG).

ILLUSTRATIONS AND MAP

Figures 83a–83e, Map 83.

84. *Tromotriche choanantha* (Lavranos & H.Hall) Bruyns in South African Journal of Botany 61,4: 204 (1995).

Cremnophyte growth form: Pendulous stem, cluster, succulent (of medium weight, cliff hanger).

Growth form formula: E:Ex:P:Ss (vb) (eg)

Etymology: Greek *choane*, funnel, and *anthos*, flower, pertaining to the funnel-shaped corolla.

DESCRIPTION AND HABITAT

Plants sparsely branched, pendent from rock faces, often filling crevices, some stems becoming subterranean and rooting. Stems obtusely 4-angled, sulcate along sides, tubercle-toothed; older branches becoming smooth and rounded; arboreal stems hanging from ledges, up to 2 m long. Leaves rudimentary, inconspicuous. Inflorescence shortly pedunculate, produced at base of stems. Flowers opening successively; pedicels short, up to 10 mm long. Corolla tubular-campanulate, up to 20 mm in diameter, red-purple on inside; surface satin-like; tube 16 mm long. Fruit paired fusiform follicles up to 100 mm long.

Phenology: Flowering from spring to midsummer. Flowers with scent of decaying meat, thus attracting pollinators. Seeds wind-dispersed.

Pollinators: Pollinated probably by flies and bluebottles.

Habitat and aspect: All aspects (more common on southern and eastern aspects) of sheer cliff faces, growing on suitable ledges, crevice and fissures. Plants often share their habitat with other cliff-dwelling succulent plants. Temperature hot in summer and with occasional cool cyclonic fronts in winter. Average daily maximum is about 25°C and average daily minimum 9°C. Rainfall (cyclonic winter rainfall and summer thunder showers) is experienced in winter and summer and ranges from 200 and 300 mm per annum.

Altitude: 250–900 m.

Associated vegetation: Gamka Thicket (Albany Thicket Biome) and Western Gwarrieveld of the Rainshadow Valley Karoo Bioregion of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Observations at ‘Die Hel’ north of Calitzdorp include *Bijlia dilatata*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula perforata*, *C. rupestris* and *Senecio ficoides*.

Geology: Quartzitic sandstone of the Nardouw Subgroup (Table Mountain Formation, Cape Supergroup).

DISTRIBUTION

Confined to cliffs along the Gamka River from Die Hel to the Huis River Pass (Groot Swartberg Mountains) between Ladismith and Calitzdorp.

RELATED SPECIES

Distinguished from related (not cremnophilous) *Tromotriche* species by its long subterete stems, pendulous nature and pendulous, spreading, campanulate flowers. The other species are cluster-forming and usually well camouflaged, while *T. choanantha* has conspicuous

pendulous stems. *Tromotriche choanantha* is immediately distinguished from *T. baylissii* by its flowers produced at the base of the stems (apically produced in *T. baylissii*).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: *Tromotriche choanantha* has pendulous, sparsely branched (leafless) but conspicuous succulent branches up to 2 m long. Branches on ledges rooting, often becoming subterranean.

Size and weight: Of medium weight.

Stem: Obscurely 4-angled (6–12 mm in diameter) to almost terete, with shallow grooves along the angles, tessellate, tubercle-toothed, becoming rounded with age, rooting where touching the ground; epidermis minutely pubescent (becoming glabrescent with age). These subterete, rope-like stems are thought to be a response to the very xeric and exposed cliff environment.

Leaves

Orientation: Reduced and rudimentary (see above).

Colour: Stems dark bluish green.

Age and persistence: Slow-growing, long-lived perennials.

Armament: Plants without conspicuous armament.

Sexual reproduction

Inflorescence and flowers: Inflorescences are basally produced in the stem grooves of young branches, shortly pedunculate. This arrangement suggests a specific pollinator. Although the stem remains functional and lengthening, no additional flowers develop. The flowers are campanulate, pendulous and spreading, maximising visibility from the bottom of the cliff.

Fruit/Seed

Dispersal: Flat seeds wind-dispersed.

Time: Seeds released from the splitting follicles in summer and autumn, maximising establishment of seedlings during the main rainy season.

Vegetative reproduction: Stems are often negatively phototropic, growing into the soil or crevices and thus establishing new clusters. Stems lengthen and will root where they find new ledges or crevices, forming new colonies. This active vegetative growth and establishment of new colonies represent an efficient backup ensuring survival in this dry, hostile environment.

CONSERVATION STATUS

Endemic, with a restricted distribution but not threatened owing to the undisturbed habitat.

ADDITIONAL NOTES

First record: First collected and recorded by Mr P.O. le Roux in 1937. Plants from this collection were grown at Kirstenbosch and flowered in September 1938 (Leach 1978).

Horticulture: Plants of *Tromotriche choanantha* are easily grown by division or from seed, as specimen pot plants. It is best suited to dry thicket and succulent karoo gardens, in dappled shade on steep embankments. Water sparingly throughout the year and renew soil every second year. Feed in spring. Outside the habitat it requires controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17161 (NBG).

ILLUSTRATIONS AND MAP

Figures 84a–84d, Map 84.

ASTERACEAE

Kleinia Mill.

85. *K. galpinii* Hook.f.

Othonna L.

86. *O. armiana* Van Jaarsv.
87. *O. capensis* L.H.Bailey
88. *O. cremnophila* B.Nord. & Van Jaarsv.
89. *O. triplinervia* DC.

Senecio L.

90. *S. medley-woodii* Hutch.
91. *S. muirii* L.Bolus
92. *S. pondoensis* Van Jaarsv. & A.E.van Wyk
93. *S. serpens* G.D.Rowley
94. *S. talinoides* Sch.Bip. subsp. *talinoides*

KLEINIA Mill.

85. *Kleinia galpinii* Hook.f. in Journal of Horticultural and Practical Gardening, Ser. 3: 3 (1892).

Cremonophyte growth form: Compact to short-stemmed shrublets (of medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ca:La (vb) (r)

Etymology: After Ernest Edward Galpin (1858–1941) who first collected this species near Barberton in Mpumalanga.

DESCRIPTION AND HABITAT

Cluster-forming, erect to decumbent, sparsely branched (1–5 branches), whitish green, succulent suffrutex, up to 120 mm tall, all parts covered with a waxy bloom. Roots slightly succulent at base, up to 3 mm in diameter; plants often sprouting from just below ground. Branches terete, succulent, greyish green, up to 10 mm in diameter, becoming deciduous towards base; with pungent odour when damaged. Leaves alternate, crowded in central rosette, dorsiventrally flattened, ascending, oblanceolate to narrowly obovate; 40–80 × 15–22 mm; midrib prominent; surface whitish green; margin slightly revolute; base cuneate; apex acute; petiole indistinct. Inflorescence a loose terminal panicle, up to 300 mm long, bearing up to 8 terminal capitula, with gradual change from leaves to bracts, each capitulum clasped by 2–5 bracts. Capitulum 30 mm long, up to about 40 mm in diameter, nodding in bud stage; involucre with about 12 phyllaries up to 18 mm long; receptacle alveolate, flat. Florets numerous, orange. Style arms up to 5 mm long. Achene angular, glabrous, cylindrical, 6 mm long; pappus 10 mm long.

Phenology: Flowering in summer to early winter (January–August).

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone cliffs and steep slopes. Plants rooted in crevices and on rock ledges. Fog often occurs in summer. Winters are cool but frost is a rarity owing to the slope. The average daily maximum temperature is 22°C and the average daily minimum is 14°C. Rainfall mainly from spring to autumn but occasionally also in winter, ranging from 1250–2000 mm per annum.

Altitude: 600–1525 m.

Associated vegetation: Barberton Montane Grassland (Mucina *et al.* 2005) and elements of afro-montane forest.

Associated cremnoophytes: *Albuca shawii*, *Crassula lanceolata*, *C. sarcocaulis*, *C. swaziensis*, and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone of the Moodies Group (Barberton Supergroup, Keyser 1997).

DISTRIBUTION

Kleinia galpinii is known only from the Barberton region and adjacent area (Mpumalanga and northern Swaziland).

RELATED SPECIES

Kleinia galpinii is related to *K. fulgens*, which occurs widespread from KwaZulu-Natal to the Limpopo Province. Superficially they are close, but *K. fulgens* (a stoloniferous species) lacks the whitish green leaves, has much longer stems and the leaves usually have a toothed margin.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact, rosulate, sparsely branched succulent herb with perennial base.

Size and weight: Clusters small, of light weight.

Leaves

Orientation: Ascending, often pointing towards the light source, avoiding direct light (with tips pointed towards the sun, thus the least amount of direct exposure). Leaves are also crowded in dense rosettes, typical of dry habitats.

Colour: Whitish green (pruinose), protected by a waxy bloom protecting the plant from extreme exposure.

Age and persistence: Evergreen, with firm long-lived leaves, but plants simply resprouting from basal shoots after frost or fire. Older leaves withering from the base. The fleshy leaves becoming turgid after rain, but often in a semi-desiccated state during dry periods.

Armament: The soft, fragile plants are without obvious armament. The pungent leaf resin is deterrent to insects and other herbivores.

Sexual reproduction

Inflorescence and flowers: Inflorescence conspicuous, displaying its bright orange capitulum (rich flowering) and attracting butterflies.

Fruit/Seed

Size: Achene angular, glabrous, cylindrical, 6 mm long; pappus 10 mm long.

Dispersal: Achenes wind-dispersed.

Time: Achenes ripening in summer and autumn, coinciding with summer and autumn rain.

Vegetative reproduction: Plants have vegetative renewal shoots that sprout after fire or drought. The shoots root when the mother plant dies, establishing new populations. This is an efficient vegetative backup strategy for survival under the harsh, xeric cliff-face conditions.

CONSERVATION STATUS

Localised and confined to the gorges but not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: *Kleinia galpinii* is an ornamental species (leaves and flowers), especially when coming into flower. Best for highveld and moist bushveld gardens, grown in rockeries, on embankments or simply as a pot plant in full sun. Outside its habitat, it should be grown under controlled conditions in a greenhouse. Propagate by division, from stem cuttings or seed.

VOUCHER

Van Jaarsveld 19360 (NBG).

ILLUSTRATIONS AND MAP

Plate 85, Figures 85a–85d, Map 85.

OTHONNA L.

86. *Othonna armiana* Van Jaarsv. in South African Journal of Botany 52,6: 569–571 (1986).

Cremonophyte growth form: Dwarf-sized compact shrublet (of light to medium weight, cliff squatter).

Growth form formula: A:S:Lar:D:Ca:La (r)

Etymology: After Mr A.R. (Anthony) Mitchell of the Island of Wight, England, who discovered this species while researching the genus *Conophytum*.

DESCRIPTION AND HABITAT

Dwarf-sized, summer-deciduous, succulent herb with fibrous roots. Caudex 30–70 mm in diameter, napiform, flattened distally with age, tapering towards base, dark brown, longitudinally fissured. Branches short, compact, 3–20 mm long, 3–10 mm in diameter, with persistent cartilaginous phyllopodia 2–5 mm long, 3 mm in diameter, brownish purple and truncate at apex; young branches slightly woolly, becoming glabrous. Leaves 5–22 × 5–18 mm, succulent; blade orbicular to obovate, rarely ovate, dorsiventrally compressed, glabrous, apically rounded, basally cuneate or rarely truncate, with entire to serrate margins, abaxially tinged with purple; petiole 2–4 mm long, slightly woolly at base. Peduncle terminal, erect, 1 or 2, 60–90 mm long, 1–1.5 mm thick, terete, glabrous, with 2–5 radiate heads 4–5 mm in diameter. Involucre campanulate, 6 mm deep; involucre bracts 8, uniseriate, ovate-lanceolate, 5–7 mm long, acute; receptacle convex, shallowly alveolate. Ray florets 8, in a single row, fertile. Achene 1.5 mm long, 1 mm wide, oblong to obovoid, finally 3 mm long when ripe, dark brown, cano-pubescent, 10-ribbed; pappus consisting of many persistent bristles.

Phenology: Flowering summer to early winter (February–May). Seeds (achenes) wind-dispersed.

Habitat and aspect: South-facing diabase rock faces in the northeastern Richtersveld, Northern Cape (800–900 m in altitude). Rainfall is mainly in winter and ranges from 100 and 150 mm per annum. Plants grow on medium to small inaccessible rocky ledges.

Altitude: 800–900 m.

Associated vegetation: Kahams Mountain Desert (Mucina *et al.* 2005).

Associated cremnoophytes: Associated cremnoophytes on the Rooiberg (Eksteenfontein), Richtersveld, are *Conophytum gratum*, *Crassula macowanii* and *C. pseudohemisphaerica*.

Geology: Proterozoic diabase.

DISTRIBUTION

Othonna armiana is known only from the Rooiberg, a diabase mountain massif northeast of Eksteenfontein in the Richtersveld.

RELATED SPECIES

Othonna armiana is related to *O. herrei*, which is widespread in the central mountain range of the Richtersveld. It is a taller shrublet (without the compact nature of *O. armiana*).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact, dwarf-sized, caudiciform plants.

Size and weight: Clusters small, of light to medium weight.

Leaves

Orientation: Ascending, often pointing towards the light source (with tips pointing towards the sun, thus the least amount of direct exposure), crowded in rosettes.

Colour: Glaucous, protected by a waxy bloom, shielding the plant from extreme exposure.

Age and persistence: Plants deciduous during the long, dry summer when they aestivate, new leaves appearing in autumn.

Armament: The soft, fragile leaves are without obvious armament. The pungent leaf resin and firm, cartilaginous phyllopodia are deterrent to insects and other herbivores.

Sexual reproduction

Inflorescence and flowers: Conspicuous yellow ray florets, pollinated by insects. Another example of rich flowering (large inflorescence compared to the relatively small plant body).

Fruit/Seed

Size: Achene oblong to obovoid, 1.5 mm long, 1 mm in diameter, finally when ripe 3 mm long, dark brown, cano-pubescent, 10-ribbed; pappus consisting of numerous persistent bristles.

Dispersal: Achenes dispersed by wind.

Time: Achenes ripening in autumn and winter, coinciding with the winter rainfall.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Although classified as critically endangered (Raimondo *et al.* 2009), it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for succulent karoo gardens, grown in rockeries, miniature succulent gardens and containers. Outside the habitat, it is best grown under controlled conditions in a greenhouse. Plants easily grown from seed sown in autumn.

VOUCHER

Van Jaarsveld 8188 (NBG).

ILLUSTRATIONS AND MAP

Plate 86, Figures 86a & 86b, Map 86.

87. *Othonna capensis* L.H.Bailey in Encyclopedia of American Horticulture: 1180 (1901).

Cremnophyte growth form: Pendent, mat-forming (of light to medium weight, cliff hanger).

Growth form formula: E:F:P:Els:E (vb)

Etymology: The epithet *capensis* refers to the Cape of Good Hope, South Africa.

DESCRIPTION AND HABITAT

Spreading, procumbent and mat-forming to pendent, glabrous, branched shrublets, branches up to 400 mm long, rooting at nodes, very variable in size. Roots fibrous. Branches terete, succulent, greyish to purplish green, sometimes developing aerial roots, at first soft becoming firm and deciduous towards base, internodes 1–25 mm apart. Leaves alternate, often crowded, erect, softly succulent, bluish green to purplish or reddish green, pruinose, cylindrical, linear-obovate, club-shaped to linear-fusiform, 17–35 × 4–11 mm; adaxial surface flat but always grooved, groove sometimes very faint, abaxial surface rounded with few faint striations; apex mucronate, sometimes purplish. Inflorescence a loose, lax, terminal corymb up to 155 mm long with up to 4 capitula, often solitary; bracts short, succulent, triangular, rarely club-shaped, 2–5 × 0.75–2.00 mm. Capitulum top-shaped, 5–8 mm broad at tip, with up to 8 phyllaries; phyllaries free at tip, triangular to triangular-lanceolate, with broad maroon striations. Ray florets 12–15, yellow, limb linear-lanceolate, 9–11 × 2.5–3.5 mm. Disc florets bisexual. Achene glabrous, 1 × 0.3 mm, tapering.

Phenology: Flowering almost throughout the year but with a peak in spring (September–November).

Pollinators: Insects.

Habitat and aspect: Sandstone, quartz or shale cliffs. Plants rooted in crevices and on rock ledges, the long extended branches rooting where they touch the soil or reach a crevice. Extreme temperatures as high of 40°C have been recorded. Winters are cooler but frost is a rarity or absent owing to the sheer habitat. The average daily maximum temperature is about 23–25°C and the average daily minimum is 10–14°C. Rainfall in summer and winter but more in spring or autumn, ranging from 300–500 mm per annum.

Altitude: 20–1220 m.

Associated vegetation: Mainly Gamtoos Thicket (Albany Thicket Biome), Upper Karoo Hardeveld (Nama-Karoo Biome) and dry Eastern Coastal Shaleband Vegetation of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Hoeree, *Othonna capensis* shares its habitat with *Adromischus cristatus* var. *zeyheri*, *Aloe perfoliata*, *Bulbine retinens* and *Crassula perforata*.

Geology: Quartzitic sandstone of the Table Mountain Group and shales of the Beaufort Group (Cape Supergroup).

DISTRIBUTION

Othonna capensis occurs widespread in the Eastern Cape, from the inland Graaff-Reinet escarpment mountains to the Kouga River in the south and further east to the dry Bashee River, confined to sheer cliff faces.

RELATED SPECIES

Othonna capensis is related to *O. carnososa* of similar sites along dry river valleys but not confined to cliff faces and more woody, with decumbent growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The plants often hang like curtains from crevices on the cliffs. The leaves are highly and softly succulent and can withstand periods of drought by producing anthocyanins (purplish red colour pigment) which protect the plants from penetration of excessive sunlight, further aiding its survival.

Size and weight: Clusters small, of light to medium weight.

Leaves

Orientation: Ascending, crowded, often pointing towards the light source (with tips towards the sun, thus the least amount of direct exposure). Leaves very succulent, storing copious amounts of moisture.

Colour: Greyish green, pruinose (bluish green covered with a powdery bloom).

Age and persistence: Plants evergreen, but leaves withering from the base although tending to remain persistent. The fleshy leaves becoming turgid after rain, but often in a semi-desiccated state (and channelled) during drought, an adaptation to the extreme dry cliff habitat.

Armament: The plants are soft and fragile, without armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence a loose, lax, terminal corymb up to 155 mm long, bearing up to 4 often solitary capitula. Capitulum top-shaped, 5–8 mm broad at the top with up to 8 phyllaries.

Fruit/Seed

Size: Achene 1×1.03 mm, tapering, pappus 2–3 mm long.

Dispersal: Achenes dispersed by wind.

Time: Achenes ripening throughout the year, also coinciding with the rainfall.

Vegetative reproduction: The procumbent stems (up to 400–600 mm long) are flaccid, rooting where they find crevices lower down and forming new colonies. Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival.

CONSERVATION STATUS

Confined to cliffs and not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket gardens, grown on steep embankments, in hanging baskets, on window sills or as a pot plant, in full sun or dappled shade. *Othonna capensis* is an excellent groundcover, with soil-binding properties. Propagate from cuttings, rooting rapidly.

VOUCHER

Van Jaarsveld 16809 (NBG).

ILLUSTRATIONS AND MAP

Plate 87, Figures 87a–87d, Map 87.

88. *Othonna cremnophila* B.Nord. & Van Jaarsv. in *Aloe* 42,1 & 2: 4–7 (2005).

Crempnophyte growth form: Compact succulent-stemmed shrublet (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D

Etymology: Greek *kremnos*, cliff, and Greek *phileein*, to love, pertaining to its cliff habitat.

DESCRIPTION AND HABITAT

Erect, branching, succulent shrubs, 200–600 mm high. Roots dark-brown, fibrous, taproot up to 7 mm in diameter. Stem basally simple, cylindrical, 35–90 mm in diameter, branching upwards, with erect-patent to ascending branches, upper branches 20–35 mm in diameter, cylindrical, apically abruptly tapering or cone-shaped and covered with white-felted wool, initially with woolly, later faintly alveolate depressed leaf scars 2–3 × 1–2 mm; older branches brownish green, becoming glabrous and almost smooth. Leaves alternate, petiolate, crowded in apical rosette with 6–8 leaves from late summer to early autumn, then deciduous, erect to patent to spreading; blade obovate, subpalmate, 30–80 × 25–40 mm, many-veined, basally tapering into petiole, pale to glaucous green with a powdery bloom, leathery, somewhat fleshy; surface smooth; margin crispate-undulate-dentate, slightly thickened; apex rounded; petiole (3–)5–15 mm long, linear, flattened. Synflorescence bearing 6–15 flower heads, terminal, erect, laxly paniculate, 170–260 mm tall. Peduncle up to 80 mm long, 4 mm in diameter at base, glaucous owing to powdery bloom, with small bract; bract and leaf axils covered with white felt-like wool; pedicels 25–60 mm long. Capitula 25–40 mm in diameter (including ligules); involucre campanulate, 7–10 mm high, 7–10 mm wide; involucre bracts

5–8, uniseriate, triangular-ovate, 6–8 mm long, 2.5–5.0 mm wide, tinged purplish, acute-acuminate, basally connate (for about a third); receptacle convex, alveolate. Ray florets 8, female, fertile, yellow; lamina oblong, 10–15 × 6–8 mm, 4–7-veined, obtuse to truncate, becoming recurved; tube cylindrical, 5–6 mm long. Style branches yellow, 1.5–2 × 0.3 mm, spreading. Cypsela oblong, subterete or somewhat compressed, 4–5 mm long, 1.5–2.0 mm wide, 10-ribbed, white-villous especially basally and between ribs, hairs mucilaginous when soaked; pappus bristles numerous, pluriseriate, 5–6 mm long, minutely barbellate, white, persistent. Disc florets functionally male; corolla yellow, 4–5 mm long; tube cylindrical; limb campanulate, 5-lobed; corolla lobes deltoid-ovate, 0.7–1.0 mm long, erect, midlined, with lateral veins. Anthers 1.5 mm long including ovate-obtuse appendage; base obtuse, excaudate; filament collar balusterform. Ovary narrowly oblong, 2.5–3.0 mm long, 5-ribbed, glabrous or sparsely minutely pilose-setose; style simple, sterile, tipped by rounded to truncate cone surrounded by collar of short sweeping hairs. Pappus bristles several, 3–4 mm long, minutely barbellate, white, caducous.

Phenology: Flowers in late autumn and winter.

Habitat and aspect: Small shrubs on quartzitic sandstone cliff faces on southern and eastern aspects. The southern slopes are cooler, with shady conditions. Winters are cool and subject to occasional coastal fog from the west coast; frost absent. The average daily maximum temperature is about 26°C and average daily minimum about 14°C. Rainfall occurs mainly from autumn (thunder showers) to spring (cyclonic winter rain), ranging from 75–150 mm per annum.

Altitude: 600–1000 m.

Associated vegetation: Rosyntjieberg Succulent Shrubland (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe meyeri*, *Bulbine pendens*, *Conophytum taylorianum* subsp. *rosynense*, *Crassula pseudohemisphaerica*, *C. sericea* var. *sericea*, *Cyrtanthus herrei*, *Pelargonium desertorum*, *Trachyandra aridimontana* and *Tylecodon ellaphieae*. Other non-succulent cremnophilous plants on these cliffs include the small trees *Ficus cordata* and *F. ilicina*.

Geology: Quartzite of the Rosyntjieberg Formation (Orange River Group).

DISTRIBUTION

Othonna cremnophila is known only from the Rosyntjieberg to the northeast of Eksteenfontein in the Richtersveld.

RELATED SPECIES

Othonna cremnophila is at once distinguished from *O. cyclophylla* by its thick and sparsely branched cylindrical stems with white-felted wool on apical branches, larger obovate undulate-dentate leaves, and the distinctly radiate capitula with bright yellow rays. *Othonna cyclophylla* is a taller, much-branched shrub with whitish grey cortex on the rather thin stems, orbicular leaves 10–20 mm in diameter, with denticulate margins, and with a few-flowered synflorescence of disciform capitula. Another shrubby species in the region, *O. graveolens*, is

more similar in leaf shape, but also has disciform capitula (like *O. cyclophylla* but smaller and more numerous) and stems with a peeling, papery, light brown cortex.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact, succulent shrublet with cylindrical stems. It is a slow grower; growth is erect from a young age and the plants become firmly wedged in crevices. They are locally abundant but are mostly restricted to inaccessible places.

Size and weight: Clusters of medium weight to heavy.

Leaves

Orientation: Ascending-spreading.

Colour: Glaucous, protected by a waxy bloom, shielding the plant from extreme exposure.

Age and persistence: Long-lived perennials, deciduous in the long, dry summer when the plants aestivate, new leaves appearing in autumn.

Armament: The soft, fragile plants are without obvious armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence terminal, erect, laxly paniculate, 170–260 mm tall (with 6–15 flower heads). *Capitula* 25–40 mm in diameter (including ligules).

Fruit/Seed

Size: Achene about 3 mm long, ribbed.

Dispersal: Achenes dispersed by wind.

Time: Achenes ripening in autumn and winter, coinciding with the winter rainfall.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Localised, but not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

General: In September 2004, few plants of *Othonna cremnophila* were noticed in accessible sites on the cliffs, stunted and malformed owing to heavy grazing.

Horticulture: Best for succulent karoo gardens, grown in rockeries or containers, in full sun (Van Jaarsveld 2000b). Outside its arid habitat, it should be grown under controlled conditions in a greenhouse. Introduced into cultivation in 1980. Plants easily grown from seed sown in autumn.

VOUCHER

Van Jaarsveld 19119 (NBG).

ILLUSTRATIONS AND MAP

Frontispiece on p. ii, Plate 88, Figures 88a–88c, Map 88.

89. *Othonna triplinervia* DC., Prodrumus 6: 478 (1838). (Cliff-face forms in tributaries of the Gamtoos River.)

Cremnophyte growth form: Squat thickset shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:Ev (r)

Etymology: The epithet *triplinervia* refers to the leaves, which often have three main veins on the lower surface.

DESCRIPTION AND HABITAT

Plants caulescent, evergreen, sparsely branched, forming small glabrous shrubs 240 mm in diameter. Branches decumbent to erect, up to 220 mm long, tapering to about 5–8 mm in diameter; caudex up to 70 × 50 mm, with smooth grey-brown bark and small leaf scars (cicatricose). Leaves fleshy, spreading, ascending, 24–45 × 22–35 mm, crowded at apex of branches, obovate; surface glaucous, 3-nerved, lower surface with powdery bloom; margin entire or sometimes shallowly to deeply lobed or toothed (up to 4-toothed or -lobed); apex obtuse; petiole short, 3–5 mm long. Inflorescence 110–200 mm long, a loose terminal corymb bearing up to 7 heads; peduncles 60–130 mm long. Capitulum 10 × 6 mm. Ray florets 5, ligulate, 15–24 × 7–8 mm, conspicuous, bright yellow. Seed (achene) hairy (villous), with long bristle-like pappus.

Phenology: Flowering almost throughout the year but with a peak in winter and spring (June–November). Seed (achenes) wind-dispersed.

Pollinators: Insects such as butterflies and bees.

Habitat and aspect: Sandstone cliffs and mainly on shady southern slopes. Plants rooted in crevices and on rock ledges, the long extended branches rooting where they touch the soil or a crevice. Extreme temperatures as high of 40°C have been recorded. Winters are cooler but frost is a rarity or absent owing to the sheer habitat. The average daily maximum temperature is 25°C and the average daily minimum is about 12°C. Rainfall in summer and winter but more in spring or autumn, ranging from 300–500 mm per annum.

Altitude: 400–700 m.

Associated vegetation: Mainly Gamtoos Thicket (Albany Thicket Biome) (Mucina *et al.* 2005).

Associated cremnophytes: At the Kouga Dam, *Othonna triplinervia* grows with *Adromischus cristatus* var. *zeyheri*, *Aloe perfoliata*, *A. pictifolia*, *Crassula perforata*, *Gasteria glomerata* and *Lampranthus affinis*.

Geology: Mainly quartzitic sandstone of the Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Othonna triplinervia tends to be confined to the cliffs of the Gamtoos River and its tributaries (Grootrivier, Baviaanskloof and Kouga River).

RELATED SPECIES

Othonna triplinervia belongs to section *Carnosa* (about 30 species) and is one of the few evergreen and easily grown species. It is one of four *Othonna* species confined to cliffs. The others are the two summer-deciduous species *O. cremnophila* (Rosyntjieberg, Richtersveld) and *O. armiana* (Eksteenfontein, Richtersveld) and the evergreen, pendent *O. capensis* (Eastern Cape). There are two distinct elements (forms) of *O. triplinervia*, the first a tall, erect shrub, usually locally common and occurring in hilly terrain. The second is an obligate cremnophyte, a small, thick-stemmed shrublet, discussed here (see Van Jaarsveld 2006c).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The plants have a squat, compact growth and the branches can become spreading and drooping. The succulent stem conserves water, which is then available during dry periods between rainfall events.

Size and weight: Clusters small.

Leaves

Orientation: Ascending, lobed, succulent, helping to store moisture.

Colour: Glaucous green, pruinose (bluish green covered with a powdery bloom), a character enabling the plant to conserve water.

Age and persistence: Plants evergreen, but leaves withering from the base, becoming turgid after rain.

Armament: The plants are soft and fragile, without armament.

Sexual reproduction

Inflorescence and flowers: The inflorescence is large in comparison to plant size, a condition that can be viewed as rich flowering.

Fruit/Seed

Size: Achene hairy (villous), with long, bristle-like pappus.

Dispersal: Achenes dispersed by wind.

Time: Achenes ripening throughout the year, and also coinciding with the rainfall.

Vegetative reproduction: When stems come into contact with the soil or find adjacent crevices, they root and form new colonies. Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival.

CONSERVATION STATUS

Confined to cliffs and not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Common name: Kouga cliff-daisy.

Horticulture: Plants easily grown from stem cuttings or seed and grown as a specimen pot collection. Best for thicket gardens, grown on balconies, steep embankments, in hanging baskets, on window sills or as a pot plant, in full sun or dappled shade.

VOUCHER

Van Jaarsveld 17122 (NBG).

ILLUSTRATIONS AND MAP

Plate 89, Figures 89a–89e, Map 89.

SENECIO L.

90. *Senecio medley-woodii* Hutch. in *The Flowering Plants of South Africa* 3: t. 83 (1923).

Cremnophyte growth form: Subpendent shrublet (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:As:S/H:Els (vb) (r)

Etymology: After the botanist John Medley Wood (1827–1915) of present-day KwaZulu-Natal.

DESCRIPTION AND HABITAT

Spreading, decumbent, sparsely branched shrublets up to 800 mm in diameter, covered with dense felt-like hairs, becoming glabrescent in part. Roots fibrous. Branches terete, succulent, greyish to purplish green, succulent, tapering, up to 400 mm long, at first soft, becoming firm and deciduous towards base. Leaves dorsiventrally flattened, ascending, shortly petiolate, firm, succulent, obovate to rhombic, 35–60 × 15–40 mm; surface whitish green owing to dense mat of white woolly hairs, becoming glabrescent with age, exposing the green surface; margin reddish, entire or bearing up to 5 shallow to larger triangular teeth; base cuneate; apex acute, mucronate. Inflorescence up to 14-flowered, a terminal loose corymb up to 190 mm

long; peduncle 30–90 mm long with a few smaller leaf-like bracts. Capitulum 37–50 mm in diameter, honeycombed at base, with up to 15 phyllaries. Ray florets up to 13, bright yellow. Disc florets dirty yellow. Achene linear, up to 4 mm long; pappus 9–10 mm long.

Phenology: Flowering from summer to early winter (February–July).

Pollinators: Insects.

Habitat and aspect: Vertical quartzitic sandstone or shale cliffs. Plants rooted in crevices and on rock ledges. Extreme temperatures as high of 40°C have been recorded. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is 24°C and the average daily minimum is 16°C. Rainfall mainly from spring to autumn but occasionally also in winter, ranging from 1000–1250 mm per annum.

Altitude: 460–800 m.

Associated vegetation: Mainly Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus cristatus* var. *zeyheri*, *Aloe arborescens*, *Cotyledon orbiculata* var. *oblonga*, *Crassula perfoliata* var. *perfoliata*, *C. perforata*, *C. sarmentosa* var. *integrifolia*, *Delosperma* sp. A, *D. tradescantioides*, *Petopentia natalensis* and *Plectranthus ernstii*.

Geology: Mainly quartzitic sandstone of the Natal Group (Cape Supergroup), also on Beaufort shale (Karoo Supergroup).

DISTRIBUTION

Senecio medley-woodii is distributed from the Mzimvubu River (Port St Johns) in the south (Eastern Cape) to northern KwaZulu-Natal and just reaching Mpumalanga (cliffs adjacent to the Pongola River at Klipwal Gold Mine).

RELATED SPECIES

Senecio medley-woodii is related to *S. pyramidatus*, *S. haworthii* and *S. scaposus* occurring further to the south in the Eastern Cape. *Senecio scaposus* sometimes grows on cliffs. It differs from *S. pyramidatus* (thicket vegetation on hilly terrain) in being more flaccid and spreading.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading stems rooting where they find a crevice.

Size and weight: Clusters of medium weight to heavy in larger shrubs.

Leaves

Orientation: Ascending, often pointing towards the light source (tips towards the sun, thus the least amount of direct exposure), crowded, the dense mat of wool protecting the plants from excessive sunlight and heat.

Colour and texture: Green, but with a dense woolly surface.

Age and persistence: Plants evergreen, bearing firm, long-lived leaves, older leaves withering from the base. The fleshy leaves becoming turgid after rain, but often in a semi-desiccated state during dry periods.

Armament: The soft, fragile plants are without obvious armament. The leaf margin is entire (northern populations) or distinctly dentate (Mzimvubu River).

Sexual reproduction

Inflorescence and flowers: Inflorescence a loose, terminal 14-flowered corymb. Flowers conspicuous and large in comparison to plant size (rich flowering).

Fruit/Seed

Size: Achene 4 mm long (excluding pappus), acting like a parachute.

Dispersal: Achenes dispersed by wind.

Time: Achenes ripening in summer, autumn and late winter, coinciding with summer and autumn rainfall.

Vegetative reproduction: The spreading to subpendent stems are flaccid, rooting where they find adjacent ledges or crevices below, forming new colonies. Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival.

CONSERVATION STATUS

Localised and confined to the gorges but not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: *Senecio medley-woodii* has ornamental properties and is widely cultivated in South Africa. It is best for subtropical coastal gardens, grown on steep embankments, window sills or balconies. Plants easily grown from stem cuttings and make attractive pot plants (full sun or partial shade). Grow in a well-drained soil mixture.

VOUCHER

Van Jaarsveld, Xaba & Harrower 20 (NBG).

ILLUSTRATIONS AND MAP

Plate 90, Figures 90a–90c, Map 90.

91. *Senecio muirii* L.Bolus in *Annals of the Bolus Herbarium* 1: 192–193 (1915).

Cremonophyte growth form: Pendent leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb) (eg)

Etymology: After John Muir (1874–1947), Scottish physician and botanical explorer who settled in South Africa.

DESCRIPTION AND HABITAT

Spreading, decumbent to pendent, leafy, succulent herb up to 1 m in diameter, rooting where stems touch the ground, all parts glabrous. Branches 5–6 mm in diameter, terete, at first softly succulent (flaccid), becoming purplish grey and slightly woody, older leaves becoming deciduous from base; branch tips often with aerial roots, rooting in crevices. Leaves obovate to oblong-obovate, dorsiventrally flattened, always vertically produced in spite of stems being pendent or spreading, succulent, bluish green, pruinose, crowded towards branch tips; lower surface with 3 prominent translucent veins; margin entire or with 1–3 pairs of shallow teeth; apex rounded to subacute, mucronate; base cuneate; petiole short, up to 2 mm long. Inflorescence a spreading to drooping, terminal, sparsely branched, lax corymb, up to 150–250 mm long. Capitulum oblong, 10 × 5 mm, with up to 8 phyllaries. Achene 3 × 0.8 mm; pappus 5–6 mm long.

Phenology: Flowering in spring, summer and autumn, often depending on rainfall.

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone and shale cliffs overlooking the Gourits River (and eastern Olifants River tributaries, and as far east as Meiringspoort). Plants rooted in crevices and on ledges. On hot days (berg wind conditions), temperatures can go up to 40°C. The average daily maximum temperature is about 23°C and average daily minimum about 11°C. Rainfall mainly in winter and summer, ranging from 300–400 mm per annum (thunder showers and cyclonic winter rain).

Altitude: 300–800 m.

Associated vegetation: Southern Cape Valley Thicket (Mucina *et al.* 2005).

Associated cremonophytes: At Badspoort near Calitzdorp, it grows with *Albuca thermarum*, *Bulbine ramosa*, *Cotyledon tomentosa* var. *tomentosa*, *Crassula atropurpurea*, *C. badspoortense*, *C. lactea* and *Tromotriche choanantha*.

Geology: Quartzitic sandstone of the Peninsula Formation and Bokkeveld shale (Cape Supergroup).

DISTRIBUTION

Confined to the mountainous region of the Gourits River and its tributaries, mainly from Calitzdorp to the Gourits Bridge along the N2.

RELATED SPECIES

Senecio muiirii is a distinct species not closely related to any other *Senecio* species. In habit it is similar to *S. pondoensis* growing on similar cliff faces in the northeastern part of the Eastern Cape. The latter has subterete leaves with a distinctive window along the groove of the upper surface.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading shrublet with drooping, elongated stems, often phototropically negative and growing into crevices, rooting and forming new plants.

Size and weight: Plants of medium weight, large plants of medium weight to heavy.

Leaves

Orientation: Ascending, pointing towards the light source (tips towards the sun, thus the least amount of direct exposure), often crowded at branch ends.

Colour: Pruinose (bluish green covered with a powdery bloom).

Age and persistence: Evergreen, but leaves withering from the base, resulting in crowded leaves at the apices. Leaves becoming turgid after rain, but often in a semi-desiccated state during dry periods, then channelled. The leaves have three distinct translucent veins running along the lower leaf surface, providing avenues of light entering the inner tissues (coming into contact with chlorophyll).

Armament: The soft, fragile plants are without armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence a spreading to drooping, terminal, sparsely branched, lax inconspicuous corymb.

Fruit/Seed

Size: Achene 3×0.8 mm, pappus 5–6 mm long.

Dispersal: Achenes dispersed by wind.

Time: Achenes ripening in summer and autumn, coinciding with autumn rainfall.

Vegetative reproduction: The spreading, pendent stems will root where they find adjacent ledges or crevices, forming new colonies (stem apices often with adventitious roots). Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival.

CONSERVATION STATUS

Localised and confined to gorges but not threatened owing to its inaccessible, undisturbed habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket and subtropical coastal gardens (Van Jaarsveld 2010), grown on steep embankments, window sills or balconies, also thriving in containers, in full sun or partial shade. Propagate from cuttings from spring to autumn. Outside the native habitat, it should be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 16106 (NBG).

ILLUSTRATIONS AND MAP

Figures 91a–91e, Map 91.

92. *Senecio pondoensis* Van Jaarsv. & A.E.van Wyk in *Aloe* 45,2: 28–29 (2008a).

Cremonophyte growth form: Subpendent spreading shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Els (vb)

Etymology: After Pondoland in the Eastern Cape where this species occurs.

DESCRIPTION AND HABITAT

Spreading, decumbent, sparsely branched, glabrous shrublets, stoloniferous, rooting at nodes. Roots fibrous. Branches terete, succulent, up to 400 mm long, greyish to purplish green, succulent, tapering, at first soft, becoming firm and deciduous towards base. Leaves ascending, softly succulent, bluish green, pruinose, linear-fusiform, often falcate, 45–60 × 5–7 mm, subterete; older leaves paler, becoming deciduous towards base of stem; adaxial surface flat to grooved, with translucent window over length of groove, abaxial surface rounded with few faint striations; apex mucronate, purplish. Inflorescence a spreading, lax corymb, terminal, branched, purplish green, 60–80 mm long; bracts slender, linear, up to 5–11 × 0.5 mm. Capitula 4–8, campanulate, 10 × 3.5 mm, with up to 8 phyllaries; involucre bracts 1 or 2, whitish green, terete, 4 × 0.5 mm, purple-tipped. Disc florets tubular, 6–7 × 0.5 mm, with pappus of white bristles 4–5 mm long; tube greenish white in basal part, expanding and white over the distal 2 mm; corolla lobes white, 5.1 × 0.75 mm, acute. Stigma bifid, white, becoming 6.5 mm long after expanding slightly (1 mm) above capitulum. Anthers 1 × 0.5 mm; filaments 0.5 mm long. Achene 1.5 × 0.3 mm; pappus 4–5 mm long.

Phenology: Flowering in spring (October–November), but also in spring. Seeds (achenes) with non-specialist dispersal strategy; dispersed in summer and autumn.

Pollinators: Insects.

Habitat and aspect: Quartzitic south-facing sandstone cliffs and on top of ledges. Plants rooted in crevices and on rock ledges. Extreme temperatures as high of 40°C have been

recorded. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is 24°C and the average daily minimum is 16°C. Rainfall mainly from spring to autumn but occasionally also in winter, ranging from 1000–1250 mm per annum.

Altitude: 200–250 m.

Associated vegetation: Eastern Valley Bushveld (Mucina *et al.* 2005).

Associated cremnophytes: At the Mzamba River, *Senecio pondoensis* shares its habitat with *Adromischus cristatus* var. *zeyheri*, *Aloe arborescens*, *Cotyledon orbiculata* var. *oblonga*, *Crassula perfoliata* var. *perfoliata*, *C. perforata*, *C. sarmentosa* var. *integrifolia*, *Delosperma* sp. A and *Petopentia natalensis*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup).

DISTRIBUTION

Senecio pondoensis is known only from the Mzamba River Gorge (Eastern Cape).

RELATED SPECIES

Senecio pondoensis is related to *S. talinoides* of similar sites along dry river valleys, but differs in its soft nature, flaccid stems that are stoloniferous from the base, and in its leaves with a distinct long, narrow window on the midrib (upper surface).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading shrublet with decumbent stems rooting where they find a crevice, or producing stolons from the base. The leaves are crowded towards the ends of the branches.

Size and weight: Clusters small, of light to medium weight.

Leaves

Orientation: Ascending, often pointing towards the light source (tips towards the sun, thus the least amount of direct exposure), crowded, with longitudinal window allowing light to penetrate more efficiently on the shady south-facing cliffs, maximising absorption of light.

Colour: Pruinose (bluish green covered with a powdery bloom).

Age and persistence: Evergreen, but leaves withering from the base. The fleshy leaves becoming turgid after rain, but often in a semi-desiccated state during dry periods.

Armament: The soft, fragile plants lack conspicuous armament.

Sexual reproduction

Inflorescence and flowers: Capitula inconspicuous.

Fruit/Seed

Size: 1.5 × 0.3 mm pappus 4–5 mm long.

Dispersal: Achenes are wind-dispersed.

Time: Achenes ripen in summer and autumn and coinciding with autumn rainfall.

Vegetative reproduction: The spreading to subpendent stems will root where they find adjacent ledges or crevices below, forming new colonies. Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival. The basal stoloniferous nature also ensures continued vegetative regeneration.

CONSERVATION STATUS

Localised and confined to the gorges but not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens and steep embankments, window sills or balconies, also doing well in containers, in full sun or partial shade. Propagate from cuttings from spring to autumn. Outside the native habitat, it should be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 19297 (NBG).

ILLUSTRATIONS AND MAP

Plate 92, Figures 92a–92c, Map 92.

93. *Senecio serpens* G.D.Rowley in National Cactus and Succulent Journal 10,2: 31 (1955).

Cremonophyte growth form: Cluster-forming to drooping shrublets (of medium weight to heavy, cliff hugger).

Growth form formula: E:F:As:S/H:Els (vb)

Etymology: The epithet *serpens*, creeping, pertains to the stems.

DESCRIPTION AND HABITAT

Sprawling, decumbent to subpendent, branched, glabrous shrublets, forming loose mats, rooting at nodes, stoloniferous from base. Roots fibrous. Branches terete, succulent, up to 200 mm long; young branches flaccid, tapering, pruinose, becoming green and eventually grey green in old stems, 5–9 mm in diameter, covered in old leaf scars. Leaves variable in shape and size, dorsiventrally flattened, adaxially concave, becoming subterete when turgid, elliptic to linear-elliptic, 20–35 × 9–10 mm in exposed habitats, 35–45 × 10 mm in

protected sites, often flattened fusiform; margin entire; surface densely pruinose, both surfaces with 8–19 translucent veins, adaxial surface flat to concave or grooved, abaxial surface rounded; apex obtuse to acute, mucronate, brownish to purplish. Inflorescence an erect, terminal, branched corymb, 200–300 mm high, with few linear bracts up to 5 mm long, discoid. Capitula few, with 10–14 phyllaries 12 mm long. Disc florets 15–30, white; corolla lobes recurved. Achene hispid.

Phenology: Flowering from spring to autumn (October–May).

Pollinators: Insects.

Habitat and aspect: Vertical quartzitic sandstone cliffs (all aspects). Plants rooted in crevices and on rock ledges. Extreme temperatures as high of 40°C have been recorded. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is 22°C and the average daily minimum is 12°C. Rainfall mainly in winter and occasionally in summer, about 500–700 mm per annum.

Altitude: 300–1000 m.

Associated vegetation: Peninsula Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnoophytes: At Chapman’s Peak cliffs, it grows with *Adromischus hemisphaericus*, *Aloe maculata*, *Cotyledon orbiculata* var. *orbiculata*, *Crassula nudicaulis*, *C. rupestris*, *Euphorbia caput-medusae*, *Lampranthus falciformis* and *Ruschia promontorii*.

Geology: Quartzitic sandstone, Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Restricted mainly to the Cape Peninsula, but with outliers from Rooiels and Hangklip to near Hermanus.

RELATED SPECIES

Related to *Senecio crassulaefolius*, a common, widespread species with much larger, erect stems and sturdier, less flaccid leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading to sprawling stems rooting where they find a crevice. Compact, bluish green leaves in apical clusters. The vegetative reproductive mode is a natural backup system ensuring long-term survival on the cliff face.

Size and weight: Clusters small, of light weight.

Leaves

Orientation: Ascending, often pointing towards the light source (tips towards the sun, thus the least amount of direct exposure), crowded, with longitudinal translucent veins allowing

light to penetrate more efficiently, especially on shady south-facing cliffs. Leaves becoming channelled during the dry season.

Colour: Pruinose (bluish green, covered with a powdery bloom).

Age and persistence: Evergreen, but leaves withering from the base. The fleshy leaves becoming turgid after rain, but often in a semi-desiccated state during dry periods, also channelled during dry periods, an adaptation to the extreme, dry habitat.

Armament: The soft, fragile plants are without armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence inconspicuous.

Fruit/Seed

Size: Not seen.

Dispersal: Achenes are dispersed by wind.

Time: Achenes ripening in winter, coinciding with autumn rainfall.

Vegetative reproduction: The spreading, decumbent to subpendent stems will root where they find adjacent ledges or crevices, forming new colonies. Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival.

CONSERVATION STATUS

Localised, common in the habitat and not threatened.

ADDITIONAL NOTES

Horticulture: *Senecio serpens* is an ornamental species (striking with its bluish green leaves) best for fynbos gardens, grown on steep embankments, window sills or balconies, also thriving in containers, in full sun or partial shade (Van Jaarsveld 2000b). Propagate from cuttings from spring to autumn. Outside the native habitat, it should be grown under controlled greenhouse conditions.

VOUCHER

Van Jaarsveld 19955 (NBG).

ILLUSTRATIONS AND MAP

Figures 93a–93d, Map 93.

94. *Senecio talinoides* Sch.Bip. subsp. *talinoides*, Schultz in Flora 28: 499 (1845).

Cremonophyte growth form: Decumbent shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Els (vb)

Etymology: The epithet *talinoides* alludes to similarity to the genus *Talinum* in the family Portulacaceae.

DESCRIPTION AND HABITAT

Spreading, decumbent, sparsely branched, glabrous shrublets, rooting at nodes. Roots fibrous. Branches terete, succulent, up to 400 mm long, greyish to purplish green, often with remnants of old petioles, tapering, at first soft, becoming firm and deciduous towards base. Leaves ascending, firm, succulent, dull bluish green, pruinose, crowded towards branch tips, linear-fusiform, often falcate, 45–80 × 5–7 mm, subterete; adaxial surface flat to slightly grooved, abaxial surface rounded, with few faint striations; apex mucronate; older leaves paler, becoming deciduous towards base of stem. Inflorescence a spreading, terminal, branched, purplish green, lax corymb, 60–80 mm long, with small bracts and 4–8 campanulate capitula. Capitulum 10 × 3.5 mm, with up to 8 phyllaries; involucre bracts 1 or 2, whitish green, terete, 2 × 0.5 mm. Stigma bifid, white, becoming extended above capitulum. Achene oblong, 4 × 0.5 mm; pappus 7 mm long.

Phenology: Spring (October–November), but also after rain.

Pollinators: Insects.

Habitat and aspect: Quartzitic south-facing sandstone cliffs. Plants rooted in crevices and on rock ledges. Extreme temperatures as high of 40°C have been recorded. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is 24°C and the average daily minimum is 16°C. Rainfall mainly from spring to autumn but occasionally also in winter, ranging from 1000–1250 mm per annum.

Altitude: 400–1800 m.

Associated vegetation: Mainly Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremonophytes: At the Bashee River at Collywobbles, *Senecio talinoides* grows on south-facing cliffs together with *Adromischus cristatus* var. *zeyheri*, *Aloe reynoldsii*, *Bulbine thomasiae*, *Cotyledon orbiculata* var. *flanaganii*, *Crassula perfoliata* var. *perfoliata*, *C. perforata* and *Haworthia cymbiformis* var. *setulifera*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup) and Beaufort shale (Karoo Supergroup).

DISTRIBUTION

Senecio talinoides occurs widespread along the cliffs of the dry river valleys of the Eastern Cape, from the Mzimvubu River in the north to East London in the south.

RELATED SPECIES

Senecio talinoides is related to *S. pondoensis* growing on similar cliff faces of the Eastern Cape. It is at once distinguished by its firmer leaves lacking the window on the adaxial surface. It is also related to the robust *S. ficoides* commonly found in thickets of the Eastern Cape growing on various formations and often also on cliff faces. The latter has much larger leaves and inflorescence.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading stems rooting where they find a crevice. Compact, bluish green leaves are cluster-forming, providing some shade.

Size and weight: Clusters small to medium-sized, large specimens of medium weight to heavy.

Leaves

Orientation: Ascending, often pointing towards the light source (tips towards the sun, thus the least amount of direct exposure), crowded.

Colour: Dull green, pruinose (covered with a powdery bloom).

Age and persistence: Evergreen, but leaves withering from the base, resulting in crowded leaves at the apices. Leaves becoming turgid after rain, but often in a semi-desiccated state during dry periods and then also channelled, an adaptation to the extreme, dry habitat.

Armament: The aromatic resinous sap is a deterrent to many insect species.

Sexual reproduction

Inflorescence and flowers: Inflorescence inconspicuous.

Fruit/Seed

Size: Achene oblong, grooved, 4×0.5 mm, pappus 7 mm long.

Dispersal: Achenes dispersed by wind.

Time: Achenes ripening in summer and autumn, coinciding with autumn rainfall.

Vegetative reproduction: The spreading, decumbent to subpendent stems will root where they find adjacent ledges or crevices, forming new colonies. Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival.

CONSERVATION STATUS

Localised and confined to steep gorges and river valleys, but not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket and subtropical coastal gardens (Van Jaarsveld 2000b), grown on steep embankments, window sills or balconies, also doing well in containers, in full sun or partial shade. Propagate from cuttings from spring to autumn. Outside its native habitat, it should be grown under controlled conditions in a greenhouse.

VOUCHERS

Van Jaarsveld 17804, 17873 (NBG).

ILLUSTRATIONS AND MAP

Figures 94a–94c, Map 94.

CACTACEAE

Rhipsalis Gaertn.

95. *R. baccifera* (J.Mill.) Stearn subsp. *mauritiana* (DC.) Barthlott

RHIPSALIS Gaertn.

95. *Rhipsalis baccifera* (J.Mill.) Stearn subsp. *mauritiana* (DC.) Barthlott in *Bradleya* 5: 100 (1987).

Cremnophyte growth form: Drooping terete stems (of medium weight, cliff hanger).

Growth form formula: E:Ex:P:St (vb) (eg)

Etymology: The epithet *baccifera*, bearing berries, pertains to the fruit.

DESCRIPTION AND HABITAT

Spreading, much branched, cluster-forming stem succulent, with drooping branches up to 600 mm long. Roots fibrous. Stems articulated, terete, soft green to reddish green, 3–6 mm in diameter, with scattered areoles with soft bristles (up to 4 mm long), especially in young plants. Flowers 1 or 2 per areole, green, small, inconspicuous, self-fertile; hypanthium bulbous, with few sepaloid segments and reduced areoles; petaloid segments oblong, 4–6, up to 3 mm long. Stamens 5–10. Ovary embedded in hypanthium; style short. Berry sessile, globose to oblong-globose, up to 10 mm in diameter. Seed oblong, irregular, 1 mm long, black to dark brown, shiny, reticulate.

Phenology: Flowering in spring and summer. Berries dispersed by frugatory birds.

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone or shale cliffs. Plants rooted in crevices and on rock ledges but also epiphytic in trees. Winters are cool but frost is a rarity or absent. The average daily maximum temperature is about 24°C and the average daily minimum about 16°C. Rainfall mainly from spring to autumn but occasionally also in winter, ranging from 1000–1250 mm per annum.

Altitude: 1000–1750 m.

Associated vegetation: Mainly KwaZulu-Natal Coastal Belt of the Indian Ocean Coastal Belt and Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Oribi Gorge, *Rhipsalis baccifera* grows together with *Aloe arborescens*, *Crassula perforata*, *C. perfoliata* var. *perfoliata*, *Delosperma* sp. A, *D. tradescantioides*, *Gasteria croucheri*, *Petopentia natalensis*, *Plectranthus ernstii* and *Senecio medleyi-woodii*.

Geology: Mainly sandstone of the Natal Group (Cape Supergroup), also on shale.

DISTRIBUTION

Rhipsalis baccifera subsp. *mauritiana* occurs widespread in southeastern Africa and central Africa, Madagascar and most of the Indian Ocean islands.

RELATED SPECIES

Rhipsalis baccifera subsp. *mauritiana* has no relatives in South Africa, in fact it is the only member of the Cactaceae in South Africa.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading, leafless stems, often with aerial roots where they find a crevice.

Size and weight: Clusters small to medium-sized, of light to medium weight.

Stems: Stems terete, pendent from a clustered growth, taking over the photosynthesis process, becoming purplish green to reddish green during stress owing to the production of anthocyanins.

Leaves

Orientation: Leaves absent.

Armament: The soft, fragile plants are without obvious armament.

Sexual reproduction

Inflorescence and flowers: Flowers 1 or 2 per areole, green, small, inconspicuous, self-fertile.

Fruit/Seed

Size: Seed 1 mm long, irregular.

Dispersal: Seed embedded in a fleshy white berry and dispersed by birds.

Time: Seeds ripening in summer and autumn, coinciding with summer and autumn rainfall.

Vegetative reproduction: The drooping to subpendent stems will root where they find adjacent ledges or crevices, forming new colonies. Detached plants landing in crevices or on ledges will root, an extensive vegetative backup strategy aiding long-term survival.

CONSERVATION STATUS

Rhipsalis baccifera subsp. *mauritiana* is localised and confined to cliffs or grows as an epiphyte on trees, but it is not threatened owing to the inaccessible habitat. In spite of its traditional medicinal use, it is still common (Smith *et al.* 1999).

ADDITIONAL NOTES

Cultural use: Smith *et al.* (1999) reported the sale of *Rhipsalis baccifera* on the medicinal plant (muti) market in Durban. It is locally known by its Zulu name *ugebeleweni*, which means ‘hanging from the cliffs’. It is mixed with other plant ingredients and used for magical purposes. Its Afrikaans name, *bostou*, means ‘rope from the forest’.

Horticulture: *Rhipsalis baccifera* is a collector’s item, best for subtropical coastal gardens. It can be grown on steep embankments, window sills or balconies, and also thrives in containers or hanging baskets, in full sun or partial shade. Propagate from cuttings from spring to autumn. Outside the native habitat, it should be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 22399 (NBG).

ILLUSTRATIONS AND MAP

Figures 95a & 95b, Map 95.

CRASSULACEAE

Adromischus Lem.

96. *A. cristatus* (Haw.) Lem. var. *mzimvubuensis* Van Jaarsv.
97. *A. cristatus* (Haw.) Lem. var. *schonlandii* (E.Phillips) Toelken
98. *A. cristatus* (Haw.) Lem. var. *zeyheri* (Harv.) Toelken
99. *A. diabolicus* Toelken
100. *A. fallax* Toelken
101. *A. leucophyllus* Uitewaal
102. *A. liebenbergii* Hutchison subsp. *orientalis* Van Jaarsv.
103. *A. schuldianus* (Poelln.) Poelln. subsp. *brandbergensis* B.Nord. & Van Jaarsv.
104. *A. subdistichus* Makin ex Bruyns
105. *A. umbraticola* C.A.Sm. subsp. *ramosus* Toelken

Cotyledon L.

106. *C. barbeyi* Schweinf. var. A
107. *C. eliseae* Van Jaarsv.
108. *C. pendens* Van Jaarsv.
109. *C. tomentosa* Harv. subsp. *tomentosa*

Crassula L.

110. *C. alba* Forssk. var. *pallida* Toelken
111. *C. atropurpurea* (Harv.) D.Dietr. var. *anomala* (Schönland & Baker f.) Toelken
112. *C. aurusbergensis* G.Will.
113. *C. badspoortense* Van Jaarsv.
114. *C. brachystachya* Toelken
115. *C. capitella* Thunb. subsp. *thyrsiflora* (Thunb.) Toelken (*C. turrita*)
116. *C. cremnophila* Van Jaarsv. & A.E.van Wyk
117. *C. cymbiformis* Toelken
118. *C. exilis* Harv. subsp. *cooperi* (Regel) Toelken
119. *C. exilis* Harv. subsp. *exilis*
120. *C. exilis* Harv. subsp. *sedifolia* (N.E.Br.) Toelken
121. *C. expansa* Dryand. subsp. *fragilis* (Baker) Toelken
122. *C. foveata* Van Jaarsv.
123. *C. intermedia* Schönland
124. *C. lanuginosa* Harv. var. *lanuginosa*
125. *C. montana* Thunb. subsp. *montana*
126. *C. montana* Thunb. subsp. *quadrangularis* (Schönland) Toelken
127. *C. nemorosa* (Eckl. & Zeyh.) Endl. ex Walp.
128. *C. orbicularis* L.
129. *C. peculiaris* (Toelken) Toelken & Wickens
130. *C. pellucida* L. subsp. *spongiosa* Toelken
131. *C. perforata* Thunb. subsp. *kougaensis* Van Jaarsv. & A.E.van Wyk
132. *C. perforata* Thunb. subsp. *perforata*
133. *C. pseudohemisphaerica* Friedrich
134. *C. pubescens* Thunb. subsp. *rattrayi* (Schönland & Baker f.) Toelken
135. *C. rupestris* Thunb. subsp. *marnieriana* (H.E.Huber & H.Jacobsen) Toelken
136. *C. rupestris* Thunb. subsp. *rupestris* (cliff form)
137. *C. sediflora* (Eckl. & Zeyh.) Endl. & Walp. var. *sediflora*

138. *C. sericea* Schönland var. *sericea*
139. *C. setulosa* Harv. var. *jenkinsii* Schönland
140. *C. setulosa* Harv. var. *longiciliata* Toelken
141. *C. setulosa* Harv. var. *setulosa*
142. *C. sladenii* Schönland
143. *C. smithii* Van Jaarsv., D.G.A.Styles & G.McDonald
144. *C. socialis* Schönland
145. *C. streyi* Toelken
146. *C. tabularis* Dinter
147. *C. tomentosa* Thunb. var. *glabrifolia* (Harv.) Toelken

Tylecodon Toelken

148. *T. aurusbergensis* G.Will. & Van Jaarsv.
149. *T. bleckiae* G.Will.
150. *T. bodleyae* Van Jaarsv.
151. *T. bruynsii* Van Jaarsv. & S.A.Hammer
152. *T. buchholzianus* (Schuldt & P.Stephan) Toelken var. *fasciculatus* G.Will.
153. *T. cordiformis* G.Will.
154. *T. decipiens* Toelken
155. *T. ellaphieae* Van Jaarsv.
156. *T. longipes* Van Jaarsv. & G.Will.
157. *T. petrophilus* Van Jaarsv. & A.E.van Wyk
158. *T. singularis* (R.A.Dyer) Toelken
159. *T. sulphureus* (Toelken) Toelken var. *armianus* Van Jaarsv.
160. *T. torulosus* Toelken
161. *T. viridiflorus* (Toelken) Toelken

ADROMISCHUS Lem.

96. *Adromischus cristatus* (Haw.) Lem. var. *mzimvubuensis* Van Jaarsv., in Van Jaarsveld & Van Wyk in Aloe 40,2: 40 (2003f).

Cremnophyte growth form: Cluster-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:Lc:Ts (vb)

Etymology: After its cliff-face habitat along the Mzimvubu River.

DESCRIPTION AND HABITAT

Plants sparsely branched, almost acaulescent, up to 60 mm high (without inflorescence), 60–110 mm in diameter. Roots fibrous. Branches erect to decumbent, very short, up to 10 mm, green, usually not visible owing to reddish brown aerial roots. Leaves crowded, in lax to dense rosette up to 110 mm in diameter, lorate-obovate to broadly obovate, 40–80 × 20–30 mm, biconvex when turgid, dorsiventrally compressed, ascending, distal third or apex incurved and flat to slightly concave; apex truncate to rounded; base cuneate, decurrent on stem; surface immaculate, slightly hairy, becoming glabrescent, pale green to olive-green; margin horny, straight to undulating, continuous on to stem. Inflorescence a simple or

branched, brownish green, spike-like thyrse up to 230 mm high, bearing 2- or 3-flowered cymes; surface covered with club-shaped trichomes; bracts triangular, adpressed, 3×1 mm; buds ascending, spreading, slightly tapering; pedicels 1.0–1.5 mm long. Calyx tubular, 3.5 mm long; lobes triangular, $1.5\text{--}2.0 \times 1$ mm. Corolla tubular, 12×4 mm; tube cylindrical, grooved, pale green, dotted with maroon; lobes broadly triangular-ovate, 5×3 mm, white-pink, maroon-red at throat, cuspidate, at first spreading, becoming recurved against tube with bases of lobes fused for 1.5 mm; apex purplish mottled; throat rough owing to club-shaped trichomes. Stamens 10 mm long, shortly included, fused to lobes in basal half; anthers yellowish, 7×4 mm. Squamae translucent, rectangular, 8×8 mm; apex slightly emarginate. Carpels 8 mm long tapering into long, erect styles.

Phenology: Flowering in summer and autumn (November–January).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: *Adromischus cristatus* var. *mzimvubuensis* was observed only on Ecca Shale cliffs (Karoo Supergroup), on all aspects. Temperatures vary and may reach 40°C in summer. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is about 22°C and the average daily minimum about 12°C . Rainfall occurs mainly in summer and ranges from 400–700 mm per annum.

Altitude: 460–800 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Cotyledon orbiculata* var. *flanaganii* (easternmost record), *Crassula cultrata* (easternmost record), *C. intermedia*, *C. multicava* subsp. *floribunda*, *C. perforata*, *Cyanotis speciosus*, *Delosperma tradescantioides*, *Gasteria croucheri* (southernmost record), *Ornithogalum longibracteatum*, *Senecio medley-woodii* and *Senecio* sp.

Geology: It was observed only on sheer Ecca shale cliffs (Karoo Supergroup), on all aspects.

DISTRIBUTION

Adromischus cristatus var. *mzimvubuensis* is confined to the Mzimvubu River in the Eastern Cape. The plants vary considerably in size and leaf shape, some forms with almost obovate leaves (more exposed north- and west-facing) and undulating margins, whereas others have mostly oblong leaves without the undulations. They are locally quite common.

RELATED SPECIES

Adromischus cristatus var. *mzimvubuensis* vary considerably in size and leaf shape, some forms with almost obovate leaves (more exposed north- and west-facing sites) and undulating margins, whereas others have mostly oblong leaves without the undulations. They are locally quite common. It is distinguished from the other varieties by its acaulescent rosettes of dorsiventrally flattened leaves which are often incurved, with a continuous horny margin to the base of the petioles. It has ginger-brown aerial roots and 2- or 3-flowered cymes. All the other varieties (var. *cristatus*, var. *clavifolius*, var. *schonlandii* and var. *zeyheri*) have stems that are 20–50 mm long and leaves with distinct petioles. The horny margin in the other varieties does not extend right around the leaf, and is confined to the distal part of the leaf. In

var. *zeyheri* (its closest relative) the margin sometimes extends to about a third from the base. The latter, however, lacks aerial roots and always develops stems up to 50 mm long. In both var. *mzimvubuensis* and var. *zeyheri* the leaves are dorsiventrally flattened. Another difference is the 3-flowered cymes found on the inflorescence, compared to the usually 1-flowered (rarely 2-) cymes in the other varieties. Var. *cristatus*, var. *clavifolius* and var. *schonlandii* are all confined to the Eastern Cape region west of the Kei River. Var. *zeyheri* is confined to quartzitic sandstone cliff faces in the Kouga Mountains and appears again in Oribi Gorge in southern KwaZulu-Natal, and remains remarkably constant, taking into consideration that var. *mzimvubuensis* occurs in between these two localities.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The plants form loose, much-branched clusters with leaves crowded at the apices. Conspicuous, often sprawling from the cliff face, well adapted to its well-drained, vertical habitat.

Size and weight: Clusters small, of light weight.

Stem: Branches erect to decumbent, very short (up to 10 mm), green and usually not visible owing to reddish brown aerial roots.

Leaves

Orientation: The relatively large leaves maximising absorption of light on the shady cliffs. Leaves firm, becoming easily detached by slight disturbances.

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Flowering in summer (November–January).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsule dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Autumn, coinciding with autumn rain and thus maximising establishment.

Vegetative reproduction: Like other *Adromischus* species, this plant proliferates from leaves that have become detached, a vegetative reproductive backup system ensuring long-term survival.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: *Adromischus cristatus* var. *mzimvubuensis* is most suitable for thicket and subtropical coastal gardens, best grown in partial shade in containers. The soil should be sandy and well drained. Keep dry during the winter months. Easily cultivated and propagated from leaf cuttings.

VOUCHER

Van Jaarsveld, Xaba & Harrower 101 (NBG).

ILLUSTRATIONS AND MAP

Figures 96a–96d, Map 96.

97. *Adromischus cristatus* (Haw.) Lem. var. *schonlandii* (E.Phillips) Toelken in *Bothalia* 12: 390 (1978).

Cremnophyte growth form: Small, cluster-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:Lc:Ts (vb)

Etymology: In honour of Selmar Schönland (1860–1940), German botanist who worked in South Africa.

DESCRIPTION AND HABITAT

Small, compact, little-branched (2–5-branched) succulents, up to 60 mm in diameter. Stems up to 30 mm long, succulent, densely covered with aerial roots, 5–70 mm in diameter. Leaves densely crowded, narrowly obtriangular to club-shaped, 15–30 × 10–15 mm; surface green to yellowish green, glandular hairy; margin acute, undulating, horny, purplish brown; apex obtuse, rounded or sometimes truncate; base cuneate; petiole terete, decurrent on blade. Inflorescence a spike-like thyrses, 120–170 mm high, bearing 1-flowered cymes; pedicel 1 mm long; buds spreading, terete, tapering, purplish tipped. Calyx 2–3 mm long. Corolla 11–13 mm long; tube green, up to 3 mm in diameter when fully opened; lobes ovate-triangular, up to 4 mm, white to pinkish, with club-shaped trichomes in throat; apices acute. Anthers included.

Phenology: Flowering in summer and autumn (January–May).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: Shady quartzitic sandstone cliff faces in deep kloofs and river gorges, on all aspects but more common on the southern faces. Temperatures vary and may reach 40°C in summer. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is about 22°C and the average daily minimum 11°C. Rainfall occurs mainly in summer but also in winter, ranging from 300–400 mm per annum.

Altitude: 100–1500 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Plants in the Baviaanskloof grow together with *Adromischus cristatus* var. *zeyheri*, *Aloe pictifolia*, *Bulbine natalensis*, *Crassula rupestris* and *Cyrтанthus montanus*.

Geology: Quartzitic sandstone of the Peninsula Formation and Natal Group (Cape Supergroup).

DISTRIBUTION

Adromischus cristatus var. *schonlandii* is known only from the tributaries of the Gamtoos River (Baviaanskloof, Kouga River and Grootrivier) near Patensie in the east (Eastern Cape).

RELATED SPECIES

Distinguished from the other varieties by its almost obtriangular, club-shaped, very brittle leaves and herb-like aroma.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants form small globose clusters (leaves crowded at the apex).

Size and weight: Clusters of light weight.

Stem: Succulent and up to 7 mm in diameter, covered with the dense aerial roots.

Leaves

Orientation: Narrow, obtriangular to club-shaped leaves maximising water storage in the well-drained cliff environment. In older specimens the blade is sometimes almost terete and sticky.

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face. The herb-like smell perhaps a chemical defence against phytophagous insects.

Sexual reproduction

Flowers: Flowering from summer to autumn (November–May), but sporadically at other times.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsule dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Autumn and winter, coinciding with the cooler rainy season and thus maximising establishment.

Vegetative reproduction: The leaves become detached very easily and will root, proliferate and establish new colonies if they fall into a new crevice, an efficient vegetative backup or adaptation to the xeric cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Variability: Local variation within a short range (fragility, shape and size of leaves) shows genetic plasticity and adaptability to the cliff face.

Horticulture: Easily cultivated from leaf cuttings or division; its vigour can be viewed as maximising survival. Does well in containers, in partial shade. Best for thicket gardens. Grow where frost is not severe.

VOUCHERS

Van Jaarsveld 15348, 17102 (NBG).

ILLUSTRATIONS AND MAP

Plate 97, Figures 97a–97d, Map 97.

98. *Adromischus cristatus* (Haw.) Lem. var. *zeyheri* (Harv.) Toelken in *Bothalia* 12: 390 (1978).

Cremonophyte growth form: Small, subpendent, cluster-forming (of light to medium weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: In honour of Karl Zeyher (1799–1858), well known German botanical explorer in South Africa.

DESCRIPTION AND HABITAT

Small, compact to lax, little-branched, succulent shrublets. Stems succulent, green, 5–10 mm in diameter, sometimes drooping from cliff faces. Roots fibrous; aerial roots absent or rarely produced. Leaves variable in size and shape, broadly obtriangular, dorsiventrally flattened, 20–60 × 15–45 mm; surface green to yellowish green, glandular hairy; margin acute, undulating, horny, green to purplish brown; apex obtuse, rounded or truncate; base cuneate; petiole terete, decurrent on blade. Inflorescence a spike-like thyrses 140–380 mm high, bearing 1-flowered cymes; pedicel 1 mm long; buds spreading, terete, tapering, purplish tipped. Calyx

2–3 mm long. Corolla 10–12 mm long; tube green, up to 8 mm in diameter when fully opened; lobes ovate-triangular, up to 4 mm, white to pinkish, with club-shaped trichomes in throat; apices acute. Anthers included.

Phenology: Flowering in summer and autumn (January–May).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: Quartzitic sandstone cliff faces, in deep, sheltered, shady kloofs and river gorges, on all aspects but more on the south-facing ones. Temperatures vary and may reach 40°C in summer. Winters are cooler but frost is a rarity or absent. Average daily maximum temperature is 20–23°C and average daily minimum 10–14°C. Rainfall occurs mainly in summer, but in the southern parts in winter as well, ranging from 300–700 mm per annum.

Altitude: 50–800 m.

Associated vegetation: Mainly Gamtoos Thicket and KwaZulu-Natal Coastal Belt of the Indian Ocean Coastal Belt (Mucina *et al.* 2005).

Associated cremnophytes: On south-facing cliffs at Oribi Gorge, plants of *Adromischus cristatus* var. *zeyheri* grow in association with *Aloe arborescens*, *Bulbine natalensis*, *Delosperma ecklonis*, *Gasteria croucheri* and *Plectranthus ernstii*.

Geology: Quartzitic sandstone of the Peninsula Formation and Natal Group (Cape Supergroup).

DISTRIBUTION

Adromischus cristatus var. *zeyheri* has a disjunct distribution. Known from the tributaries of the Gamtoos River (Baviaanskloof, Kouga River and Grootrivier) near Patensie in the east (Eastern Cape) and then again from Oribi Gorge and Umtamvuna River Valley (KwaZulu-Natal) and the adjacent Mzamba River (Eastern Cape).

RELATED SPECIES

Differs from var. *cristatus* by its longer, green, hairless branches up to 100 mm long (little or unbranched) and leaves of which the upper margin is broad and undulating. Distinguished from the ordinary level-ground forms of *Adromischus cristatus* by its longer stems, which are less compact, and by a lack of the conspicuous aerial roots of the latter. The var. *zeyheri* has larger, broader, flattened leaves that are not brittle when handled.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants form loose, little-branched subpendent clusters with leaves crowded at the apices. Stems becoming subpendent to pendent, up to 200 mm long, an adaptation to its xeric but shady conditions.

Size and weight: Clusters of small to medium weight.

Stem: Succulent, green, and up to 10 mm in diameter, not covered with the dense aerial roots as in level-ground species, a character that can be related to its shady, south-facing habitat and

optimising absorption of light through the branches. The longer stems (and sometimes subpendulous nature) can be viewed as adaptation to the cliff environment.

Leaves

Orientation: The relatively large, dorsiventrally flattened leaves maximising absorption of light on the shady cliffs. The leaves are firm, not becoming detached by slight disturbances like those of related level-ground species (detached leaves rooting and proliferating, forming new plants).

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Flowering from summer to autumn (November–May) but sporadically at other times.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsules dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Autumn and winter, coinciding with the cooler rainy season and thus maximising establishment.

Vegetative reproduction: Detached leaves and pendent stems finding new crevices will root spontaneously, an efficient backup strategy for survival in this xeric cliff-face environment.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Easily cultivated and best suited to containers in thicket gardens. Outside its native habitat, it should be grown under controlled conditions in a green house. It is best grown in dappled shade, in a sandy, slightly acid mixture. Its vigour can be viewed as maximising survival. Easily grown from leaf or stem cuttings.

VOUCHERS

Van Jaarsveld 11295, 15990, 16054, 16656 (NBG).

ILLUSTRATIONS AND MAP

Figures 98a–98c, Map 98.

99. *Adromischus diabolicus* Toelken in Bothalia 12: 633 (1979).

Cremonophyte growth form: Small, mat-forming (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:Lc:Ts (vb)

Etymology: The epithet *diabolicus* perhaps pertaining to the hot, dry habitat where the plant grows on life-threatening, sheer cliff face.

DESCRIPTION AND HABITAT

Dwarf-sized, densely branched, compact plant, up to 50 mm high, 80 mm in diameter, from tuberous rootstock. Branches green at first, becoming grey, up to 3 mm in diameter. Leaves 15–20 × 7–17 mm, brittle, obovate to broadly obovate or rarely orbicular, grey-green to green, immaculate, biconvex, or flat on adaxial surface during drought; margin horny in distal part; apex obtuse, rounded to truncate; base cuneate. Inflorescence a spike-like monochasium up to 150 mm long, bearing 1–3 flowers; pedicel(s) 5–10 mm long. Calyx up to 3.5 mm long. Corolla 12.5–14.0 mm long; tube funnel-shaped, yellowish green; lobes ovate-triangular, 2.5–3.5 mm long, with club-shaped trichomes in throat; apices acute. Anthers included.

Phenology: Flowering in midsummer (November–December).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: Shady quartz cliff faces on southern aspects of mountains. Temperatures vary and may reach 45°C in summer. Winters are cooler but frost is absent. The average daily maximum temperature is 26–28°C and the average daily minimum 13–15°C. Rainfall occurs mainly in spring, autumn and winter (cyclonic cold fronts and thunder showers in late summer and autumn), ranging from 50–100 mm per annum.

Altitude: 300–800 m.

Associated vegetation: Eastern Gariiep Rocky Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremonophytes: Plants on south-facing cliffs at Pellaberg grow in association with *Adromischus trigynus*, *Aloe dabenorisana*, *Conophytum fulleri*, *Crassula exilis* subsp. *exilis*, *C. garibina* and *Tylecodon sulphureus* var. *armianus*.

Geology: Metaquartzitic gneiss of the Hom Formation (Bushmanland Group).

DISTRIBUTION

Northern Bushmanland, Pellaberg, Dabenorisberg, Blesberg Mine in eastern Richtersveld.

RELATED SPECIES

Closely related to *Adromischus nanus*, but differs in its dense mat-forming habit. This vigorous vegetative output that fills crevices is probably an adaptation to the cliff environment, maximising on its long-term survival. Most species of non-cliff habitats have mottled leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The plants are slow-growing, forming tight, dense, much-branched mats with leaves crowded at the apices. The plants are conspicuous on the cliff face, often filling an entire crevice. There is a reduction in size (compared to level-ground species), which can be viewed as an adaptation to the well-drained, vertical, small crevice habitat.

Size and weight: Clusters small, of light to medium weight.

Stem: Succulent, grey, up to 10 mm in diameter, forming dense mats, rooting at the nodes, thus ensuring a successful vegetative strategy and reducing competition from other cliff dwellers.

Leaves

Orientation: Texture firm, leaves not becoming detached by slight disturbances like those of related level-ground species, not readily forming plantlets when they do become detached like those of so many other *Adromischus* species. This reduction in vegetative output can be viewed as a different mechanism of vegetative increase and as an adaptation to the undisturbed cliff face.

Colour: Light green.

Age and persistence: Perennial, thus functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face. Mottled leaves prominent on most of the level-ground species.

Sexual reproduction

Flowers: Flowering from summer to autumn (November–December).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsules dehiscent, with seeds spontaneously released and dispersed by the wind.

Time: Summer and autumn, in time for autumn rains and thus maximising establishment.

Vegetative reproduction: Forming dense vegetative mats, rooting at the nodes. This ensures long-term survival on the cliff (vegetative backup) and also excludes competition from other succulent plants.

CONSERVATION STATUS

Rare (Raimondo *et al.* 2009), but well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Easily cultivated, its vigour viewed as maximising survival. Best for dry desert gardens, grown in small containers and on rockeries. Grow in sandy soil, in dappled shade. Easily propagated from cuttings or dividing mats. Very slow-growing (compared to species in fertile soil such as another cremnophyte, *Adromischus fallax* from shale soils), a strategy adapting to the low nutritional value of the quartzitic cliff habitat and the very xeric conditions.

VOUCHER

Van Jaarsveld 19155 (NBG).

ILLUSTRATIONS AND MAP

Figures 99a–99c, Map 99.

100. *Adromischus fallax* Toelken in *Bothalia* 12: 387 (1978).

Creemnophyte growth form: Mat-forming (of light to medium weight, cliff hugger).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: Latin *fallax*, deceptive, perhaps pertaining to its status.

DESCRIPTION AND HABITAT

Plants low, forming loose clusters or mats. Roots fibrous. Branches decumbent, flaccid, up to 200 mm long, 4–8 mm in diameter, sometimes drooping. Leaves sometimes arranged in a apical rosette, 20–50 × 8–20 mm, oblanceolate to elliptic, spreading, soft, grey-green, immaculate; adaxial surface concave; abaxial surface convex; apex obtuse to acute; base cuneate. Inflorescence a thyrse, 100–300 mm high, bearing 1–5 flowers; pedicel(s) 5–15 mm long. Calyx up to 4–5 mm long. Corolla 10–13 mm long; tube funnel-shaped; lobes triangular-ovate, up to 3.0–4.5 mm long, pink, with club-shaped trichomes in throat; apices acute. Anthers included.

Phenology: Flowering in midsummer (January–February).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: South-facing cliffs more than a 1000 m above sea level. Plants firmly rooted in crevices, and size often depends on the growing space allowed by the crevice. The average daily maximum temperature is about 23°C and the average daily minimum about 8°C. Temperature high in summer (30°C). Winters are cooler but with occasional frost or snow. Rainfall occurs mainly in summer (also occasional cold fronts in winter), with a peak in spring and autumn, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 800–1500 m.

Associated vegetation: Camdeboo Escarpment Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: On the Tandjiesberg near Graaff-Reinet, the following species have been recorded: *Cotyledon orbiculata* var. *orbiculata*, *Crassula exilis* subsp. *cooperi*, *C. lanceolata* subsp. *lanceolata*, *C. nemorosa*, *C. perforata*, *Delosperma* spp., *Drimia uniflora* and *Haemanthus humilis* subsp. *hirsutus*.

Geology: Beaufort shales (Adelaide Subgroup, Karoo Supergroup).

DISTRIBUTION

Confined to the southern great escarpment margin from Graaff-Reinet to Beaufort West in the west.

RELATED SPECIES

Distinguished from non-cremnophilous *Adromischus* species by its leaves, which are persistent. *Adromischus fallax* does not readily root from cuttings like most other level-ground *Adromischus* species. The leaves are a uniform grey-green and not mottled as found in many level-ground species. The section *Brevipedunculata* consists of six species of which most are associated with steep slopes and cliffs. Plants in this section generally occur under somewhat shady conditions and have softer leaves that do not have the horny margin and do not proliferate readily when detached. *Adromischus caryophyllaceus* is the only member of section *Brevipedunculata* that occurs on level ground and has mottled leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants relatively fast growing and forming loose clusters with leaves crowded at the apices. Branches rooting where they touch ground. The plants are conspicuous on the cliff face, often filling an entire crevice.

Size and weight: Clusters small, of light to medium weight.

Stem: Succulent, grey-green, up to 10 mm in diameter and 200 mm long, sometimes drooping from the cliff face. The long stems can be viewed as an adaptation to its undisturbed cliff-face habitat.

Leaves

Orientation: Leaves are larger and more flattened compared to those of non-cremnophilous *Adromischus* species, maximising absorption of light on the shady cliffs. Detached leaves furthermore do not readily proliferate to form plantlets as in the other *Adromischus* species. This difference in vegetative output can be viewed as an alternative mechanism of vegetative increase and as an adaptation to the undisturbed cliff face.

Colour: Grey green, immaculate.

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft, flaccid plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Tubular, with pink lobes, pollinated by insects. Flowering from summer to autumn (December–February).

Fruit/Seed

Size: Minute and ideal for establishment in crevices.

Dispersal: Fruiting capsules dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Summer and autumn, in time for autumn rains and thus maximising establishment.

Vegetative reproduction: Plants increase by vegetative growth and stems will root when they touch the ground or become detached and fall on a ledge or in a crevice.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for dry karoo and thicket gardens. It is easily cultivated, its vigour viewed as maximising survival. Easily propagated by cuttings or division and grown in sandy soil. Thrives in containers, in partial shade. Keep dry in winter.

VOUCHER

Van Jaarsveld 16690 (NBG).

ILLUSTRATIONS AND MAP

Plate 100, Figures 100a–100c, Map 100.

101. *Adromischus leucophyllus* Uitewaal in National Cactus and Succulent Journal 9: 58 (1954).

Cremonophyte growth form: Small mats and drooping clusters (of light to medium weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: Greek *leukos*, white, and *phyllon* leaf, alluding to the pale-coloured (pruinose) leaves.

DESCRIPTION AND HABITAT

Dwarf-sized, sparsely branched, spreading, succulent herb, up to 55 × 130 mm. Roots fibrous, often stilted. Stems 2–6 mm in diameter, succulent, at first grey-green with powdery bloom, becoming brownish, up to 6 mm in diameter at base. Leaves 10–30 × 8–25 mm, dorsiventrally compressed, obovate to suborbicular, very brittle, grey to whitish green, with powdery bloom, occasionally with few purplish spots, usually immaculate, young leaves green, shiny; margin horny, acute, decurrent on petiole; adaxial surface flat to convex; abaxial surface convex; apex rounded, mucronate; base cuneate. Inflorescence an erect spike-like thyrses up to 150 mm high, bearing 1–4-flowered cymes; buds ascending, terete, tapering. Calyx 2.0–2.5 mm long. Corolla cylindrical, 11–13 × 3 mm, slightly widening to throat; lobes triangular-lanceolate, white with pink median stripes, with club-shaped trichomes at throat. Anthers not protruding.

Phenology: Flowering in midsummer (January–February).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: Quartzitic sandstone cliffs of kloofs and mountain slopes. *Adromischus leucophyllus* grows on all aspects but more on southern ones. In summer the temperature may reach 40°C. Winters are cooler but frost is absent. The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Rainfall in summer and winter, ranging from 300–400 mm per annum.

Altitude: 500–1000 m.

Associated vegetation: Mosaic of South Sonderend Sandstone Fynbos and Robertson Karoo (Mucina *et al.* 2005).

Associated cremnophytes: At Waterkloof, near De Doorns, it has been recorded in association with the following cliff dwellers: *Adromischus filicaulis* subsp. *marlothii*, *Aloe perfoliata*, *Crassula badspoortense*, *C. muscosa* var. *muscosa*, *C. perforata*, *Haemanthus coccineus*, *Nerine ridleyi* and *Senecio crassulaefolius*.

Geology: Mainly quartzitic sandstone of the Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Adromischus leucophyllus is confined to the western Little Karoo, from De Doorns (Worcester) in the west to near Ladismith in the east.

RELATED SPECIES

Adromischus leucophyllus is related to *A. subdistichus*, another cremnophyte from the eastern Little Karoo and western extreme of the Baviaanskloof, but without the pale white leaves. *Adromischus leucophyllus* varies considerably in size, with a dwarf-sized form on the Warmwaterberg (near Barrydale). At Waterkloof near De Doorns, plants are robust and larger than average.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants form loose, sparsely branched clusters, often becoming drooping and well-adapted to its well-drained, vertical habitat.

Size and weight: Clusters small, of light to medium weight.

Stem: Branches spreading to decumbent, up to 200 mm long.

Leaves

Orientation: The pale, orbicular leaves covered in a powdery waxy bloom, protecting the plants from excessive sunlight and preventing too much transpiration in the xeric cliff-face environment. Leaves brittle, easily becoming detached by slight disturbances.

Colour: Whitish green, covered with a powdery bloom, well-adapted to the dry cliff habitat.

Age and persistence: Functional for more than a year.

Armament and camouflage: Plants with brittle leaves without armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Flowering in summer (November–January).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsules dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Autumn, coinciding with autumn rain and thus maximising establishment.

Vegetative reproduction. *Adromischus* species generally regenerate rapidly from detached leaves and the same is true for *A. leucophyllus*. This behaviour is an effective vegetative reproductive backup system ensuring long-term survival.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: *Adromischus leucophyllus* with its pale, white leaves is an ornamental species, popular in cultivation and most suitable for rockeries and containers in succulent karoo

gardens. It is easily cultivated and propagated by leaves, this vigour viewed as maximising survival. Grow in sandy soil, in partial shade.

VOUCHERS

Van Jaarsveld 17429, 19556, 19634 (NBG).

ILLUSTRATIONS AND MAP

Plate 101, Figures 101a–101d, Map 101.

102. *Adromischus liebenbergii* Hutchison subsp. *orientalis* Van Jaarsv., in Van Jaarsveld & Van Wyk in Aloe 40,2: 39–40 (2003f).

Cremonophyte growth form: Small, cluster-forming (of medium weight, cliff hugger).

Growth form formula: E:F:S/H:As:Es (vb)

Etymology: The epithet *orientalis*, eastern, pertains to its distribution towards the east.

DESCRIPTION AND HABITAT

Small, sparsely branched shrublets, up to 200 mm high, about 120 mm in diameter. Roots fibrous. Branches erect to decumbent, 170 mm long, grey to grey-green, up to 20 mm in diameter. Leaves obtriangular to narrowly obtriangular, 40–55 × 30–40 mm, dorsiventrally compressed, ascending, biconvex when turgid; apex truncate to rounded; base cuneate, with indistinct, short, subterete petiole; surface waxy, flaking, dull green to grey-green, immaculate; margin entire, horny at truncate apex, without a mucro. Inflorescence a green, spike-like thyrse, up to 200 mm high, bearing 1-flowered cymes, with suppressed buds; bracts triangular, adpressed, 2 × 1.3 mm; pedicel 1.5 × 1 mm; buds ascending-spreading to spreading, slightly tapering. Calyx tubular, 3.5 mm long; lobes triangular, 1 × 1 mm. Corolla 10–11 × 2.5–2.8 mm, tubular; tube cylindrical, not grooved, pale green; lobes white, broadly triangular, up to 2 mm long, cuspidate, reflexed against tube; apex purplish mottled; margin undulate, frilled; throat rough, pale green, not grooved. Stamens 10 mm long, shortly exerted, fused to lobes in basal half; anthers yellowish, 7 × 4 mm. Squamae translucent, rectangular, 8 × 8 mm; apex slightly emarginate. Carpels 8 mm long, tapering into erect styles.

Phenology: Flowering in summer (November–January).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: *Adromischus liebenbergii* subsp. *orientalis* occurs on north-facing, exposed cliff faces of the lower Mbashe River in the Eastern Cape. Winters are cool but frost is absent. The average daily maximum temperature is about 22°C and the average minimum temperature about 14°C. Rainfall occurs mainly in spring and summer and ranges from 600–1000 mm per annum.

Altitude: 300–800 m.

Associated vegetation: Eastern Valley Bushveld (Sub-Escarpment Savanna Bioregion) of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: At the Mbashe River near Ludonga, it has been observed rooted firmly in rock crevices and on ledges, sharing its habitat with other drought-adapted cliff dwellers such as *Aloe reynoldsii*, *Crassula lactea*, *C. perfoliata* var. *minor*, *C. perforata*, *Kalanchoe rotundifolia*, *Ornithogalum longibracteatum*, *Plectranthus madagascariensis* and *Portulacaria afra*. Larger non-succulent plants in its habitat include *Commiphora harveyi* and *Ficus ingens*.

Geology: Ecca shale cliffs (Cape Supergroup).

DISTRIBUTION

Known only from the Kei and Mbashe Rivers in the Eastern Cape, growing on sheer cliff faces. They are locally abundant.

RELATED SPECIES

Adromischus liebenbergii subsp. *orientalis* is at once distinguished from the typical subspecies by its much larger, robust stature, larger obtriangular leaves of 40–55 × 30–40 mm without distinct petioles and lacking a mucro at the leaf apex. The truncate to rounded apices are not flattened towards the leaf tips. Subsp. *liebenbergii* differs in its rhombic-spathulate leaves, 12–25 × 12–20 mm, which are distinctly flattened towards the apex, with a distinct petiole up to 10 mm long and a mucro at the apex. In subsp. *orientalis* the petiole is short and indistinct. In both taxa the leaf surface is grey-green, lacking spots. Subsp. *liebenbergii* occurs in the southern Great Karoo in the Whitehill and Laingsburg region. It occurs in a mosaic of Succulent Karoo and Nama-Karoo on exposed rocky ridges and outcrops.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, stout clusters.

Size and weight: Clusters of medium weight.

Stem: Branches erect to decumbent, 170 mm long, grey to grey-green, up to 20 mm in diameter.

Leaves

Orientation: Ascending, obtriangular to narrowly obtriangular.

Colour: Dull green to grey green, without spots.

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Flowers tubular, with pink lobes, pollinated by insects. Flowering in summer (November).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsules dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Summer, in time for the autumn rains and thus maximising establishment.

Vegetative reproduction: Leaves rooting when they become detached.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common, well protected and not threatened owing to the undisturbed cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for bushveld and thicket gardens. Plants do well in cultivation and are easily grown from leaf cuttings. They thrive in containers. Water sparingly throughout the year.

VOUCHER

Van Jaarsveld 16908 (NBG).

ILLUSTRATIONS AND MAP

Figure 102a, Map 102.

103. *Adromischus schuldianus* (Poelln.) Poelln. subsp. *brandbergensis* B.Nord. & Van Jaarsv., in Van Jaarsveld *et al.* in *Bothalia* 34,1: 35–38 (2004b).

Cremonophyte growth form: Small, cluster-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:Lc (vb)

Etymology: After its habitat on the Brandberg in central Namibia.

DESCRIPTION AND HABITAT

Dwarf-sized, mat-forming, branched succulent, up to 70 mm high, filling crevices in granite rock fissures. Roots fibrous. Branches short, succulent, in cultivation up to 70 × 10 mm. Leaves alternate, spreading, subfusiform-ellipsoid to semiterete, 20–70 × 10–15 mm, without distinct margin, flattened to shallowly concave above, tapering to base and to acute-obtuse, often

somewhat recurved tip, dark green, marbled with white or dull red areas. Peduncle 150–500 mm long (in cultivation), 1.2–1.5 mm thick, simple or branching above middle, terete, glabrous, greenish brown or reddish, with 2–15 almost patent flowers in a one-sided raceme; bracts 1.5 mm long, acute, succulent; bracteoles 2, basal, subulate, 1 mm long, acute; pedicels 5–17 mm long, somewhat thickened towards apex. Calyx lobes narrowly triangular, 1.8–2.0 mm long, 0.6–1 mm wide, acute. Corolla 12–15 mm long, pinkish white or wax-coloured; tube cylindrical, 2.5–3.0 mm wide; lobes patent, deltoid, acute, with somewhat wavy margins; throat bright purple inside. Squamae oblong, bifid, 1 mm long, 0.8 mm wide, white. Filaments white or pinkish; 5 longer ones adnate for 5 mm, 12 mm long; 5 shorter ones adnate for 3 mm, 10 mm long; anthers 0.4 mm long. Styles subulate-filiform, 5–8 mm long, apically white, basally light green.

Phenology: Flowering in early summer (November).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: Granite cliffs and steep south- and east-facing slopes of the Brandberg. It is nowhere common, but occurs scattered in protected fissures and crevices in small to dense groups owing to vegetative proliferation. The Brandberg is an isolated granite inselberg of about 21 × 25 km in diameter and Königstein (2573 m) represents the highest peak in Namibia. It is surrounded by the Namib Desert, with typical species such as *Welwitschia mirabilis*, annual herbs and grasses, and foothills with woody species including *Acacia montis-usti*, *Adenolobus garipensis*, *Commiphora saxicola*, *C. virgata*, *C. wildii* and *Moringa ovalifolia*. Rainfall in the habitat is about 200–400 mm per annum (on the foothills less than 100 mm).

Altitude: 500–2200 m.

Associated vegetation: Mosaic of Arid Savanna and Desert.

Associated cremnophytes: Associated plants in the same habitat include *Aloe dichotoma*, *A. hereroensis*, *A. littoralis*, *Cyphostemma currorii* and *Kalanchoe lanceolata*, also *Diospyros acocksii*, *Euphorbia mauritanica*, *Ficus ilicina*, *Obetia carruthersiana*, *Salvia garipensis* and *Tetradenia riparia*.

Geology: Granite.

DISTRIBUTION

Known only from the Brandberg massif in northern central Namibia.

RELATED SPECIES

Adromischus schuldtianus subsp. *brandbergensis* belongs to section *Boreali* (Toelken 1978), which includes a few other *Adromischus* taxa confined to northern parts of South Africa and Namibia, for example *A. trigynus*, *A. umbraticola* and *A. schuldtianus* subsp. *schuldtianus*. The subsp. *brandbergensis* is at once distinguished from them by its subfusiform (to almost terete) leaves which are distinctly concave on the upper side. It is found the furthest north in Africa of any other *Adromischus* taxon. Of all the members of section *Boreali*, *A. trigynus* has the most southern distribution. It is confined to dolerite outcrops, growing in shallow soil at altitudes above 1000 m in the Nama-Karoo Biome, in an area that receives predominantly summer and autumn rainfall. *Adromischus trigynus* ranges from southern Namibia and

Pofadder in the west to Aliwal North and the southern Free State in the east. *Adromischus umbraticola* occurs mainly on south-facing cliffs and in shallow soil associated with sandstone and quartzite outcrops on the Highveld of Gauteng, mountains of the North West Province and further north to the Blouberg and Chuniespoort (Limpopo Province). It is common on rocky ridges of the Witwatersrand and the Magaliesberg range. The vegetation of its habitat consists mainly of short, dry savanna. It has very brittle leaves and plants often colonise shallow pockets of soil, with little competition from mesophytic taxa. *Adromischus schuldtianus* subsp. *schuldtianus* is characterised by oblanceolate to obovate leaves. Toelken (1985) recognises two subspecies mainly differentiated by their stem and branch length, 40–80 mm tall and little branched, with branches 10–30 mm long in subsp. *schuldtianus*, which occurs in arid savanna in central Namibia, from the Erongo and Avas Mountains in the north to near Aus and the Karas Mountains in the south. It grows on rock outcrops, usually with a southern aspect. The second subspecies, *A. schuldtianus* subsp. *juttae*, is confined to the Karasberg in southern Namibia and is differentiated by its longer branches; the plants occur in Nama-Karoo. Bruyns (1990) observed variability in the leaf shape of subsp. *brandbergensis* on the Brandberg. He found flat- and subfusiform-leaved plants occurring together. However, in spite of some local variation, most specimens encountered on the Brandberg are represented by the subterete-leaved plants.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming dense clusters and filling up crevices. Branches and leaves rooting where they touch ground. The plants are conspicuous on the cliff face, often filling an entire crevice.

Size and weight: Clusters of light to medium weight.

Stem: Branches short and succulent, in cultivation up to 70 × 10 mm.

Leaves

Orientation: Alternate, subfusiform-ellipsoid, the flattened adaxial side with a faint window, which can be viewed as an adaptation allowing and spreading light to the abaxial surface in the often shady cliff environment. The subfusiform leaves are typical of many cremophilous succulent plant species, an adaptation to the harsh cliff habitat.

Colour: Dark green and marbled with white or dull red areas.

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Flowers tubular, with pink lobes, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Wind-dispersed.

Time: Summer, in time for the autumn rains and thus maximising establishment.

Vegetative reproduction: Like other *Adromischus* species, this plant proliferates from detached leaves (caused by heavy wind or other disturbances), a vegetative reproductive backup system ensuring long-term survival. *Adromischus schuldtianus* subsp. *brandbergensis* often fills entire crevices.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Easily cultivated but should be kept dry in winter. Best for Namib and Karoo gardens. Thrives in small containers (well-drained, sandy medium), under controlled conditions. Easily grown from cuttings or division. Does well in partial shade.

VOUCHER

Van Jaarsveld 17969 (NBG).

ILLUSTRATIONS AND MAP

Figures 103a–103c, Map 103.

104. *Adromischus subdistichus* Makin ex Bruyns in South African Journal of Botany 58,1: 50–51 (1992).

Cremonophyte growth form: Small, cluster-forming and drooping stems (of light weight, cliff hugger).

Growth form formula: E:F:P:Els:E (vb)

Etymology: Latin *sub*, almost, Greek *dis*, twice, and *stichous*, a line, referring to the leaves which are almost in two opposite rows.

DESCRIPTION AND HABITAT

Little-branched, small, decumbent to erect plant, up to 70 mm high, 150 mm in diameter. Roots fibrous. Branches green at first and up to 3 mm in diameter, becoming grey-green and 4–5 mm in diameter. Leaves 15–20 × 10–17 mm, spreading to ascending, brittle, obovate, grey-green, shiny, sometimes purplish but not spotted; adaxial surface flat to convex; abaxial surface convex; margin white, acute, horny for most of the length, shortly decurrent on stem; apex obtuse or rounded, mucronate; base auriculate. Inflorescence a spike-like thyrses up to 180 mm high, bearing 1- or 2-flowered cymes; pedicel 4–8 mm long; buds spreading, terete, tapering. Calyx up to 2 mm long. Corolla 11–12 mm long; tube greenish yellow; lobes

lanceolate-triangular, 3–4 mm, pink, with club-shaped trichomes in throat; apices acute. Anthers shortly exerted.

Phenology: Flowering in midsummer (January–February).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: *Adromischus subdistichus* grows on quartzitic sandstone (southern aspects). The average daily maximum temperature is 26°C and the average daily minimum 11°C. Temperatures vary and may reach 40°C in summer. Winters are cooler but frost is a rarity or absent. Although the rainfall occurs in summer and winter (from 300–400 mm per annum), it is more in the summer months.

Altitude: 500–2000 m.

Associated vegetation: Groot Thicket (Mucina *et al.* 2005).

Associated cremnophytes: At Toorwaterspoort southwest of Willowmore, *Adromischus subdistichus* grows on south-facing cliffs together with cliff dwellers such as *Albuca tortuosa*, *Bulbine* sp., *Cotyledon woodii*, *Crassula capitella* subsp. *thyrsiflora*, *C. cotyledonis*, *C. muscosa* var. *muscosa*, *C. pellucida* subsp. *marginalis*, *C. perfoliata* var. *minor*, *C. pubescens* var. *radicans*, *C. rupestris*, *Cyrtanthus montanus*, *Drimia uniflora* (*Litanthus pusillus*), *Haemanthus albiflos*, *Haworthia decipiens* var. *decipiens*, *H. viscosa*, *Lampranthus affinis*, and *Senecio talinoides*.

Geology: Mainly quartzitic sandstone of the Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Adromischus subdistichus is confined to the eastern Little Karoo, from Toorwaterspoort west of Willowmore to the Nuwekloof Pass at the western end of Baviaanskloof.

RELATED SPECIES

Adromischus subdistichus is related to *A. leucophyllus*, another cremnophyte from the western Little Karoo. Differences are discussed under the latter.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants form loose, sparsely branched clusters, often with drooping stems and well-adapted to its well-drained, vertical habitat.

Size and weight: Clusters small, of light weight.

Stem: Branches spreading to decumbent, up to 200 mm long.

Leaves

Orientation: Orbicular, brittle, easily becoming detached by slight disturbances.

Colour: Glaucous green, turning reddish during periods of drought and thus protecting the plants from excessive sunlight and preventing unnecessary transpiration.

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Flowering in summer (November–January).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsules dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Autumn, coinciding with autumn rain and maximising establishment.

Vegetative reproduction: Like other *Adromischus* species, this plant proliferates from detached leaves (caused by heavy wind or other disturbances), a vegetative reproductive backup system ensuring long-term survival.

CONSERVATION STATUS

Locally common and not threatened owing to the undisturbed cliff habitat.

ADDITIONAL NOTES

Horticulture: *Adromischus subdistichus* is popular in cultivation, best suited to rockeries and containers in thicket, succulent karoo and dry fynbos gardens. It is easily cultivated and propagated by leaves, this vigour viewed as maximising survival. Grow in sandy soil, in partial shade. Thrives in containers.

VOUCHER

Van Jaarsveld 17408 (NBG).

ILLUSTRATIONS AND MAP

Plate 104, Figures 104a–104d, Map 104.

105. *Adromischus umbraticola* C.A.Sm. subsp. *ramosus* Toelken in *Bothalia* 12: 386 (1978).

Cremonophyte growth form: Small, cluster-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:Lc (vb)

Etymology: Latin, *ramus*, a branch, pertaining to its branching habit.

DESCRIPTION AND HABITAT

Dwarf-sized, compact, little-branched plant, up to 120 mm in diameter, with tuberous base. Branches decumbent, up to 120 mm long, grey to grey-green. Roots fibrous. Leaves 15–65 × 5–21 mm, dorsiventrally compressed, compact, brittle, ascending, oblanceolate, green tinged brown, rarely grey-green. Inflorescence a spike-like thyse, up to 350 mm high, bearing 1-flowered cymes 1.5–3.5 mm long; pedicel 2–10 mm long; buds erect, 5-angled, gradually tapering. Calyx lobes up to 3 mm long. Corolla 10–13 long, tubular; tube 2 mm in diameter, dull green, grooved lengthwise; lobes triangular-ovate, up to 2.5 mm long, white or tinged pink, acute. Anthers shortly exserted.

Phenology: Flowering in early summer (November).

Pollinators: The tubular flowers are pollinated by insects.

Habitat and aspect: Mainly cliffs (all aspects), sometimes in the shade. Plants firmly rooted in crevices. Temperature high in summer (30°C and more). The average daily maximum temperature is about 22–24°C and the average daily minimum 8–10°C. Rainfall occurs mainly in summer, ranging from 600–800 mm (thunder showers).

Altitude: 1500–1700 m.

Associated vegetation: Gold Reef Mountain Bushveld and Waterberg Mountain Bushveld of the Central Bushveld Bioregion, Savanna Biome (Mucina *et al.* 2005).

Associated cremnohytes: On sheer cliffs in the Blouberg (Limpopo Province), plants grow with *Aeollanthus canescens*, *Aloe arborescens*, *A. vogtsii*, *Cotyledon barbeyi*, *Crassula setulosa* var. *setulosa*, *C. swaziensis*, *Plectranthus mutabilis* and *Sarcostemma viminalis*.

Geology: Quartzitic sandstone (Setlaole Formation, Waterberg Group and Wylties Poort Formation, Soutpansberg Group).

DISTRIBUTION

Known only from isolated collections near Middelburg (Mpumalanga), Chuniespoort, the Soutpansberg and the Blouberg (Limpopo Province).

RELATED SPECIES

Distinguished from the var. *umbraticola* mainly by its longer stems. The var. *umbraticola* also often occurs on cliff faces, its leaves usually grey-green and only rarely mottled. The plant belongs to section *Boreali* consisting of three species of which *A. trigynus* and *A. schuldtianus* occur on level ground. *Adromischus trigynus* has distinctly mottled leaves and *A. schuldtianus* somewhat mottled leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming loose clusters and stems sometimes becoming drooping. Branches and leaves rooting where they touch ground. The plants are conspicuous on the cliff face, often filling an entire crevice.

Size and weight: Clusters small, of light weight.

Stem: Succulent, grey to grey-green, up to 120 mm long. This length is much longer than in related species, suggesting an adaptation in becoming pendent from the cliff face.

Leaves

Orientation: Brittle when becoming detached, suggesting a vegetative reproductive strategy so as to fully occupy the crevice.

Colour: Uniform dull green, not mottled and tinged brownish.

Age and persistence: Functional for more than a year.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, adapted to the undisturbed cliff face.

Sexual reproduction

Flowers: Flowers tubular, with pink lobes, pollinated by insects. Flowering in summer (November).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Fruiting capsules dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Summer, in time for the autumn rains and thus maximising establishment.

Vegetative reproduction: Like other *Adromischus* species, this plant proliferates from detached leaves (caused by heavy wind or other disturbances), a vegetative reproductive backup system ensuring long-term survival.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Easily cultivated, its vigour viewed as maximising survival. Easily grown from cuttings or division. Thrives in containers, in partial shade. Best for bushveld gardens, grown on rockeries or in containers.

VOUCHER

Van Jaarsveld 19794 (NBG).

ILLUSTRATIONS AND MAP

Figures 105a–105c, Map 105.

COTYLEDON L.

106. *Cotyledon barbeyi* Schweinf. var. A, Schweinfurth in The Gardeners' Chronicle, Ser. 3, 13: 624 (1893). (Wyllies Poort form.)

Cremonophyte growth form: Small rounded shrublets (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: The specific epithet honours William Barbey (1842–1914), Swiss philanthropist and botanist.

DESCRIPTION AND HABITAT

Erect, branched, dwarf-sized, compact shrublet, up to 100 mm tall. Branches ascending, 5–7 mm in diameter at base; bark brownish grey. Leaves glabrous, 25–40 × 17–25 mm, oblanceolate; adaxial surface flat; surface glabrous, pale white-green, with powdery bloom; margin reddish; apex mucronate, reddish; base cuneate; petiole short. Inflorescence an erect thyrse of 3–5 dichasia, up to 100 mm high; peduncle with 1 or 2 pairs of bracts. Calyx lobes green, 6 × 4 mm. Corolla tubular, orange-red, 20 mm long; tube 14–18 mm long; base inflated with 5 bulges in between calyx lobes, each bulge 5 mm long; lobes free for 15 mm at apex, recurved. Stamens exerted for 5–14 mm, fused to base of corolla, in 2 whorls, free for 22 mm; anthers yellow, spherical. Squamae spreading, oblong, 4–5 × 1.5 mm, yellow-green. Carpels tapering, decurrent on styles, 28 mm long.

Phenology: Flowering in midwinter (June–August).

Pollinators: The conspicuous tubular flowers are pollinated by sunbirds.

Habitat and aspect: West-facing sandstone cliffs on the lower northern slopes of the Soutpansberg. Plants rooted in crevices and on ledges. Temperature can often go up to 40°C. Average daily maximum temperature about 29°C and average daily minimum 17°C. Rainfall occurs mainly in summer, ranging from 350–400 mm per annum (mainly thunder showers).

Altitude: 400–600 m.

Associated vegetation: Soutpansberg Mountain Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus umbraticola*, *Albuca fastigiata*, *Aloe petrophila*, and *Crassula swaziensis*.

Geology: Sandstone of the Wyllies Poort Formation (Soutpansberg Group).

DISTRIBUTION

Known only from Wyllies Poort on the northern foothills of the Soutpansberg.

RELATED SPECIES

Cotyledon barbeyi is distinctive and easily distinguished by the ampulaceous corolla with a distinctive bulge between the calyx lobes. It is very variable in size, habit and leaf shape, with many local forms. This cremnophilous form can be distinguished by its smaller stature and small, white leaves and slightly smaller flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The small shrublets, 100 mm high, and reduction in size can be viewed as an adaptation to the well-drained, vertical habitat.

Size and weight: Clusters small, of medium weight.

Stem: Woody but more flexible than the shrubby forms of *Cotyledon barbeyi*.

Leaves

Orientation: Ascending, smaller than in the normal non-cremnophilous forms.

Colour: Pale whitish green, surface covered with a powdery bloom (both sides), with a reddish purple margin in distal third. The pruinose nature and production of anthocyanins (reddish colour under dry conditions) suggest a response to the xeric, hot, cliff-face habitat, reducing penetration of excessive light.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Flowering in winter and early spring.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Seeds spontaneously released upon dehiscence of the capsules and dispersed by wind.

Time: Spring, just in time for the spring rains and thus maximising establishment.

Vegetative reproduction: Stems root when they find a new crevice. Fallen stems will root when landing on a suitable ledge, an efficient backup strategy for survival in this xeric cliff-face environment.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Variability: *Cotyledon barbeyi* is very variable, with many forms. The Wyllies Poort form appears to be a small obligate cremnohyte.

Horticulture: It has ornamental value and is most suitable for dry bushveld gardens, on steep embankments in full sun. It also does well in containers, in well-drained, slightly acidic soils. Keep dry in summer. It is easily propagated from stem cuttings. This growing vigour can be viewed as maximising its survival under the xeric cliff conditions.

VOUCHER

Van Jaarsveld 18035 (NBG).

ILLUSTRATIONS AND MAP

Plate 106, Figures 106a & 106b, Map 106.

107. *Cotyledon eliseae* Van Jaarsv. in *Bradleya* 15: 65–66 (1997a).

Cremonophyte growth form: Small shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb) (r)

Etymology: After Elise Bodley (1922–1998), botanical artist who painted the type plant and artist of *Cotyledon* and *Tylecodon* species in Van Jaarsveld & Koutnik (2004).

DESCRIPTION AND HABITAT

Rounded, dwarf-sized, branched shrublet, up to 200 mm high (without inflorescence). Branches up to 5 mm in diameter; older branches woody, with peeling bark. Leaves glandular hairy, green, obovate, 15 × 34–10–14 mm; both surfaces convex; margin reddish purple in distal third. Inflorescence a thyrse with 1–3 dichasia, up to 90 mm long; peduncle brownish purple, 2 mm in diameter; pedicels up to 18 mm long. Calyx lobes 2.5 × 3 mm, with green purplish markings. Corolla tube deep red, 12 mm long, 5–6 mm wide; lobes 15 mm long, lanceolate, spreading, glabrous on inside (except tuft of hairs where stamens fused). Stamens 12 mm long, white, flattened; anthers flattened, 1 mm in diameter. Squamulae square, 1 × 1 mm, yellow, fleshy, spreading ascending.

Phenology: Flowering in late spring and early summer (October–January).

Pollinators: The conspicuous tubular flowers are pollinated by sunbirds.

Habitat and aspect: Southeast-facing cliffs overlooking the Gourits River. Plants rooted in crevices and on ledges. On hot days with berg wind conditions the temperature can go up to 40°C. The average daily maximum temperature is about 23°C and average daily minimum 11°C. Rainfall in winter and in summer, ranging from 300–400 mm per annum (thunder showers and cyclonic winter rain).

Altitude: 200–300 m.

Associated vegetation: Southern Cape Valley Thicket of the Thicket Biome (Mucina *et al.* 2005).

Associated cremnohytes: At the Gourits Bridge near Albertinia, it grows with *Albucca kirstenii*, *Aloe arborescens*, *Crassula atropurpurea*, *C. lactea* and *Haworthia turgida*.

Geology: Quartzitic sandstone of the Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Confined to the mountainous region of the lower Gourits River Valley between the national road and Schoemanshoek farm.

RELATED SPECIES

Distinguished from *Cotyledon woodii*, the common level-ground Little Karoo species, by its smaller, compact growth (200 mm high), hairy leaves and tall erect peduncles (rich-flowering inflorescence) bearing 3 or more flowers. *Cotyledon woodii* is a much-branched, stiff, erect shrub up to 1 m high, usually with glabrous leaves and not densely flowering, the inflorescence often reduced to a single flower. Branches often droop from cliff faces and plants are less woody. *Cotyledon eliseae* can also be confused with *C. tomentosa* subsp. *tomentosa*, the latter with distinctly apically toothed, broader leaves and a short inflorescence. Its corolla has a shorter tube, narrowing towards the throat (parallel-sided and longer in *C. eliseae*).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The small clusters of up to 20 cm high and reduction in size can be viewed as an adaptation to the well-drained, vertical habitat.

Size and weight: Clusters of medium weight.

Stem: Woody, but more flexible than in *Cotyledon woodii* and occasionally subpendulous; can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Ascending, obovate, convex on both surfaces, with reddish purple margin in distal third.

Colour and texture: Epidermis green, covered with glandular hairs (sticky). The reddish colour (production of anthocyanins) under dry conditions reduces penetration of excessive light, an adaptation to the xeric cliff conditions. Plants adapted to grow in partial shade, explaining the green leaf colour.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived.

Armament and camouflage: Plants without any conspicuous armament or camouflage properties as opposed to the level-ground species, which have firm leaves and more woody branches.

Sexual reproduction

Flowers and fruit: Flowers pendent, in late spring and summer (November–January), the capsules becoming erect after fertilisation.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Seeds spontaneously released by the dehiscent erect capsules and dispersed by wind.

Time: Summer and autumn, just in time for the winter rains and thus maximising establishment.

Vegetative reproduction: Stems root when they find new crevices. Fallen stems will root when landing on a suitable ledge, an efficient backup strategy for continued existence in this xeric cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common, well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: *Cotyledon eliseae* is best grown in thicket gardens. It is ideal for steep embankments (dappled shade or full sun) and also thrives in containers and hanging baskets, preferably in partial shade. Easily cultivated, displaying vigorous growth. Propagation is from seed or cuttings.

VOUCHER

Van Jaarsveld 14629 (N BG).

ILLUSTRATIONS AND MAP

Figures 107a & 107b, Map 107.

108. *Cotyledon pendens* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 40,2: 36–37 (2003f).

Cremonophyte growth form: Drooping mats (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (eg) (vb) (r)

Etymology: Latin *pendens*, hanging, after its pendent growth.

DESCRIPTION AND HABITAT

Much-branched, rapid-growing shrublets. Roots fibrous. Stems flaccid, dense, curtain-forming, pendent, up to 600 mm long (without inflorescence), about 2 mm in diameter, whitish green owing to a powdery bloom, sparsely glandular-hairy, becoming glabrescent, continuously branching from nodes, lower branches up to 5 mm in diameter, with brownish peeling bark, becoming more woody with age; nodes 7–15 mm apart. Leaves crowded, highly succulent, decussate, spreading, pendent; lamina ellipsoidal to elliptic-ovoid, 18–25 × 10–15 mm, 7–10 mm thick; apex mucronate; base cuneate; surface sparsely whitish grey-green owing to a powdery bloom, glandular-hairy becoming glabrescent; margin rounded, obscurely maroon-spotted and more so towards apex; petiole 1.5–2.0 mm long. Inflorescence a terminal, pendent thyrse, 50–90 mm long, ending in a simple dichasium bearing 2–4 flowers, rarely with a solitary flower, but then also with distinct peduncle 25–30 mm long, a pair of smaller opposite bracts and 2 or 3 very small bracts alternately arranged; peduncle glandular-hairy, 30–40 mm long, 2 mm in diameter, with a leaf-like pair of linear-elliptic bracts 5–10 × 2.5 mm; pedicels 8–12(–18) mm long, glandular-hairy; receptacle funnel-shaped, 12 mm long, glandular-hairy. Calyx lobes green, triangular, 5 × 5 mm, adpressed to flower. Corolla orange-red, 40–45 × 12–13 mm; tube cylindrical, up to 20 mm long, slightly bulging in middle; lobes linear-lanceolate, 25 × 8 mm long, slightly longer than tube, spreading, but not recoiling. Stamens 10, in 2 whorls, erect, yellowish green, 18 and 20 mm long respectively, fused to tube in basal third, with a dense tuft of hairs at point of attachment; anthers spheroid, yellow, 1.5–2.2 mm long. Squamae transversely oblong, sides rounded, 2 × 3 mm, erect, yellowish green; apices sometimes slightly emarginate. Carpels 5, tapering to slender styles 20 mm long. Capsule pendent or becoming spreading, but always pointed away from cliff face.

Phenology: Flowering in summer (end of November–January).

Pollinators: The conspicuous tubular flowers are pollinated by sunbirds.

Habitat and aspect: *Cotyledon pendens* grows on south-facing cliffs, the plants firmly rooted in crevices and forming drooping mats. The average daily maximum temperature is about 24°C, and average daily minimum about 14°C. Rainfall occurs mainly in summer and ranges from 1000–1250 mm per annum (mainly thunder showers, October–May).

Altitude: 300–400 m.

Associated vegetation: Eastern Valley Bushveld (Sub-Escarpment Savanna Bioregion) of the Savanna Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Cotyledon pendens* shares its habitat with other succulent plants such as *Albuca batteniana*, *Bulbine thomasiae*, *Ceropegia sandersonii* (southernmost record),

Crassula cordata, *C. intermedia*, *C. perforata*, *Drimia anomala*, *D. loedolffiae*, *Haemanthus albiflos*, *Haworthia cymbiformis* var. *setulifera*, *Ledebouria* sp., *Ornithogalum longibracteatum*, *Pelargonium acraeum*, *Peperomia blanda*, *Plectranthus hadiensis* var. *hadiensis* and *Rhipsalis baccifera*. Other non-succulent plants sharing the habitat include *Bauhinia bowkeri*, *Ficus burkei*, *F. burtt-davyi* and *Schotia latifolia*.

Geology: Ecce sandstone and mudstone (Adelaide Subgroup, Karoo Supergroup).

DISTRIBUTION

Cotyledon pendens is endemic to the dry Bashee River Valley, from Collywobbles in the west to near the river mouth in the east.

RELATED SPECIES

Distinguished from *Cotyledon woodii* by its flaccid stems, rapid pendent growth and pendent terminal thyse. Like *C. woodii*, it often produces solitary flowers. *Cotyledon woodii* is a sturdy, erect, woody shrub up to 1 m high from the southern parts of the Eastern Cape; it grows in a variety of habitats, occasionally also on cliffs.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Pendent mats, branched from the base but less so towards the apex. The plants form conspicuous silvery mats with stems up to 600 mm long, a character that can be viewed as an adaptation to its sheer habitat.

Size and weight: Clusters small, of medium weight.

Stem: The soft, flaccid, pendent growth can be viewed as adaptation to the cliff environment.

Leaves

Orientation: Pendent and, compared to other *Cotyledon* species, there is a reduction in size.

Colour: Glaucous colour due to the powdery bloom can be viewed as an adaptation to the very xeric conditions of the cliff face.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, as opposed to the level-ground species with firm leaves and more woody branches.

Sexual reproduction

Flowers: Flowering in summer (end November–January).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: After fertilisation the fruiting capsule becomes erect, the seeds spontaneously released by the dehiscent capsule and dispersed by wind.

Time: Autumn and coincides with rain experienced in autumn.

Vegetative reproduction: The stems of *Cotyledon pendens* will root where they come into contact with the soil or find cracks in the adjacent rock. It will also grow from detached leaves (like *Adromischus* and *Crassula*), which can root and proliferate, a unique adaptation in the genus *Cotyledon*. This vegetative proliferation represents a reproductive backup strategy for so many cremnophytes and reflects the harsh, difficult terrain.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: *Cotyledon pendens* is best grown in dry bushveld or thicket gardens and is suitable for steep embankments, rockeries and containers. Plants are mat-forming and this growth habit should prevent soil erosion. It would be ideal for dry, south-facing window sills and should preferably be grown in partial shade. A suitable subject for a hanging basket. Easily propagated from stem or leaf cuttings. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Easily cultivated, its vigour viewed as maximising its survival.

VOUCHER

Van Jaarsveld 16889 (NBG).

ILLUSTRATIONS AND MAP

Plate 108, Figures 108a–108c, Map 108.

109. *Cotyledon tomentosa* Harv. subsp. *tomentosa*, Harvey, Flora capensis 2: 373 (1862).

Cremonophyte growth form: Small shrublet to rounded clusters, sometimes with drooping branches (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb) (r)

Etymology: Latin *tomentosa*, hairy, referring to the hairy leaves.

DESCRIPTION AND HABITAT

Dwarf-sized freely branched, compact, rounded, succulent shrublet, up to 110 mm high. Branches green, with long hairs. Leaves variable in hairiness, shape and teeth, oblanceolate to oblong oblanceolate, 23–65 × 15–32 mm, flattened, green, tomentose, with 3–8 reddish teeth in distal third. Inflorescence a thyrses of 1–3 dichasia, up to 160 mm high; peduncle reddish, 4 mm in diameter at base; pedicels 7–8 mm long. Calyx lobes green, 6 × 5 mm. Corolla orange-

red, 12–16 mm long; tube 15 × 9 mm, tapering; lobes recurved, free for 10 mm. Stamens exerted for 3 and 5 mm respectively; anthers yellow, 1.5 mm long, flattened. Squamae transversely oblong, 2 × 1 mm, green.

Phenology: Flowering in midwinter to spring (June–September).

Pollinators: The conspicuous tubular flowers are pollinated by sunbirds.

Habitat and aspect: Quartzitic sandstone cliff faces in kloofs and river valleys, on all aspects but more on the south-facing ones. Temperatures vary and may reach 40°C in summer. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is about 25–27°C and the average daily minimum 9–10°C. Rainfall occurs in winter and summer and ranges from 300–400 mm per annum.

Altitude: 300–700 m.

Associated vegetation: Gamka and Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Gert Smitskloof in the Baviaanskloof, it grows with *Adromischus cristatus* var. *zeyheri*, *Albuca cremnophila*, *Cyrtanthus montanus*, *C. labiatus*, *Delosperma elsieae*, *Gasteria rawlinsonii*, *Haworthia gracilis* var. *picturata*, *H. viscosa*, *Othonna triplinervia* and *Plectranthus verticillatus*.

Geology: Quartzitic sandstone, Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Cotyledon tomentosa subsp. *tomentosa* is distributed from the Baviaanskloof and Kouga Mountains in the east to the mountains near Calitzdorp (Gourits River), but is confined to cliffs in often shady kloofs.

RELATED SPECIES

Distinguished from *Cotyledon tomentosa* subsp. *ladismithiensis*, a level-ground Little Karoo species, by its smaller, compact growth (110 mm high) and smaller hairy leaves. The subsp. *ladismithiensis* is a much-branched, stiff, erect shrub up to 400 mm high, usually with terete leaves. Also related to *C. eliseae*; for differences see under that species.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The small clusters of up to 110 mm high and reduction in size can be viewed as an adaptation to the well-drained, vertical habitat.

Size and weight: Clusters small, of medium weight.

Stem: Woody but more flexible than in *Cotyledon woodii* and occasionally subpendulous, a character that can be viewed as adaptation to the cliff environment. Unlike in level-ground *Cotyledon* species and most other Crassulaceae, the branches are strong and difficult to detach without pulling up whole plant.

Leaves

Orientation: Ascending, very hairy, oblanceolate to oblong oblanceolate, flattened, the large leaves in relation to plant size an adaptation maximising absorption of light. The function of the large, firm, reddish teeth on the leaf apices is unknown.

Colour and texture: Green, with 3–8 reddish teeth in distal third. The hairy nature is probably an adaptation reducing transpiration, compensating for the large leaf size and an adaptation resulting from the extreme run-off in the sheer habitat.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived.

Armament and camouflage: Soft-leaved plant bodies, no conspicuous armament or camouflage properties as in the level-ground species, which have firm leaves and more woody branches.

Sexual reproduction

Flowers: Flowering from midwinter to spring (July–September).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: After fertilisation the fruiting capsule becomes erect, the seeds spontaneously released by the dehiscent capsule and dispersed by wind.

Time: Spring and summer, coinciding with summer rainfall and maximising establishment.

Vegetative reproduction. Stems root where they find new crevices. Fallen stems will root on a suitable ledge, an efficient backup strategy for survival in this xeric cliff-face environment.

CONSERVATION STATUS

Although classified as vulnerable (VU C1, Raimondo *et al.* 2009), it is locally common, widespread and well protected in the cliff-face habitat.

ADDITIONAL NOTES

Horticulture: *Cotyledon tomentosa* subsp. *tomentosa* is best grown in thicket gardens and is suitable for rockeries and containers. It makes a worthwhile pot plant. It should preferably be grown in partial shade. Easily propagated from cuttings and easily grown. Outside the habitat, it is best grown under controlled greenhouse conditions (Van Jaarsveld 1988b).

VOUCHERS

Van Jaarsveld 17180, 17772 (NBG).

ILLUSTRATIONS AND MAP

Plate 109, Figures 109a–109c, Map 109.

CRASSULA L.

110. *Crassula alba* Forssk. var. *pallida* Toelken in Bothalia 12: 634 (1979).

Cremonophyte growth form: Small cluster (of medium weight, cliff squatter).

Growth form formula: A:S:Lper:R:C:La (vb)

Etymology: Latin *pallida*, pale, pertaining to the pale-coloured flowers.

DESCRIPTION AND HABITAT

Plants rosulate, proliferating from base to form small groups. Roots slightly fleshy. Leaves spirally arranged, dorsiventrally flattened, lanceolate to linear-lanceolate, 60–170 × 5–15 mm; upper surface folded to channelled, glabrous, green to yellowish green, sometimes with purple spots, lower surface purplish; margin ciliate; apex acute. Inflorescence an erect terminal flat-topped thyrse, up to 250 mm long, bearing many dichasia; bracts leaf-like, becoming shorter distally. Flowers pedicellate. Calyx lobes up to 2 mm long, acute, with marginal cilia. Corolla white, tubular, up to 4 mm long, erect; lobes oblong-obovate, up to 5.5 mm long, fused shortly at base, with acute, slightly hooded apices, spreading to recurved. Anthers dark brown.

Pollinators: The conspicuous diurnal white flowers suggest a day-flying insect.

Habitat and aspect: *Crassula alba* var. *pallida* occurs mainly on sandstone cliffs where the plants grow in shallow soil on sunny rocky ledges. Temperature moderate in summer and mild to cold in winter. Average daily maximum temperature is 24–26°C and daily minimum ranges from 12–14°C. Rainfall occurs mainly in summer (mainly thunder showers) and ranges from 1000–1500 mm per annum.

Altitude: 400–2000 m.

Associated vegetation: Lydenburg Montane Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremonophytes: At the Abel Erasmus Pass, *Aloe spicata*, *Crassula swaziensis* and *Tetradenia riparia* grow together with *C. alba* var. *pallida*.

Geology: Mainly quartzitic sandstone on various formations.

DISTRIBUTION

Crassula alba var. *pallida* is distributed from the northern Drakensberg in KwaZulu-Natal to Mount Anderson in Mpumalanga.

RELATED SPECIES

Differs from *Crassula alba* var. *alba*, a grassland species, by its cluster-forming habit and usually red to pinkish flowers. The var. *parvisepala* also has red flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Cluster-forming, plants becoming conspicuous and not camouflaged.

Size and weight: Clusters small, of medium weight.

Stem: Erect, short, woody.

Leaves

Orientation: Compact, in ascending rosettes, becoming reddish during dry periods. This compact, rosulate nature can be viewed as an adaptation to the dry conditions on the cliff face. The soft texture and fragile nature suggest adaptation to the sheltered, undisturbed cliff face.

Colour: Epidermis green to yellowish green, becoming reddish. The reddish colour (production of anthocyanins) under dry conditions reduces penetration of excessive light, an adaptation resulting from the well-drained habitat.

Age and persistence: The plants are relatively slow-growing, long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowers in late summer and autumn (March–April), pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by the wind.

Time: Seeds released in late autumn or winter.

Vegetative reproduction: Plants proliferating and cluster-forming, filling up crevices. This differs from *Crassula alba* var. *alba* (solitary rosettes) on level ground and can be viewed as an adaptation to the cliff habitat.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for highveld gardens, grown in rockeries and containers. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or division.

VOUCHER

Toelken 5694 (PRE).

ILLUSTRATIONS AND MAP

Figure 110a, Map 110.

111. *Crassula atropurpurea* (Harv.) D.Dietr. var. *anomala* (Schönland & Baker f.) Toelken in Journal of South African Botany 41: 96 (1975).

Cremonophyte growth form: Spreading, mat-forming (of medium weight, cliff hugger).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: Latin *anomala*, diverging from the normal.

DESCRIPTION AND HABITAT

Plants sparsely branched, forming loose, decumbent clusters up to 200 mm in diameter. Roots fibrous. Branches up to 10 mm in diameter, covered with short erect hairs, green, becoming yellowish. Leaves spreading, narrowly to broadly oblanceolate, dorsiventrally flattened, 10–25 × 5–13 mm; apex obtuse; base cuneate; margin horny; surface densely covered with short erect hairs, lower surface convex; younger leaves ascending; older leaves becoming deciduous. Inflorescence an erect, elongated thyrse with several glomerate dichasia at the 3–5 nodes of peduncle; peduncle up to 200 mm long. Calyx lobes triangular-lanceolate, up to 3 mm long; margin ciliate. Corolla tubular; lobes fused at base, cream or white, panduriform to 2.0–4.5 mm long, ending in a beak-like structure. Squamae oblong-cuneate, pale yellow.

Phenology: Flowering from spring to early summer (October–December).

Pollinators: The white to cream corolla suggests a flying insect.

Habitat and aspect: Cliffs (mainly south-facing), in shade or partly exposed, in shallow soil on rocky ledges. It is hot in summer and cool in winter. Average daily maximum temperature is 18–20°C and daily minimum ranges from 7–10°C. Rainfall occurs mainly in winter (cyclonic winter rain) but with a portion of summer rain towards the east (thunder showers), ranging from 450–800 mm per annum.

Altitude: 800–2000 m.

Associated vegetation: Peninsula Sandstone Fynbos (Mucina *et al.* 2005).

Associated cremonophytes: On Table Mountain (Cape Town, Western Cape), the following plants occur on a cliff face: *Bulbine lagopus*, *Crassula lanceolata* var. *lanceolata*, *C. rupestris* subsp. *rupestris*, *Haemanthus coccineus* and *Scopelogenia verruculata*.

Geology: Mainly quartzitic sandstone of the Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Crassula atropurpurea var. *anomala* occurs on the northern face of Table Mountain and from Worcester to Montagu, on sheer south-facing slopes.

RELATED SPECIES

Differs from other members in section *Globulea* immediately in its thicker branches (10 mm) and prominent dorsal appendage of the petals. Differs from var. *atropurpurea* in its decumbent branches and parts covered with erect hairs. Leaves are reddish, linear to broadly obovate, with obtuse apices. Inflorescence with basal 1 or 2 bracts without dichasia. Dichasia of densely clustered flowers. Corolla lobes with canaliculate dorsal appendage.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Sparsely branched, loose clusters, sometimes subpendulous.

Size and weight: Clusters small, of light to medium weight.

Stem: Decumbent, up to 10 mm in diameter, flaccid.

Leaves

Orientation: Spreading, younger leaves ascending, narrowly to broadly oblanceolate, dorsiventrally flattened.

Colour and texture: Dull green, surface densely covered with short erect hairs; older leaves becoming deciduous. The dense hairs can be viewed as an adaptation to the xeric cliff-face habitat.

Age and persistence: Plants are relatively rapid-growing but long-lived perennials.

Armament: Plants with soft, fragile, flaccid branches without conspicuous armament, an adaptation to the cliff habitat.

Sexual reproduction

Flowers: Inflorescence an erect, elongated thyse bearing cream to white flowers in spring.

Fruit/Seed

Size: Seed minute, ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer and late summer.

Vegetative reproduction: Stems of *Crassula atropurpurea* var. *anomala* root where they come into contact with the soil, filling crevices—an ideal long-term survival backup on the sheer cliff face. Detached branches will root on other ledges or in new crevices.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for dry fynbos gardens, grown in rockeries or small containers. Easily cultivated, its vigour viewed as maximising survival. Easily grown from seed or division.

VOUCHERS

Van Jaarsveld 16943, 17442 (NBG).

ILLUSTRATIONS AND MAP

Figures 111a–111d, Map 111.

112. *Crassula aurusbergensis* G.Will. in *Cactus and Succulent Journal* (U.S.) 64: 288–289 (1992).

Cremonophyte growth form: Dwarf-sized, compact cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: After the Aurusberg in southern Namibia.

DESCRIPTION AND HABITAT

Plants dwarf-sized, branched, compact succulents forming rounded tufts up to 95 mm in diameter. Roots fibrous. Branches short, internodes not visible. Leaves in rosettes, ascending-spreading, becoming spreading, oblanceolate to oblong-oblanceolate, 10–25 × 7–14 mm; lamina dorsiventrally compressed; upper surface flat to slightly convex, with off-centre groove, lower surface convex; epidermis glabrous, grey-green; margin ciliate; apex acute to round; older leaves persistent. Inflorescence a rounded thyrse with a peduncle up to 25 mm high, with few spherical dichasia. Calyx lobes narrow-triangular, papillate, up to 3 mm long, apices obtuse. Corolla up to 3 mm long, cup-shaped; lobes fused at base, white, apices obtuse, without dorsal appendage. Anthers yellow. Squamae fleshy, transversely oblong, yellow.

Phenology: Flowering in summer.

Pollinators: The small white flowers suggest a flying insect.

Habitat and aspect: *Crassula aurusbergensis* grows on south-facing cliffs. Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. It is locally abundant. Temperatures are moderate to high in summer but frequently drop owing to cold winds and fog from the Atlantic Ocean. Winters are cooler but frost is absent. Average daily maximum temperature about 16–18°C and average daily minimum for the region is 7–8°C. Rainfall is mainly in winter (cyclonic), ranging from 50–75 mm per annum.

Altitude: 900–1050 m.

Associated vegetation: Mainly Succulent Karoo.

Associated cremnophytes: Associated cremnophytes include *Conophytum ernianum*, *Holothrix filicornis* and *Tylecodon aurusbergensis*.

Geology: Quartzitic sandstone of the Namaqua Metamorphic Complex.

DISTRIBUTION

Endemic to Aurusberg, southern Namibia.

RELATED SPECIES

Crassula aurusbergensis belongs to section *Argyrophylla*. It differs from other members of the section in its small rosettes of smooth (margin crenulate, hyaline), unequally bilobed leaves with acute apices.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous clusters, an adaptation to the undisturbed cliffs.

Size and weight: Clusters small, of light weight, up to about 100 mm in diameter.

Stem: Short, not visible.

Leaves

Orientation: Ascending-spreading, becoming spreading, open rosettes maximising penetration of light on the shady, south-facing cliffs.

Colour: Epidermis grey-green, glabrous, margin crenulate.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived, suggesting adaptation to the xeric cliff conditions and mineral-poor soil.

Armament and camouflage: Plants with soft leaves and plant bodies without conspicuous armament or camouflage properties, as opposed to the level-ground species such as *Crassula namaquensis*, *C. sericea* and *C. alstonii*, which are well camouflaged, with a different firmer leaf texture.

Sexual reproduction

Flowers: Corolla white.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed during autumn rains, maximising establishment.

Vegetative reproduction: Plants proliferate from the base, forming small mats, rooting and spreading by vegetative means, filling crevices. This differs from the solitary rosulate forms on level ground and represents an adaptation to the cliff habitat.

CONSERVATION STATUS

Classified as rare (Loots 2005). Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for containers in dappled shade. Keep dry during the summer months. Outside its desert habitat, it is best grown under controlled conditions in a greenhouse. Easily cultivated, its vigour viewed as maximising survival. Propagate by division.

VOUCHER

Williamson 4416 (NBG).

ILLUSTRATIONS AND MAP

Map 112.

113. *Crassula badspoortense* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 38,1 & 2: 29–30 (2001a).

Cremonophyte growth form: Loose clusters with spreading to drooping stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: After its native habitat at Badspoort in the Little Karoo.

DESCRIPTION AND HABITAT

Spreading, sparsely branched (3–8 branches) shrublets, up to 100 mm high, up to 400 mm in diameter. Stems 3–4 mm in diameter, spreading, becoming pendulous; internodes 6–10 mm long. Leaves sessile, broadly ovate, 20–35 × 20–35 mm, flat to slightly biconvex, spreading at right angles but slightly ascending and forwardly curved; apex subacute; bases fused, amplexicaul, forming a sheath; surface smooth, glaucous to whitish green; margins entire; hydathodes concentrated towards margins. Inflorescence a short, rounded thyrse, up to 40 mm long, up to 65 mm in diameter, with many 5-merous, pedicellate flowers in dichasia; peduncle indistinct owing to gradual transition to bracts; basal bracts 8 × 5 mm, becoming smaller (2 × 1 mm) on inflorescence, triangular ovate. Flowers star-shaped, up to 4.5 mm in diameter, white; pedicels 2–5 mm long. Calyx lobes triangular, 1.3 × 0.8 mm, apices acute. Corolla

lobes lorate-lanceolate, 3.5×1.0 mm, recurved, apices obtuse to subacute. Stamens: filaments 2 mm long; anthers 0.2 mm long, dark maroon; pollen yellow. Squamae truncate, 0.3 mm in diameter, 0.2 mm high, thick, fleshy, yellowish orange. Carpels 2 mm long; ovary bottle-shaped, tapering into short, outward pointing style, inner side of ovary asperulous.

Phenology: Flowering in summer and autumn (January–March).

Pollinators: The small white flowers suggest a flying insect.

Habitat and aspect: *Crassula badspoortense* grows on south-facing quartzitic sandstone cliffs. Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. It is locally abundant to less prominent. Temperature moderate to high in summer and can reach 40°C. Winters are cooler but frost is absent. The average daily maximum temperature is 25–26°C and the average daily minimum for the region 9–10°C. Rainfall in winter (cyclonic) and summer (thunder showers), ranging from 250–350 mm per annum.

Altitude: 500–800 m.

Associated vegetation: Western Gwarrieveld, Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated cremnophytes observed at the type locality at Badspoort near Calitzdorp: *Aloe comptonii*, *Crassula cotyledonis*, *C. muscosa*, *C. perforata*, *Haemanthus coccineus*, *Lampranthus affinis*, *Litanthus pusillus* and *Tylecodon leucothrix*.

Geology: Quartzitic sandstone of the Peninsula Formation, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Western Little Karoo, from Badspoort on the Olifants River (west of Oudtshoorn) in the east to Waterkloof near De Doorns (Hex River Valley, Western Cape) in the west.

RELATED SPECIES

Distinguished from the related *Crassula rupestris* by its larger, almost whitish green leaves and larger, rounded inflorescence. The plants are sympatric. The young inflorescence is recurved at first, a diagnostic feature that separates *C. badspoortense* from *C. rupestris*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, branches spreading to drooping from cliff face.

Size and weight: Clusters of medium weight, about 400 mm in diameter.

Stem: Flexible, shorter and pendulous or subpendulous. The softer, less woody and pendulous nature of the stems can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Fused into opposite discs, an adaptation to xeric conditions of the cliff face.

Colour: Epidermis white, grey-green to glaucous (covered with powdery bloom), an adaptation resulting from the extreme run-off in the sheer habitat.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived, an adaptation to the xeric cliff conditions.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, as opposed to the level-ground species, which are more woody.

Sexual reproduction

Flowers: In a large round-topped thyrses, conspicuous, from midsummer to autumn (November–April), diurnal.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed during autumn rains, maximising establishment.

Vegetative reproduction: The vigorous, spreading growth ensures vegetative increase and branches will occupy new crevices by active growth. A branch blown from a cliff face and landing in a crevice, will root. This vegetative increase is an effective backup growth strategy ensuring long-term survival on the cliff.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket and succulent karoo gardens, grown in rockeries, on embankments or as a pot plant. Outside its native habitat, it is best grown under controlled conditions in a greenhouse. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or seed.

VOUCHER

Van Jaarsveld 17169 (NBG).

ILLUSTRATIONS AND MAP

Figures 113a–113d, Map 113.

114. *Crassula brachystachya* Toelken in Journal of South African Botany 41: 97 (1975).

Cremonophyte growth form: Cluster-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Greek *brachys*, short, and *stachus*, an ear of corn (a spike), pertaining to the sessile dichasia.

DESCRIPTION AND HABITAT

Plants rosulate, solitary or proliferating from base to form small, dense clusters, all parts fragile, brittle. Roots fleshy, up to 3 mm in diameter. Branches short but sometimes up to 100 mm long. Leaves in basal rosettes up to 150(–240) mm in diameter, spirally arranged, oblanceolate-oblong, (20–)30–80(–120) × 4–15(–20) mm; surface glabrous, dotted with crateriform hydathodes, spotted purplish towards apex; margin ciliate; apex acute. Inflorescence a spike-like thyrses (rarely up to 3), 110–230 mm high, bearing sessile dichasia on a distinct peduncle; bracts triangular-ovate, 12 × 9 mm, ciliate. Calyx lobes oblong-elliptic, 3.5–4.5 mm, ciliate. Corolla tubular, 6 mm long; lobes oblong, 4–5 mm long, fused shortly at base, apices spreading, white.

Phenology: Flowering in summer (November–January).

Pollinators: The conspicuous diurnal flowers suggest day-flying insects.

Habitat and aspect: Sheltered to exposed cliffs. Plants grow in shallow soil among leaf litter on shady rocky ledges and often in the shade of cliffs. Temperature is moderate in summer and mild in winter. Average daily maximum temperature is 20–23°C and daily minimum 5–8°C. Rainfall in winter (cyclonic) and summer, ranging from 200–400 mm per annum.

Altitude: 1300–2000 m.

Associated vegetation: Western Little Karoo of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremonophytes: At Besemfontein kloof, plants grow with *Aloe perfoliata*, *Drimys uniflora*, *Crassula rupestris* subsp. *rupestris* and *Euphorbia multifolia*.

Geology: Quartzitic sandstone of the Table Mountain and Witpoort Formation (Cape Supergroup).

DISTRIBUTION

Crassula brachystachya is confined to the Klein Swartberg foothills and adjacent regions of the Laingsburg district.

RELATED SPECIES

Crassula brachystachya belongs to section *Rosulares* which includes 22 species (Toelken 1985). It is related to *C. capitella* subsp. *thyrsiflora*, but is at once distinguished from this taxon by its distinct peduncle and abruptly shortened bracts.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Loose clusters, plants conspicuous and not camouflaged. The succulent roots and leaves in a rosette can be seen as an adaptation to the xeric cliff face.

Size and weight: Clusters small, of light weight.

Stem: Short (up to 100 mm), usually unexposed.

Leaves

Orientation: Rosulate, spreading and compact, an adaptation to the dry conditions on the cliff face.

Colour: Epidermis light green, becoming reddish during dry periods. The reddish colour (production of anthocyanins) reduces penetration of light and can be viewed as an adaptation to the xeric cliff conditions.

Age and persistence: Plants long-lived perennials.

Armament: With soft, flaccid leaves and brittle plant bodies without conspicuous armament, suggesting adaptation to the cliff environment.

Sexual reproduction

Flowers: Flowering from November–January, conspicuous, white, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer, thus ready for the onset of autumn showers, maximising establishment.

Vegetative reproduction: *Crassula brachystachya* proliferates, forming small mats and cushions, an efficient vegetative backup strategy for surviving the harsh conditions on the cliff face. When an offshoot (or leaf) becomes detached (by heavy wind or some other disturbance), it will root if it falls into a new crevice, ensuring long-term survival.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Although *Crassula brachystachya* is not common locally, it is well protected by the inaccessible cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for succulent karoo gardens, in rockeries or containers. Outside its habitat, it should be grown under controlled conditions in a greenhouse, in a sandy well-drained soil.

Grow in dappled shade. Easily cultivated, and its vigour can be viewed as maximising survival. Propagate from seed or division. Leaves succumb to rust in moist coastal climates.

VOUCHER

Van Jaarsveld 19504 (NBG).

ILLUSTRATIONS AND MAP

Figures 114a–114d, Map 114.

115. *Crassula capitella* Thunb. subsp. *thyrsiflora* (Thunb.) Toelken in Journal of South African Botany 41: 100 (1975). (Baviaanskloof, Kougadam, Gourits form.)

Cremnophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *thyrsus*, a thyrsus, and *flos*, a flower, pertaining to the inflorescence.

DESCRIPTION AND HABITAT

Plants proliferating from base, forming small, dense mats to clusters 80 mm in diameter. Roots fibrous. Branches short, herbaceous, 20–40 mm long, terete, sparsely to densely strigose, 1.5–3.0 mm in diameter, green, reddish when exposed. Leaves sessile, crowded, compact, 4-ranked, becoming smaller distally forming a pyramidal shape, ovate-triangular, 6–13 × 3–7 mm; surface glabrous, green to reddish; margin with translucent cilia. Inflorescence a conspicuous elongated, loose, spike-like thyrsus, often with stalked dichasia, 20–90 mm long; peduncle conspicuously reddish; bracts ovate, leaf-like, becoming smaller distally. Flowers 2 mm long, 3.0–3.5 mm in diameter, diurnal, sweetly scented. Corolla lobes oblong-ovate, white to pink, apices recurved.

Phenology: Flowering in summer (December–March) and early autumn. Flowers diurnal, strongly scented (unpleasant indoors).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs, often confined to dry river valleys and narrow shady kloofs (mainly on southern and eastern aspects). Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer, sometimes reaching 40°C. Winters are cooler but frost is absent. The average daily maximum temperature is about 26–27°C and the average daily minimum temperature about 10–11°C. Rainfall throughout the year but with a peak in spring and summer, ranging from 200–300 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 300–1000 m.

Associated vegetation: Mainly thicket (Southern Cape, Gamtoos, Groot and Gamka Thicket) and Grootrivier Quartzitic Fynbos (Mucina *et al.* 2005).

Associated cremnophytes: At the Kouga Dam, it grows with *Albuca cremnophila*, *Aloe pictifolia*, *Cotyledon tomentosa*, *Crassula perfoliata* var. *minor*, *C. perforata*, *Cyrtanthus flammousus* and *Gasteria glomerata*.

Geology: Quartzitic sandstone of the Peninsula Formation (Cape Supergroup) and shale cliffs (Gourits River).

DISTRIBUTION

Baviaanskloof and Kouga Mountains in the Eastern Cape and the lower Gourits River at the eastern end of the river.

RELATED SPECIES

Distinguished from the level-ground populations by its strictly 4-ranked leaves, smaller size and sometimes drooping branches and inflorescences. The related level-ground forms are much larger, more robust, with leaves and flowers more laxly and untidily arranged.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous reduction in size and compact mats compared to the typical non-cremnophilous form of *Crassula capitella* subsp. *thyrsoflora*.

Size and weight: Clusters small, of light weight, forming mats up to 80 mm in diameter.

Stem: Short, usually unexposed owing to arrangement of leaves.

Leaves

Orientation: Leaves 4-ranked, forming compact pyramidal bodies. This reduction in size and compact growth can be viewed as an adaptation to the extreme xeric conditions of the cliff face.

Colour: Epidermis yellowish green, becoming reddish during dry periods. The stems have translucent white cilia. The reddish colour (due to anthocyanins) under dry conditions reduces penetration of light and is typical of many succulent plants in xeric habitats.

Age and persistence: Plants long-lived perennials.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties, as opposed to the level-ground species of which some, such as *Crassula capitella* subsp. *capitella* and subsp. *nodulosa*, have a solitary habit or a few branches, the compact clusters suggesting adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Flowering in late summer or early autumn, the strong scent suggesting a day-flying specialist pollinating agent (insect).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: *Crassula capitella* subsp. *thyrsoiflora* is prolific from the base, forming dense vegetative clusters. As in most other *Crassula* taxa, these offshoots will root if they become detached and fall into a new crevice (as a result of heavy wind or other disturbances), a vegetative reproductive backup system ensuring long-term survival.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Ideal for thicket and dry fynbos gardens, grown in miniature rockeries. It thrives in containers and the reddish colour of the leaves is appealing. Its vigour can be viewed as maximising survival. Dividing annually and rapidly, forming dense clusters. Easily grown from cuttings. Best grown in full sun or dappled shade, in sandy soil. Feed in spring.

VOUCHER

Van Jaarsveld 7234, 17115 (NBG).

ILLUSTRATIONS AND MAP

Plate 115, Figures 115a–115h, Map 115.

116. *Crassula cremnophila* Van Jaarsv. & A.E.van Wyk in *Aloe* 36,4: 71–72 (1999).

Cremnophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Greek *kremnos*, cliff, and Greek *phileein*, to love, pertaining to its cliff habitat.

DESCRIPTION AND HABITAT

Dwarf-sized, perennial, sparsely to moderately branched, forming clusters or small mats 12–25 mm high (up to 70 mm high with inflorescence). Leaves rosulate, alternately arranged, spreading, imbricate, recurved, forming a hemispherical body 20–70 mm in diameter; blade broadly obovate, 15–35 × 10–32 mm; surface glabrous, glaucous green; margin ciliate; apex rounded to subacute, mucronate. Inflorescence a terminal, erect, round-topped thyrse up to 30 mm in diameter, bearing numerous clustered dichasia; peduncle up to 35 mm long; bracts

lanceolate, 7×2 mm; flowers sessile to shortly pedicellate (up to 1 mm). Calyx lobes oblong-lanceolate, 3×1 mm long; margin ciliate; apex acute, ending in translucent bristle. Corolla scented, up to 7 mm long; lobes not fused at base, ascending-spreading, pink, oblong-ob lanceolate, up 7×1.5 mm; apices obtuse to subacute. Filaments 4 mm long, not broadening towards base; anthers yellow, 0.5 mm long. Squamae narrow-oblong, broadening towards apex, $5-7 \times 2$ mm translucent, slightly yellowish. Carpels 2.5 mm long; ovaries reniform, abruptly constricted into outward pointing, short, reflexed styles.

Phenology: Flowering from spring to midsummer (September–January).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Mainly sheltered south-facing cliffs (all aspects, more on southern ones). Plants grow in shallow soil among leaf litter on shady rocky ledges and often in the shade of cliff-dwelling shrubs or trees. Temperature is high in summer and mild in winter. The average daily maximum temperature is about 27°C and daily minimum about 12°C . Rainfall in winter (cyclonic winter rain) and summer (thunder showers), ranging from 200–300 mm per annum.

Altitude: 500–800 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Cotyledon orbiculata*, *Crassula lactea*, *C. perfoliata* var. *minor*, *C. perforata*, *Drimia anomala* and *Ornithogalum longibracteatum*.

Geology: Quartzitic sandstone (Table Mountain Formation, Cape Supergroup).

DISTRIBUTION

Crassula cremnophila is confined to the Baviaanskloof and Kouga Rivers.

RELATED SPECIES

Crassula cremnophila belongs to section *Rosulares*, which includes 22 species (Toelken 1985). It is related to both *C. montana* subsp. *quadrangularis* and *C. hemisphaerica* (section *Rosulares*). It is at once distinguished from these species by its glaucous leaves, hemispherical bodies and pink corolla 7 mm long. The flowers of *C. hemisphaerica* are 2–2.8 mm long. The stamens of *C. cremnophila* are also without black anthers. *Crassula montana* subsp. *quadrangularis* is a smaller mat-forming species (square bodies) with white flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Sparsely clustered, plants conspicuous and not camouflaged. The tight, imbricate leaves and glaucous colouring can be seen as an adaptation to the xeric cliff face.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Compact, rosulate, alternately arranged, becoming reddish during dry periods. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour: Glaucous, becoming reddish. The reddish colour (production of anthocyanins) under dry conditions reduces penetration of excessive light, an adaptation to the dry, well-drained habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering from spring to midsummer, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer and autumn, coinciding with rainy conditions and maximising establishment.

Vegetative reproduction: *Crassula cremnophila* proliferates, forming small mats and cushions, an efficient vegetative backup strategy helping the plants to survive the harsh conditions on the cliff face. When an offshoot becomes detached and falls into another crevice (as a result of heavy wind or other disturbance), it will root, ensuring long-term survival.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Although *Crassula cremnophila* is not common locally, it is well protected by the inaccessible cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket gardens, grown in rockeries, miniature succulent gardens and containers. Easily cultivated, its vigour viewed as maximising survival. Propagate by division. Water sparingly throughout the year and it is best kept in dappled shade. Outside the cliff habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17368 (NBG).

ILLUSTRATIONS AND MAP

Plates 116 & 116a, Figures 116a–116d, Map 116.

117. *Crassula cymbiformis* Toelken in Flora of southern Africa 14: 163 (1985).

Cremonophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: The epithet *cymbiformis*, boat-shaped, pertains to the leaves.

DESCRIPTION AND HABITAT

Sparsely branched, decumbent to erect, tufted, succulents, up to 120 mm high (in flower). Roots fibrous. Branches firm, decumbent. Leaves sessile, 4-ranked; lamina 15–95 × 15–32 mm, green to reddish green; basal leaves ovate-triangular to oblong-obovate; distal leaves lanceolate, dorsiventrally flattened, cymbiform; surface glabrous; margin ciliate; apex acute; base cuneate. Inflorescence a terminal, flat-topped thyrse bearing many dichasia; pedicels up to 6 mm long. Calyx lobes linear-triangular, up to 1 mm long. Corolla tubular, up to 5 mm long, shortly fused at base; lobes up to 4 mm long, lanceolate, spreading, becoming recurved. Anthers black.

Phenology: Flowering from early summer to early autumn (December–March).

Pollinators: The conspicuous white flowers suggest a day-flying insect.

Habitat and aspect: Cliffs on the southern margin of the Waterberg (Limpopo Province). Also deeply dissected kloofs of the escarpment (southern aspects). Plants are rooted in crevices and on ledges. Winters are cool but frost is absent or light. Temperature moderate, the average daily maximum about 27°C and the average daily minimum for the region about 15°C. Rainfall mainly in summer, ranging from 700–800 mm per annum.

Altitude: 1000–1750 m.

Associated vegetation: Waterberg-Magaliesberg Summit Sourveld of the Grassland Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Aeollanthus buchnerianus*, *A. parvifolius*, *Agapanthus coddii*, *Aloe arborescens*, *Bulbine natalensis*, *Crassula cymbiformis*, *C. sarcocaulis*, *C. setulosa*, *C. swaziensis*, *Delosperma waterbergensis*, *Lobelia aquamontana*, *Teedia pubescens* and *Tetradenia brevispicata*.

Geology: Quartzitic sandstone Matlabas Subgroup (Waterberg Group).

DISTRIBUTION

Known only from the Waterberg, east of Thabazimbi (Limpopo Province), confined to sheer cliffs.

RELATED SPECIES

Crassula cymbiformis belongs to section *Rosulares*, which contains 22 species of which eight are cremonophilous. Members of the section are characterised by ciliate leaves in a basal rosette. *Crassula cymbiformis* is at once distinguished by its compact, triangular-ovate, reddish leaves (in four ranks), flat-topped thyrse and flowering time in summer.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Tight, compact mats.

Size and weight: Clusters of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Compact, in opposite pairs (decussate), becoming reddish during dry periods. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour: Epidermis green, becoming reddish purple (during dry periods) owing to anthocyanins which reduce penetration of excessive light.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering from early summer to early autumn.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer and autumn, during the rainy season.

Vegetative reproduction: *Crassula cymbiformis* is prolific from the base, forming dense vegetative clusters. As in most other *Crassula* taxa, these offshoots will root if they become detached and fall into other crevices (as a result of heavy wind or other disturbances), a vegetative reproductive backup system ensuring long-term survival.

CONSERVATION STATUS

Although classified as critically rare (Raimondo *et al.* 2009), it is common in its habitat. It is also not threatened owing to the undisturbed habitat and protection within the borders of the Marakele National Park.

ADDITIONAL NOTES

Lost and found: This species was named in 1985. It was lost after its discovery by Mr Dave Hardy but found again in 2003 by Mr Andrew Hankey and the author on the south-facing cliffs of the Marakele National Park.

Horticulture: Best for highveld gardens, grown in rockeries or containers. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or division. Plant fairly fast-growing, dividing annually and forming small, dense clusters.

VOUCHER

Van Jaarsveld 17952 (NBG).

ILLUSTRATIONS AND MAP

Figures 117a–117c, Map 117.

118. *Crassula exilis* Harv. subsp. *cooperi* (Regel) Toelken in Journal of South African Botany 41: 104 (1975).

Cremonophyte growth form: Dwarf-sized, mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: After Thomas Cooper (1815–1913), British traveller and plant collector who collected at the Cape from 1859–1862.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, proliferating from base to form dense cushions up to about 100 mm in diameter. Roots fibrous. Branches often with adventitious roots. Leaves oblanceolate, ovate to linear-elliptic, 6.0–35 × 3–10 mm, spirally arranged, spreading, dorsiventrally flattened, light to dark green becoming purplish with drought stress, glabrous; upper surface flat to convex, with conspicuous purplish indentations (pitted), lower surface convex; margin ciliate; apex acute. Inflorescence a terminal, flat-topped thyrse; peduncle covered with recurved hairs.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs of mainly shady southern and eastern aspects at higher altitudes. Plants grow in shallow soil on shady rocky ledges. Temperature high in summer, mild in winter. Average daily maximum temperature 23–25°C, average daily minimum 8–10°C. Rainfall mainly in summer (thunder showers), ranging from 500–1000 mm per annum.

Altitude: 900–1500 m.

Associated vegetation: Karoo Escarpment Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremonophytes: Species recorded at the Valley of Desolation: *Cotyledon orbiculata* var. *orbiculata*, *Crassula lanceolata* subsp. *lanceolata*, *C. nemorosa*, *C. perforata*, *Delosperma* spp., *Drimia uniflora* and *Haemanthus humilis* subsp. *hirsutus*.

Geology: Beaufort shales (Adelaide Subgroup, Karoo Supergroup).

DISTRIBUTION

Crassula exilis subsp. *cooperi* is confined to the Eastern Cape between Graaff-Reinet and Aliwal North, its distribution just entering the Northern Cape (Aliwal North district).

RELATED SPECIES

Crassula exilis subsp. *cooperi* belongs to section *Rosulares*, which contains 22 species (Toelken 1985). It can immediately be separated from any other *Crassula* by its follicles spreading at right angles at maturity. It can be distinguished from the other two subspecies by its larger, oblanceolate, less succulent, mottled leaves. *Crassula exilis* is related to *C. capitella* subsp. *thyrsiflora* (not a cremnophyte) but can at once be distinguished by its very dwarf-sized stature and terminal, flat-topped thyrse. *Crassula capitella* has an elongated inflorescence.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense mats and cushions, plants fairly conspicuous. The tightly arranged leaves and prolific, mat-forming nature suggest an adaptation to the xeric cliff face, filling the crevice rapidly lowering establishment of other cremnophytes.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Compact, spreading, becoming reddish during dry periods. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face. Leaves pitted, purplish and attractive, soft texture and fragile nature suggesting adaptation to the sheltered, undisturbed cliff face.

Colour: Epidermis dark green, mottled, green becoming reddish, indentations remaining purplish. The reddish colour under dry conditions blocks excessive light, an adaptation resulting from the well-drained habitat.

Age and persistence: Rapid vegetative growth leading to constant renewal of populations, plants thus long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in summer and autumn, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in autumn at the onset of cooler conditions, maximising establishment.

Vegetative reproduction: *Crassula exilis* subsp. *cooperi* proliferates, forming dense mats and cushions, an efficient vegetative backup strategy helping the plants to survive the harsh conditions on the cliff face. When an offshoot becomes detached (as a result of heavy wind or some other disturbance), it will root if it falls into a new crevice, ensuring long-term survival.

CONSERVATION STATUS

Locally common and not threatened owing to the undisturbed cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for dry karoo gardens, grown in miniature succulent gardens, roof gardens or containers. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or division. Grows best in sandy, slightly acid soil, preferably in dappled shade.

VOUCHER

Van Jaarsveld 18273 (NBG).

ILLUSTRATIONS AND MAP

Figures 118a & 118b, Map 118.

119. *Crassula exilis* Harv. subsp. *exilis*, Harvey, *Flora capensis* 2: 347 (1862).

Cremonophyte growth form: Dwarf-sized, mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *exilis*, weak, thin and slender, pertaining to the plants.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, proliferating from base to form dense cushions up to about 50 mm in diameter. Roots fibrous. Branches often with adventitious roots; main branch up to 10 mm in diameter. Leaves linear-elliptic to linear-obovate, 4–15 × 2–3 mm, spirally arranged or decussate, ascending-spreading, dorsiventrally flattened; upper surface flat to convex; lower surface markedly convex; surface light to dark green, uniform, glabrous; margin ciliate; apex acute. Inflorescence a terminal dichasium with pedicellate flowers. Calyx lobes up to 2.5 mm long, narrow to broadly triangular; margin ciliate; apex acute, with a firm apical hair. Corolla white, tubular, 5 mm long; lobes oblong-obovate, up to 4 mm long, apices acute. Anthers yellow.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Vertical sheltered south-facing cliffs (shady southern and eastern aspects). Plants grow in shallow soil on shady rocky ledges. Temperature is high in summer and mild in winter. The average daily maximum temperature is 25–26°C and the average daily minimum 10–12°C. Rainfall occurs mainly in winter (mainly cyclonic cold fronts) and summer (thunder showers in spring and autumn) and ranges from 100–200 mm per annum.

Altitude: 900–1100 m.

Associated vegetation: Namaqualand Blomveld of the Namaqualand Hardeveld Bioregion of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus alstonii*, *Cotyledon orbiculata*, *Haworthia arachnoidea*, *Tylecodon paniculatus* and *T. tuberosum*.

Geology: Quartz of the Khurisberg Subgroup, Bushmanland Group.

DISTRIBUTION

Crassula exilis subsp. *exilis* is confined to northern Namaqualand between Ratelpoort and Steinkopf, just north of Springbok (Northern Cape). It is also known from Dabenorisberg.

RELATED SPECIES

Crassula exilis subsp. *exilis* belongs to section *Rosulares*, which includes 22 species (Toelken 1985). *Crassula exilis* can immediately be separated from any other *Crassula* by its follicles spreading at right angles at maturity. The subsp. *exilis* can be distinguished from the other two subspecies by its leaves, which are not pitted (indentations absent). The leaves are also fleshier than those of the other two related subspecies. *Crassula exilis* is related to *C. capitella* subsp. *thyrsiflora* (non-cremnophilous) and can at once be distinguished by its very dwarf-sized stature and terminal, flat-topped thyrse. *Crassula capitella* has an elongated inflorescence.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense cushions, plants conspicuous and not camouflaged. The tightly arranged leaves are not camouflaged and can be seen as an adaptation to the xeric cliff face in absence of larger herbivores.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed, main branch up to 10 mm, succulent.

Leaves

Orientation: Compact, ascending-spreading, frail and fragile, becoming reddish during dry periods. The fragile and compact nature can be viewed as an adaptation to the dry, undisturbed conditions on the cliff face.

Colour: Epidermis green, becoming reddish. The reddish colour (production of anthocyanins) under dry conditions protects the plants by preventing penetration of excessive light, an adaptation to the xeric cliff habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Conspicuous in when flowering from autumn to spring, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in winter and spring under cool, moist conditions, maximising establishment.

Vegetative reproduction: *Crassula exilis* subsp. *exilis* proliferates, forming dense mats and cushions, an efficient vegetative backup strategy helping the plants to survive the harsh conditions on the cliff face. When an offshoot becomes detached, it will root if it falls into a new crevice (as a result of heavy wind or some other disturbance), ensuring long-term survival.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common and well protected by the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for dry succulent karoo gardens, grown in miniature succulent gardens, roof gardens or containers. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or division. Grows best in sandy, slightly acid soil, preferably in dappled shade.

VOUCHER

Van Jaarsveld 22160 (NBG).

ILLUSTRATIONS AND MAP

Figures 119a–119d, Map 119.

120. *Crassula exilis* Harv. subsp. *sedifolia* (N.E.Br.) Toelken in Journal of South African Botany 41: 104 (1975).

Cremonophyte growth form: Dwarf-sized, mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: The epithet *sedifolia* (*sedes*, position, and *folium*, leaf) perhaps pertains to the position of the leaves.

DESCRIPTION AND HABITAT

Plants dwarf-sized, rosulate, proliferating from base to form dense cushions up to about 60 mm in diameter. Roots fibrous. Branches often with adventitious roots; main branch thickened, up to 10 mm in diameter. Leaves linear-elliptic, 4–15 × 1–3 mm, spirally arranged, spreading, dorsiventrally flattened, light to dark green becoming purplish with drought stress, glabrous; upper surface flat to convex with conspicuous purplish indentations (pitted), lower surface keeled; margin ciliate; apex acute. Inflorescence a terminal flat-topped thyrse; peduncle glabrous.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs, growing mainly on shady southern and eastern aspects, in shallow soil on shady rocky ledges. Temperature high in summer and mild in winter. The average daily maximum temperature is 27–28°C and the average daily minimum 11–12°C. Rainfall occurs mainly in summer (mainly thunder showers) and winter (cyclonic winter rain) and ranges from 200–300 mm per annum.

Altitude: 500–900 m.

Associated vegetation: Eastern Gariiep Rocky Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremonophytes: On Pellaberg, the following species have been recorded: *Adromischus diabolicus*, *Aloe dabenorisana*, *Crassula garibina* and *Tylecodon sulphureus* var. *armianus*.

Geology: Quartz (Aggeneys Formation, Bushmanland Group, Proterozoic).

DISTRIBUTION

Crassula exilis subsp. *sedifolia* is confined to the lower Orange River Valley between Pella and Kakamas (Northern Cape) as well as southern Namibia, from Auros to Riemvasmaak.

RELATED SPECIES

At once distinguished from the other subspecies by its glabrous peduncle and thickened main branch. *Crassula exilis* subsp. *sedifolia* belongs to section *Rosulares*, which includes 22 species (Toelken 1985). It can immediately be separated from its related subspecies by the thickened main branch and glabrous peduncles.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense cushions, plants conspicuous and not camouflaged. The tightly arranged leaves and prolific, mat-forming nature suggests an adaptation to the xeric cliff face, filling the crevice rapidly lowering establishment of other dwarf-sized cremnophytes.

Size and weight: Clusters dwarf-sized, of light weight.

Stem: Short, usually unexposed, main stem succulent, up to 10 mm in diameter.

Leaves

Orientation: Compact, becoming reddish during dry periods. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face. Leaves pitted, purplish and attractive, soft texture and fragile nature suggesting adaptation to the sheltered, undisturbed cliff face.

Colour: Epidermis green, becoming reddish, indentations remaining purplish. The reddish colour (production of anthocyanins) under dry conditions reduces penetration of excessive light, an adaptation to the xeric cliff environment.

Age and persistence: Rapid vegetative growth leading to constant renewal of populations, plants thus long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in summer and autumn, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by the wind.

Time: Seeds released in autumn at onset of cooler conditions, maximising establishment.

Vegetative reproduction. *Crassula exilis* subsp. *sedifolia* proliferates, forming dense mats and cushions, an efficient vegetative backup strategy helping the plants to survive the harsh conditions on the cliff face. When an offshoot becomes detached, it will root if it falls into a new crevice (as a result of heavy wind or some other disturbance), ensuring long-term survival.

CONSERVATION STATUS

Locally common and not threatened owing to the undisturbed cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for dry karoo gardens, grown in miniature succulent gardens, roof gardens or containers. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or division. Grows best in sandy, slightly acid soil, preferably in dappled shade.

VOUCHER

Van Jaarsveld 19154 (NBG).

ILLUSTRATIONS AND MAP

Figures 120a–120d, Map 120.

121. *Crassula expansa* Dryand. subsp. *fragilis* (Baker) Toelken in Journal of South African Botany 41: 105 (1975).

Cremonophyte growth form: Dwarf-sized, mat-forming (of light weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: Latin *fragilis*, fragile, pertaining to its soft delicate nature.

DESCRIPTION AND HABITAT

Spreading, delicate, mat-forming, succulent herbs up to 100 mm high and 250 mm in diameter, rooting at nodes. Roots fibrous. Branches decumbent, green to reddish, glabrous to tomentose, up to 2.5 mm in diameter. Leaves shortly petiolate or with cuneate base; blade 2–10 × 4–6 mm, dorsiventrally compressed, ovate to broadly elliptic, rarely obovate, green to greyish green; upper surface flat; lower surface convex; margin often reddish with a ring of hydathodes; apex acute; base cuneate. Flowers axillary in terminal clusters or solitary; pedicels 6–18 mm. Calyx lobes 2–5 mm long, linear. Corolla star-shaped, 4 mm long, up to 6 mm in diameter, petals white.

Phenology. Flowering in summer (November–April).

Pollinators: The small white flowers suggest an insect as possible pollinator.

Habitat and aspect: Shady wooded cliffs (mostly southern aspects) in river valleys and kloofs. Plants grow in shallow soil on shady rocky ledges. Temperatures are high in summer and warm to mild in winter. Average daily maximum temperature is 24–30°C and daily minimum 8–10°C. Rainfall mainly in summer (thunder showers), ranging from 450–1000 mm per annum.

Altitude: 50–1800 m.

Associated vegetation: Savanna Biome (Mucina *et al.* 2005).

Associated cremnohytes: At Penge (Mpumalanga), the following plants have been recorded on a cliff face: *Delosperma vandermerwei*, *Gasteria batesiana* var. *dolomitica*, *Orbeanthus hardyi* and *Plectranthus dolomiticus*.

Geology: It has been recorded as occurring on rock of the following formations: Mesozoic rhyolite (Jozini Formation) of the Lebombo Group, Palaeozoic sandstone and shale (Madzaringwe Formation) of the Karoo Sequence and quartzitic sandstone (Mozaan Formation) of the Pongola Sequence, dolomite of the Malmani Subgroup and Vaalian dolomites of the Chuniespoort Group (Transvaal Supergroup).

DISTRIBUTION

Widespread from the Eastern Cape to Limpopo Province, usually associated with savanna vegetation. It also occurs further north to Tanzania and on Madagascar.

RELATED SPECIES

Crassula expansa subsp. *fragilis* can be distinguished from the non-cremnophilous subspecies by its dorsiventrally flattened leaves. The subsp. *peculiaris* has a procumbent habit and is very similar to the subsp. *fragilis*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Mat-forming, fragile, filling crevices, sometimes pendulous. The mat-forming and pendulous nature, compared to that of the level-ground species, suggests an adaptation to the undisturbed cliff habitat.

Size and weight: Clusters dwarf-sized, of light weight.

Stem: Erect, 100–300 mm in diameter, soft, fragile and flaccid.

Leaves

Orientation: Ascending-spreading to spreading, dwarf-sized, fragile, an adaptation to the undisturbed cliff face. The tomentose forms of the savanna regions suggest adaptation to the hot summers and xeric conditions on the cliff face.

Colour: Green to light green, turning reddish during dry periods as a result of the production of anthocyanins, reducing penetration of light.

Age and persistence: The plants are relatively rapid-growing, leading to constant vegetative renewal.

Armament: Branches soft and fragile without conspicuous armament, an adaptation to the cliff habitat.

Sexual reproduction

Flowers: Flowers axillary in terminal clusters, or solitary, white.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late summer.

Vegetative reproduction: Stems of *Crassula expansa* subsp. *fragilis* root where they come into contact with the soil. New branches are continuously formed during the growing season, filling crevices—an ideal long-term survival backup on the sheer cliff face. Branches that have become detached will root when landing on other ledges or in new crevices.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best for bushveld and subtropical coastal gardens, on embankments and miniature rock gardens. Grow in dappled shade, in a sandy mixture. Thriving and popular as a pot plant. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or by division.

VOUCHERS

Van Jaarsveld 17456, 19307 (NBG).

ILLUSTRATIONS AND MAP

Figures 121a & 121b, Map 121.

122. *Crassula foveata* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Bothalia* 33,1: 116–117 (2003e).

Cremonophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *foveatus*, pitted, pertaining to the pitted leaves.

DESCRIPTION AND HABITAT

Plants proliferating from base, forming small, dense mats to clusters 100 mm in diameter. Roots fibrous. Branches short, herbaceous, 20–40 mm long, terete, sparsely strigose, glabrous lower down, 1–1.5 mm in diameter, green, becoming reddish when exposed. Leaves in a loose rosette, sessile, crowded, compact, decussately arranged, sometimes falcate and spreading, slightly recurved, becoming smaller distally, linear-lanceolate to triangular-lanceolate, 12–24 × 3–7

mm; surface glabrous, green becoming reddish, distinctly pitted (shallow leaf depressions), the pits consisting of rounded, reddish depressions 0.3–0.5 mm in diameter, abaxial surface rounded, foveate, adaxial surface canaliculate; margin rounded, thickened, sparsely beset with recurved translucent cilia; apex acute, apiculate. Inflorescence a conspicuous rounded to flat-topped thyrse up to 50 mm high and 50 mm in diameter, bearing 1–several dichasia; peduncle with translucent recurved hairs and a gradual transition of leaves to bracts, reddish; bracts ascending-spreading, distal bracts cymbiform, sparsely pitted, margin entire to sparsely ciliate. Flowers diurnal, sweetly scented, white to light pink, buds 3 mm long, open flowers 4 mm in diameter. Calyx lobes triangular with stout hair at apex, 1.5×0.8 mm. Corolla lobes spreading, oblong-ovate white to pink, apices apiculate. Corolla tubular; petals white, ovate-lanceolate, spreading, 2 mm long, acute. Stamens 1.5 mm long; anthers yellowish, 0.1 mm long. Squamae transversely oblong, 0.4×0.1 mm, yellowish orange. Carpel and style 2 mm long.

Phenology: Flowering in early autumn (March–April). Flowers diurnal, strongly scented.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Cliffs along river valleys (all aspects but mainly exposed northern and western aspects). Plants grow among leaf litter in shallow soil on rocky ledges and often in the shade of cliff-dwelling shrubs or trees. Temperatures are high in summer and mild in winter. The average daily maximum temperature is about 24°C and the average daily minimum about 12°C. Rainfall occurs mainly in summer and ranges from 800–1000 mm per annum (thunder showers, October–May).

Altitude: 300–800 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Collywobbles, *Crassula foveata* grows with *Aptenia cordifolia*, *Cotyledon orbiculata*, *Crassula cordata*, *C. lactea*, *C. perfoliata* var. *minor*, *C. perforata*, *Delosperma* sp., *Drimia anomala* and *Ornithogalum longibracteatum*.

Geology: Sandstone and mudstone (Adelaide Subgroup, Karoo Supergroup).

DISTRIBUTION

Crassula foveata appears to be endemic to the dry river valleys of the Eastern Cape (Mbashe and Mzimvubu Rivers).

RELATED SPECIES

Crassula foveata belongs to section *Rosulares*, which contains 22 species of which eight are cremnophilous. It can immediately be distinguished by its reddish, densely pitted leaves. The leaves are variable in shape, almost subulate to dorsiventrally compressed.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compared to other species in section *Rosulares*, there is a reduction in size and the plants tend to form compact mats, typical of so many cremnophytes.

Size and weight: Clusters small, of light weight.

Stem: Short, ascending to spreading.

Leaves

Orientation: Ascending-spreading, almost subulate, compact, decussately arranged, becoming reddish during dry periods. The rounded, almost subulate leaves, reduction in size and compact nature so typical of many cremnophytes can be viewed as adaptations to the dry conditions on the cliff face.

Colour: Epidermis green, becoming reddish purple, darker pitted surface resulting in a mottled appearance. Margin sparsely ciliate. The reddish colour (production of anthocyanins) under dry conditions reduces penetration of excessive light, an adaptation resulting from the well-drained habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament as opposed to the level-ground species of which some, such as *Crassula capitella* subsp. *capitella* and subsp. *nodulosa*, have a solitary habit or a few branches, the compact clusters suggesting adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Flowering in autumn, the strong scent suggesting a day-flying specialist pollinating agent (insect).

Fruit/Seed

Size: Seed minute, and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in autumn and winter at the onset of cooler conditions, maximising establishment.

Vegetative reproduction: *Crassula foveata* is prolific from the base, forming dense vegetative clusters. When an offshoot becomes detached, it will root if it falls into a new crevice (as a result of heavy wind or some other disturbance), a vegetative reproductive backup strategy ensuring long-term survival.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common, well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens, in dappled shade in rockeries or containers. Easily cultivated, its vigour viewed as maximising survival. Propagate by division or cuttings.

VOUCHER

Van Jaarsveld, Xaba & Harrower 13 (NBG).

ILLUSTRATIONS AND MAP

Figures 122a & 122b, Map 122.

123. *Crassula intermedia* Schönland in Transactions of the Royal Society of South Africa 17: 244 (1929).

Cremnophyte growth form: Small to dense clusters (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *intermedius*, pertaining to its relationships with others in the group such as *Crassula montana* subsp. *quadrangularis* and *C. orbicularis*.

DESCRIPTION AND HABITAT

Plants rosulate, usually proliferating from base to form dense groups up to 60 mm high (without inflorescence). Roots fibrous. Leaves obovate to oblong-obovate, dorsiventrally flattened, 20–50 × 13–25 mm, distal leaves ascending, tightly imbricate, forming hollow cup, basal leaves spreading, not imbricate; surface grey-green to pale green, glabrous; margin ciliate; apex acute to obtuse. Inflorescence a terminal, elongate to round-topped thyrse bearing many clustered dichasia; peduncle up to 150 mm long. Calyx lobes up to 1.5 mm, ovate, ciliate. Corolla tubular, up to 3 mm long; lobes oblong-obovate, up to 2.5 mm long, fused shortly at base, apex rounded. Anthers yellow.

Phenology: Flowering in spring (August to October).

Pollinators: The small white flowers suggest a flying insect.

Habitat and aspect: *Crassula intermedia* is most often associated with sheltered south-facing cliffs. It occurs in large numbers and is easily detected. Summers are hot and humid but winters are cooler. The average daily maximum temperature is about 21–22°C and the average daily minimum for the region 12–13°C. Rainfall mainly in summer, ranging from 400–1000 mm per annum.

Altitude: 50–500 m.

Associated vegetation: Mainly Eastern Valley Bushveld (Mucina *et al.* 2005).

Associated cremnophytes: At Mzimvubu River cliffs near the Welch Bridge (northeastern part of the Eastern Cape), *Crassula pellucida* subsp. *alsinoides*, *Gasteria excelsa*, *Haemanthus albiflos* and *Ornithogalum longibracteatum* have been recorded.

Geology: Varied, shale and sandstone (Cape Supergroup).

DISTRIBUTION

Crassula intermedia occurs widespread in the Eastern Cape, especially in dry river valleys.

RELATED SPECIES

Related to *Crassula montana* subsp. *quadrangularis* but immediately distinguished by its pale grey-green, cup-shaped rosettes.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous clusters, an adaptation to the undisturbed cliffs.

Size and weight: Clusters of light to medium weight.

Stem: Short, not visible.

Leaves

Orientation: In a dense cup-shaped rosette, the open rosettes maximising absorption of light on the south-facing cliffs.

Colour: Epidermis glaucous to pale green.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived, suggesting adaptation to the xeric cliff conditions.

Armament and camouflage: Leaves soft, bodies without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Conspicuous when in flower, insect-pollinated.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed during spring rains, maximising establishment.

Vegetative reproduction: Many forms proliferate from the base, forming dense groups, a vegetative backup survival strategy and adaptation to the sheer cliffs and high run-off. Detached offshoots will root where they fall into crevices below.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket and subtropical coastal gardens, grown in rockeries or containers, in dappled shade. Easily cultivated, its vigour viewed as maximising survival. Grow from cuttings or by division.

VOUCHERS

Van Jaarsveld 17815, 18756 (NBG).

ILLUSTRATIONS AND MAP

Figures 123a–123c, Map 123.

124. *Crassula lanuginosa* Harv. var. *lanuginosa*, Harvey, Flora capensis 2: 347 (1862).

Cremonophyte growth form: Dwarf-sized, mat-forming (of light weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: Latin *lana*, wool, pertaining to the wool-like hairs on the leaves.

DESCRIPTION AND HABITAT

Densely branched, decumbent to prostrate, mat-forming plant up to 50 mm high and 200 mm in diameter. Roots fibrous. Branches about 1 mm in diameter, hairy, sometimes internodes not visible on short side branches owing to dense leaf arrangement, sometimes with aerial roots. Leaves elliptic to obovate, 2–10 × 1–4.5 mm, spreading ascending, dorsiventrally compressed, biconvex; epidermis with spreading hairs; apex acute, with long cilia. Inflorescence a thyse up to 15 × 5 mm, bearing 3–7 flowers and usually with 1 pair of bracts below inflorescence; peduncle 3–15 mm long; bracts triangular-oblong, 1 × 0.3 mm. Corolla up to 3 mm long, tubular; lobes fused at base, becoming recurved, lorate-obovate bearing a dorsal appendage, white to cream. Anthers black.

Phenology: Flowering in summer (January–March).

Pollinators: The white to cream corolla suggests a flying insect.

Habitat and aspect: Mainly shady cliffs, sometimes exposed. Plants grow in shallow soil on shady rocky ledges. Temperatures hot in summer and warm to mild in winter. Average daily maximum temperature is 24–25°C and daily minimum 9–10°C. Rainfall occurs mainly in summer (thunder showers) but with some winter rainfall (cyclonic) and occasional snow during cold fronts. It ranges from 200–450 mm per annum.

Altitude: 1000–3000 m.

Associated vegetation: Karoo Escarpment Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnohytes: At Danielshoek (between Cradock and Pearston), the following plants have been recorded on a cliff face: *Crassula lanceolata* var. *lanceolata*, *C. nemorosa*, *Delosperma* sp., *Drimia uniflora* and *Haemanthus albiflos*.

Geology: Mainly Beaufort shales (Adelaide Subgroup, Karoo Supergroup).

DISTRIBUTION

Crassula lanuginosa var. *lanuginosa* is distributed from Graaff-Reinet, Cradock to Aliwal North in the Eastern and Northern Cape Provinces.

RELATED SPECIES

Differs from other members in section *Argyrophylla* in its soft fragile texture, small leaf size and mat-forming habit. Differs from *C. lanuginosa* var. *pachystemon* in its smaller leaves with sharply acute apices with apical cilia. In comparison, its level-ground relatives have firm, sturdy leaves, and the soft texture of var. *lanuginosa* can be interpreted as the result of a lack of disturbance by herbivores, having evolved in the absence of such disturbances.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Mat-forming, filling crevices, sometimes pendulous. This mat-forming, dwarf-sized, pendulous nature, compared to that of the level-ground species, suggests an adaptation to the sheer cliff face, where the plants often fill small crevices.

Size and weight: Clusters, dwarf-sized, of light weight.

Stem: Erect, 40–100(–150) mm long.

Leaves

Orientation: Ascending-spreading, soft, hairy.

Colour and texture: Grey-green to green. The soft texture is an adaptation to the undisturbed environment, and the hairiness an adaptation to the xeric conditions on the cliff face.

Age and persistence: The plants are relatively rapid-growing, but long-lived perennials.

Armament: Branches soft and fragile without conspicuous armament, an adaptation to the cliff habitat.

Sexual reproduction

Flowers: Inflorescence a thyrse, bearing 3–7 white to cream flowers.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late summer.

Vegetative reproduction: Stems of *Crassula lanuginosa* var. *lanuginosa* root where they come into contact with the soil. New branches are continuously formed during the growing season, filling crevices—an ideal long-term survival backup strategy on the sheer cliff face. Detached branches will root when they land on other ledges or in new crevices.

CONSERVATION STATUS

Locally common and well protected by the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for miniature succulent gardens or small containers in karoo and thicket gardens. Outside the habitat, it is best grown under controlled conditions in a greenhouse. Easily cultivated, its vigour viewed as maximising survival. Easily grown from seed or by division.

VOUCHER

Van Jaarsveld 18268 (NBG).

ILLUSTRATIONS AND MAP

Figures 124a–124d, Map 124.

125. *Crassula montana* Thunb. subsp. *montana*, Thunberg in Nova Acta Physico-Medica Academiae Caesareae Leopoldino-Carolinae ... 6: 329, 332 (1778).

Crempnophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *montana*, mountain, pertaining to the habitat where this species grows.

DESCRIPTION AND HABITAT

Plants rosulate, usually proliferating from base to form small, dense groups up to 30 mm high (without inflorescence). Roots fibrous. Leaves ovate to broadly obovate, 15–25 × 10–16 mm, decussate, in dense basal rosette, becoming smaller distally, light to dark green, with dark green dots, glabrous but with short marginal cilia; apex acute to obtuse. Inflorescence a terminal spike-like thyrses, occasionally flat-topped, 50–90 mm high, bearing sessile dichasia; peduncle 10–80 mm long; bracts leaf-like, obovate to lanceolate 5–14 × 6–8 mm, ciliate. Calyx lobes 2–4 mm long, triangular-lanceolate, ciliate. Corolla tubular, 6 mm long; lobes oblong, 5 mm long, fused shortly at base.

Phenology: Flowering in spring (August–October).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs on mountain ranges and kloofs. Plants grow in shallow soil on shady rocky ledges and often in shade. Temperatures are high in summer and mild in winter. Average daily maximum temperature is 25–27°C and the average daily minimum 10–12°C. Rainfall occurs mainly in winter (cyclonic winter rain) and summer (thunder showers) and ranges from 200–300 mm per annum.

Altitude: 200–2000 m.

Associated vegetation: Agter-Sederberg Shrubland (Fynbos Biome) and Western Gwarrieveld (Succulent Karoo Biome) (Mucina *et al.* 2005).

Associated cremnophytes: On the Wolfberg, the following cliff dwellers have been recorded: *Bulbine* sp., *Crassula nudicaulis*, *C. tomentosa* var. *glabrifolia* and *Senecio crassulaefolius*.

Geology: Quartzitic sandstone (Table Mountain Formation, Cape Supergroup).

DISTRIBUTION

Crassula montana subsp. *montana* is distributed from the southern Cedarberg to Badspoort south of Calitzdorp. Also recently reported from the Piekenierskloof Pass.

RELATED SPECIES

Crassula montana subsp. *montana* can be distinguished by its tight cushions of 4-ranked, obovate, mottled leaves forming almost cup-shaped rosettes.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The dense clusters can be viewed as vegetative output on the cliff face, filling crevices in absence of disturbances by larger herbivores.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Spreading, in open rosettes, compact, decussately arranged. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour: Epidermis green, mottled, becoming reddish during dry periods. The reddish colour (production of anthocyanins) reduces penetration of light, an adaptation resulting from the well-drained, dry habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in spring, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer at the onset of thunder showers, maximising establishment.

Vegetative reproduction. Plants proliferating, forming dense cushions, a vegetative backup strategy enabling the plants to survive the harsh conditions on the cliff face.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best for dry fynbos and succulent karoo gardens, grown in rockeries or containers. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Keep dry during the summer months. Grow in a sandy soil, feed in autumn. Easily cultivated, its vigour viewed as maximising survival. Propagate by division. Dividing annually, rapidly forming dense clusters.

VOUCHERS

Van Jaarsveld 17167, 19545 (NMG).

ILLUSTRATIONS AND MAP

Plate 125, Figures 125a–125g, Map 125.

126. *Crassula montana* Thunb. subsp. *quadrangularis* (Schönland) Toelken in Journal of South African Botany 41: 109 (1975).

Cremonophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: The epithet *quadrangularis*, with four angles, refers to the four-ranked arrangement of the leaves.

DESCRIPTION AND HABITAT

Plants rosulate, proliferating from base to form small, dense mats up to 30 mm high. Roots fibrous. Leaves in basal rosette, 4-ranked, obovate, 7–20 × 4–15 mm, abruptly tapering towards apex, forming a flat square rosette, light to dark green, with dark green dots, glabrous but with short marginal cilia; apex acute to obtuse. Inflorescence a terminal flat-topped thyrse 50–70 mm high, bearing sessile dichasia; bracts leaf-like, obovate to lanceolate, 5–14 × 6–8 mm, ciliate. Calyx lobes 4–5 mm long, triangular-lanceolate, ciliate. Corolla tubular, 6 mm long; lobes oblong, 5 mm long, fused shortly at base, apices spreading, white.

Phenology: Flowering in spring (August–October).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs, mainly on southern aspects. Plants grow in shallow soil among leaf litter on shady rocky ledges. Temperature high in summer and mild in winter. The average daily maximum temperature is 25–27°C and average daily minimum 10–12°C. Rainfall occurs in winter (cyclonic winter rain) and summer (thunder showers) and ranges from 200–300 mm per annum.

Altitude: 1000–1400 m.

Associated vegetation: Steytlerville Karoo (Rainshadow Valley Karoo Bioregion) of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Cotyledon orbiculata*, *Crassula lactea*, *C. perfoliata* var. *minor*, *C. perforata*, *Drimia anomala* and *Ornithogalum longibracteatum*.

Geology: Quartzitic sandstone (Table Mountain Formation, Cape Supergroup).

DISTRIBUTION

Crassula montana subsp. *quadrangularis* is confined to the eastern Great Karoo and southwards to the lower slopes of the Cape Fold Belt mountains bordering the southern Great Karoo, from Laingsburg in the west to the Baviaanskloof in the east.

RELATED SPECIES

Crassula montana subsp. *quadrangularis* is related to *C. cremnophila* (section *Rosulares*). It is at once distinguished from this species by its square bodies, green leaves and white flowers. *Crassula cremnophila* has spherical, grey leaves and pinkish flowers. It is also related to *C. hemisphaerica* growing in non-cliff habitats, usually solitary, with mottled leaves and well camouflaged.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense, compact clusters and mat-forming on cliffs and rock overhangs. The dense clusters can be viewed as vegetative output on the cliff face, filling crevices in absence of disturbances by larger herbivores.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Compact, decussately arranged, ascending, spreading, in tight rosettes. The dwarf-sized rosettes and compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour: Epidermis green, becoming reddish. The reddish colour (production of anthocyanins) appears under dry conditions, reducing penetration of excessive light, an adaptation resulting from the xeric conditions of the cliff habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in spring, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer at the onset of rainy conditions, maximising establishment.

Vegetative reproduction: *Crassula montana* subsp. *quadrangularis* proliferates, forming dense mats and cushions, an efficient vegetative backup strategy enabling the plants to deal with the harsh conditions on the cliff face. When an offshoot becomes detached (as a result of heavy wind or other disturbance), it will root if it falls into a new crevice, ensuring long-term survival.

CONSERVATION STATUS

Crassula montana subsp. *quadrangularis* is common in the habitat, well protected by the cliff environment.

ADDITIONAL NOTES

Horticulture: Best for thicket gardens, grown in rockeries, miniature succulent gardens, roof gardens or containers. Grow in dappled shade. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or by division. Grows best in sandy, slightly acid soil.

VOUCHER

Van Jaarsveld 22356 (NBG).

ILLUSTRATIONS AND MAP

Figures 126a–126c, Map 126.

127. *Crassula nemorosa* (Eckl. & Zeyh.) Endl. ex Walp., *Repertorium botanices systematicae* 2: 253 (1843).

Cremonophyte growth form: Geophyte, compact cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lar:D (vb)

Etymology: Latin *nemorosa*, woods and groves, perhaps pertaining to its wooded cliff-face habitat.

DESCRIPTION AND HABITAT

Geophytes with erect, branched to unbranched stems up to 150 mm high. Tuber spherical, with fibrous adventitious roots. Leaves broadly ovate to orbicular, 3–15 × 4–13 mm, dorsiventrally flattened; margin entire; surface glabrous, grey-green with brown lines; petiole 3–15 mm long; apex rounded to truncate; base cordate to abruptly cuneate. Inflorescence a lax terminal thyrse without peduncle. Calyx lobes triangular-ovate, up to 2.5 mm; apices acute to obtuse. Corolla stellate, shallowly cup-shaped, up to 8 mm in diameter, yellowish green; lobes lanceolate, up to 3.5 mm long; apices becoming recurved. Anthers yellow.

Phenology. Flowering from May–August.

Pollinators: The pale yellow corolla suggests a flying insect.

Habitat and aspect: Sheltered to somewhat exposed cliffs on mountain slopes and kloofs. Plants grow in shallow soil on shady rocky ledges. Temperatures hot in summer and warm to mild in winter. The average daily maximum temperature is 22–24°C and daily minimum 9–14°C. Rainfall occurs mainly in summer (thunder showers) in the eastern part, with winter rainfall in Namaqualand (cyclonic), ranging from 200–450 mm per annum.

Altitude: 200–1800 m.

Associated vegetation: Albany Thicket, Nama-Karoo and Succulent Karoo Biomes (Mucina *et al.* 2005).

Associated cremonophytes: At Danielshoek (between Cradock and Pearston), the following plants have been recorded on a cliff face: *Crassula lanceolata* var. *lanceolata*, *C. lanuginosa* var. *lanuginosa*, *Delosperma* sp., *Drimia uniflora* and *Haemanthus albiflos*.

Geology: Mainly Beaufort shales (Adelaide Subgroup, Karoo Supergroup), dolomite (Namibia).

DISTRIBUTION

Crassula nemorosa is widely distributed in the Eastern Cape around Queenstown, on the mountains of the southern Great Karoo and again in the Richtersveld and Hunsberg of southern Namibia.

RELATED SPECIES

Differs from other members of section *Petrogeton* (eight species) in its small size, glaucous, distinctly succulent leaves, of which the hydathodes are arranged in a ring on the leaf margin, and in the shallow cup-shaped flowers. This reduction in size and succulent, glaucous leaves can be seen as an adaptation to its xeric cliff-face habitat.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Forming small, loose clusters, often filling hairline cracks. The often dwarf size and unarmed, soft texture of the plants are adaptations to the undisturbed cliff-face habitat. The perennial succulent geophytic base ensures survival during dry periods.

Size and weight: Clusters dwarf-sized, of light weight.

Stem: Erect, 40–100(–150) mm long, flaccid, fragile.

Leaves

Orientation: Ascending-spreading.

Colour: Glaucous.

Age and persistence: Summer-deciduous, long-lived perennials.

Armament: Branches soft and fragile without conspicuous armament, an adaptation to the cliff habitat.

Sexual reproduction

Flowers: Inflorescence a lax terminal thyrse without peduncle, the flowers with a stellate, shallowly cup-shaped, yellowish green corolla, up to 8 mm in diameter. The flowers are relatively large, suggesting a specialist pollinator.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late summer.

Vegetative reproduction: Proliferates from its subterranean tubers, filling crevices, an efficient vegetative backup strategy enabling the plants to deal with the harsh conditions on the cliff face.

CONSERVATION STATUS

Classified as rare in Namibia (Loots 2005). Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for miniature succulent gardens and containers. Allow for a resting period. Keep in dappled shade. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 21079 (NBG).

ILLUSTRATIONS AND MAP

Figures 127a–127d, Map 127.

128. *Crassula orbicularis* L., Species plantarum, edn 1: 283 (1753). (Luputana form.)

Cremonophyte growth form: Rarely solitary, small clusters, mat-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: The epithet *orbicularis*, rounded, pertains to the round leaves of some forms.

DESCRIPTION AND HABITAT

Plants rosulate, solitary or forming small to dense clusters of up to about 50 plants by vegetative arboreal stolons. Roots fibrous. Main branch short. Leaves in a dense rosette 30–60 mm in diameter consisting of 10–12 leaves; blade dorsiventrally flattened, green to reddish on undersurface, broadly ovate, 20–35 × 15–25 mm; margin ciliate; adaxial surface convex, with a distinct off-centre groove from close to apex and parallel to margin for a third to two thirds of leaf length, lower surface concave; apex subacute. Inflorescence a terminal, ascending, elongated, lax thyrse up to 150 mm high, bearing several dichasia; peduncle 20 mm long, reddish green; pedicels short, up to 1 mm long. Corolla 3 mm in diameter, shortly tubular; lobes white, ovate-lanceolate, up to 3 mm long. Stamens 2 mm long.

Phenology: Flowering from midwinter to early summer (June–November).

Pollinators: The small white flowers suggest a flying insect.

Habitat and aspect: *Crassula orbicularis* is often associated with cliffs, some forms confined solely to cliff faces, usually on sheltered southern aspects. It occurs in large numbers

and is easily detected. Summers are hot and humid but it is cooler in winter. The average daily maximum temperature is about 20–24°C and the average daily minimum for the region 12–15°C. Rainfall in the south is in winter and summer and in the north it occurs mainly in summer, ranging from 400–1000 mm per annum.

Altitude: 50–1800 m.

Associated vegetation: Mainly Succulent Karoo, Albany Thicket and Eastern Valley Bushveld (Mucina *et al.* 2005).

Associated cremnophytes: At Luputana Gorge in the northeastern part of the Eastern Cape, the following plants have been recorded: *Begonia dregei*, *Crassula pellucida* subsp. *alsinoides*, *Haemanthus albiflos*, *Ornithogalum longibracteatum*, *Peperomia rotundifolia*, *Plectranthus saccatus* subsp. *pondoensis* and *Streptocarpus liliputana*.

Geology: Varied, shale and sandstone and often associated with quartzitic sandstone of the Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Crassula orbicularis occurs widespread from near Worcester to northern KwaZulu-Natal.

RELATED SPECIES

Crassula orbicularis var. *orbicularis* (Luputana form) belongs to section *Argyrophylla*. It differs from other members in its small rosettes of smooth (margin crenulate, hyaline), unequally bilobed leaves with acute apices.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous clusters, an adaptation to the undisturbed cliffs.

Size and weight: Clusters of medium weight.

Stem: Short, not visible.

Leaves

Orientation: Spreading, in dense rosettes, the open rosettes maximising penetration of light on the south-facing cliffs.

Colour: Epidermis light green.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived, an adaptation to the xeric cliff conditions.

Armament and camouflage: Plants with soft leaves and bodies without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Inflorescence conspicuous, the reddish stems and white flowers contrasting against the light green leaves.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed during spring rains, maximising establishment.

Vegetative reproduction: Many forms with runners forming dense groups, a vegetative survival backup and adaptation to the sheer cliffs and high run-off.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Variability: Although as a species it is not an obligate cremnohyte, it is extremely variable, with some obligate cremnophilous forms, and therefore incorporated in this study.

Horticulture: Often grown by lovers of succulent plants. Best grown in succulent karoo, thicket and subtropical coastal gardens. Grow in dappled shade in rockeries or containers. Easily cultivated and a popular succulent plant. Its vigour can be viewed as maximising survival. Propagate by division or from stolons.

VOUCHER

Van Jaarsveld 16421 (NBG).

ILLUSTRATIONS AND MAP

Figures 128a–128c, Map 128.

129. *Crassula peculiaris* (Toelken) Toelken & Wickens in *Journal of South African Botany* 41: 105 (1975).

Cremnohyte growth form: Dwarf-sized, mat-forming (of light weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: Latin *peculiaris*, peculiar, perhaps pertaining to its peculiar habitat in the Western Cape, as opposed to that of its close relative, var. *fragilis*, from the warm subtropical summer-rainfall region.

DESCRIPTION AND HABITAT

Spreading, delicate, mat-forming, succulent herbs up to 300 mm in diameter, with aerial roots and rooting at nodes. Roots fibrous. Branches decumbent, tomentose, green to reddish, glabrous to tomentose, up to 2.5 mm in diameter. Leaves shortly petiolate (3 mm); blade ovate to broadly elliptic, 2–10 × 4–6 mm, tomentose, dorsiventrally compressed, green; upper surface flat, lower surface convex; margin with a ring of hydathodes; apex acute; base cuneate. Flowers solitary in leaf axils; pedicels 6–18 mm long. Calyx lobes 2–5 mm long, linear. Corolla star-shaped, 4 mm long, up to 6 mm in diameter.

Phenology: Flowering in late spring and summer (November–March).

Pollinators: The small white flowers suggest an insect as possible pollinator.

Habitat and aspect: Shady sheltered cliffs and boulders at high altitudes. Plants grow in shallow soil on shady rocky ledges. Temperatures hot in summer and cool in winter, with occasional snow. The average daily maximum temperature is 17–20°C and average daily minimum 6–8°C. Rainfall occurs mainly in winter (cyclonic) and summer (thunder showers) and ranges from 800–2000 mm per annum.

Altitude: 1200–1800 m.

Associated vegetation: North Swartberg Sandstone Fynbos (Mucina *et al.* 2005).

Associated cremnophytes: Solitary and not sharing with other succulent plants.

Geology: Quartzitic sandstone of the Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Crassula peculiaris is restricted to the Groot Swartberg (Western Cape).

RELATED SPECIES

Crassula peculiaris differs from the other level-ground species in its distinctly papillose seeds. It has solitary flowers in the leaf axils.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Mat-forming, fragile, flaccid stems, filling crevices, sometimes pendulous. The safe cliff environment allows for its survival (absence of larger herbivores).

Size and weight: Clusters small, of light weight.

Stem: Ascending to spreading, flaccid, 100–300 mm in diameter.

Leaves

Orientation: Ascending-spreading.

Colour: Green.

Age and persistence: Plants relatively rapid-growing, with constant vegetative renewal.

Armament: Branches soft and fragile without conspicuous armament, an adaptation to the cliff habitat.

Sexual reproduction

Flowers: Flowers solitary in leaf axils. Corolla star-shaped, 4 mm long, up to 6 mm in diameter.

Fruit/Seed

Size: Seed minute, distinctly papillate and ideal for establishment in crevices (becoming stuck in crevices).

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late summer.

Vegetative reproduction: The vigorous mat-forming growth ensures vegetative increase. Branches occupy new crevices by active growth or when they drop from the cliff face, landing and rooting in new crevices. This vegetative increase represents effective backup growth, ensuring long-term survival on the cliff.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common, well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for cool, moist fynbos gardens. Outside the habitat, it is best grown under controlled conditions in a greenhouse (cool, moist atmosphere). Easily cultivated, thriving in containers. Propagation from cuttings or by division.

VOUCHER

Van Jaarsveld 19510 (NBG).

ILLUSTRATIONS AND MAP

Figures 129a & 129b, Map 129.

130. *Crassula pellucida* L. subsp. *spongiosa* Toelken in Journal of South African Botany 41: 114 (1975).

Cremonophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: Latin *spongia*, a sponge, pertaining to the lower part of the ovaries which become spongy.

DESCRIPTION AND HABITAT

Procumbent, mat-forming, with branches up to about 200 mm high, often rooting at nodes. Roots fibrous. Branches terete, green up to 3 mm in diameter; internodes 10–30 mm long. Leaves ovate to broadly ovate, grey-green, 10–22 × 7–18 mm; margin entire, papillose; apex obtuse or acute; base cuneate, decurrent on stem and fused shortly at base to opposite leaf pair. Inflorescence an irregular terminal dichasium up to 30 mm long; pedicels 5–7 mm long. Calyx lobes linear-triangular, up to 2 × 1 mm. Corolla star-shaped, white to pink, up to 10 mm in diameter; lobes ovate, 3 × 2 mm; apices acute. Stamens 2 mm long; anthers yellow.

Phenology: Flowering in late spring (October–November).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs on mountains and kloofs. Plants grow in shallow soil among leaf litter on shady rocky ledges. It is cool in summer and cold in winter. The average daily maximum temperature is 19–21°C and average daily minimum 10–11°C. Rainfall is mainly in winter (cyclonic) and ranges from 800–2000 mm per annum.

Altitude: 800–1600 m.

Associated vegetation: Peninsula Sandstone Fynbos and Western Altimontane Sandstone Fynbos (Mucina *et al.* 2005).

Associated cremnophytes: *Cotyledon orbiculata*, *Crassula coccinea*, *Scopelogena verruculata* and *Senecio serpens*.

Geology: Quartzitic sandstone (Table Mountain Formation, Cape Supergroup).

DISTRIBUTION

Crassula pellucida subsp. *spongiosa* is confined to the higher cliffs of Table Mountain, Du Toits Kloof, Matroosberg, southern Cedarberg and occurs northwards to Calvinia and Nieuwoudtville (Western Cape).

RELATED SPECIES

Crassula pellucida subsp. *spongiosa* can be distinguished from subsp. *pellucida* by its smaller stature, fragile nature, glaucous leaves and spongy basal part of the ovary.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small mats of procumbent stems (rooting at nodes), sometimes becoming drooping.

Size and weight: Clusters small, of light weight.

Stem: Up to 200 mm long.

Leaves

Orientation: Fused at the base, spreading at right angles (decussately arranged). The reduction in size (in comparison to other subspecies of *Crassula pellucida*), compact arrangement and glaucous colour can be viewed as adaptations to the dry conditions on the cliff face.

Colour: Epidermis glaucous, becoming purplish. The purplish colour under dry conditions (production of anthocyanins) reduces penetration of excessive light, an adaptation resulting from the well-drained habitat.

Age and persistence: Plants short-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in spring, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer.

Vegetative reproduction. Plants proliferating and forming dense mats, soon filling new crevices—an effective vegetative backup for continued existence under the harsh conditions on the cliff face. Detached parts that fall into adjacent crevices will root in the new spot.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best for dry fynbos gardens, grown in rockeries in dappled shade. Outside its habitat, it is best grown under controlled greenhouse conditions. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings. Plants soon forming dense mats.

VOUCHER

Van Jaarsveld 17740 (NBG).

ILLUSTRATIONS AND MAP

Figures 130a–130d, Map 130.

131. *Crassula perforata* Thunb. subsp. *kougaensis* Van Jaarsv. & A.E.van Wyk in Aloe 46,1: 22–23 (2009b).

Cremonophyte growth form: Cluster of drooping, leafy stems (of light weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: After its habitat along the Kouga River in the Eastern Cape.

DESCRIPTION AND HABITAT

Plants dwarf-sized, drooping, sparsely to moderately branched shrublets, 80 × 40 mm. Roots fibrous. Branches flaccid, leafy, pendent, 0.8 mm in diameter (usually not visible owing to crowded leaves), grey; younger branches purplish, succulent. Leaves decussate, persistent, ovate to broadly ovate, 8–10 × 8–10 mm, fused at base, closely clasping around stem, forming 4-angled column; blade 3–7 × 2.5–6.0 mm, cymbiform, keeled towards apex; surface smooth, grey- to bluish green, becoming yellowish to reddish towards base, with waxy layer, adaxial surface flattened to convex, abaxial surface convex; margin entire, purplish red with hydathodes (0.4 mm apart); apices acute; oldest leaves withering. Inflorescence a rounded thyrse 6–10 mm in diameter; peduncle curved, up to 5–8 mm long; bracts clasping, 1.0–1.5 mm long, amplexicaul at base. Calyx lobes triangular 0.5 × 0.4 mm long. Corolla 3.5 mm in diameter, tubular, pale yellow; lobes oblong, 2 × 1 mm long, shortly fused at base. Stamens 1.75 mm long; anthers versatile, 0.5 mm long, yellow. Squamulae rectangular, 0.25 mm long. Follicles 1.5 mm long, tapering. Seed pear-shaped, 0.25 × 0.20 mm; surface verrucose.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect. Bluebottles have been observed visiting flowers in habitat.

Habitat and aspect: Exposed cliffs (mainly northern and western aspects). Plants are firmly rooted in crevices (often very small hairline cracks), often solitary in small crevices or socially with other cremonophytes. It is warm to hot in summer and temperatures can reach 40°C. The average daily maximum temperature is about 23–25°C and the average daily minimum for the region 10–12°C. Winters are cooler but frost is absent. Rainfall in winter and summer, ranging from 300–400 mm per annum (cyclonic winter rain or thunder showers).

Altitude: 400–800 m.

Associated vegetation: Gamtoos Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Adromischus cristatus* var. *schonlandii*, *Aloe pictifolia*, *Centella* sp., *Cotyledon tomentosa* var. *tomentosa* and *Crassula perfoliata* var. *minor*.

Geology: Quartzitic sandstone of the Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Restricted to cliffs adjacent to the Kouga River, near Hankey (Eastern Cape).

RELATED SPECIES

Distinguished from the normal forms of *Crassula perforata* by its dwarf-sized stature, flexible and drooping stems, tight 4-ranked leaves forming a rectangular oblong body, and short rounded thyrses. This dwarf-sized Kouga form occurs sympatrically with *C. perforata* and *C. rupestris* subsp. *rupestris*. *Crassula perforata* and *C. rupestris* usually occur on steep rocky slopes below or above the cliff face or on well-vegetated larger ledges. No intermediates or hybridisation have been observed. Grown in cultivation, plants retain their dwarf size. The Kouga form is closely related to *C. perforata*, which has similar flowers, and to *C. rupestris*, both with woody stems. Branches of the subsp. *kougaensis* are flaccid, drooping from cliff faces, and not woody.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Pendent clusters (leafy, flaccid branches) with compact growth.

Size and weight: Clusters dwarf-sized, of light weight. The dwarf size enables plants to occupy small vertical rock crevices.

Stem: Branches flaccid, pendulous to subpendulous. This less woody and pendent nature of the stems can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Leaves spreading, closely packed and forming an oblong, rectangular body about 8×8 mm, becoming distinctly purplish reddish during dry periods. This columnar feature is typical of many cremnophytes and can be viewed as an adaptation to the extreme xeric conditions of the cliff face.

Colour: Epidermis grey-green to glaucous (covered with powdery bloom). The reddish colour under dry conditions reduces penetration of light, an adaptation resulting from the extreme xeric conditions of the cliff habitat.

Age and persistence: Plants long-lived perennials. The long-lived leaves and slow growth rate can be viewed as an adaptation to the mineral-poor quartzitic sandstone soil.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties as opposed to the level-ground species, which are more woody (*Crassula perforata*).

Sexual reproduction

Flowers: Flowering from summer to early autumn (December–March), diurnal, scented, about 3.5 mm in diameter, pale yellow. Bluebottles have been observed visiting flowers in the habitat.

Fruit/Seed

Size: Seed pear-shaped, 0.25×0.20 mm, with verrucose surface ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Summer and autumn, just in time for the winter rains, maximising establishment.

Vegetative reproduction: Like most other *Crassula* taxa, this species will root when stems find new crevices or when pieces become detached (as a result of heavy wind or other disturbances), a vegetative reproductive backup system ensuring long-term survival.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: *Crassula perforata* subsp. *kougaensis* is best grown in thicket gardens, on rockeries but owing to the small size, rather in containers. It can be grown in full sun or dappled shade in sandy, acidic soil. Add ample compost and feed in spring. Easily propagated from seed, cuttings or division.

VOUCHER

Van Jaarsveld 9905 (NBG).

ILLUSTRATIONS AND MAP

Plate 131, Figures 131a–131d, Map 131.

132. *Crassula perforata* Thunb. subsp. *perforata*, Thunberg in Nova Acta Physico-Medica Academiae Caesareae Leopoldino-Carolinae ... 6: 319, 338 (1778). (Eastern Cape and KwaZulu-Natal forms.)

Cremonophyte growth form: Loose clusters with spreading to drooping, flaccid stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: Latin *perforata*, pierced with holes, pertaining to the fused leaf pairs.

DESCRIPTION AND HABITAT

Spreading and scrambling to pendulous, branched shrub up to 500 mm high, variable in size and leaf shape. Roots fibrous. Branches grey-brown, up to 3 mm in diameter, flaccid. Leaves 14–33 × 12–20 mm, dorsiventrally flattened to cymbiform, decussate, abruptly constricted and fused basally to opposite leaf; lamina ovate; surface glabrous, grey-green; margin reddish; apices acute or obtuse; older leaves persistent. Inflorescence an elongated thyrses up to 80 mm long, bearing sessile flowers; peduncle with gradual change from leaves to bracts. Calyx triangular, up to 1 mm long, acute. Corolla tubular, yellowish, shortly fused at base; lobes oblong, up to 2.5 mm long. Anthers brown.

Phenology: Flowering in summer and autumn (November–April).

Pollinators: The small yellowish flowers suggest a flying insect.

Habitat and aspect: Cliffs at altitudes of up to about 800 m (all aspects, common on northern and western aspects). Plants firmly rooted in crevices and size often depends on the growing space allowed by the crevice. It is warm to hot in summer and temperatures can reach 40°C. The average daily maximum temperature is about 22–24°C and the average daily minimum for the region 12–14°C. Winters are colder but frost is absent. Rainfall in the eastern parts (Eastern Cape and KwaZulu-Natal) ranges from 400–800 mm per annum (mainly summer rain).

Altitude: 300–800 m.

Associated vegetation: Mainly Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Collywobbles (Eastern Cape), the following plants have been recorded: *Aloe reynoldsii*, *Cotyledon orbiculata*, *Crassula cordata*, *Drimia anomala*, *Haworthia cymbiformis* var. *setulifera* and *Ornithogalum longibracteatum*.

Geology: Shale of the Beaufort Subgroup (Beaufort Group, Karoo Supergroup), quartzitic sandstone of the Peninsula Formation (Cape Supergroup).

DISTRIBUTION

From Worcester in the Western Cape eastwards and northeastwards to the dry river valleys of southern KwaZulu-Natal.

RELATED SPECIES

A very variable species and distinguished from the level-ground forms by its more flexible, flaccid stems and less woody growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, spreading branches drooping from the cliff face.

Size and weight: Clusters smaller (of medium weight and about 200 mm in diameter) compared to the more robust woody level-ground forms (shrubs up to 600 mm in diameter).

Stem: Flaccid and flexible, shorter, pendulous or subpendulous. The softer, less woody and pendulous nature of the stems can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Leaves spreading at right angles. Compared to other karoo forms of this species, the cliff face forms are more closely packed (genotypic) than level-ground forms, often becoming distinctly purplish reddish during dry periods. This reduction in size and compact growth can be viewed as adaptations to the xeric conditions found on the cliff face.

Colour: Epidermis grey-green to glaucous (covered with powdery bloom). The reddish colour under dry conditions reduces penetration of light, an adaptation resulting from the extreme run-off in its sheer habitat.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived, suggesting adaptation to the xeric cliff conditions.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties as opposed to the level-ground species, which are more woody.

Sexual reproduction

Flowers: Flowering from midsummer to autumn (November–April), diurnal.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with the seeds spontaneously released and dispersed by the wind.

Time: Seeds dispersed in time for autumn rains, maximising establishment.

Vegetative reproduction: The vigorous, spreading growth ensures vegetative increase. Branches will occupy new crevices by active growth or branches blown from the cliff face will root in crevices where they land. This vegetative increase is an effective backup growth ensuring long-term survival on the cliff.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket and succulent karoo gardens, grown in rockeries, on embankments or as a pot plant. Outside the native habitat, it is best grown under controlled conditions in a greenhouse. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or seed.

VOUCHER

Van Jaarsveld 17060 (NBG).

ILLUSTRATIONS AND MAP

Figures 132a–132c, Map 132.

133. *Crassula pseudohemisphaerica* Friedrich in *Mitteilungen der Botanischen Staatssammlung München* 3: 594 (1960).

Cremonophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Greek *pseudo*, false, and *hemisphaerica*, half a sphere, pertaining to its likeness to *Crassula hemisphaerica*.

DESCRIPTION AND HABITAT

Sparsely branched, decumbent to erect, compact herbs forming small to larger, often dense clusters up to 300 mm in diameter and up to 200 high (when flowering). Roots fibrous. Leaves obovate to orbicular, 8–45 × 10–50 mm, dorsiventrally flattened, 4-ranked, tightly imbricate, forming neat spherical bodies, green to reddish green, mottled; margin ciliate; apex rounded. Inflorescence a terminal elongated thyse bearing many dichasia; peduncle up to 250 mm high. Calyx lobes oblong-triangular, up to 3 mm long. Corolla yellowish, tubular, up to 5 mm long, shortly fused at base. Corolla lobes oblong-oblancheolate, up to 4 mm long, spreading and becoming recurved. Anthers yellow.

Phenology: Flowering from spring to early summer (September–November).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs and mainly on southern aspects. Plants grow in shallow soil on shady rocky ledges. Temperatures high in summer and mild in winter. The average daily maximum temperature is 25–27°C and the average daily minimum 10–12°C. Rainfall occurs mainly in winter (cyclonic) and occasionally in autumn (thunder showers) and ranges from 100–300 mm per annum.

Altitude: 50–900 m.

Associated vegetation: Mainly Succulent Karoo and Desert Biomes (Mucina *et al.* 2005).

Associated cremonophytes: Associated cliff-dwelling succulent plants at Kuamsibberg Mountain (southern Namibia) include *Aloe pavelkae*, *Tylecodon buchholzianus*, *T. racemosa* and *T. rubrovenosus*.

Geology: Sandstone and shale.

DISTRIBUTION

Widespread in the Northern Cape, from north of Vanrhynsdorp to Lüderitz in southwestern Namibia.

RELATED SPECIES

Crassula pseudohemisphaerica is related to *C. hemisphaerica*, a widespread species from the south growing on flats and hills. The latter is at once distinguished by its solitary growth (also

section *Rosulares*). *Crassula pseudohemisphaerica* is also related to *C. orbicularis*, also growing on cliffs and mat-forming. It is at once distinguished from that species by its mottled green, 4-ranked leaves and pointed papillae on the ovary.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small to dense, tight clusters that can be viewed as vegetative output on the cliff face, the plants filling crevices in the absence of disturbance by larger herbivores.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Spreading to spreading-recurved, the body often dome-shaped. The compact leaves are 4-ranked, mottled and purplish to reddish green, especially during dry periods. The compact nature and open rosettes can be viewed as an adaptation to the dry conditions on the cliff face.

Colour: Epidermis green, often becoming reddish, often mottled. The reddish colour under dry conditions (production of anthocyanins) reduces penetration of light, an adaptation resulting from the well-drained habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in spring, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer.

Vegetative reproduction: Plants proliferating and forming dense cushions, a vegetative backup enabling the plants to survive the harsh conditions on the cliff face. Crevices are soon occupied by the vegetative growth and by detached plants that fall and root in new crevices, forming new populations.

CONSERVATION STATUS

Not threatened owing to the undisturbed cliff habitat.

ADDITIONAL NOTES

Horticulture: An ornamental species with attractive mottled leaves. Best grown in succulent karoo gardens, on rockeries or containers, in dappled shade. Outside its native habitat, it should rather be grown under controlled conditions in a greenhouse. Sensitive to leaf rust (in moist climates). Propagate by division. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 17589 (NBG).

ILLUSTRATIONS AND MAP

Figures 133a–133d, Map 133.

134. *Crassula pubescens* Thunb. subsp. *ratrayi* (Schönland & Baker f.) Toelken in Journal of South African Botany 41: 116 (1975).

Cremonophyte growth form: Dwarf-sized, mat-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:Lc:Ts (vb)

Etymology: After George Rattray (1872–1941) a Scotsman, teacher and naturalist.

DESCRIPTION AND HABITAT

Dwarf-sized, much-branched, succulent herbs forming small, tight clusters up to 100 mm high. Roots fibrous. Branches succulent, short, green to reddish green, becoming grey-brown. Leaves in a basal rosette, oblanceolate, obovate to oblanceolate, 15–35 × 5–12 mm, dorsiventrally flattened, spreading; surface pubescent; adaxial side flat to channelled, abaxial surface convex; margin rounded to acute, minutely ciliate; apex obtuse to acute; base cuneate. Inflorescence an erect elongated spike-like thyrse 60–80 mm high, bearing 1–several dichasia in distal half; peduncle with 1–3 pairs of bracts; basal bracts 5 × 4 mm, erect, triangular-ovate. Calyx lobes oblong, 1.5 mm long. Corolla tubular, white; lobes oblong-panduriform, up to 3 mm long, fused shortly at base, with ovoid to globose apical appendage.

Phenology: Flowering in summer (end November–January).

Pollinators: The small white to cream corolla suggests a flying insect.

Habitat and aspect: Sheltered south-facing cliffs more than 800 m above sea level. Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (30°C). Winters are cooler, with occasional frost or snow. The average daily maximum temperature is about 23°C and the average daily minimum 8°C. Rainfall occurs throughout the year but with a peak in spring and summer, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 800–1500 m.

Associated vegetation: Camdebo Escarpment Thicket (Mucina *et al.* 2005).

Associated cremnophytes: At Tandyiesberg (southern escarpment margin) near Graaff-Reinet, the following species have been recorded: *Adromischus fallax*, *Cotyledon orbiculata* var. *orbiculata*, *Crassula exilis* subsp. *cooperi*, *C. lanceolata* subsp. *lanceolata*, *C. nemorosa*, *C. perforata*, *Delosperma* spp., *Haemanthus humilis* subsp. *hirsutus* and *Litanthus pusillus*.

Geology: Beaufort shales (Adelaide Subgroup, Karoo Supergroup).

DISTRIBUTION

Known only from the escarpment mountains near Graaff-Reinet.

RELATED SPECIES

Differs from subsp. *pubescens* and subsp. *radicans* in its small basal rosettes and clustered growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Basal rosette and clustered growth, a structural adaptation typical of many cremnophytes.

Size and weight: Clusters dwarf-sized, of light weight.

Stem: Short, decumbent.

Leaves

Orientation: Ascending-spreading (rarely almost recurved), in a basal rosette, dorsiventrally flattened.

Colour: Green with a pubescent epidermis.

Age and persistence: The plants are relatively rapid-growing but long-lived perennials.

Armament: Branches soft and fragile without conspicuous armament, an adaptation to the cliff habitat.

Sexual reproduction

Flowers: Inflorescence an erect, elongated, spike-like thyrse bearing white flowers pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late summer.

Vegetative reproduction: The brittle, succulent leaves will root when they become detached, forming new plantlets—a vegetative backup strategy and efficient adaptation helping the plants to deal with the harsh cliff-face conditions.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Easily cultivated, its vigour viewed as maximising survival. Easily grown from seed or division, thriving in small containers.

VOUCHER

Van Jaarsveld 18283 (NBG).

ILLUSTRATIONS AND MAP

Figures 134a & 134b, Map 134.

135. *Crassula rupestris* Thunb. subsp. *marnieriana* (H.E.Huber & H.Jacobsen) Toelken in Journal of South African Botany 41: 116 (1975).

Cremnophyte growth form: Loose clusters with spreading to drooping stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: After Marnier la Postolle, grower of succulent plants in France.

DESCRIPTION AND HABITAT

Spreading to pendulous, branched shrublets up to 200 mm in diameter, rooting where branches touch ground. Stems 1–2 mm in diameter, spreading and becoming pendulous. Leaves crowded and internodes not visible, sessile, ovate, 3–6 × 4–6 mm, bases fused (over half leaf length) into a disc; surface smooth, glaucous; margins entire; hydathodes concentrated along margins; apex rounded. Inflorescence a short, sessile, rounded thyrse up to 15 mm in diameter, with many flowers in dichasia. Flowers 5-merous, star-shaped, up to 4.5 mm in diameter, white; pedicels 2–5 mm long. Calyx lobes triangular, 1 mm long, apices acute. Corolla lobes oblong-elliptic, 3–4 mm long, recurved; apices obtuse. Stamens up to 3.5 mm long; anthers brown; pollen yellow. Squamae oblong to square, 0.4–0.9 × 0.3–0.6 mm, thick, fleshy, yellowish orange.

Phenology: Flowering in autumn (April–May).

Pollinators: The small white flowers suggest a flying insect.

Habitat and aspect: *Crassula rupestris* subsp. *marnieriana* is confined mainly to south-facing quartzitic sandstone cliffs at 800–1500 m. It is locally abundant, firmly rooted in crevices, size often depending on the growing space allowed by the crevice. It is warm to hot in summer and temperatures can reach 40°C. Winters are cooler but frost is absent. The average daily maximum temperature is about 25–26°C and the average daily minimum for the region 9–10°C. Rainfall occurs mainly in winter (cyclonic) and summer (thunder showers), ranging from 250–350 mm per annum.

Altitude: 800–2000 m.

Associated vegetation: Mainly Gamka Thicket, Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated cremnophytes include *Aloe comptonii*, *Crassula cotyledonis*, *C. muscosa*, *C. perforata* and *Haemanthus coccineus*.

Geology: Quartzitic sandstone of the Peninsula Formation, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Northwestern Little Karoo, Anysberg to Klein Swartberg and mountains along the Huis River Pass (Western Cape).

RELATED SPECIES

Differs from the typical subsp. *rupestris* in its smaller, spreading habit (readily rooting at the nodes) and its short internodes not visible (forming a cylindrical ‘body’), and in the opposite, round-ovate leaves fused into an orbicular disk obtuse at the apices.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, spreading branches drooping from the cliff face.

Size and weight: Clusters of medium weight and smaller (about 200 mm in diameter) compared to the larger and more woody level-ground forms of *Crassula rupestris*.

Stem: Flaccid, shorter and pendulous or subpendulous. The softer, less woody and pendulous nature of the stems (compared to the woody subsp. *rupestris* on non-cliff habitats) can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Spreading, closely packed, forming a cylindrical body. Leaf pairs fused by half or more into a disc, this crowded leaf arrangement an adaptation to the xeric conditions of the cliff face.

Colour: Epidermis glaucous, an adaptation resulting from the extreme run-off in the sheer habitat.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived, suggesting adaptation to the xeric cliff conditions.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties as opposed to the level-ground *Crassula rupestris* subsp. *rupestris*, which is more woody.

Sexual reproduction

Flowers: In a large round-topped thyrses, conspicuous, in autumn and winter (April–June).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in time for autumn rains, maximising establishment.

Vegetative reproduction: The spreading growth ensures vegetative increase and branches will occupy new crevices by active growth. This vegetative increase is an effective backup growth ensuring long-term survival on the cliff.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Variability: Plants variable in size, with many different forms.

Horticulture: Best for succulent karoo and dry fynbos gardens, in rockeries or containers. Propagate from cuttings or by division. Grow in full sun or dappled shade, preferably in slightly acid, sandy soil.

VOUCHER

Van Jaarsveld 17431 (NBG).

ILLUSTRATIONS AND MAP

Figures 135a–135d, Map 135.

136. *Crassula rupestris* Thunb. subsp. *rupestris*, Thunberg in Nova Acta Physico-Medica Academiae Caesareae Leopoldino-Carolinae ... 6: 329, 337 (1778). (Olifantsrivier and Peninsula forms.)

Cremnophyte growth form: Cluster with spreading to drooping stems (of light to medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: Latin *rupes*, a cliff or rock, pertaining to its often rock or cliff habitat.

DESCRIPTION AND HABITAT

Plants small, drooping to rounded, branched shrublets up to 180 × 180 mm. Roots fibrous. Branches leafy, flaccid, pendent, becoming woody at base, up to 4 mm in diameter; bark peeling; younger branches 2 mm in diameter, succulent. Leaves 10–14 × 9–14 mm, dorsiventrally flattened; adaxial surface flat to convex, concave towards base, abaxial surface convex; blade broadly ovate; surface glabrous grey-green to glaucous, with powdery bloom, constricted towards base, fused with opposite leaf pair basally; margin entire, reddish; apex acute or obtuse. Inflorescence a rounded thyrses, 25 × 25 mm; peduncle up to 10 mm long; basal bracts spreading, up to 7 mm long. Calyx lobes oblong-triangular, up to 1 mm long. Corolla 5 mm in diameter, tubular, white to light pink, sweetly scented; lobes oblong, 3 mm long, shortly fused at base. Anthers brown. Seed minute.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Cliffs at altitudes of up to about 700 m (mainly northern and western aspects). Plants grow firmly rooted in crevices, size often depending on the space allowed by the crevice. Warm to hot in summer, temperatures reaching 40°C. Winters are cooler but frost is absent. Average daily maximum temperature 22–24°C, average daily minimum for the region 12–14°C. Rainfall mainly in winter, 400–1000 mm per annum (mainly cyclonic winter rain).

Altitude: 400–700 m.

Associated vegetation: Mainly fynbos.

Associated cremnoophytes: On Karbonkelberg (Cape Peninsula), the plants have been recorded with *Aloe succotrina*, *Bulbine lagopus*, *Cotyledon orbiculata* var. *orbiculata*, *Crassula coccinea*, *Scopelogena verruculata* and *Tylecodon paniculatus*.

Geology: Quartzitic sandstone of the Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Table Mountain and Karbonkelberg (Cape Peninsula), Piketberg, Hottentots Holland and Olifantsrivier Mountains of the Western Cape.

RELATED SPECIES

Distinguished from the non-cremnophilous forms of *Crassula rupestris* by its smaller, compact and flaccid growth and internodes that are 2–3 mm long (as opposed to 7–10 mm in other forms). Branches often droop from cliff faces and plants are less woody.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, with reduction in size and compact growth.

Size and weight: Clusters of small to medium weight.

Stem: Shorter but pendulous or subpendulous. The softer, less woody (flaccid stems) and pendulous nature of the stems can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Closely packed, almost forming a subcylindrical body about 15–18 mm in diameter, often becoming distinctly purplish reddish during dry periods. The reduction in size and the compact growth can be viewed as adaptations to the xeric conditions on the cliffs.

Colour: Epidermis grey-green to glaucous (covered with powdery bloom). The reddish colour under dry conditions reduces penetration of light, an adaptation resulting from the extreme run-off in the sheer habitat.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived.

Armament and camouflage: Soft-leaved plant bodies without conspicuous armament or camouflage properties as opposed to the level-ground species, which are more woody.

Sexual reproduction

Flowers: Flowering in early autumn (February–March), diurnal, scented, about 5 mm in diameter, white to light pink. This suggests a day-flying specialist pollinating agent (insect).

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Autumn, just in time for the winter rains and thus maximising establishment.

Vegetative reproduction: As in most other *Crassula* taxa, stems or detached pieces (as a result of heavy wind or other disturbances) of this species will root when finding a crevice, a vegetative reproductive backup strategy ensuring long-term survival.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best for fynbos gardens, grown on steep embankments and rockeries, and it also thrives in containers, in sandy soil. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or division.

VOUCHER

Van Jaarsveld 18418 (NBG).

ILLUSTRATIONS AND MAP

Figures 136a & 136b, Map 136.

137. *Crassula sediflora* (Eckl. & Zeyh.) Endl. ex Walp. var. *sediflora*, Walpers, Repertorium botanices systematicae 2: 254 (1843).

Cremnophyte growth form: Loose cluster (of light weight, cliff hugger).

Growth form formula: E:F:P:Els (vb)

Etymology: The epithet *sediflora* pertains to the flowers resembling the genus *Sedum*.

DESCRIPTION AND HABITAT

Decumbent, branched, wiry perennials, up to 400 mm high. Branches with internodes 4–15 mm long. Leaves linear, 10–35 × 1–2 mm, dorsiventrally flattened; leaf pairs alternately arranged; surface slightly papillose (becoming smooth), green to yellowish green; margin ciliate towards base; apex acute. Inflorescence an erect, terminal, round-topped thyrse bearing 1–many dichasia; bracts leaf-like, becoming shorter distally. Flowers shortly pedicellate, lax. Calyx lobes broadly triangular, up to 2 mm long, surface glabrous. Corolla tubular, cream to white, up to 3 mm long; lobes oblong-obovate, up to 2.5 mm long, fused shortly at base; apices rounded, slightly hooded, recurved. Anthers yellow.

Pollinators: The conspicuous diurnal white to cream flowers suggest a day-flying insect.

Habitat and aspect: Mainly on sheltered south-facing cliffs, in shallow soil on sunny rocky ledges. Temperatures moderate in summer and mild to low in winter. The average daily maximum temperature is 22–23°C and the average daily minimum 6–7°C. Rainfall occurs mainly in summer (mainly thunder showers) and ranges from 700–1000 mm per annum.

Altitude: 350–950 m.

Associated vegetation: Midlands Mistbelt Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Crassula* species, *Ledebouria* sp. and *Merwillia plumbea*.

Geology: Mainly sandstone (Natal Group).

DISTRIBUTION

Crassula sediflora var. *sediflora* is distributed from near Seymour (Eastern Cape) to eastern, central KwaZulu-Natal.

RELATED SPECIES

Differs from var. *amatolica* in its thinner, longer leaves without the distinct cilia on the leaf margin. The latter variety is a grassland species with shorter, broader leaves (Toelken 1975). Differs from the related *Crassula southii* in its leaf apices lacking the long central hair.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Loose clusters, becoming drooping. Plants conspicuous and not camouflaged. The unarmed, soft texture of the plants is an adaptation to the undisturbed cliff-face habitat.

Size and weight: Clusters small, of light weight.

Stem: Decumbent, flaccid, up to 400 mm long.

Leaves

Orientation: Leaves spreading to recurved, linear, soft, dorsiventrally flattened and with a slightly papillose (becoming smooth) surface. Margin ciliate only towards base; apex acute.

Colour and texture: Epidermis green to yellowish green. The soft texture and fragile nature suggest adaptation to the sheltered and undisturbed cliff face.

Age and persistence: The plants are fast-growing, long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in summer (February) and autumn (to May), pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late autumn or winter.

Vegetative reproduction: Stems will root when coming into contact with the soil. The prolific nature of the plants (vegetative backup) ensures long-term survival on the cliffs.

CONSERVATION STATUS

Locally common and well protected by the cliff-face habitat.

ADDITIONAL NOTES

Horticulture: For subtropical coastal gardens; shady embankments or containers. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings. Keep moist in summer.

VOUCHER

Van Jaarsveld 22391 (NBG).

ILLUSTRATIONS AND MAP

Figures 137a & 137b, Map 137.

138. *Crassula sericea* Schönland var. *sericea*, Schönland in Botanische Jahrbücher 45: 254 (1910). (Cliff-face form from the Richtersveld.)

Cremnophyte growth form: Rounded cluster to mat-forming (of light weight, cliff hugger).

Growth form formula: A:S:Lper:Lc:Ts (vb)

Etymology: Latin *sericea*, with closely depressed silky hairs, pertaining to the leaves of the species.

DESCRIPTION AND HABITAT

Plants much-branched, forming rounded, spreading tufts, 60 × 200 mm. Leaves very fragile, variable, mainly broadly obovate, oblanceolate to orbicular, 10–25 × 10–25 mm; blade very swollen, somewhat dorsiventrally compressed; surface grey-green with spreading to recurved hairs, adaxial surface flat to convex, abaxial surface convex; margin reddish distally; apex obtuse; base cuneate. Inflorescence an elongated thyrses, 40–100 mm, with few to many dichasia; peduncle hairy, purplish, 2 mm in diameter at base; bracts triangular, clasping, 2 mm high. Calyx lobes triangular-lanceolate, 1 mm high. Corolla tubular, sessile, 4 × 2 mm; lobes oblanceolate, 3 × 1.3 mm, ascending-spreading, white. Anthers brown.

Phenology: Flowering mainly in winter (May–August).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs, at altitudes of up to about 800 m. Plants grow in shallow soil on shady rocky ledges. Temperatures are high in summer and mild in winter. The average daily maximum temperature is about 24°C and daily minimum about 10–12°C. Rainfall in the western Richtersveld region occurs mainly in winter (cyclonic winter rain) and in the eastern part (Bushmanland) mainly in summer. It ranges from 75–250 mm per annum.

Altitude: 100–800 m.

Associated vegetation: Western Gariiep Hills Desert, Noms Mountain Desert and Richtersveld Mountain Desert. Also Bushmanland Arid Grassland of the Nama-Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: In the upper reaches of the Gannakouriep River (Richtersveld Transfrontier National Park), *Crassula sericea* var. *sericea* has been recorded with other cliff-

dwelling succulent plants such as *Aloe meyeri*, *Bulbine pendens*, *Ornithogalum suaveolens* and *Tylecodon ellaphieae*.

Geology: Quartzitic sandstone, Rosyntjieberg Formation (Orange River Group; Proterozoicum).

DISTRIBUTION

Crassula sericea var. *sericea* is confined to the lower Orange River Valley, from Kakamas to the Richtersveld, also Karasberg and Witputz region.

RELATED SPECIES

Crassula sericea var. *sericea* is related to var. *hottentotta* but the latter is not as fragile and the leaves have rounded trichomes.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense, rounded, compact clusters.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Ascending-spreading, very fragile, compact. Compared to other varieties of *Crassula sericea*, which are larger, the reduction in size and compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour: Epidermis greyish to brownish green, becoming brownish or reddish green. The reddish colour under dry conditions (production of anthocyanins) reduces penetration of light, an adaptation resulting from the well-drained habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering mainly in winter and early spring and pollinated by insects. Inflorescence is an elongated thyrse (indication of wind-dispersed seed). Corolla tubular, ascending-spreading, white-flowered.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in spring and summer.

Vegetative reproduction. Plants proliferating and forming dense cushions, a vegetative backup strategy enabling the plants to survive the harsh conditions on the cliff face. When becoming detached, the fragile leaves will root if they fall into a crevice.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best for succulent karoo gardens, in shady rockeries or grown as a pot plant. Outside its habitat, it should preferably be grown under controlled conditions in a greenhouse. Easily cultivated, its vigour viewed as maximising survival. Propagate from leaf cuttings or division. Tends to get fungal rust in coastal parts (Cape Town coast).

VOUCHER

Van Jaarsveld 22258 (NBG).

ILLUSTRATIONS AND MAP

Figures 138a–138d, Map 138.

139. *Crassula setulosa* Harv. var. *jenkinsii* Schönland in Transactions of the Royal Society of South Africa 17: 239 (1929).

Cremonophyte growth form: Dwarf-sized, mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: After T.J. Jenkins, assistant at the Transvaal Museum during Mrs Leendertz's time.

DESCRIPTION AND HABITAT

Plants with erect, irregularly arranged leaves, proliferating to form dense, untidy clusters up to 250 mm in diameter. Roots fibrous. Leaves lanceolate to linear lanceolate, 10–30 × 6–14 mm, dorsiventrally flattened; upper surface flat, glabrous, lower surface convex, glabrous, green to reddish when exposed; margin ciliate; apex acute. Inflorescence a terminal cyme with 1–5 flowers; axillary buds below flowers characteristic of this variety, brittle, rooting when becoming detached. Corolla white, tubular, up to 4 mm long; lobes oblong to oblanceolate, fused shortly at base, apices spreading to recurved. Anthers dark purple to black.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Exposed cliffs above altitudes of 500 m. Plants grow in shallow soil on rocky ledges. Temperatures are high in summer and mild in winter. The average daily maximum temperature is 27–28°C and the average daily minimum 10–12°C. Rainfall occurs mainly in summer (mainly thunder showers) and ranges from 500–1000 mm per annum.

Altitude: 1000–1800 m.

Associated vegetation: Waterberg-Magaliesberg Summit Sourveld of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: On the Blouberg (Limpopo Province), plants grow with *Adromischus umbraticola* subsp. *umbraticola*, *Aloe mutabilis*, *Cotyledon barbeyi* and *Crassula swaziensis*.

Geology: Mainly quartzitic sandstone on various formations.

DISTRIBUTION

Crassula setulosa var. *jenkinsii* is widely distributed in Gauteng and the Limpopo Province, from the Magaliesberg range to Soutpansberg in the north.

RELATED SPECIES

At once distinguished from the other varieties or *Crassula* species by its erect leaves and untidy mats.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense and often untidy cushions, plants conspicuous and not camouflaged. The tightly arranged leaves and mat-forming prolific nature suggest an adaptation to the xeric cliff face, the plants rapidly filling crevices and thus lowering establishment of other dwarf-sized cremnophytes.

Size and weight: Clusters dwarf-sized, of light weight.

Stem: Lengthening and becoming spreading, adpressed against the rocks.

Leaves

Orientation: Ascending to erect. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour and texture: Epidermis green, becoming reddish. The reddish colour (production of anthocyanins) under dry conditions reduces penetration of light, an adaptation resulting from the well-drained habitat. The soft texture and fragile nature suggest adaptation to the sheltered and undisturbed cliff face.

Age and persistence: Rapid vegetative growth leading to constant renewal of populations, plants thus long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Sparsely flowering, and vegetative buds on inflorescence distinct. Flowering in late summer and autumn, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late autumn or winter.

Vegetative reproduction: The inflorescence has axillary buds that are brittle and when they become detached and fall into crevices below they will root, thus spreading by vegetative means, filling crevices. This differs from the situation in solitary rosulate forms on level ground and represents an adaptation to the cliff habitat.

CONSERVATION STATUS

Locally common and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: *Crassula setulosa* var. *jenkinsii* is best for highveld gardens, grown in miniature rockeries. Plants can be grown in full sun or dappled shade. Easily cultivated, fast-growing and its vigour can be viewed as maximising survival. Propagate from cuttings (rosettes) or division.

VOUCHERS

Van Jaarsveld 18019, 18038 (NBG).

ILLUSTRATIONS AND MAP

Figures 139a–139d, Map 139.

140. *Crassula setulosa* Harv. var. *longiciliata* Toelken in *Journal of South African Botany* 41: 119 (1975).

Cremonophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *longi*, long, and *cilium*, an eyelash, pertaining to the leaves with long hairs on the margins.

DESCRIPTION AND HABITAT

Plants rosulate, forming erect branches up to 150 mm high, often with rosette-like buds on main branch in winter. Roots fibrous. Leaves elliptic-oblong to oblanceolate, 3–10 × 2–3 mm, dorsiventrally flattened; upper surface flat, glabrous, lower surface convex, glabrous, green to

reddish when exposed; margin ciliate; apex acute. Inflorescence a terminal flat-topped thyrse with many flowers. Corolla white, tubular, up to 4 mm long; lobes oblong-ob lanceolate, fused shortly at base; apices spreading to recurved, rounded. Anthers dark purple to black.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Exposed cliffs above altitudes of 1000 m. Plants grow in shallow soil on rocky ledges. Temperatures are moderate in summer and mild to low in winter. The average daily maximum temperature is 18–20°C and daily minimum 6–8°C. Rainfall occurs mainly in summer (mainly thunder showers) and ranges from 1000–1500 mm per annum.

Altitude: 1000–3000 m.

Associated vegetation: Lydenburg Montane Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe challisii*, *Ledebouria* spp., *Rhodohypoxis baurii* and *Senecio orbicularis*.

Geology: Mainly quartzitic sandstone on various formations.

DISTRIBUTION

Crassula setulosa var. *longiciliata* is distributed from the northern Drakensberg in KwaZulu-Natal to Mount Anderson in Mpumalanga.

RELATED SPECIES

Differs from var. *setulosa* by its woody branches up to 150 mm long and the rosulate buds along the stem in winter.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense cushions, plants conspicuous and not camouflaged. The tightly arranged leaves clasping the stem and prolific nature are an adaptation to the xeric cliff face, the plants rapidly filling crevices and thus lowering establishment of other dwarf-sized cremnophytes.

Size and weight: Clusters small, of light weight.

Stem: Erect, woody, with rosettes in leaf axils.

Leaves

Orientation: Ascending-spreading.

Colour and texture: Epidermis green, becoming reddish. The reddish colour under dry conditions reduces penetration of excessive light, an adaptation resulting from the well-drained habitat. The soft texture and fragile nature suggest adaptation to the sheltered and undisturbed cliff face.

Age and persistence: Rapid vegetative growth leading to constant renewal of populations, plants thus long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in late summer and autumn, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with the seeds spontaneously released and dispersed by the wind.

Time: Seeds released in late autumn or winter.

Vegetative reproduction: Stems lengthening and forming rosettes in the axils. These brittle vegetative propagules break loose and will root if they fall into a crevice or come into contact with the soil. This differs from the situation in solitary rosulate forms on level ground and represents an adaptation to the cliff habitat.

CONSERVATION STATUS

Locally common and well protected by the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Easily cultivated, its vigour viewed as maximising survival. Propagate from rosettes. Not often grown.

VOUCHER

Van Jaarsveld 16986 (NBG).

ILLUSTRATIONS AND MAP

Figures 140a & 140b, Map 140.

141. *Crassula setulosa* Harv. var. *setulosa*, Harvey, Flora capensis 2: 347 (1862).

Cremonophyte growth form: Dwarf-sized, mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *seta*, a bristle, and pertaining to the leaves.

DESCRIPTION AND HABITAT

Plants rosulate, proliferating from procumbent branches to form dense clusters up to 250 mm in diameter. Roots fibrous. Leaves elliptic, broadly elliptic to ovate-lanceolate, 10–30 × 6–14 mm, dorsiventrally flattened, recurved, in a tight rosette (when exposed to sun) at first, becoming more lax in flower; surface variable in colour and vestiture, with recurved hairs, to glabrous, green to reddish when exposed, upper surface flat to slightly channelled, lower surface convex; margin ciliate; apex acute; base cuneate. Inflorescence a terminal round-topped thyrse bearing 1–few dichasia. Flowers sessile. Calyx lobes triangular, up to 3 mm long, margin ciliate; apices with sturdy apical hair. Corolla tubular, up to 4 mm long, white; lobes oblong-lanceolate, up to 3.5 mm long, shortly fused at base; apices acute, spreading to recurved. Anthers yellow to brown.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs above altitudes of 1000 m (mainly exposed northern and western aspects). Plants grow in shallow soil on exposed rocky ledges. Temperatures are moderate in summer and low in winter, with snow on the high escarpments. The average daily maximum temperature is 18–22°C and daily minimum 6–10°C. Rainfall occurs mainly in summer (mainly thunder showers) and ranges from 800–2000 mm per annum.

Altitude: 1000–3000 m.

Associated vegetation: Southern Drakensberg Highland Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremophytes: On Aasvoëlkop (Northcliff, Johannesburg) plants grow with *Adromischus umbraticola* subsp. *umbraticola* and *Crassula swaziensis*.

Geology: Mainly quartzitic sandstone on various formations.

DISTRIBUTION

Crassula setulosa var. *setulosa* is widely distributed from the higher eastern Drakensberg escarpment mountains in South Africa and northwards to Mount Mulanje in Malawi.

RELATED SPECIES

At once distinguished from the other varieties by its regular rosettes of ovate to elliptic, usually hairy leaves. *Crassula setulosa* var. *setulosa* belongs to section *Rosulares*, which includes 22 species (Toelken 1985). Var. *jenkinsii* has indistinct basal rosettes. The var. *deminuta* has smaller and less cauline leaves. Differs from the other related level-ground *Crassula* species in its dwarf size and dense habit of brittle leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense cushions, plants fairly conspicuous. The tightly arranged leaves and prolific, mat-forming nature suggest an adaptation to the xeric cliff face.

Size and weight: Clusters small, of light weight.

Stem: Short, adpressed against the rocks.

Leaves

Orientation: Ascending-spreading, compact. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour and texture: Epidermis green, becoming reddish. The reddish colour (production of anthocyanins) under dry conditions reduces penetration of light, an adaptation resulting from the well-drained habitat. The soft texture and fragile nature reflect the sheltered habitat on the undisturbed cliff face.

Age and persistence: Rapid vegetative growth leading to constant renewal of populations, plants thus long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in summer and autumn, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in autumn and winter.

Vegetative reproduction: *Crassula setulosa* var. *setulosa* proliferates, forming dense mats and cushions, an efficient vegetative backup strategy for surviving the harsh conditions on the cliff face. A detached offshoot will root if it falls into a new crevice (as a result of heavy wind or some other disturbance), ensuring long-term survival.

CONSERVATION STATUS

Locally common and well protected by the cliff habitat.

ADDITIONAL NOTES

Horticulture: *Crassula setulosa* var. *setulosa* is best for highveld gardens, grown in miniature rockeries. Plants can be grown in full sun or dappled shade. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings (rosettes) or division.

VOUCHER

Van Jaarsveld 17339 (NBG).

ILLUSTRATIONS AND MAP

Figures 141a–141c, Map 141.

142. *Crassula sladenii* Schönland in Annals of the South African Museum 9: 46 (1912).

Cremnophyte growth form: Cluster of drooping, leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb) (e)

Etymology: After the Percy Sladen Expedition. Funds provided with the help of the Percy Sladen Memorial Trust (William Percy Sladen, a British naturalist who died in 1900).

DESCRIPTION AND HABITAT

Spreading, somewhat scrambling, sparsely branched shrub up to 500 mm high. Roots fibrous. Branches grey-brown, 4 mm in diameter. Leaves ovate to ovate-lanceolate, 25–40 × 15–25 mm, dorsiventrally flattened, basally fused with opposite leaf; surface glabrous, grey-green or pale green, with a powdery bloom, upper surface flat, lower surface convex; margin reddish; apices obtuse or acute; older leaves persistent. Inflorescence an elongated, round-topped thyrse; peduncle short, up to 20 mm long, with sessile flowers. Calyx triangular-lanceolate, up to 2 mm long, acute. Corolla tubular, white, shortly fused at base; lobes oblong-elliptic, up to 5 mm long. Anthers black.

Phenology: Flowering in midsummer.

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Cliffs at altitudes of up to about 1000 m (all aspects). Plants are firmly rooted in crevices (often very small hairline cracks), often solitary in small crevices or socially with other cremnophytes. Temperatures are moderate to high in summer and can reach 40°C. Winters are cooler but frost is absent. The average daily maximum temperature is 27°C and the average daily minimum for the region is 13°C. Rainfall occurs mainly in winter, ranging from 75–200 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 500–1100 m.

Associated vegetation: Western Gariep Lowland Desert of the Desert Biome as well as Succulent Karoo Biome.

Associated cremnophytes: On Kuansibberg in southern Namibia, *Crassula sladenii* grows in association with *Aloe pavelkae*, *Crassula macowanii*, *Hartmanthus* sp., *Haworthia tessellata* and *Tylecodon racemosus*.

Geology: Dolomite and sandstone of the Kuibis and Schwarzrand Subgroups (Nama Group). Substrate rough, with many ledges, crevices and fissures, ideal for the establishment of plants.

DISTRIBUTION

Restricted to cliffs along the lower Orange River Valley (Northern Cape in South Africa and in southern Namibia), mainly on dolomite, but also sandstone.

RELATED SPECIES

Related to *Crassula perforata*, *C. rupestris* and *C. badspoortense*. Immediately distinguished from them by its larger, more robust stature.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Clusters of pendent, leafy branches

Size and weight: Clusters of medium weight.

Stem: Branches bending down at the apices, becoming pendulous to subpendulous. This epinastic growth, becoming pendent, can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Spreading, decussate, closely packed and fused at the bases.

Colour: Grey-green to glaucous, covered with a powdery bloom (becoming distinctly purplish reddish during dry periods), suggesting adaptation to the extreme xeric conditions of the cliff face. The reddish colour under dry conditions reduces penetration of light, another adaptation resulting from the extreme run-off in the sheer habitat.

Age and persistence: Plants long-lived perennials. Leaves also persistent and long-lived.

Armament and camouflage: Soft, flaccid, leafy plant bodies without conspicuous armament or camouflage properties as opposed to the level-ground species, which are more woody.

Sexual reproduction

Flowers: Flowering in midsummer.

Fruit/Seed

Size: Seed very fine dust diaspores, ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Summer and autumn, just in time for the winter rains and thus maximising establishment.

Vegetative reproduction: Stems will root when coming in close contact with crevices, an efficient vegetative backup strategy for surviving the harsh conditions on the cliff face. A detached branch will root.

CONSERVATION STATUS

Classified as near threatened (Raimondo *et al.* 2009). However, locally abundant and well protected in the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for desert and succulent karoo gardens and ideal for steep embankments. Grow in a sandy soil, keep dry in summer. Outside the desert habitat, it should be grown under controlled conditions in a greenhouse. *Crassula sladenii* is easily propagated from cuttings.

VOUCHER

Van Jaarsveld 19917 (NBG).

ILLUSTRATIONS AND MAP

Plate 142, Figures 142a–142c, Map 142.

143. *Crassula smithii* Van Jaarsv., D.G.A.Styles & G.McDonald in *Aloe* 45,4: 90–92 (2008).

Cremonophyte growth form: Compact small clusters (of medium weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: After Professor Gideon Smith (1959–), current Chief Director, Biosystematics Research and Biodiversity Collections, at the South African National Biodiversity Institute, who discovered this species.

DESCRIPTION AND HABITAT

Perennials forming compact, rosulate, basal clusters, when in flower up to 250 mm tall, 200 mm in diameter. Roots fibrous. Stems erect to decumbent, succulent, glabrous, terete, up to 8 mm in diameter, yellowish green at first, becoming reddish brown with age. Leaves sessile, firm, distinctly succulent, linear-triangular, 40–160 × 8–12 mm; adaxial surface flat to slightly channelled, lower surface rounded, yellowish to reddish green; margin entire; apex acute, bearing a mucro. Inflorescence a terminal, round-topped thyrse with many pedicellate, 5-merous flowers in 1–many dichasia; basal part of inflorescence glabrous, distal parts with scattered, recurved, scabrid hairs; bracts triangular-subulate, becoming smaller distally; basal bracts 10 × 4 mm, distal bracts 4 × 1.5 mm; pedicels 7–25 mm long. Sepals triangular, 4 × 1.5 mm, surface subglabrous, with scattered recurved translucent scabrid hairs, with distinct marginal cilia; apex acute. Petals triangular, 5 × 1.8 mm, spreading, slightly recurved at tip; apex reddish with distinct subulate dorsal appendage, 0.5 mm long. Stamens 5 × 0.8 mm, tapering towards apex; anthers 0.8 × 0.5 mm, brown; pollen yellow. Squamae 0.3 × 0.5 mm, slightly emarginate, orange. Carpels tapering into subulate styles.

Phenology: Flowering in summer (January–March).

Pollinators: The conspicuous diurnal white flowers suggest a day-flying insect.

Habitat and aspect: Exposed cliffs at altitudes of up to about 1000 m. Plants grow in shallow soil on sunny rocky ledges. Temperature moderate in summer and mild to lower in winter. Average daily maximum temperature is about 24°C and daily minimum about 12°C. Rainfall mainly in summer (mainly thunder showers), ranging from 700–800 mm per annum.

Altitude: 800–1300 m.

Associated vegetation: KwaZulu-Natal Sandstone Sourveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: According to David Styles (pers. comm.) who recently visited the habitat, the following cliff dwellers occur there: *Aeollanthus parvifolius*, *Aloe arborescens*, *Crassula perfoliata* var. *heterotricha*, *Cyanotis* sp., *Delosperma* sp. (white flowers), *Plectranthus purpuratus* subsp. *purpuratus* and *Senecio rhyncholaenus*.

Geology: Mainly quartzitic sandstone of the Natal Group (Cape Supergroup).

DISTRIBUTION

Crassula smithii is known only from the Noodsberg, northwest of Durban, KwaZulu-Natal.

RELATED SPECIES

Differs from *Crassula alba* (flat terrain) by its subulate, very succulent leaves (increase in succulence). The leaf margin in *C. smithii* is not ciliate, there are fewer bracts on the inflorescence and the peduncle is glabrous. The calyx lobes are smaller (half the length of those of *C. alba*).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Cluster-forming, plants conspicuous and not camouflaged. The aloe-like leaves in a rosette are well adapted to the undisturbed cliff face.

Size and weight: Clusters small, of medium weight.

Stem: Ascending to decumbent, very short.

Leaves

Orientation: Ascending-spreading to erect, compact, in a basal rosette. The compact, rosulate nature and subulate form can be viewed as an adaptation to the dry conditions on the cliff face.

Colour and texture: Epidermis green to yellowish green, becoming reddish. The reddish colour under dry conditions reduces penetration of light, an adaptation resulting from the well-drained habitat. The soft texture and fragile nature reflect the sheltered, undisturbed cliff face.

Age and persistence: The plants are relatively slow-growing, long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in late summer and autumn (March–April), pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in autumn or winter.

Vegetative reproduction: Plants proliferating and cluster-forming, filling up crevices. This differs from the situation in solitary rosulate forms (*Crassula alba* var. *alba*) on level ground and can be viewed as an adaptation to the cliff habitat.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Easily cultivated, its vigour viewed as maximising survival. Easily grown from seed or division. Dividing and rapidly forming dense clusters.

VOUCHER

Smith s.n. (NBG).

ILLUSTRATIONS AND MAP

Plate 143, Figures 143a & 143b, Map 143.

144. *Crassula socialis* Schönland in Transactions of the Royal Society of South Africa 17: 241 (1929).

Cremonophyte growth form: Dwarf-sized, mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *socialis*, social, pertaining to its prolific nature, occurring in dense groups.

DESCRIPTION AND HABITAT

Plants rosulate, proliferating from base to form dense, rounded clusters up to 40 mm high (without inflorescence). Roots fibrous. Leaves ovate to elliptic, 4–11 × 8–16 mm, dorsiventrally compressed, 4-ranked, light to dark green, glabrous but with marginal cilia; apex acute. Inflorescence a terminal rounded thyrse bearing 1–3 dichasia up to 70 mm high,

with sessile flowers. Calyx lobes triangular-ovate, up to 1.5 mm long, ciliate. Corolla tubular, 6 mm long, white; lobes oblong-obovate, up to 2.5 mm long, fused shortly at base; apices spreading. Anthers yellow. Carpels with reniform ovaries and short, reflexed styles.

Phenology: Flowering in spring (August–October).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: South-facing cliffs. Plants firmly rooted in crevices. Temperatures are high in summer (35–40°C). Winters are cooler but frost is absent. The average daily maximum temperature is about 29°C and daily minimum 14°C. Rainfall occurs throughout the year but with a peak in spring and summer, ranging from 300–400 mm per annum (thunder showers or cyclonic winter rain).

Altitude: 800–1200 m.

Associated vegetation: Mainly Great Fish Noorsveld of the Albany Thicket Biome (Mucina *et al.* 2005)

Associated cremnophytes: North of Grahamstown along the Great Fish River, the following plants have been recorded: *Bulbine latifolia*, *Crassula cultrata*, *C. perfoliata* var. *minor*, *Gasteria excelsa* and *Ornithogalum juncifolium* var. *emsii*.

Geology: Dark-coloured and smooth-textured Ecca shale (Fort Brown Formation) of the Karoo Supergroup.

DISTRIBUTION

Confined to the Eastern Cape, between King William's Town and Kommadagga.

RELATED SPECIES

Crassula socialis belongs to section *Rosulares*, which includes 22 species (Toelken 1985). It can be confused with *C. montana* subsp. *quadrangularis* but is at once distinguished by its much smaller heads and flowers with reflexed styles. It is distinguished from related non-cremnophilous *Crassula* species by its dwarf-sized, compact growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Dense, rounded clusters, plants conspicuous and not camouflaged. The tight, imbricate leaves that are not camouflaged and the dwarf-sized, compact nature can be seen as an adaptation to the xeric conditions on the cliff face.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Spreading, compact, 4-ranked. The compact nature can be viewed as an adaptation to the dry conditions on the cliff face.

Colour: Epidermis green, becoming reddish. The reddish colour under dry conditions is due to the production of anthocyanins (reducing excessive penetration of light), an adaptation resulting from the well-drained cliff habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in spring, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late spring at the onset of summer rain conditions and thus maximising establishment.

Vegetative reproduction: *Crassula socialis* proliferates, forming dense mats and cushions, an efficient vegetative backup strategy for surviving the harsh conditions on the cliff face. When an offshoot becomes detached, it will root if it falls into a new crevice (as a result of heavy wind or some other disturbance), ensuring long-term survival.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Locally common and well protected in the undisturbed cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket gardens, grown in rockeries, miniature succulent gardens, roof gardens and containers. Easily cultivated, its vigour viewed as maximising survival. Propagate from cuttings or division. Grows best in sandy slightly acid soil, preferably in dappled shade.

VOUCHER

Van Jaarsveld 16806 (NBG).

ILLUSTRATIONS AND MAP

Figures 144a–144d, Map 144.

145. *Crassula streyi* Toelken in The Flowering Plants of Africa 42: t. 1672 (1973).

Cremonophyte growth form: Cluster (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: After Rudolf Georg Strey (1907–1988) farmer and botanist who first collected this species.

DESCRIPTION AND HABITAT

Decumbent to erect, sparsely branched, succulent herbs 100–200 high (without inflorescence). Roots fibrous. Branches 5–10 mm in diameter, reddish. Leaves sessile, 40–65 × 25–40 mm ascending-spreading, becoming slightly recurved, flat; blade ovate to elliptic, dark green, often mottled above, purplish below; margin entire to subcrenulate, slightly revolute to revolute; apex rounded to acute, cuspidate. Inflorescence an ascending rounded thyrse bearing several dichasia; peduncle up to 80 mm long. Calyx lobes linear-triangular, up to 2 mm long. Corolla 4- or 5-merous, star-shaped, 10 mm in diameter; lobes fused at base, lanceolate, up to 4.5 × 2 mm, yellowish green. Anthers yellow.

Phenology: Flowering in midwinter (May–June).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Cliffs, at altitudes of up to 250 m. Plants grow in shallow soil among leaf litter on shady rocky ledges, often in the shade of cliff-dwelling shrubs. Temperature high in summer and mild in winter. The average daily maximum temperature is about 24°C and average daily minimum about 15°C. Rainfall occurs mainly in summer, ranging from 800–1000 mm per annum.

Altitude: 50–250 m.

Associated vegetation: KwaZulu-Natal Coastal Belt of the Indian Ocean Coastal Belt (Mucina *et al.* 2005).

Associated cremonophytes: *Cotyledon orbiculata*, *Crassula perfoliata* var. *minor*, *C. perforata*, *Delosperma* sp., *Gasteria croucheri*, *Ornithogalum longibracteatum*, *Plectranthus ernstii* and *P. saccatus* subsp. *pondoensis*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup).

DISTRIBUTION

Crassula streyi is confined to quartzitic sandstone gorges in southern KwaZulu-Natal and into the adjacent northern Eastern Cape.

RELATED SPECIES

Crassula streyi is related to *C. multicava* but is at once distinguished by its larger, mottled leaves and less vigorous nature.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small clusters of very fleshy leaves. The very succulent nature of the clusters can be viewed as an adaptation to the dry cliff-face conditions, the plants able to fill crevices in the absence of disturbances by larger herbivores.

Size and weight: Clusters of medium weight.

Stem: Short, ascending to decumbent, usually purplish.

Leaves

Orientation: Ascending-spreading, compact, decussately arranged.

Colour: Epidermis green, becoming reddish. The upper side often white-mottled and very attractive. The reddish colour under dry conditions (production of anthocyanins) reduces penetration of light, an adaptation resulting from the well-drained habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in spring, pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in spring at the onset of rainy conditions and thus maximising establishment.

Vegetative reproduction: Plants proliferating and forming small cushions. Branches or detached leaves touching the soil will root, a vegetative backup strategy enabling the plants to survive the harsh conditions on the cliff face.

CONSERVATION STATUS

Locally common and well protected in the undisturbed cliff habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens, grown in rockeries or as a pot plant in dappled shade. Outside the habitat, it is best grown as a pot plant under controlled conditions in a greenhouse. Propagate from leaf or stem cuttings.

VOUCHER

Van Jaarsveld 18258 (NBG).

ILLUSTRATIONS AND MAP

Plates 145 & 145a, Figures 145a–145d, Map 145.

146. *Crassula tabularis* Dinter in Repertorium Specierum Novarum Regni Vegetabilis 19: 146 (1923).

Cremonophyte growth form: Mat-forming cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb)

Etymology: Latin *tabularis*, horizontally flattened, pertaining to the plant body.

DESCRIPTION AND HABITAT

Plants rosulate, solitary or proliferating from base to form small clusters up to 300 mm high (inflorescence included). Roots fibrous. Leaves lanceolate to ovate, 10–45 × 5–15 mm, ascending-spreading, dorsiventrally compressed; surface glabrous, upper surface flat, lower surface somewhat keeled; margin ciliate; apex acute to acuminate. Inflorescence a terminal elongated thyrse bearing many dichasia; peduncle not distinct. Flowers sessile. Calyx lobes triangular, up to 3 mm long; margin ciliate; apex acute, bearing a larger apical hair. Corolla tubular, 5 mm long, white; lobes oblong-obovate, up to 4.5 mm long; apices acute, spreading, becoming reflexed. Anthers yellow.

Phenology: Flowering in summer and autumn (February–April).

Pollinators: The conspicuous diurnal flowers suggest a day-flying insect.

Habitat and aspect: Sheltered cliffs, at altitudes of about 1000–2000 m. Plants grow in shallow soil on shady rocky ledges. Temperatures are high in summer and mild in winter. The average daily maximum temperature is 25–27°C and daily minimum 10–12°C. Rainfall occurs mainly in summer (thunder showers) and ranges from 300–400 mm per annum.

Altitude: 1200–2000 m.

Associated vegetation: Dry Grassland, Nama-Karoo and dry Savanna (Mucina *et al.* 2005).

Associated cremonophytes: On the Auasberg Mountains it has been recorded with *Adromischus schuldianus*, *Ceterach cordatum*, *Cotyledon orbiculata* var. *orbiculata* and *Crassula sericea* var. *sericea*.

Geology: Mainly sandstone and mudstone.

DISTRIBUTION

Crassula tabularis is confined to the northern parts of the Great Karoo (Northern Cape, southern Free State) extending northwards to central Namibia, especially the Auasberg south of Windhoek.

RELATED SPECIES

Crassula tabularis is related to *C. capitella* subsp. *thyrsiflora* but is immediately distinguished by its flat rosettes of mottled leaves. The two species also do not overlap in distribution. *Crassula capitella* subsp. *thyrsiflora* occurs in the Succulent Karoo and Albany Thicket Biomes and is a more robust species.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: With compact growth, often forming small, dense clusters typical of so many cremnophilous species.

Size and weight: Clusters small, of light weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Spreading, in flat compact rosettes (of spirally arranged leaves).

Colour: Epidermis green, becoming reddish. The reddish colour under dry conditions (production of anthocyanins) reduces penetration of light, an adaptation resulting from the well-drained habitat.

Age and persistence: Plants long-lived perennials.

Armament: Soft-leaved plant bodies without conspicuous armament.

Sexual reproduction

Flowers: Flowering in summer and early autumn (February–April), pollinated by insects.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in summer and autumn at the onset of cooler conditions, maximising establishment.

Vegetative reproduction: Plants proliferating and forming dense cushions, a vegetative backup strategy for continued existence despite the harsh conditions on the cliff face.

CONSERVATION STATUS

Well protected by the undisturbed cliff-face habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Easily cultivated from seed or division. Dividing annually and forming dense clusters.

VOUCHER

Van Jaarsveld 17469 (NBG).

ILLUSTRATIONS AND MAP

Figures 146a–146c, Map 146.

147. *Crassula tomentosa* Thunb. var. *glabrifolia* (Harv.) Toelken in Flora of southern Africa 14: 188 (1985).

Cremnophyte growth form: Compact cluster (of light weight, cliff hugger).

Growth form formula: A:S:Lper:R:C:Ts:La (vb) (r)

Etymology: The epithet *glabrifolia*, smooth leaves, pertains to the leaf surface without hairs.

DESCRIPTION AND HABITAT

Plants proliferating from base, cluster-forming, rosulate, up to 300 mm high (with inflorescence). Roots fibrous. Leaves 2-ranked, tightly packed, broadly obovate, 5–25 × 5–30 mm, dorsiventrally flattened; surface grey-green to green, tomentose, with marginal cilia; apex truncate. Inflorescence a terminal branched spike-like thyrses 300 mm high, bearing many dichasia, with basal dichasia pedunculate; peduncle indistinct, with leaf-like bracts becoming smaller distally; flowers spreading in sessile, decussate, glomerate dichasia. Calyx lobes triangular-ovate, up to 3 mm long, tomentose, with marginal cilia. Corolla tubular; lobes oblong-panduriform, 4.5 mm long, fused in basal part, off-white to pale yellow, spreading, becoming slightly recurved. Anthers black.

Phenology: Flowering in spring and summer (October–December).

Pollinators: The pale yellow corolla suggests a flying insect.

Habitat and aspect: Shady sheltered cliffs of the northern Cape Fold Belt mountains. Plants grow in shallow soil on shady rocky ledges. Temperatures hot in summer and mild in winter. The average daily maximum temperature is 24–26°C and average daily minimum 8–10°C. Rainfall occurs mainly in winter (cyclonic winter rain) and summer (thunder showers), ranging from 75–300 mm per annum.

Altitude: 400–1700 m.

Associated vegetation: Vanrhynsdorp Shale Renosterveld of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated plants on the Gifberg include *Aloe perfoliata*, *Crassula nudicaulis* and *Oscularia alba*.

Geology: Mainly quartz (Khurisberg Subgroup, Aggeneys and Hom Formation) (Bushmanland Group), dolomite of the Holgat Formation (Gariep Supergroup) sandstone and shale of the Ecca Formation (Karoo Supergroup).

DISTRIBUTION

Crassula tomentosa var. *glabrifolia* is widely distributed along the margin of the winter-rainfall Karoo region, from Matjiesfontein in the south to the Gifberg and Bushmanland in the north and entering southern Namibia.

RELATED SPECIES

This variety of *Crassula tomentosa* differs from the non-cremnophytes in its smaller size (up to 300 mm in flower), and densely branched, tight, fragile rosettes. Leaves are shorter than 15 mm, broadly obovate, with truncate apices. The inflorescence is an unbranched, spike-like thyrse with pedunculate flowers. As in *C. tomentosa* var. *tomentosa*, each rosette is monocarpic, dying after flowering.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Forming tight clusters, rosettes flowering in succession, plants conspicuous and not camouflaged. The unarmed, soft texture of the plants is an adaptation to the undisturbed cliff-face habitat.

Size and weight: Clusters small, of light weight.

Stem: Decumbent, up to 100 mm long.

Leaves

Orientation: Ascending, in a tight rosette. The leaves are much shorter than those of the typical variety, broadly obovate with truncate apices. The reduction in size, soft texture and rosulate orientation suggest an adaptation to the undisturbed cliff face. The truncate apices might be an adaptation to the chasmophytic life style in areas where herbivores can reach.

Colour and texture: Green to dark green, soft-textured.

Age and persistence: The plants are relatively slow-growing, long-lived perennials.

Armament: Soft, fragile rosettes without conspicuous armament, an adaptation to the cliff habitat.

Sexual reproduction

Flowers: Spring to summer (October–December). Heads monocarpic but not all flowering in the same season, the plants thus with a longer life than those of var. *tomentosa*, suggesting an adaptation to the cliff face where establishment of seed is more difficult than on level ground. It is advantageous for the plants not being fully monocarpic.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds released in late summer.

Vegetative reproduction: *Crassula tomentosa* var. *glabrifolia* continuously proliferates from the base, forming small dense clusters, an ideal long-term survival backup strategy on the sheer cliff face. When becoming detached, these rosettes will root where they land on other ledges or in new crevices.

CONSERVATION STATUS

Locally common and well protected by the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries and miniature succulent gardens. Easily cultivated, its vigour viewed as maximising survival. Easily grown from seed or division. Dividing and rapidly forming dense clusters.

VOUCHER

Van Jaarsveld 19104 (NBG).

ILLUSTRATIONS AND MAP

Figures 147a–147d, Map 147.

TYLECODON Toelken

148. *Tylecodon aurusbergensis* G.Will. & Van Jaarsv., in Williamson in Aloe 29,3 & 4: 60–62 (1992).

Cremonophyte growth form: Dwarf-sized, tapering stem (of light weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: After the Aurusberg in the Sperrgebiet in southern Namibia, where the species was found.

DESCRIPTION AND HABITAT

Sparsely branched, erect plant up to 80 mm high, with conical, smooth to knobbly, succulent caudex up to 40 mm in diameter; bark grey, peeling, exposing green tissue. Leaf-bearing branches 2–3 mm in diameter, grey, with short, sharp, bract-like leaves up to 0.5 mm long; phyllopodia rounded, truncate, up to 1 mm long. Stem sparsely branched, with 1–several erect, succulent stems with grey bark and short, truncate phyllopodia. Leaves ovate to obovate-spathulate, 18–20 × 15–35 mm, crowded at apices; adaxial surface concave to channelled, abaxial surface with maroon striations, glandular hairy; apex obtuse; base cuneate. Inflorescence a short, almost sessile monochasium with 1–3 glandular hairy flowers; peduncle 2–20 mm long; pedicels 2–3 mm long. Corolla tubular, about 10 mm long, tube light green, glandular pubescent; lobes pink to pink-lilac, becoming recurved.

Phenology: Flowering from summer through to early autumn (March–April).

Pollinators: Insects.

Habitat and aspect: *Tylecodon aurusbergensis* grows mainly on quartzitic sandstone cliffs, the plants occurring in crevices, on ledges and in shady rock veins on southern aspects. Temperature moderate to high in summer but mild to warm in winter (frost absent). The average daily maximum temperature is about 22–24°C and the average daily minimum for the region 10–12°C. Rainfall is mainly in winter and autumn, ranging from 50–75 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 600–900 m.

Associated vegetation: Succulent Karoo and Desert Biomes.

Associated cremnophytes: *Conophytum taylorianum* subsp. *taylorianum*, *Crassula aurusbergensis* and *Holothrix filicornis*.

Geology: Quartzitic sandstone cliffs (Gariiep Complex).

DISTRIBUTION

Endemic to the Aurusberg in southern Namibia.

RELATED SPECIES

Tylecodon aurusbergensis is related to *T. torulosus*, a related cremnophilous species from near Lekkering. The latter is larger and more robust. Compared to non-cremnophilous species, the small size and lack of defence mechanisms suggest adaptation to the undisturbed cliff-face.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, with lax, slender growth (single-stemmed or sparsely branched) from a tuberous base.

Size and weight: Dwarf-sized, up to 80 mm high, of light weight.

Roots: Fleshy at the base, otherwise fibrous. The fleshy nature can be viewed as an adaptation to the xeric conditions on the cliff face.

Stem: Succulent, grey-green with peeling bark and up to 3 mm in diameter, covered with grey phyllopodia.

Leaves

Orientation: Ascending-spreading. The rosulate presentation maximises absorption of light.

Colour and texture: Epidermis dark green. The very soft, fragile, succulent nature reflects a lack of disturbance by larger animals.

Age and persistence: Plants slow-growing, long-lived perennials. Leaves becoming deciduous during the long, dry summer, an adaptation to the moist conditions in winter.

Armament and camouflage: Plants fleshy and fragile without conspicuous armament or camouflage properties as opposed to the non-cremnophilous *Tylecodon* species, the reduction in camouflage and armament due to the undisturbed conditions on the cliff face.

Sexual reproduction

Flowers: The small, tubular flowers suggest a pollinator such as a flying insect with a long proboscis.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: *Tylecodon aurusbergensis* will root from branches that touch the soil.

CONSERVATION STATUS

Classified as near threatened (Loots 2005). It is rare and confined to the Aurusberg in southern Namibia, a region that falls within a protected reserve.

ADDITIONAL NOTES

Horticulture: Best for dry succulent karoo gardens, grown in dappled shade in containers. Keep dry in summer. Propagate from stem cuttings in autumn or winter.

VOUCHER

Williamson 4417 (NBG).

ILLUSTRATIONS AND MAP

Map 148.

149. *Tylecodon bleckiae* G.Will. in *Cactus and Succulent Journal* (U.S.) 70,3: 127–128 (1998).

Cremnophyte growth form: Cluster-forming (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: In honour of Ms Mary Bleck, Curator of the succulent plant collection of the Johannesburg Botanical Gardens from 1983–1990, who collected the plant together with Mr John Lavranos.

DESCRIPTION AND HABITAT

Dwarf-sized, cluster-forming, succulent shrublet up to 80 mm tall, from an elongated spreading tuberous base. Tubers up to 70 × 30 mm. Stems numerous, often tangled and not branched, up to 70 × 2.5–4 mm, ascending to spreading, grey with raised black plaques. Leaves 3–7 in a terminal rosette, 6–8 × 3–4 mm, elliptical, with centric groove on upper surface, dull green, glandular hairy. Inflorescence with 1 or 2 dichasia on erect peduncle 10 × 1.2 mm. Calyx lobes ovate-triangular, up to 2.5 × 1.8 mm, glandular pubescent. Corolla cylindrical, 12 × 4.5 mm, pale green, with spreading lobes, becoming recurved; lobes ovate-acute, light red with dark pink to red streaks and white margins. Squamae narrowly ovate, emarginate, cream-yellow.

Phenology: Flowering from mid- to late summer.

Pollinators: Insects.

Habitat and aspect: Quartzite cliffs, occurring mainly on eastern and south-facing slopes. Plants occur in crevices and on ledges on southern and southwest-facing aspects. Temperature moderate to high in summer and mild to warm in winter (frost absent), but occasionally lowered by fog from the Atlantic Ocean. The average daily maximum temperature is about 22°C and the average daily minimum for the region 14°C. Rainfall is mainly in winter and autumn, about 50–150 mm per annum (mainly cyclonic winter rain and thunder showers in autumn). Regular fog provides extra moisture.

Altitude: 600–900 m.

Associated vegetation: Succulent Karoo.

Associated cremnophytes: *Gasteria pillansii* var. *ernesti-ruschii*.

Geology: Quartzite, lava, tuff (Richtersveld Suite).

DISTRIBUTION

Restricted to the lower Orange River Valley adjacent to Rosh Pinah and Rooiberg in the Richtersveld Transfrontier National Park (Northern Cape).

RELATED SPECIES

Tylecodon bleckiae is at once distinguished from the related *T. buchholzianus* var. *buchholzianus* by its elongated, tuberous roots and unbranched to little-branched, tangled stems up to 70 mm long. Generally it is smaller and plants are about 120 mm in diameter. It differs further by its branches of 2.5–4.0 mm in diameter. The branches are soft and fragile. The var. *buchholzianus* is a larger, ascending, sturdy and robust plant without tuberous roots.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Densely clustered and with spreading branches, but not pendulous. The reduction in size (compared to its sister taxon *Tylecodon buchholzianus* var. *buchholzianus*) and spreading nature can be viewed as an adaptation to the cliff environment.

Size and weight: Clusters medium-sized, up to 120 mm in diameter, of medium weight.

Roots: Tuberous roots viewed as an adaptation to the extreme xeric conditions on the cliff face.

Stem: Numerous, often tangled, not branched, up to 70 × 2.5–4.0 mm, ascending to spreading, grey, with raised black plaques, fragile.

Leaves

Orientation: Ascending-spreading, 3–7 in a terminal rosette.

Colour and texture: Dull green and glandular hairy.

Age and persistence: Plants slow-growing, long-lived perennials. Leaves fragile, becoming deciduous during the long, dry summer, suggesting an adaptation to the moist conditions in winter.

Armament and camouflage: Plants fleshy and fragile without conspicuous armament or camouflage properties as opposed to the larger, robust, single-stemmed level-ground *Tylecodon buchholzianus* var. *buchholzianus*, the reduction in camouflage and armament due to the undisturbed conditions on the cliff face.

Sexual reproduction

Inflorescence and flowers: Inflorescence with 1 or 2 dichasia on an erect peduncle 10 × 1.2 mm. Calyx lobes ovate-triangular, up to 2.5 × 1.8 mm, glandular pubescent. Corolla cylindrical, 12 × 4.5 mm, pale green with spreading lobes, becoming recurved; lobes ovate-acute, light red with dark pink to red streaks and white margins.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: Densely branched, the branches rooting where they touch the ground or where they find new crevices (vegetative spread), an efficient vegetative backup for surviving the harsh cliff environment.

CONSERVATION STATUS

Rare but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside the habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Bleck & Lavranos s.n. (NBG).

ILLUSTRATIONS AND MAP

Figures 149a–149c, Map 149.

150. *Tylecodon bodleyae* Van Jaarsv. in *Cactus and Succulent Journal* (U.S.) 64,2: 57–61 (1992b).

Cremonophyte growth form: Erect shrublet (of light weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: Commemorates Mrs Elise Bodley (1922–1997), well known illustrator of succulents and who illustrated most known *Tylecodon* and *Cotyledon* species (Van Jaarsveld & Koutnik 2004).

DESCRIPTION AND HABITAT

Dwarf-sized, erect, sparsely branched succulent, up to 100 mm high, from tuberous base up to 60 mm in diameter; bark yellow-brown, peeling. Branches ascending, grey-green, with dark longitudinal striations, articulated at nodes; younger branches 4–5 mm in diameter; phyllopodia short, truncate. Leaves obovate to elliptic, 8–15 × 6–14 mm, green to pale green, sparsely glandular hairy or glabrous; apex acute; base cuneate. Inflorescence a thyrse up to

40 mm high, of 1 or 2 monochasia each bearing 1 or 2 flowers; pedicels 6–16 mm long, glandular pubescent; bracts linear, acute, 1–1.5 mm long. Calyx 4 mm long, 2.5 mm in diameter; lobes triangular-lanceolate, 3 × 1 mm. Corolla 11–15 mm long; tube funnel-shaped, yellowish green, 3 mm wide at base, expanding to 4 mm at throat, glandular hairy; lobes oblong, 5 × 2.5 mm, spreading, becoming recoiled, with long hairs on inner surface, white. Stamens erect, 13 mm long. Squamae oblong, 1 × 0.5 mm, emarginate, erect, yellowish green.

Phenology: Flowering in midsummer (January–February).

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone cliffs, plants occurring in crevices and on ledges on eastern and southern aspects. Temperatures are moderate to high in summer and mild to warm in winter (frost absent), but are regularly lowered by fog from the Atlantic Ocean. The average daily maximum temperature is about 18°C and the average daily minimum for the region 10°C. Rainfall is mainly in winter, about 50 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 350–470 m.

Associated vegetation: Vyftienmyl se Berge Succulent Shrubland of the Richtersveld Bioregion of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Conophytum stephanii*, *Gasteria pillansii* var. *ernesti-ruschii*, *Tylecodon racemosus* and *T. similis*.

Geology: Quartz acetose of the Stinkfontein Formation (Gariiep Supergroup).

DISTRIBUTION

Southern Oograbies Mountains, 23 km east of Port Nolloth (Northern Cape).

RELATED SPECIES

Tylecodon bodleyae is similar to *T. similis* but is at once distinguished by its erect, robust not scandent nature and large, conspicuous, white flowers. It differs further in its articulated stems and larger, dorsiventrally flattened leaves. *Tylecodon similis* is a smaller, inconspicuous species, well camouflaged among the shrublets in succulent karoo.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Erect, sparsely branched, dwarf-sized shrublet.

Size and weight: Up to 100 mm high.

Roots: Tuberous.

Stem: Branches ascending, grey-green, with dark longitudinal striations, articulated at nodes; younger branches 4–5 mm in diameter; phyllopodia short, truncate.

Leaves

Orientation: Spreading, in a apical rosette.

Colour and texture: Green to pale green, sparsely glandular hairy or glabrous.

Armament and camouflage: Plants fleshy and fragile without conspicuous armament or camouflage properties as opposed to the smaller *Tylecodon similis* which is well camouflaged among the karoo shrubs. The fragile nature and lack of defence properties reflect the undisturbed cliff habitat.

Sexual reproduction

Inflorescence and flowers: Rich flowering. Inflorescence a conspicuous thyrses up to 40 mm high, with 1 or 2 monochasia, each bearing 1 or 2 flowers; pedicels 6–16 mm long, glandular pubescent; bracts linear, acute, 1–1.5 mm long. Calyx 4 mm long, 2.5 mm in diameter; lobes triangular-lanceolate, 3 × 1 mm. Corolla 11–15 mm long; tube funnel-shaped, yellowish green, 3 mm wide at base, expanding to 4 mm at throat, glandular hairy; lobes oblong, 5 × 2.5 mm, spreading, becoming recoiled, with long hairs on inner surface.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: Detached branches will root if they fall into new crevices (vegetative spread), an efficient vegetative backup for survival in the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009), but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 22311 (NBG).

ILLUSTRATIONS AND MAP

Figures 150a–150f, Map 150.

151. *Tylecodon bruynsii* Van Jaarsv. & S.A.Hammer in *Cactus and Succulent Journal* (US) 81,5: 235–238 (2009).

Cremonophyte growth form: Loose stem clusters (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: After Peter Bruyns, mathematician and botanist at the University of Cape Town who first located this species.

DESCRIPTION AND HABITAT

Cluster-forming, much-branched, summer-deciduous, dwarf-sized shrublets, becoming subpendent, up to 400 mm in diameter; base often thickset, up to 40 mm in diameter. Roots fibrous. Branches up to 170 mm long, 15–20 mm in diameter, succulent, grey-green, smooth, light grey, somewhat flaking, exposing grey green epidermis; phyllopodia slightly raised, stem tapering at apex; petiole short, indistinct, up to 2 mm long. Leaves softly succulent, in apical rosettes, spreading, 25–45 × 15–30 mm; blade broadly obovate to subrotund, spreading, 2–4 mm thick, occasionally 3-lobed; both sides covered in short, translucent, glandular hairs; adaxial surface flat to slightly concave, greyish green, abaxial surface flattened, greyish green; margin entire; apex obtuse to rounded to subacute. Inflorescence a sparsely branched, short thyrse up to 30 mm long, bearing 1 or 2 apical monochasia (each with 1–3 flowers), glandular pubescent; peduncle greenish, 15 mm long, 1 mm in diameter at base, glandular pubescent; pedicels 7 mm long. Calyx 3 mm long, glandular pubescent, green; lobes 2 × 1 mm. Corolla funnel-shaped, glandular pubescent; tube 12 mm long, 4 mm at base, expanding to 6 mm at throat, yellowish green; lobes 5 × 3 mm, becoming slightly recurved, white; apices acute. Stamens up to 10 mm long, attached to throat, protruding for 5 mm; anthers 1 mm long. Squamae slightly tapering, 1 × 0.6 mm, emarginate, pale green, translucent. Gynoecium 22 mm long; carpels 5, free, about 10 mm long, tapering into styles 12 mm long and protruding for 12 mm from corolla apex. Follicles 8 × 1.7 mm. Seeds not seen.

Phenology: Flowering in midsummer (January–February).

Pollinators: Insects.

Habitat and aspect: Vertical quartzitic sandstone cliffs, mainly on cooler southern aspects offering shady conditions. Plants are firmly rooted in crevices large enough to support the roots and stem clusters. Temperature high during the day and the average daily summer temperature is about 26°C. Winters are cooler and subject to regular coastal fog from the west coast. Frost is absent. Rainfall mainly from autumn (thunder showers) to spring (cyclonic winter rain), and ranging from about 50–125 mm per annum.

Altitude: 700–800 m.

Associated vegetation: Succulent Karoo.

Associated cremonophytes: *Aloe pavelkae*, *Conophytum ricardianum*, *Crassula macowaniana*, *C. pseudoemisphaerica*, *C. sericea* var. *velutina*, *C. sladenii*, *Tylecodon buchholzianus*, *T. racemosus* and *T. rubrovenosus*.

Geology: Sandstone of the Kuibis and Schwarzrand Subgroups (Nama Group). Substrate rough, with many ledges crevices and fissures, ideal for establishment of plants.

DISTRIBUTION

Tylecodon bruynsii is confined to the upper slopes of the southern mountain range along the Orange River and adjacent area of the same geological formation. It mainly includes the Sonberg and Kuamsibberg.

RELATED SPECIES

Related to both *Tylecodon longipes* and *T. torulosus* (also a cremnophyte) but at once distinguished by its larger size, becoming pendent. Its branches are grey-green, with peeling bark, the obovate to subrotund leaves with a glandular hairy epidermis. The branches of *T. torulosus* are distinctly torulose (young bark dark brown) and the leaves often folded inwards. *Tylecodon longipes* has a compact growth, with many short branches, and plants do not become pendent.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, loose, pendent clusters. The summer-deciduous nature is an adaptation to the long, dry summers; the fragile texture not adapted to disturbances by larger herbivores.

Size and weight: Clusters medium-sized, pendent for up to 300 mm, of medium weight.

Roots: Tuberous.

Stem: Branches grey-white, up to 30 mm in diameter at the base; phyllopodia sometimes swollen (not torulose); bark grey, smooth; older branches flaking.

Leaves

Orientation: Spreading, apically grouped.

Colour and texture: Greyish green. The glandular hairy leaf indumentum indicative of adaptation to the regular fog from the Atlantic Ocean.

Age and persistence: Plants slow-growing, long-lived perennials, typical of cremnophilous succulent plants.

Armament and camouflage: Plants conspicuous, fleshy, fragile and without armament or camouflage properties, reflecting the disturbance-free cliff face. In comparison, the related *Tylecodon schaeferianus* of level ground is smaller, inconspicuous and a master of camouflage.

Sexual reproduction

Inflorescence and flowers: Inflorescence a sparsely branched, short thyrses up to 30 mm long, bearing 1 or 2 apical monochasia (each with 1–3 flowers), glandular pubescent; peduncle greenish, 15 mm long, 1 mm in diameter at base, glandular pubescent; pedicels 7 mm long. Calyx 3 mm long, glandular pubescent, green; lobes 2 × 1 mm. Corolla funnel-

shaped, glandular pubescent, tube 12 mm long, 4 mm at base, expanding to 6 mm at throat, yellowish green; lobes 5 × 3 mm, becoming slightly recurved, white; apices acute.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: The spreading branches will root where they touch the soil, forming loose, pendent mats (vegetative spread), an efficient vegetative backup for surviving the harsh cliff-face environment.

CONSERVATION STATUS

Rare but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 21088 (NBG).

ILLUSTRATIONS AND MAP

Plate 151, Figures 151a–151c, Map 151.

152. *Tylecodon buchholzianus* (Schuldt & P.Stephan) Toelken var. *fasciculatus* G.Will. in *Aloe* 29,3 & 4: 62–63 (1992).

Cremnophyte growth form: Cluster-forming stem succulent (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: Latin *fasciculus*, a little bundle, pertaining to its clustered (fasciculate) branching.

DESCRIPTION AND HABITAT

Branched, ascending, spreading, summer-deciduous, densely clustered succulent, up to 270 mm in diameter, up to 150 mm high, often with drooping branches from cliff face up to 220 long. Branches grey-green, smooth, brittle, up to 12 mm in diameter at base, tapering to 5–7

mm, much-branched, sometimes remaining leafless and photosynthetically active; bark scaly, exposing green living tissue; leaf scars 1–1.3 mm wide. Leaves 1 or 2 occasionally produced, spreading, linear-terete, 8–10 × 3–5 mm; bract-like leaves reddish, subulate, 1 mm long. Inflorescence an erect, almost sessile thyrse up to 20 mm high, consisting of a solitary monochasium bearing 1–3 flowers. Calyx lobes triangular, 1 × 1.5 mm. Corolla tubular, purplish to yellow-green, 10 × 4 mm; lobes hairy on inside, spreading, becoming recurved. Squamulae 1.5 × 0.6 mm, emarginate, pale white, translucent.

Phenology: Flowering from mid- to late summer (February).

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone cliffs, the plants occurring in crevices and on ledges on eastern and southern aspects. Temperature moderate to high in summer and mild to warm in winter (frost absent), but regularly lowered by fog from the Atlantic Ocean. The average daily maximum temperature is about 18°C and the average daily minimum for the region 10°C. Rainfall mainly in winter, about 50 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 50–700 m.

Associated vegetation: Vyftienmyl se Berge Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnoophytes: *Anacampseros scopata*, *Conophytum stephanii*, *Crassula pseudohemisphaerica*, *Gasteria pillansii* var. *ernesti-ruschii* and *Tylecodon similis*.

Geology: Quartz acetose of the Stinkfontein Formation (Gariiep Supergroup).

DISTRIBUTION

Oograbies Mountains, 23 km east of Port Nolloth and running parallel to the coast for approximately 18 km (Northern Cape).

RELATED SPECIES

Tylecodon buchholzianus var. *fasciculatus* is at once distinguished from the typical variety by its densely branched, clustered growth, often with spreading to drooping stems from the cliff face. It differs further by its much-branched, thicker, grey-green photosynthetically active branches (only rarely producing 1 or 2 leaves, soon aborted). The branches are softer and more fragile. The var. *buchholzianus* is a larger, ascending, sturdy plant with a solitary main stem and thinner branches producing leaves in winter. The densely clustered, spreading to drooping and more compact growth with fragile branches can be viewed as an adaptation to the undisturbed cliff face.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Densely clustered, often drooping from the cliff face, typical of many cremnoophytes. The reduction in size and compact growth can be viewed as adaptations to the cliff environment.

Size and weight: Clusters of medium weight.

Stem: Branches grey-green, smooth, brittle, up to 12 mm in diameter at the base, tapering to 5–7 mm, proliferating and forming dense clusters; bark scaly and exposing the green living tissue; leaf scars 1.0–1.3 mm wide. Branches sometimes remain leafless but photosynthetically active, a character that can be viewed as a xeromorphic adaptation to the dry cliff-face.

Leaves

Orientation: Ascending-spreading, one or two in number, occasionally produced.

Colour: Greyish green to green.

Age and persistence: Plants slow-growing, long-lived perennials. Leaves fragile, becoming deciduous during the long, dry summer, an adaptation to the moist conditions in winter.

Armament and camouflage: Plants fleshy, fragile and without conspicuous armament as opposed to the larger, robust, single-branched, level-ground *Tylecodon buchholzianus* var. *buchholzianus*, the reduction in camouflage and armament properties due to the undisturbed conditions on the cliff face.

Sexual reproduction

Inflorescence and flowers: Inflorescence an erect, almost sessile thyrse up to 20 mm high, consisting of a solitary monochasium with 1–3 flowers. Corolla tubular, purplish to yellow-green, 10 × 4 mm.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: The spreading branches root where they touch the soil, forming loose, mats (vegetative spread), an efficient vegetative backup for surviving the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Localised, common, but restricted to the Oograbies Mountains in the Richtersveld where it is well protected by the cliff-face habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 9456 (NBG).

ILLUSTRATIONS AND MAP

Figures 152a–152d, Map 152.

153. *Tylecodon cordiformis* G.Will. in *Cactus and Succulent Journal* (U.S.) 70,5: 255 (1998).

Cremnophyte growth form: Loose stem clusters (of light weight, cliff hugger).

Growth form formula: E:F:As:S/H:Ca:D (vb) (ft)

Etymology: The epithet *cordiformis*, heart-shaped, pertains to the shape of the leaves.

DESCRIPTION AND HABITAT

Dwarf-sized, spreading, branched, succulent subshrub, 20–50 mm high from tuberous base. Tubers spreading, up to 50 mm in diameter. Branches grey, 5–45 mm long, 4–8 mm in diameter, with phyllopodia present. Leaves 2–4, cordiform to orbicular, up to 35 × 20 mm, shiny, dark green, covered with erect, transparent-white, glandular trichomes; petiole 5–8 mm long. Inflorescence a 1- or 2-flowered dichasium; peduncle up to 10 mm long, glandular hairy; pedicels 10 mm long, glandular hairy. Calyx lobes rectangular, 2 mm long, covered with glandular trichomes. Corolla tube funnel-shaped, light green, covered with glandular trichomes, 10 mm long, yellowish; lobes spreading, 4 mm long, glandular hairy externally. Squamae transversely oblong, 0.5–0.8 mm long.

Phenology: Flowering in midsummer (December–January).

Pollinators: Insects.

Habitat and aspect: Confined to east-facing quartz cliffs where the plants grow in crevices and in ample soil on ledges of the upper slopes. Plants are subject to some amount of fog. Average daily maximum temperature is more or less 20°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall mainly in winter (cyclonic cold fronts), ranging from 50–100 mm per annum.

Altitude: 400–600 m.

Associated vegetation: Namaqualand Heuweltjie Veld of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other cremnophytes observed at Haras include *Adromischus montium-klinghardtii*, *Conophytum chrisocruxum*, *Crassula elegans*, *C. pseudohemisphaerica*, *Cyrtanthus herrei*, *Tylecodon buchholzianus* and *T. cordiformis*.

Geology: Nakanas Formation (Bushmanland Group)

DISTRIBUTION

Appears to be confined to Harasberg (Northern Cape).

RELATED SPECIES

Tylecodon cordiformis is similar to *T. bayeri* but is at once distinguished by its larger, heart-shaped leaves and less creeping habit.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading, branched, dwarf-sized shrublet.

Size and weight: Up to 50 mm high.

Roots: Tuberous.

Stem: Branches ascending, spreading, grey-green, younger branches 4–8 mm in diameter.

Leaves

Orientation: Spreading and apically grouped, heart-shaped to orbicular and varying according to the source and brightness of light.

Colour and texture: Dark green, glandular hairy and ideal for absorbing fog.

Armament and camouflage: Plants fleshy, fragile and without conspicuous armament or camouflage properties as opposed to the smaller *Tylecodon bayeri* which is well camouflaged among the karoo shrubs. The fragile nature and lack of defence properties reflect the undisturbed cliff habitat.

Sexual reproduction

Inflorescence and flowers: Rich flowering. Inflorescence a conspicuous thyrses bearing 1 or 2 bright yellow, tubular flowers.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at onset of rainy season, maximising establishment.

Vegetative reproduction: Detached branches will root if they fall into a crevice (vegetative spread), an efficient vegetative backup for survival in the harsh cliff-face environment.

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009), but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 18787 (NBG).

ILLUSTRATIONS AND MAP

Figures 153a–153e, Map 153.

154. *Tylecodon decipiens* Toelken in *Bothalia* 12: 379 (1978).

Crempnophyte growth form: Mat-forming stem succulent (of medium weight, cliff hugger).

Growth form formula: A:S:Lar:D (vb)

Etymology: Latin *decipiens*, deceiving, referring to the misleading superficial resemblance to *Tylecodon schaeferianus*.

DESCRIPTION AND HABITAT

Dwarf-sized, mat-forming, highly branched, summer-deciduous species, from tuberous base. Branches 7–8 mm in diameter, pale grey-green, smooth, without phyllopodia, densely intertwined, often forming dense cushions up to 250 mm in diameter. Leaves oblanceolate, 5–14 × 6–10 mm, dorsiventrally flattened, glabrous; adaxial surface flat to grooved; apex obtuse. Inflorescence an erect thyrse up to 40 mm high with 1 or 2 monochasia, each bearing 1 or 2 flowers; bracts linear, up to 1.5 × 0.3 mm, becoming dry before flowers open; pedicels 10 mm long. Calyx 2–3 mm long; lobes triangular to triangular-lanceolate, about 1 × 1 mm, green. Corolla tubular, 9–10 × 3–4 mm; tube 5-angular, light green purplish on ridges; lobes pink, 5 × 2 mm, spreading, becoming recurved. Anthers yellow. Squamae linear, 1.5 × 0.3 mm, white translucent.

Phenology: Flowering in midsummer (January–February).

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone cliffs, mainly on southern and east-facing slopes. Plants occur in crevices and on ledges. Temperature moderate to high in summer and mild to warm in winter (frost absent), but regularly lowered by fog from the Atlantic Ocean. The average daily maximum temperature is about 18°C and the average daily minimum for the region 10°C. Rainfall mainly in winter, about 50–75 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 300–480 m.

Associated vegetation: Namaqualand Strandveld of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus caryophyllaceus*, *Conophytum* sp., *Crassula brevifolia*, *C. macowanii*, *C. muscosa* var. *muscosa*, *Gasteria pillansii* var. *ernesti-ruschii*, *Haemanthus coccineus* and *Tylecodon similis*.

Geology: Quartzitic sandstone of the Stinkfontein Formation (Gariiep Supergroup).

DISTRIBUTION

Kleinzee, rocky northern bank of the Buffelsrivier on the Atlantic coast (Northern Cape).

RELATED SPECIES

Tylecodon decipiens is at once distinguished from the closely related *T. schaeferianus* by its conspicuous, densely branched, clustered growth, often with spreading to drooping stems from the cliff face. It differs further by its thicker grey branches 8 mm in diameter. *Tylecodon schaeferianus* usually occurs on accessible flat terrain, well camouflaged among the desert sand and gravel. It is smaller, less branched, with thinner braches. The densely clustered, spreading to drooping, more compact growth with fragile branches can be viewed as an adaptation to the undisturbed cliff face.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, densely clustered, often drooping from the cliff face, typical of many cremnophytes.

Size and weight: Clusters medium-sized, up to 250 mm in diameter.

Roots: Tuberous.

Stem: Branches 7–8 mm in diameter, pale grey-green, smooth, without phyllopodia, densely intertwined, often forming dense cushions up to 250 mm in diameter. The dense stem clusters and often pendulous nature can be viewed as an adaptation to the cliff environment.

Leaves

Orientation: Ascending-spreading, apically grouped.

Colour: Glaucous, glabrous.

Age and persistence: Plants slow-growing, long-lived perennials, typical of cremnophilous succulent plants. Summer-deciduous, an adaptation to the dry conditions in summer.

Armament and camouflage: Plants conspicuous, fleshy, fragile and without armament or camouflage properties, reflecting the disturbance-free cliff face. By comparison, the closely related *Tylecodon schaeferianus* is smaller, inconspicuous and a master of camouflage.

Sexual reproduction

Inflorescence and flowers: Conspicuous in flower. Inflorescence an erect thyrses up to 40 mm high, with 1 or 2 monochasia, each bearing 1 or 2 flowers. Corolla tubular, 9–10 × 3–4 mm; tube 5-angular, light purplish green on ridges; lobes pink, 5 × 2 mm, spreading, becoming recurved.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at onset of rainy season, maximising establishment.

Vegetative reproduction: Densely branched, procumbent and will fill crevices by active growth, forming dense, tight mats (vegetative spread), an efficient vegetative backup for survival in the harsh cliff environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009) but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Toelken 5252 (BOL).

ILLUSTRATIONS AND MAP

Figures 154a & 154b, Map 154.

155. *Tylecodon ellaphieae* Van Jaarsv. in *The Flowering Plants of Africa* 50: t. 1983 (1989a).

Cremnophyte growth form: Dwarf-sized stem cluster (of light to medium weight, cliff squatter).

Growth form formula: A:S:Lar:D (vb) (r) (ft)

Etymology: After Ellaphie Ward-Hilhorst (1920–1994), botanical artist.

DESCRIPTION AND HABITAT

Compact, solitary, summer-deciduous, cluster-forming plant up to 100 mm in diameter, with swollen base up to 50 mm in diameter, with 2–8 short, erect branches up to 20–50 mm long,

covered with spine-tipped and a few truncate phyllopodia. Caudex peeling in yellowish grey flakes. Phyllopodia green, strigose. Stems grey-green, about 8 mm in diameter. Roots fibrous. Leaves dimorphic; normal leaves soft, fleshy, ascending-spreading, dorsiventrally compressed, oblanceolate-ovate to ovate-spathulate, up to 70 × 70 mm, concave, shortly petiolate, blade decurrent on petiole, base cuneate, somewhat channelled, surface glandular-pubescent; modified leaves rudimentary, spine-tipped, up to 3 mm long, persistent, curving outwards. Inflorescence an erect flat-topped thyrse up to 60–120 mm high, with 1–several dichasia, each bearing 1–3 flowers; peduncle glandular pubescent. Corolla tubular, 15 mm long, 4 mm wide at base; lobes spreading, white and glabrous on inside, glandular-pubescent on outside. Follicles enclosed by dry persistent corolla. Seed fine.

Phenology: Flowering in midsummer (January–February).

Pollinators: Insects.

Habitat and aspect: South-facing quartzitic sandstone cliffs, the plants occurring in crevices, on ledges and in shady rock veins on southern aspects. Temperature moderate to high in summer but mild to warm in winter (frost absent). The average daily maximum temperature is about 22–24°C and the average daily minimum for the region 10–12°C. Rainfall is mainly in winter and autumn, 50–150 mm per annum (mainly cyclonic winter rain and thunder showers in autumn). Regular fog provides extra moisture.

Altitude: 400–1200 m.

Associated vegetation: Rosyntjieberg Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe meyeri*, *Conophytum taylorianum* subsp. *rosynense*, *Othonna cyclophylla* and *Trachyandra aridimontana*.

Geology: Quartzitic sandstone cliffs (Rosyntjieberg Formation) of the Richtersveld Suite.

DISTRIBUTION

Endemic to the Rosyntjieberg (including the adjacent Oemsberg in the Richtersveld Transfrontier National Park of the Northern Cape).

RELATED SPECIES

Tylecodon ellaphieae is distinct in general morphology. It can be confused with *T. torulosus*, a related cremnophyte from near Lekkersing. Both have white flowers but that is where the resemblance ends. *Tylecodon ellaphieae* has a more compact growth. Normal leaves are produced at the beginning of the season, soon replaced by the rudimentary spine-tipped leaves (Bruyns 1990). The stems of *T. torulosus* are smooth and torulose. *Tylecodon ellaphieae* occurs in the fog zone (500–1200 m above sea level) where the large, spreading, glandular pubescent, concave leaves as well as the phyllopodia and rudimentary, curved, spine-tipped leaves function as a moisture trap. The conspicuous white tubular flowers are thought to be pollinated by insects and the very tiny, light seeds are wind-dispersed.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, compact clusters typical of many cremnohytes. The reduction in size and compact growth can be viewed as an adaptation to the cliff environment.

Size and weight: Clusters small, up to 100 mm in diameter, of medium weight.

Roots: The fleshy roots can be viewed as an adaptation to the xeric conditions on the cliff face.

Stem: Succulent, grey-green, up to 8 mm in diameter, covered with green, strigose phyllopodia.

Leaves

Orientation: Ascending spreading to spreading from an apically grouped rosette. Dimorphic, normal leaves large, soft, fleshy, fragile, modified leaves rudimentary, spine-tipped, up to 3 mm long, persistent, curving outwards.

Colour and texture: Epidermis light green. The very soft, succulent nature an adaptation to the undisturbed cliff conditions.

Age and persistence: Plants slow-growing, long-lived perennials. Leaves becoming deciduous during the long, dry summer, suggesting an adaptation to the moist conditions in winter.

Armament and camouflage: Plants fleshy, fragile and without conspicuous armament or camouflage properties as opposed to the level-ground *Tylecodon* species, the reduction in camouflage and armament due to the undisturbed conditions on the cliff face.

Sexual reproduction

Inflorescence and flowers: Rich flowering. Inflorescence a conspicuous erect, flat-topped thyrse up to 60–120 mm high, with 1–several dichasia each bearing 1–3 flowers; peduncle glandular pubescent. Corolla tubular, 15 mm long, 4 mm wide at base; lobes spreading, white and glabrous on inside, glandular-pubescent on outside; dry persistent corolla enclosing follicles.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at onset of rainy season, maximising establishment.

Vegetative reproduction: Plants will root from branches reaching crevices or pockets of soil. Detached parts of branches will root if they fall into adjacent crevices. This is an effective vegetative backup strategy for surviving the harsh conditions on the cliff face.

CONSERVATION STATUS

Localised and rare, confined to the Rosyntjieberg in the Richtersveld Transfrontier National Park, but not threatened.

ADDITIONAL NOTES

Horticulture: Best grown in dry succulent karoo gardens in containers. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from branch cuttings. Easily grown, keep dry in summer.

VOUCHER

Van Jaarsveld & Drijfhout 5523 (NBG).

ILLUSTRATIONS AND MAP

Plate 155, Figures 155a–155d, Map 155.

156. *Tylecodon longipes* Van Jaarsv. & G. Will. in *Aloe* 31,3 & 4: 56–59 (1994).

Cremnophyte growth form: Mat-forming clusters (of medium weight, cliff hugger).

Growth form formula: A:S:Lar:D (vb)

Etymology: The epithet *longipes* (*longus*, long, and *pes*, a foot) pertains to the long petioles.

DESCRIPTION AND HABITAT

Dwarf-sized, highly branched, mat-forming, summer-deciduous succulents up to 30 mm high and 200 mm in diameter. Branches up to 20 mm in diameter; bark silvery grey, cracking, exposing green tissue. Leaves 1–4 per branch, crowded, spreading, lanceolate, broadly ovate to spatulate, sometimes 3-lobed, 15–35 × 10–20 mm, glandular hairy; petiole up to 5 mm long, rarely somewhat channelled; apex obtuse; base cuneate; bract-like leaves subulate, 1 mm long, drying soon. Inflorescence a short thyrses up to 30 mm high, of 1–3 monochasia; peduncle 10–20 mm long, glandular hairy; pedicels 7 mm long. Calyx lobes triangular, up to 2 × 1 mm. Corolla tubular, up to 15 mm long; tube cylindrical to funnel-shaped, green-white; lobes oblong, 4–6 × 2 mm. Stamens 10 mm long; anthers rectangular to pyriform, 0.5 mm long. Squamulae transversely rectangular, 0.70 mm high, pale green.

Phenology: Flowering in midsummer (January–February).

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone cliffs. Plants occur in crevices and on ledges on eastern and southern aspects. Temperature moderate to high in summer and mild to warm in winter (frost absent), but regularly lowered by fog from the Atlantic Ocean. The average daily maximum temperature is about 18°C and the average daily minimum for the region about

10°C. Rainfall mainly in winter, about 50–75 mm per annum (mainly cyclonic winter rain). Regular fog from the Atlantic Ocean provides extra moisture.

Altitude: 400–800 m.

Associated vegetation: Lekkersing Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Adromischus caryophyllaceus*, *Conophytum* sp., *Crassula brevifolia*, *C. macowanii*, *C. muscosa* var. *polypodacea*, *Haemanthus coccineus*, *Haworthia arachnoidea*, *Mitrophyllum clivorum*, *Tylecodon buchholzianus* and *T. racemosus*.

Geology: Quartzitic sandstone of the Stinkfontein Formation (Gariiep Supergroup).

DISTRIBUTION

Spitskloof near Lekkersing (Northern Cape).

RELATED SPECIES

Related to *Tylecodon decipiens*, another cremnophyte, but at once distinguished by its thicker and shorter branches covered with short, linear-acute, bract-like leaves. It differs further by its normal leaves which are distinctly petiolate.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, densely clustered, typical of many cremnophytes.

Size and weight: Clusters medium-sized, up to 200 mm in diameter, of medium weight.

Roots: Tuberous.

Stem: Branches up to 20 mm in diameter, with silvery grey bark cracking and exposing the green tissue. The thick, clustered, fragile nature can be viewed as an adaptation to the xeric but undisturbed conditions found on the cliff face.

Leaves

Orientation: Ascending spreading, 1–4 per branch, crowded at branch ends.

Colour and texture: Grey-green, the leaf indumentum and somewhat channelled leaf bases indicative of adaptation to the regular fog from the Atlantic Ocean.

Age and persistence: Plants slow-growing, long-lived perennials, typical of cremnophilous succulent plants.

Armament and camouflage: Plants conspicuous, fleshy, fragile, without armament or camouflage, reflecting the disturbance-free cliff face. By comparison, the closely related *Tylecodon schaeferianus* of level ground is smaller, inconspicuous and a master of camouflage.

Sexual reproduction

Inflorescence and flowers: Rich flowering. Inflorescence a short thyrses, up to 30 mm high, with 1–3 monochasia; peduncle 10–20 mm long, glandular hairy; pedicels 7 mm long. Calyx lobes triangular, up to 2×1 mm. Corolla tubular, up to 15 mm long; tube cylindrical to funnel-shaped, green-white; lobes oblong, $4\text{--}6 \times 2$ mm.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at onset of rainy season, maximising establishment.

Vegetative reproduction: Densely branched, procumbent and will fill crevices by active growth, forming dense, tight mats (vegetative spread), an efficient vegetative backup for survival in the harsh cliff environment.

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009), but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 13063 (NBG).

ILLUSTRATIONS AND MAP

Figures 156a–156d, Map 156.

157. *Tylecodon petrophilus* Van Jaarsv. & A.E.van Wyk in *Aloe* 45,2: 31–33 (2008b).

Cremonophyte growth form: Medium-sized stem cluster (of medium weight, cliff squatter).

Growth form formula: A:S:Lar:D (vb)

Etymology: Greek *petra*, a rock, and *philein*, to love, after its rock-dwelling habitat.

DESCRIPTION AND HABITAT

Cluster-forming, much-branched, summer-deciduous shrublets, becoming subpendent and up to 400 mm in diameter. Roots fibrous. Branches 10–17 mm in diameter, succulent, densely

covered in short, slightly tapering, grey-green, woody phyllopodia 4–5 mm long and 4–10 mm in diameter at base. Leaves softly succulent, in apical rosettes, spreading, covering stem and base; blade broadly obovate to subrotund, 50–100 × 35–70 mm, about 2–3 mm thick, faintly striate; both surfaces covered in short, translucent glandular hairs up to 0.5 mm long, adaxial surface flat to slightly concave, green to dull green, abaxial surface flat, dull green and purplish, bearing faint midrib; margin entire; apex obtuse to rounded; petiole short, indistinct. Inflorescence a sparsely branched, ascending thyrse up to 350 mm long, bearing 1 or 2 apical monochasia each bearing 2 or 3 flowers, basally with spirally arranged, leaf-like bracts; basal bracts 20 × 5 mm, becoming smaller distally, of same colour and texture as leaves; peduncle reddish brown, glandular pubescent, 3 mm in diameter at base. Flowers ascending-spreading, yellowish green; pedicels 8–10 mm long, green. Calyx 6–7 mm long, glandular tomentose, purplish green; lobes 6–7 × 2 mm. Corolla glandular pubescent; tube cylindrical, 11–12 × 5–6 mm; lobes 12 × 5 mm, distinctly recurved, yellowish green; margins white; apices acute. Stamens up to 10 mm long, attached to throat, protruding for 5 mm; anthers 1 mm long. Squamae slightly tapering 1 × 0.6 mm, emarginate, pale green, translucent. Gynoecium 22 mm long; carpels 5, free, about 10 mm long, tapering into styles 12 mm long and protruding for 12 mm from corolla apex. Follicles 8 × 1.7 mm. Seeds not seen.

Phenology: Flowering in midsummer (December–January).

Pollinators: Insects.

Habitat and aspect: South-facing quartzitic sandstone cliffs, the plants occurring in crevices, on ledges and in shady rock veins on southern aspects. Temperature moderate to high in summer but mild to warm in winter (frost absent). The average daily maximum temperature is about 22–24°C and the average daily minimum for the region 10–12°C. Rainfall mainly in winter and autumn, ranging from 100–250 mm per annum (mainly cyclonic winter rain). Occasional fog provides extra moisture.

Altitude: 400–600 m.

Associated vegetation: Namaqualand Shale Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Bulbine pendens*, *Colpias molle*, *Ornithogalum pendens* and *Ornithogalum* sp.

Geology: Quartzitic sandstone cliffs (Kuibus Formation) of the Nama Group.

DISTRIBUTION

Endemic to the Skaaprivierspoort northwest of Springbok.

RELATED SPECIES

Tylecodon petrophilus is related to both *T. hirtifolius* from Esselfontein at the top of Spektakel Pass and *T. ellaphieae* from cliffs along the Rosyntjieberg. It is at once distinguished by its dense leaf canopy completely covering its stems. It differs from *T. hirtifolius* mainly in its broadly obovate to subrotund leaves, grey-green phyllopodia and tubular corolla. *Tylecodon hirtifolius* is a sprawling species with distinctive black stems and obovate to oblanceolate leaves which are

grooved above and lack the purplish coloration. It occurs in the shade of small shrubs on shale soil and has large leaves not covering the stems. The corolla of *T. hirtifolius* is funnel-shaped.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact clusters typical of many cremnophytes. The compact growth can be viewed as an adaptation to the cliff environment.

Size and weight: Clusters up to 400 mm in diameter, of medium weight.

Roots: Fibrous.

Stem: Succulent, grey-green, up to 8 mm in diameter, covered with grey-green phyllopodia truncate at the apices.

Leaves

Orientation: Large, spreading and crowded in a central rosette.

Colour and texture: Soft, fleshy, fragile; epidermis light green, with a glandular-pubescent surface.

Age and persistence: Plants slow-growing, long-lived perennials. Leaves becoming deciduous during the long, dry summer, an adaptation to the moist conditions in winter.

Armament and camouflage: Plants fleshy, fragile and without conspicuous armament or camouflage properties as opposed to the level-ground *Tylecodon* species, the reduction in camouflage and armament due to the undisturbed conditions on the cliff face.

Sexual reproduction

Inflorescence and flowers: Elongated inflorescence with 1 or 2 dichasia each bearing 1–3 flowers; peduncle glandular pubescent. Corolla tubular, 12–15 × 5–6 mm.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at onset of rainy season, maximising establishment.

Vegetative reproduction: Plants will root from branches reaching crevices or pockets of soil. Detached parts of branches will root if they fall into adjacent crevices. This is an effective vegetative backup strategy for surviving the harsh conditions on the cliff face.

CONSERVATION STATUS

Localised and rare, confined to the Skaaprivierspoort northwest of Springbok, but not threatened.

ADDITIONAL NOTES

Horticulture: Best grown in containers in dry succulent karoo gardens. Outside the habitat, it is best grown under controlled conditions in a greenhouse. Propagate from branch cuttings. Easily grown, keep dry during the summer months.

VOUCHER

Van Jaarsveld 21117 (NBG).

ILLUSTRATIONS AND MAP

Plate 157, Figures 157a–157c, Map 157.

158. *Tylecodon singularis* (R.A.Dyer) Toelken in *Bothalia* 12: 380 (1978).

Cremonophyte growth form: Solitary geophyte (of light to medium weight, cliff squatter).

Growth form formula: A:S:Lar:D (ft)

Etymology: Latin *singularis*, remarkable, reflecting its uniqueness.

DESCRIPTION AND HABITAT

Dwarf-sized, perennial geophyte with subterranean tuberous base. Branch solitary or rarely branched, short, glabrous. Roots succulent, fusiform. Leaves usually single (up to 4 in cultivation), produced every season; blade orbicular, 80–150 mm in diameter, concave, cordate at base, shortly petiolate, glandular hairy, purplish below; petiole channelled. Inflorescence an erect, spreading thyrse 80–60 mm high consisting of 2–4 monochasia each bearing 5–10 flowers. Corolla tubular, up to 13 mm long, slightly widening towards throat, pale yellowish green, with short hairs on inside; lobes 6–7 mm long, recurved. Squamae square, about 1×1 mm, entire or emarginate, yellowish.

Phenology: Flowering in late spring (October–November).

Pollinators: Insects.

Habitat and aspect: Dolomite cliffs southeast of Namuskluft (Dolomite of the Port Nolloth Zone, Gariep Supergroup). Plants occur in crevices and on ledges on southern and eastern aspects. Temperature moderate to high in summer and mild to warm in winter (frost absent), but regularly lowered by fog from the Atlantic Ocean. Average daily maximum temperature about 24°C and average daily minimum for the region 10°C. Rainfall mainly in winter, about 50–75 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 800–1100 m.

Associated vegetation: Succulent Karoo.

Associated cremnophytes: At Konsertinaberg (type locality), *Tylecodon singularis* has been recorded with *Crassula sladenii*, *C. tomentosa* var. *tomentosa*, *Drosanthemum inornatum*, *Hartmanthus* sp. and *T. buchholzianus*.

Geology: Dolomite cliffs of the Port Nolloth Zone (Gariiep Supergroup).

DISTRIBUTION

Southern Namibia, east of Rosh Pinah.

RELATED SPECIES

Related to *Tylecodon atropurpureus*, a non-cremnophilous geophyte from the Northern Cape. The latter with rosettes of smaller leaves and large subterranean tubers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: The conspicuous nature reflects its habitat, the undisturbed cliff face.

Size and weight: Plants small to medium-sized, up to 80 mm in diameter, of light to medium weight.

Roots: Rootstock tuberous; roots succulent, fusiform.

Stem: Solitary or rarely branched, short, glabrous. Squamae square, about 1×1 mm, entire or emarginate, yellowish.

Leaves

Orientation: Solitary, large, spreading, blade orbicular, 50–80 mm in diameter, concave, cordate at the base and shortly petiolate.

Colour and texture: Green, glandular hairy, purplish below; petiole channelled. The leaf indumentum, concave shape and somewhat channelled petiole clearly form a ‘fog trap’, an adaptation to the regular fog from the Atlantic Ocean. The fragile nature of the leaf points to a lack of disturbance by larger herbivores in the habitat.

Age and persistence: Plants slow-growing, long-lived perennials, typical of cremnophilous succulent plants. The summer-deciduous nature is an adaptation to the long, dry summers.

Armament and camouflage: Plants conspicuous, fleshy, fragile and lacking in armament or camouflage properties, reflecting the disturbance-free cliff face.

Sexual reproduction

Inflorescence and flowers: Rich flowering. Inflorescence an erect, spreading thyrse, 80–60 mm high, consisting of 2–4 monochasia each bearing 5–10 flowers. Corolla tubular, up to 13 mm long, slightly widening towards throat, pale yellowish green, with short hairs on inside; lobes 6–7 mm long, recurved.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in summer and autumn at onset of rainy season, maximising establishment.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Classified as rare (Loots 2005), confined to dolomite cliffs within the confines of a national park where it is well protected.

ADDITIONAL NOTES

Horticulture: Best grown under controlled greenhouse conditions, in an alkaline soil. Keep dry in summer. Cultivated plants tend to grow very large leaves. Propagate from seed. Seldom grown.

VOUCHER

Van Jaarsveld 21074 (NBG).

ILLUSTRATIONS AND MAP

Figures 158a–158e, Map 158.

159. *Tylecodon sulphureus* (Toelken) Toelken var. *armianus* Van Jaarsv. in *The Flowering Plants of Africa* 50,2: t. 1984 (1989b).

Crempnophyte growth form: Dwarf-sized stem cluster (of light weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: After A.R. Mitchell, an Englishman from the Isle of Wight who discovered the species.

DESCRIPTION AND HABITAT

Dwarf-sized, cluster-forming succulents up to 100 mm in diameter; base tuberous, tubers up to 30 mm in diameter. Branches ascending, spreading to pendulous, covered with rounded phyllopodia. Leaves oblanceolate, elliptic to linear, 10–25 × 3–8 mm, glabrous; surface minutely papillate, upper surface grooved, lower surface convex; apex obtuse. Inflorescence an erect, flat-topped thyrse 35–60 mm high consisting of 1–3 monochasia; peduncle glandular pubescent, up to 20 mm high; bracts 6 × 1 mm, linear-subulate, glandular pubescent. Calyx lobes linear-lanceolate, up to 2 mm long, purplish green. Corolla tubular, 8–14 × 3–4 mm, glandular pubescent, white to pink; lobes recurved. Anthers yellow. Squamae oblong, 1 × 0.3 mm, truncate to emarginate, green.

Phenology: Flowering in midsummer (January–February).

Pollinators: Insects.

Habitat and aspect: Confined to south-facing metaquartzitic gneiss cliffs. The plants grow in shady crevices up to about 900 m (mainly southern aspects) in association with other succulent plants. Summers are hot and dry. The average daily maximum temperature is about 28°C and average daily minimum about 13°C, with frost absent from the habitat. Rainfall in spring, autumn and winter (cyclonic cold fronts and thunder showers in late summer and autumn), ranging from 50–100 mm per annum.

Altitude: 700–1110 m.

Associated vegetation: Eastern Gariiep Rocky Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnohytes: Other succulents observed at its habitat at Groot Pellaberg include *Adromischus trigynus*, *Aloe dabenorisana*, *Bowiea gariepensis*, *Conophytum fulleri*, *Crassula exilis* subsp. *sedifolia* and *C. garibina*.

Geology: Metaquartzitic gneiss of the Hom Formation (Bushmanland Group).

DISTRIBUTION

Known only from northern Bushmanland on cliffs of similar geological formations (Northern Cape). It appears to be confined to Dabenorisberg and Pellaberg (northwest of Pofadder).

RELATED SPECIES

Tylecodon sulphureus var. *armianus* is closely related to *T. sulphureus* var. *sulphureus*, a quartz flats species from the northern Bushmanland region. The latter differs in being a much smaller and less branched geophyte (yellow flowers) that is difficult to detect as it is so well camouflaged. Only the stem apices are exposed, bearing a few leaves. The conspicuous white tubular flowers are thought to be pollinated by insects and the very tiny, light seeds are wind-dispersed. *Tylecodon reticulatus* is a conspicuous, robust stem succulent growing in exposed sites, but well armed with persistent dry inflorescences, protecting its softer growth points and leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, compact to loose clusters, sometimes with fragile, drooping branches. The habit is typical of related cremnohytes and the fragile nature reflects the undisturbed cliff habitat.

Size and weight: Clusters small, up to 100 mm in diameter, of light weight.

Roots: The fleshy roots can be viewed as an adaptation to the xeric conditions on the cliff face.

Stem: Succulent, grey-green, up to 3–5 mm in diameter, covered with rounded phyllopodia. Branches ascending, spreading to pendulous.

Leaves

Orientation: Ascending-spreading.

Colour and texture: Light green, epidermis minutely papillate; upper surface grooved; lower surface convex.

Age and persistence: Plants slow-growing, long-lived perennials. Leaves becoming deciduous during the long, dry summer, suggesting adaptation to moist conditions in winter.

Armament and camouflage: Plants fleshy, fragile and without conspicuous armament or camouflage properties as opposed to the level-ground *Tylecodon* species, the reduction in camouflage and armament due to the undisturbed conditions on the cliff face.

Sexual reproduction

Inflorescence and flowers: Inflorescence an erect, flat-topped thyrse, 35–60 mm high, consisting of 1–3 monochasia; peduncle glandular pubescent, up to 20 mm high; bracts linear-subulate, 6 × 1 mm, glandular-pubescent. Calyx lobes linear-lanceolate, up to 2 mm long, purplish green. Corolla tubular, 8–14 × 3–4 mm, glandular pubescent, white to pink, with recurved lobes. Anthers yellow.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at onset of rainy season, maximising establishment.

Vegetative reproduction: Branches spreading and will fill new crevices by active growth, forming loose to tight mats (vegetative spread), an efficient vegetative backup strategy for continued existence in the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009) but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHERS

Van Jaarsveld 19153, Van Jaarsveld & Patterson 6639 (NBG).

ILLUSTRATIONS AND MAP

Plate 159, Figures 159a–159e, Map 159.

160. *Tylecodon torulosus* Toelken in *Bothalia* 12: 381 (1978).

Cremonophyte growth form: Loose stem clusters (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: Latin *torulosus*, cylindrical with swollen portions at intervals, referring to the cylindrical stems with characteristic contractions.

DESCRIPTION AND HABITAT

Small, sparsely branched, ascending, thickset, succulent shrublet up to 250 mm tall, 250 mm wide, with tuberous base, sometimes with pendulous branches from rock face up to 300 mm long. Branches grey-white, up to 30 mm in diameter at base, tapering to 5 mm in diameter at apices; nodes characteristically swollen (torulose); bark grey, smooth; older branches flaking. Leaves ovate to spatulate, occasionally 3-lobed, 25–40 × 13–22 mm, spreading, crowded at apex, grey to yellowish green, flat; apex obtuse or acute, often becoming recurved; base cuneate. Inflorescence a short, rounded, almost sessile thyrse of 2–5 monochasia each bearing 1–3 tubular flowers; peduncle 2–3 mm long; pedicels 3–5 mm long. Calyx lobes triangular-ovate, 3 × 2 mm, green, fleshy. Corolla tubular, 14–23 × 4–5 mm, slightly expanding distally, yellowish green, glandular pubescent on outside, with purplish striations on ridges; lobes 5 × 3 mm, inside white, outside with maroon striations towards centre, lobate, spreading, becoming recurved. Squamae 1.5 × 1 mm, deeply emarginate (lobes acute), white, slightly translucent.

Phenology: Flowering in midsummer (end January–February).

Pollinators: Insects.

Habitat and aspect: Quartzitic sandstone cliffs, the plants occurring in crevices and on ledges on eastern and southern aspects. Temperature moderate to high in summer and mild to warm in winter (frost absent), but regularly lowered by fog from the Atlantic Ocean. The average daily maximum temperature is about 18°C and the average daily minimum for the region 10°C. Rainfall mainly in winter, about 50–75 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 300–500 m.

Associated vegetation: Lekkersing Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Adromischus caryophyllaceus*, *Conophytum* sp., *Crassula brevifolia*, *C. macowanii*, *C. muscosa* var. *polypodacea*, *Haemanthus coccineus*, *Haworthia arachnoidea*, *Mitrophyllum clivorum*, *Tylecodon buchholzianus* and *T. racemosus*.

Geology: Quartzitic sandstone of the Stinkfontein Formation (Gariiep Supergroup).

DISTRIBUTION

Karrachab Poort near Lekkersing (Northern Cape).

RELATED SPECIES

Related to *Tylecodon decipiens*, another cremnophyte, but at once distinguished by its thicker, torulose and longer branches with much larger leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous, loose clusters.

Size and weight: Clusters medium-sized, up to 250 mm in diameter, of medium weight.

Roots: Tuberous.

Stem: Branches grey-white, up to 30 mm in diameter at the base, tapering to 5 mm at the apices, the nodes characteristically swollen (torulose); bark grey, smooth, older branches flaking.

Leaves

Orientation: Ascending-spreading, crowded at apex.

Colour and texture: Grey to yellowish green, epidermis smooth. The fragile texture is an adaptation to the absence of disturbances by larger herbivores.

Age and persistence: Plants slow-growing, long-lived perennials, typical of cremnophilous succulent plants. The summer-deciduous nature is an adaptation to the long, dry summers.

Armament and camouflage: Plants conspicuous, fleshy, fragile, lacking in armament or camouflage properties, reflecting the disturbance-free cliff face. By comparison, the related *Tylecodon schaeferianus* of level ground is smaller, inconspicuous and a master of camouflage.

Sexual reproduction

Inflorescence and flowers: Rich flowering. Inflorescence a short, rounded, almost sessile thyrses of 2–5 monochasia each bearing 1–3 tubular flowers; peduncle 2–3 mm long; pedicels 3–5 mm long. Calyx lobes triangular-ovate, 3 × 2 mm, green, fleshy. Corolla tubular, 14–23 × 4–5 mm, slightly expanding upwards, yellowish green, glandular pubescent on outside with purplish striations on ridges; lobes lobate, 5 × 3 mm, inside white, outside with maroon striations towards centre, spreading, becoming recurved.

Fruit/Seed

Size: Seed minute and ideal for establishment in crevices.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind.

Time: Seeds dispersed in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: Branches spreading and will root where they touch the soil, forming loose mats (vegetative spread), an efficient vegetative backup strategy for surviving the harsh cliff-face environment.

CONSERVATION STATUS

Classified as vulnerable (Raimondo *et al.* 2009). Although rare, it is well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Toeken 5317 (PRE).

ILLUSTRATIONS AND MAP

Figures 160a–160c, Map 160.

161. *Tylecodon viridiflorus* (Toelken) Toelken in *Bothalia* 12: 382 (1978).

Crempnophyte growth form. Ascending compact shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:D (vb)

Etymology: Latin *viridiflorus*, (*viridis*, green, *flos*, flower), pertaining to the green corolla of the plant.

DESCRIPTION AND HABITAT

Erect, sparsely branched, succulent shrub up to 350 mm high, 200 mm in diameter; base slightly tuberous, up to 15 mm in diameter, with a single to few main branches up to 10 mm in diameter; bark grey, peeling; young branches brown at first, becoming paler with age. Leaves crowded, ascending to spreading, elliptic, oblanceolate, to broadly ovate, dorsiventrally flattened, 20–55 × 8–30 mm, occasional 3-lobed; surface glandular hairy, adaxial surface often channelled; apex obtuse to acute; base cuneate. Inflorescence a thyse up to 45 mm high, of 1–3 monochasia each bearing 1 or 2 flowers; pedicels up to 12 mm long. Corolla tubular, 14–20 × 5 mm long, greenish; lobes triangular-lanceolate, up to 7 mm long, spreading, becoming recurved, distinctly yellowish green. Calyx lobes linear-lanceolate, up to 9 mm long. Squamae oblong, 1.5 mm long, slightly tapering, cream. Seed winged, a unique character in the Crassulaceae in South Africa.

Phenology: Flowering in midsummer (January).

Pollinators: Insects.

Habitat and aspect: Shady quartzitic sandstone cliffs, the plants occurring in crevices and on ledges on eastern and southern aspects. Temperature moderate to high in summer and mild to warm in winter (frost absent), but regularly lowered by fog from the Atlantic Ocean. The average daily maximum temperature is about 22°C and the average daily minimum for the region 11°C. Rainfall mainly in winter, about 50–100 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 600–900 m.

Associated vegetation: Central Richtersveld Mountain Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Near Eksteenfontein the following plants were observed in its habitat: *Adromischus caryophyllaceus*, *Conophytum* spp., *Crassula brevifolia*, *C. macowanii*, *C. muscosa* var. *muscosa*, *Cyrtanthus herrei*, *Haemanthus coccineus*, *Haworthia arachnoidea*, *Mitrophyllum clivorum*, *Tylecodon buchholzianus* and *T. racemosus*.

Geology: Quartzitic sandstone of the Stinkfontein Formation (Gariep Supergroup).

DISTRIBUTION

Central Richtersveld mountains, from Eksteenfontein to Kuboes in the north (Northern Cape).

RELATED SPECIES

Related to *Tylecodon fragilis*, another widespread species of level ground. *Tylecodon viridiflorus* is at once distinguished by its dorsiventrally flattened, hairy leaves and grey bark, which is not striate, and by the winged seed.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Erect shrublets.

Size and weight: Clusters medium-sized, up to 30 mm high, of medium weight.

Roots: Tuberous.

Stem: Base slightly tuberous, up to 15 mm in diameter, with a single to a few main branches up to 10 mm in diameter, with grey bark peeling vertically. Young branches brown at first, becoming paler with age.

Leaves

Orientation: Ascending to spreading, crowded.

Colour and texture: Dull green, surface glandular hairy; adaxial surface often channelled.

Age and persistence: Plants slow-growing, long-lived perennials, typical of cremnophilous succulent plants.

Armament and camouflage: Plants conspicuous, fleshy, fragile and lacking in armament or camouflage properties, reflecting the disturbance-free cliff face. By comparison, the closely related *Tylecodon fragilis* of level ground is smaller, inconspicuous and a master of camouflage among the shrublets of its habitat.

Sexual reproduction

Inflorescence and flowers: Rich flowering. Inflorescence a thyrses, up to 45 mm high, of 1–3 monochasia each bearing 1 or 2 flowers; pedicels to 12 mm long. Corolla tubular, 14–20 × 5 mm long, greenish; lobes triangular-lanceolate, up to 7 mm long, distinctly yellowish green, spreading, becoming recurved. Calyx lobes linear-lanceolate, up to 9 mm long. Squamae oblong, 1.5 mm long, cream, slightly tapering.

Fruit/Seed

Size: Seed winged and much larger and different from that of all other *Tylecodon* species.

Dispersal: Follicles dehiscent, with seeds spontaneously released and dispersed by wind. The winged seeds are a clear adaptation to wind dispersal, very effective on the cliff face.

Time: Seeds dispersed in autumn at the onset of the rainy season, maximising establishment.

Vegetative reproduction: Detached branches will root if they fall into a new crevice (vegetative spread), an efficient vegetative backup strategy for surviving the harsh cliff-face environment.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009) but well protected owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown in succulent karoo gardens, in rockeries or containers. Outside its habitat, it is best suited to a greenhouse, grown under controlled conditions. Propagate from stem cuttings. Easily cultivated, its vigour viewed as maximising survival.

VOUCHER

Van Jaarsveld 22285 (NBG).

ILLUSTRATIONS AND MAP

Figures 161a–161f, Map 161.

GERANIACEAE

Pelargonium L'Hér.

162. *P. mutans* Vorster

163. *P. vanderwaltii* Van Jaarsv.

PELARGONIUM L'Hér.

162. *Pelargonium mutans* Vorster in The Flowering Plants of Africa 52,1: t. 2060 (1992).

Cremonophyte growth form: Dwarf-sized, compact to spreading shrublet (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: The epithet *mutans*, changeable, pertains to the changeable number of petals (varying between 4 and 5).

DESCRIPTION AND HABITAT

Spreading, trailing, succulent shrub with stems up to 2 m long, moderately branched. Roots fibrous. Stems spreading, erect or decumbent, succulent, 8–10 mm in diameter, terete, green at first, characteristically articulated, swollen at nodes; surface covered with gland-tipped and non-gland-tipped hairs, becoming brownish green and glabrescent with age and bearing remnants of persistent stipules. Leaves simple, crowded at apices, ascending; indumentum membranaceous as in young stems; lamina 40–70 × 45–80 mm, with or without purplish zonal markings, shallowly to deeply 5-lobed; margin with shallow dentations; apex obtuse; base cordate; petiole 20–45 mm long. Inflorescence terminal, producing a solitary 6–8-flowered pseudo-umbel on peduncles 45–250 mm long; pseudo-umbels up to 80 mm in diameter; pedicels 5–10 mm long, pilose. Sepals linear-lanceolate, 5 × 2 mm, acute, pilose. Petals 5, linear-obovate, apices rounded to slightly retuse, white; posterior two 15 × 5 mm, reflexed; anterior three 15 × 3.4 mm. Stamens 6, fertile. Mericarps 7 mm long, tail 30–34 mm long.

Phenology: Flowering throughout the year, but with a peak in spring. Seeds with typical *Pelargonium* seed dispersal strategy.

Pollinators: Insects.

Habitat and aspect: *Pelargonium mutans* grows on cliffs and cliff tops where the plants occur in sandstone rock crevices. Summers are very hot, with temperatures frequently above 30°C. Winters are mild and frost is absent or very light. The average daily maximum temperature is about 27°C and the average daily minimum about 14°C. Average annual rainfall varies from 800–1000 mm and occurs mainly in the summer months (mainly thunder showers).

Altitude: 400–1000 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: Near Kranskop in KwaZulu-Natal *Pelargonium mutans* grows with the following cliff-dwelling plants: *Crassula expansa* subsp. *fragilis*, *C. perfoliata*, *Delosperma lebomboensis* and *Gasteria batesiana*.

Geology: Mainly sandstone of Natal Group (Cape Supergroup).

DISTRIBUTION

Pelargonium mutans grows in river valleys of KwaZulu-Natal, from the Pongola River in the north to near Durban in the south.

RELATED SPECIES

Pelargonium mutans is related to *P. multibracteatum*, an East African species differing from it in its much thicker, articulated, succulent stems and much thinner petals.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small spreading shrublets, stems rooting where they enter crevices, plants becoming deciduous during the dry season.

Size and weight: Clusters small, of medium weight.

Stems: Terete, succulent, articulated at intervals, the nodes swollen where moisture is stored on the elongated stems.

Leaves

Orientation: Ascending-spreading, crowded at apices.

Colour: Green, sometimes with purplish zonal markings.

Age and persistence: Deciduous during the dry season.

Armament: Plants unarmed.

Sexual reproduction

Inflorescence and flowers: Inflorescence terminal, producing a solitary pseudo-umbel. Petals 5, white, pollinated by insects.

Fruit/Seed

Size: Mericarps 7 mm long, tail 30 mm long.

Dispersal: Mericarps spontaneously released and dispersed by wind.

Time: Mainly in summer and autumn.

Vegetative reproduction: *Pelargonium mutans* is a vigorous grower with spreading stems, rooting where they come into contact with adjacent ledges or crevices and forming new colonies. This vegetative regeneration is a vegetative backup, aiding long-term survival.

CONSERVATION STATUS

Localised on the cliffs of dry river valleys where it is not threatened owing to the safe inaccessible habitat.

ADDITIONAL NOTES

Horticulture: *Pelargonium mutans* is best for dry subtropical, coastal and bushveld gardens (Van Jaarsveld 2010). It can be grown on steep embankments, window sills or balconies, also doing well in containers, in full sun or partial shade. Propagate from cuttings from spring to autumn. Outside its native habitat, it should be grown under controlled conditions in a greenhouse. At Kirstenbosch, it has quickly spread to other containers in the cremnophyte nursery, the seed dispersed by wind.

VOUCHER

Van Jaarsveld 18042 (NBG).

ILLUSTRATIONS AND MAP

Figures 162a–162d, Map 162.

163. *Pelargonium vanderwaltii* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 43,2 & 3: 32–34 (2006c).

Cremonophyte growth form: Dwarf-sized, compact shrublet (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: Commemorates Johannes Jacobus Adriaan (Adri) van der Walt (1938–2004), botanist and *Pelargonium* specialist.

DESCRIPTION AND HABITAT

Succulent shrublet up to 180 mm tall, 300 mm in diameter, much and irregularly branched, compact, winter-deciduous, slightly aromatic. Roots fibrous. Stems erect or decumbent, succulent, (5–)8–10 mm in diameter, terete, green at first becoming reddish brown, dark brown and smooth with age; surface of young branches sericeous (densely covered with soft white hairs) becoming glabrescent with age. Leaves simple, crowded at apices, ascending; lamina broadly ovate-cordate to almost subrotund, 15–30(–50) × 25–38(–65) mm; margin dentate, sinuate, minutely ciliate; adaxial surface pilose, veins prominent, abaxial surface pilose (sparsely covered with multicellular translucent hairs); apex rounded; base cordately incised, shortly cuneate; petiole (20–)40–100(–175) mm long, persistent, drying to grey-white;

stipules persistent, triangular, 2×3 mm, minutely velutinous, margin ciliate. Inflorescence terminal, producing a solitary 3-flowered pseudo-umbel, 50–70 mm in diameter; peduncle short, 5–10 mm long, pilose; pedicels 20 mm long, pilose. Sepals linear-lanceolate, 5×1.5 –2.5 mm, acute, pilose. Hypanthium 3 mm long, pilose. Petals 5, spathulate, apices rounded to slightly retuse, varying from dark to pale mauve (Purple Group 76a–d, RHS Colour Chart); posterior two 12×6 mm, reflexed at 90° ; anterior three 9×4 mm, reflexed at more than 90° . Stamens 6, fertile, 2 shorter; pollen white. Mericarps 5 mm long, tail 12 mm long.

Phenology: Flowering throughout the year, but with a peak in December. Seeds with typical *Pelargonium* seed dispersal strategy.

Pollinators: Insects.

Habitat and aspect: Grows on south-facing cliffs and cliff tops, on the Otjihipa Mountains just east of Otjinhungwa, where the plants occur in granite rock crevices. The habitat preference of *P. vanderwaltii* in the Kaokoveld reflects an afromontane affinity rather than adaptation to the arid semidesert conditions prevailing in the region. The average annual rainfall in the Kaokoveld varies from less than 50 mm along the coast to about 350 mm on the highlands (Mendelsohn *et al.* 2002). Precipitation is erratic and occurs mainly in the form of thunder showers in summer. At Otjihipa the average annual rainfall is estimated at 150–250 mm.

Altitude: 1800–1900 m.

Associated vegetation: Mainly arid savanna.

Associated cremnophytes: *Pelargonium vanderwaltii* occurs sympatrically with other cliff-dwelling succulents such as *Aeollanthus haumannii*, *Kalanchoe lanceolata* and *Tetradenia kaokoensis*.

Geology: Granite (Fransfontein Granite Suite, Simplified Geological Map of Namibia, 1980).

DISTRIBUTION

Known only from the Otjihipa Mountains in northwestern Namibia.

RELATED SPECIES

Pelargonium vanderwaltii is a member of section *Cortusina* and is closely related to three other species in the same section, *P. cortusifolium*, *P. echinatum* and *P. crassicaule*. It is at once distinguished from these species by being winter-deciduous, by its long, (20–)40–100(–175) mm, persistent petioles, and broadly cordate-ovate to almost subrotund leaves of which the surface is only sparsely pilose. It further differs in its solitary pseudo-umbel of 3 or 4 flowers and mericarps of which the tails are only 12 mm long.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, compact shrublets, becoming deciduous during the dry season.

Size and weight: Clusters small.

Stems: Terete, succulent where moisture is stored.

Leaves

Orientation: Ascending, crowded at apices.

Colour and texture: Green, both surfaces pilose.

Age and persistence: Becoming deciduous during the dry season.

Armament: The persistent petioles can be viewed as a form of armament.

Sexual reproduction

Inflorescence and flowers: Inflorescence terminal, producing a solitary 3-flowered pseudo-umbel, 50–70 mm in diameter; peduncle short, 5–10 mm long. Petals 5, spatulate, apices rounded to slightly retuse, varying from dark to pale mauve (Purple Group 76a–d, RHS Colour Chart).

Fruit/Seed

Size: Mericarps 5 mm long, tail 12 mm long.

Dispersal: Mericarps spontaneously released and dispersed by wind.

Time: Summer and autumn (rainy season in its habitat).

Vegetative reproduction: The succulent stems will root where they come into contact with adjacent ledges or crevices, forming new colonies. This vegetative regeneration is a vegetative backup, aiding long-term survival.

CONSERVATION STATUS

Localised and confined to the Otjhipa Mountains where it is not threatened owing to the safe inaccessible habitat.

ADDITIONAL NOTES

Horticulture: *Pelargonium vanderwaltii* is best for dry semidesert, warm-temperate gardens (Van Jaarsveld 2010). It can be grown on steep embankments, window sills and balconies, also doing well in containers, in full sun or partial shade. Propagate from cuttings from spring to autumn. Outside its native habitat, it should be grown under controlled greenhouse conditions.

VOUCHER

Van Jaarsveld 18873 (NBG).

ILLUSTRATIONS AND MAP

Figures 163a & 163b, Map 163.

GESNERIACEAE

Streptocarpus Lindl.

164. *S. kentaniensis* L.L.Britten & Story

STREPTOCARPUS Lindl.

164. *Streptocarpus kentaniensis* L.L.Britten & Story in *Bothalia* 6,2: 433 (1954).

Cremnophyte growth form: Clusters with drooping foliage (of light to medium weight, cliff squatter).

Growth form formula: A:S:Lper:Lc:Ca (vb)

Etymology: After Kentani near the Kei River in the Transkei, Eastern Cape.

DESCRIPTION AND HABITAT

Perennial, stemless, rosulate, succulent plants up to 300 mm in diameter. Roots fibrous. Leaves linear-lanceolate, 100–190 × 15–30 mm, thick, fleshy, ascending-spreading, becoming drooping on cliff; surface rugose, covered with short non-glandular hairs, lower surface densely and prominently veined, veins succulent; margin crenate, undulating, slightly revolute; apex acute; petiole distinct, purplish, up to 10–30 mm long, 6–7 mm in diameter, fleshy, succulent, continuing along lower leaf surface. Peduncle hairy, 90–120 mm long, arising from distal end of petiole in series of 3–5 and extending shortly on lamina, 2-flowered. Calyx 3 mm long; segments hairy. Corolla 25–29 mm long, tubular, cylindrical, slightly curved, hairy, light violet, spotted; limb 17–20 mm across; lobes 5–6 mm long. Stamens with twisted filaments, 4 mm long; anthers connivent, explosive; pollen powdery. Gynoecium 13 mm long; ovary and style hairy, style about twice as long as ovary. Capsule slender, about 50 mm long, scabrous. (Description partly based on Story 1955.)

Phenology: Flowering in midwinter. Seed wind-dispersed.

Pollinators: Insects.

Habitat and aspect: Shale cliffs and mainly on shady southern aspects. Plants are rooted in crevices and on rock ledges. Winters are cool but frost is a rarity or absent. The average daily maximum temperature is 22°C and the average daily minimum 14°C. Rainfall occurs from spring to autumn but occasionally also in winter and ranges from 1000–1250 mm per annum.

Altitude: 100–200 m.

Associated vegetation: Buffels Thicket, Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Near Kei Mouth, the plants grow with the following cliff dwellers: *Crassula cordata*, *C. foveata*, *C. lactea*, *C. spathulata*, *Cyrtanthus sanguineus*, *Delosperma*

sp., *Haworthia cymbiformis* var. *setulifera*, *Kalanchoe crenata*, *Peperomia blanda*, *Petropentia natalensis*, *Plectranthus strigosus*, *Rhipsalis baccifera* and *Stenoglottis fimbriata*.

Geology: Mainly Beaufort shale (Karoo Supergroup).

DISTRIBUTION

Streptocarpus kentaniensis is confined to cliff faces of the lower Kei River and its tributaries.

RELATED SPECIES

Streptocarpus kentaniensis with its markedly succulent leaves with a thick midrib is a distinct species not confused with any other southern African species. It is in fact the most succulent of all *Streptocarpus* species and has been taken up in the succulent lexicon of Egli (2002: 304).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact, rosulate growth, the thick succulent leaves (especially the midrib) enabling plants to survive periods of drought on the sheer cliff face. The plants sometimes become desiccated during dry periods but soon regain turgidity after sufficient rain, ensuring their survival on the cliff face. When the thick petiole is damaged or falls into a crevice, it will simply root, a valuable vegetative backup system.

Size and weight: Clusters small.

Leaves

Orientation: Spreading-ascending to drooping.

Colour: Green.

Sexual reproduction

Inflorescence and flowers: Peduncle 90–120 mm long, 2-flowered. Corolla 25–29 mm long. Conspicuous, light violet coloured, spotted.

Fruit/Seed

Size: Very fine dust diaspores.

Dispersal: Seeds explosively released and dispersed by wind.

Time: Flowering in midwinter ensures that seeds ripen by spring, in time for spring rains.

Vegetative reproduction: *Streptocarpus kentaniensis* regenerates from leaves (midrib) that come into contact with soil or land in crevices, establishing new colonies. Detached leaves that fall into adjacent crevices will root and establish new plants. This vegetative regeneration is a vegetative backup, aiding long-term survival.

CONSERVATION STATUS

Classified as vulnerable (Raimondo *et al.* 2009). However, it is localised and confined to cliffs where it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: *Streptocarpus kentaniensis* is an ornamental species, best for dry subtropical, coastal and thicket gardens. It can be grown as a house plant or on steep embankments, window sills or balconies, also doing well in containers in partial shade (Van Jaarsveld 2010). Propagate from leaf cuttings in a sand-peat mixture from spring to summer. Outside its native habitat, it should be grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17923 (NBG).

ILLUSTRATIONS AND MAP

Plate 164, Figures 164a & 164b, Map 164.

LAMIACEAE

Aeollanthus Mart. ex Spreng.

- 165. *A. haumannii* Van Jaarsv.
- 166. *A. rydingianus* Van Jaarsv. & A.E.van Wyk

Plectranthus L'Hér.

- 167. *P. dolomiticus* Codd
- 168. *P. ernstii* Codd
- 169. *P. mutabilis* Codd
- 170. *P. mzimvubuensis* Van Jaarsv.
- 171. *P. purpuratus* Harv. subsp. *purpuratus*
- 172. *P. saccatus* Benth. subsp. *pondoensis* Van Jaarsv. & Milstein

Tetradenia Benth.

- 173. *T. kaokoensis* Van Jaarsv. & A.E.van Wyk

AEOLLANTHUS Mart. ex Spreng.

165. *Aeollanthus haumannii* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Aloe* 43,4: 72–73 (2006d).

Cremonophyte growth form: Dwarf-sized, ascending, succulent shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: After Mr Tielman Haumann and his son, Dr Carl Haumann, farmers and lovers of African plants.

DESCRIPTION AND HABITAT

Soft, semisucculent, herbaceous, single to multistemmed (branched from base, rarely dichotomously branched) perennial up to 160 mm tall, most parts beset with minute glandular hairs, aromatic (smell of *leberwurst*), becoming glabrescent with age. Roots fibrous. Branches 4-angled to subterete, at first pale to almost whitish green, becoming grey-brown, eventually black; main branches up to 8 mm in diameter (9 mm at swollen nodes), often articulated and becoming ribbed; nodes distinctly swollen, internodes (10–)20(–30) mm long; main branches often distinctly grooved (above each leaf axil); younger branches 4 mm in diameter, sparsely covered with translucent glandular hairs shorter than 0.1 mm. Leaves fleshy, decussate, petiolate, broadly ovate to broadly triangular-ovate to ovate, 35–55(–60) × 28–35(–45) mm; adaxial surface pale glaucous green; margin serrate (bearing 4–8 pairs of teeth), sometimes slightly wavy, often decurrent on petiole; apex obtuse, subacute to subrotund; base truncate, rarely cuneate to attenuate; petiole subterete, 15–25(–30) mm long, spreading. Inflorescence a lax, terminal, candelabra-shaped panicle up to 150 mm high and about 220 mm wide at base; peduncle 3 mm in diameter at base, gradually narrowing distally; axis of main spike 25–30 mm long, with opposite flowers (not secund), becoming gradually smaller towards tip; other

spikes bearing 1 or 2 flowers at each node (secundly arranged, and 1–4 flowers opening at the same time on each spike); basal spikes up to 80 mm long (with stalks up to 35 mm long), bearing leaf-like bracts at base, each bearing short side branches from base. Corolla white or light mauve, laterally compressed; tube 5–6 mm long, 0.7–1.0 mm in diameter, expanding to 2.5 mm at throat (angle of expansion about 35–45°). Stamens in 2 pairs, upper two longer, exposed for 4–6 mm, lower two shorter, with slightly larger anthers, exposed for about 2–3 mm; anthers of lower pair reniform, 0.7 mm long; pollen pale orange. Disc circular, about 1 mm in diameter (bearing a prominent lobe in fruiting stage). Style at first 8–10 mm long, exposed for 3–4 mm from throat, bifid, lengthening up to 13 mm when ripe. Nutlets roundish, 0.8 × 0.6 mm, smooth, black, shiny.

Phenology: Flowering in autumn (March–April).

Pollinators: Insects.

Habitat and aspect: *Aeollanthus haumannii* grows on south-facing cliffs on both peaks of the Otjihipa Mountains just east of Otjinhungwa where the plants occur in granite rock crevices. The habitat preference of *A. haumannii* in the Kaokoveld reflects an afromontane affinity rather than adaptation to the arid semidesert conditions prevailing in the region. Average annual rainfall is estimated at 150–250 mm.

Altitude: 1500–1900 m.

Associated vegetation: Mainly arid savanna.

Associated cremnophytes: Occurs sympatrically with other cliff-dwelling succulents such as *Kalanchoe lanceolata*, *Pelargonium vanderwaltii* and *Tetradenia kaokoensis*.

Geology: Granite (Fransfontein Granite Suite, Simplified Geological Map of Namibia, 1980).

DISTRIBUTION

Known only from the Otjihipa Mountains in northwestern Namibia.

RELATED SPECIES

Aeollanthus haumannii is most closely related to *A. candelabrum* (not a cremnophyte), from which it differs by being a much smaller and fragile perennial with 4-angled or subterete branches which turn distinctly black and ribbed with age (often articulated at nodes).

Aeollanthus candelabrum is a larger, rigid subshrub up to 1 m high. It sometimes also has thickened nodes, but that is where the resemblance ends. The small size and fragile nature of *A. haumannii* can be seen as an adaptation to the undisturbed cliff-face habitat.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small, brittle shrublets at first with whitish green, succulent stems. During the dry season the leaves become deciduous.

Size and weight: Shrublet small, of medium weight.

Leaves

Orientation: Ascending-spreading.

Colour: Pale green, turning purplish (production of anthocyanins) during drought stress, a character that can be related to the vertical cliff habitat. This change of colour reduces the penetration of light, thus also reducing the photosynthesis process, and is typical of succulent plants.

Age and persistence: Plants deciduous. The fleshy leaves become turgid after rain, but are often in a semi-desiccated state during dry periods. The fact that the leaves are aromatic can perhaps be interpreted as a chemical defence mechanism against predation by phytophagous insects. Plants re-sprout from the rootstock if damaged.

Armament and camouflage: The plants are mechanically unarmed, with conspicuous succulent stems.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, short racemes. The white to pink flowers attract insects in the bee family.

Fruit/Seed

Size: Seed (nutlet) rounded, small, 0.6–0.8 mm in diameter.

Dispersal: Nutlets released once calyx breaks free at the abscission layer and then locally dispersed. A habitat specialist, with plants well adapted to remain in the cliff-face sites.

Time: Germination after about 21 days.

Vegetative reproduction: Stems will root when reaching a crevice.

CONSERVATION STATUS

Localised and not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best suited to dry bushveld (savanna) gardens. Outside the habitat, it is best suited to a greenhouse where conditions can be controlled. Propagate from stem cuttings in spring or summer after plants have sprouted, in sandy, well-drained soil. Keep in dappled shade and feed in spring and summer.

VOUCHER

Van Jaarsveld 18874 (NBG).

ILLUSTRATIONS AND MAP

Figures 165a–165c, Map 165.

166. *Aeollanthus rydingianus* Van Jaarsv. & A.E.van Wyk in *Bothalia* 35,2: 157–160 (2005f).

Cremonophyte growth form: Ascending, succulent shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:D (vb)

Etymology: After Olof Ryding of Sweden, specialist on the genus *Aeollanthus*.

DESCRIPTION AND HABITAT

Softly semisucculent, herbaceous, branched, erect subshrubs up to 600 mm tall, most parts covered with glandular hairs and sharply aromatic. Roots fibrous. Branches terete, main branch up to 20 mm in diameter, with brown peeling bark at base; younger branches 7–8 mm in diameter, green, sparsely covered with translucent glandular hairs up to 2 mm long; nodes 20–30 mm long, internodes covered in short, axillary, crowded, leafy branches, each with 3 pairs of leaves overtopped by normal leaves. Leaves decussate; those on axillary branches 20–40 × 15–20 mm (occasionally much shorter), very shortly petiolate; normal leaves spreading, long-petiolate, 70–140(–200) × 40–80(–100) mm, becoming drooping, often exposing suppressed, axillary branches; lamina broadly ovate to broadly triangular-ovate, fleshy, tomentose, slightly viscous owing to glandular translucent hairs; adaxial surface channelled, slightly rugose, densely covered in soft translucent glandular hairs 0.5–2.0 mm long, abaxial surface reticulate; veins prominent, densely beset with glandular hairs, elsewhere hairy; margin dentate with 7–10 pairs of teeth 5–7 mm long and each with secondary tooth at base, decurrent on petiole; apex acute to subacute; base cuneate to attenuate; petiole 15–40 mm long, 5 mm in diameter, subterete. Inflorescence a terminal, lax pyramid-shaped panicle, 100–125(–200) mm high, 60 mm wide at base; spikes becoming gradually smaller towards tip, those of main axis with opposite flowers, other spikes bearing 1 or 2 flowers at each node; basal spikes up to 30 mm long, shortly stalked, each with a pair of short side branches at base; peduncle 4 mm in diameter at base, gradually becoming thinner distally; bracts concave, broadly ovate, densely imbricate, 5.5–8.0 × 4.0–5.5 mm, surface with 3 obscure veins, covered with short glandular hairs, apex acute, sterile bracts slightly smaller. Calyx green, 1.75–2.5 mm long, bell-shaped, basal part circular, 1 mm in diameter, widening towards apex; upper lip 3-lobed; lower lip infolded. Corolla white (Angola) or mauve (Namibia), (12–)18–19 mm long, 2-lipped; tube 1 mm in diameter at base, widening to 3.5 mm at throat; upper lip erect, 4-lobed, 8 mm high, bearing dark purple dots; lower lip 8–9 mm long, horizontal, cymbiform, obtuse at apex. Stamens 8–9 mm long, mauve; anthers 1 mm in diameter; pollen yellow. Style (9–)15–16 mm long, lengthening to up to (11–)17–18 mm when ripe. Nutlets 1.3 × 1 mm, smooth, black.

Phenology: Flowering in late autumn and winter (May–August). Seeds with local non-specialist dispersal strategy.

Habitat and aspect: In the Kaokoveld (northwestern corner of Namibia) this taxon is confined to the upper sandstone cliffs of the southeastern part of the Baynes Mountains. This rugged range consists of a flat-topped sandstone massive that rises to about 2000 m and is bordered by sheer cliffs. Plants of *Aeollanthus rydingianus* occur in a restricted area on a narrow south-facing ledge. Although the plants grow in the shade of the cliffs in winter, they receive some sunlight for part of the day in summer. The average annual rainfall in the Kaokoveld varies from less than 50 mm along the coast to 350 mm on the highlands (Mendelsohn *et al.* 2002). Precipitation is erratic and occurs mainly in the form of thunder showers in the summer months. At Omavanda, where the average annual rainfall is an

estimated 250–300 mm, *A. rydingianus* receives substantial additional moisture in the form of water that seeps from the porous sandstone rock. Its habitat clearly represents a restricted relatively moist refuge in a generally arid area.

Altitude: 1600 m.

Associated vegetation: Mainly arid savanna. However, the occurrence of *Aeollanthus rydingianus* in the Kaokoveld reflects an afro-montane affinity rather than an adaptation to the arid semidesert conditions prevailing in the region. Its presence in the Kaokoveld may be an outlier occurrence and this would also support its treatment as a taxon conspecific with *Aeollanthus* sp. A of the Huila Plateau. It is likely that more records of the new species would come from the wetter and botanically still poorly explored Serra da Chella mountain range, which extends from the Huila Plateau southwards towards the Kaokoveld.

Associated cremno-phytes: Associated species include the trees *Cussonia angolensis*, *Ficus bubu*, *F. glumosa*, *F. ilicina* and *Nuxia congesta*, as well as the pendent *Aloe omavandae*.

Geology: Sandstone of the Damara Sequence (Simplified Geological Map of Namibia, Geological Survey of Namibia, 1980).

DISTRIBUTION

Aeollanthus rydingianus is known only from two localities, one in Kaokoveld, northwestern Namibia, the other in southern Angola (Lubango), a disjunction.

RELATED SPECIES

Aeollanthus rydingianus belongs to section *Rotundobasis*, a group that also includes *A. elsholzioides* (Angola), *A. rehmannii* (Namibia and South Africa) and *A. parvifolius* (South Africa). It is most closely related to the annual *A. elsholzioides*, from which it differs in being a perennial, semisucculent subshrub up to 600 mm high. It furthermore differs from *A. elsholzioides* in having an indumentum that is more densely glandular, long-petioled, triangular-ovate leaves that are larger, 70–140(–200) × 40–80(–100) mm, an inflorescence that is a lax, pyramidal, terminal panicle up to 125 × 60 mm, shortly stalked, dense spikes, larger and broader, subacute, imbricate fertile bracts, 5.5–8.0 × 4.0–5.5 mm, and a larger corolla (12–)18–19 mm long.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Herbaceous semisucculent plants.

Size and weight: Shrubs of medium weight.

Leaves

Orientation: Ascending-spreading.

Colour and texture: Green, sticky.

Age and persistence: Plants are evergreen. The fleshy leaves become turgid after rain, but are often in a semi-desiccated state during dry periods. The fact that the leaves are aromatic can perhaps be interpreted as a chemical defence mechanism against predation by phytophagous insects. Plants re-sprout from the rootstock if damaged.

Armament and camouflage: The plants are mechanically unarmed, with conspicuous succulent stems.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, short racemes. The white to pink flowers attract insects in the bee family.

Fruit/Seed

Size: Seed (nutlet) rounded, small, 1.3 mm in diameter.

Dispersal: Black nutlets released once calyx breaks free at the abscission layer and then locally dispersed. Plants thus well adapted, releasing nutlets close to the mother plant and remaining in the cliff-face sites.

Time: Late winter and spring.

Vegetative reproduction: At and after flowering, the inflorescence develops vegetative branchlets, a vegetative dispersal method that can be viewed as a backup strategy. Fallen branchlets will root under suitable conditions, ensuring long-term survival.

CONSERVATION STATUS

Localised and not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best grown in highveld or dry bushveld gardens, on embankments or in containers, in dappled shade. Outside its habitat, it is best suited to a greenhouse where the conditions can be controlled. *Aeollanthus rydingianus* is an attractive perennial and is floriferous in cultivation. Propagate it from cuttings or from branchlets formed on the inflorescence.

VOUCHER

Van Jaarsveld 17481 (NBG).

ILLUSTRATIONS AND MAP

Plate 166, Figures 166a–166d, Map 166.

PLECTRANTHUS L'Hér.

167. *Plectranthus dolomiticus* Codd in Bothalia 15: 142 (1984).

Cremonophyte growth form: Pendent cluster (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: The epithet *dolomiticus* refers to its dolomitic, rocky substrate.

DESCRIPTION AND HABITAT

Decumbent, semisucculent herb, up to 300 mm tall. Rootstock tuberous. Branches square to subterete. Leaves fleshy, broadly ovate, 20–30 × 18–30 mm; surface almost glabrous; margin crenate-dentate with 5–7 pairs of teeth; apex acute or obtuse; base truncate; petiole up to 35 mm long. Inflorescence a terminal raceme up to 130 mm long, occasionally with a pair of basal branches. Calyx 2.5 mm long, enlarging to 6 mm after flowering. Corolla up to 10 mm long, violet-purple, deflexed and widening towards throat. Nutlets 1.75 mm long, brown.

Phenology: Flowering in autumn (March–April), but also in spring and summer.

Pollinators: Insects.

Habitat and aspect: *Plectranthus dolomiticus* is confined to dolomitic cliffs and steep slopes, growing in dry bushveld (savanna). Plants trail from rock crevices, fissures and ledges in dappled shade or full sun. In Zimbabwe it has been collected on granites. Extreme temperatures as high of 40°C have been recorded. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is 26°C and the average daily minimum about 16°C. Rainfall is low, 400–500 mm per annum, and occurs mainly from spring to autumn.

Altitude: 800–1000 m.

Associated vegetation: Mainly Bushveld and recorded from Pong Dolomite Mountain Bushveld (Mucina *et al.* 2005).

Associated cremonophytes: *Crassula expansa* subsp. *fragilis*, *Gasteria batesiana* var. *dolomitica* and *Orbea hardyi*.

Geology: Dolomite of the Malmani Subgroup, Chuniespoort Group (Transvaal Subgroup).

DISTRIBUTION

Plectranthus dolomiticus appears to be endemic to the Olifants River in Mpumalanga and Limpopo Provinces.

RELATED SPECIES

Recognised by its Dutchman's pipe violet-purple flowers, small semisucculent, broadly ovate leaves and tuberous roots. This species is closely related to *Plectranthus petiolaris*, which has

larger leaves and fibrous roots, occurring in river valleys. The small size and tuberous roots of *P. dolomiticus* can be seen as adaptations to the xeric conditions of the dolomite cliff face.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading, pendent nature, forming loose clusters up to 500 mm in diameter. Stems becoming drooping, often rooting where in contact with soil. During the dry season the leaves become purplish green to purplish. The succulent roots help with conservation of water in the extreme vertical environment. It grows more slowly than the non-cremnohyte *Plectranthus petiolaris*. The slow growth rate is retained in cultivation.

Size and weight: Clusters small, of medium weight.

Leaves

Orientation: Ascending-spreading, small.

Colour: Green, turning purplish under drought stress, a character that can be related to its vertical cliff habitat. This change of colour reduces unnecessary penetration of light, thus also reducing photosynthesis, and is typical of succulent plants.

Age and persistence: Evergreen, but with leaves withering from the base. The fleshy leaves become turgid after rain, but are often in a semi-desiccated state during dry periods. The fact that the leaves are aromatic can perhaps be interpreted as a chemical defence mechanism against predation by phytophagous insects. Plants re-sprout from the rootstock if damaged.

Armament and camouflage: The plants are mechanically unarmed, with conspicuous succulent stems.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, short racemes. The conspicuous violet-purple flowers attract insects in the bee family.

Fruit/Seed

Size: Seed (nutlet) rounded, 1.75 mm in diameter.

Dispersal: Nutlets shaken from the fruiting calyx and locally dispersed.

Time: Nutlets ripening in summer and autumn, coinciding with the rainfall. Germination after about 21 days.

Vegetative reproduction: The pendent to spreading branches root where they touch the soil. This is an efficient vegetative backup strategy for surviving the harsh, xeric cliff-face conditions.

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009). However, although localised to the dolomite formations of the Olifants River gorge, it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for dry subtropical and bushveld (savanna) gardens, grown on embankments, rockeries or in containers, also a useful drought-tolerant groundcover (Van Jaarsveld 2010). Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from stem cuttings in spring or summer. Flowering throughout summer and autumn.

VOUCHER

Van Jaarsveld 7052 (NBG).

ILLUSTRATIONS AND MAP

Figures 167a–167c, Map 167.

168. *Plectranthus ernstii* Codd in *The Flowering Plants of Africa* 47: t. 1855 (1982).

Crempnophyte growth form: Dwarf-sized cluster (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Ca:Ev (vb)

Etymology: After Ernst van Jaarsveld (1953–), horticulturist at Kirstenbosch National Botanical Garden.

DESCRIPTION AND HABITAT

Decumbent to erect, cluster-forming, succulent herb up to 120 mm high. Roots fibrous to somewhat succulent, up to 4 mm in diameter. Branches compact, articulated at nodes, short, somewhat moniliform, occasionally globose, brownish striated, becoming grey, up to 50 mm in diameter, succulent, younger stems square. Leaves succulent, broadly ovate to deltoid, 12–30 × 10–25 mm, dentate, with 3 pairs of teeth; both surfaces green, purplish tinged, glabrescent to puberulous, undersurface with reddish brown to pale gland dots, pleasantly aromatic; apex acute to obtuse; base obtuse to truncate. Inflorescence 50–170 mm long, often with a pair of side branches, racemose; verticillasters 6-flowered, 5–12 mm apart; bracts ovate, 3 mm long, persistent beyond flowering stage; pedicel 4–5 mm long. Corolla 7–12 mm long, white to mauve; tube 6–8 mm long, ventricose at base, constricted at throat. Fruiting calyx 3–5 mm long. Nutlets rounded, 2 mm long, brown.

Phenology: Flowering in autumn (March–April), but also in spring.

Pollinators: Insects.

Habitat and aspect: South-facing sandstone cliffs. Plants are rooted in crevices and on rock ledges. Extreme temperatures as high of 40°C have been recorded. Winters are cooler but frost is a rarity or absent. The average daily maximum temperature is about 24°C and the average daily minimum 16°C. Rainfall mainly from spring to autumn but occasionally also in winter, ranging from 1000–1250 mm per annum.

Altitude: 200–350 m.

Associated vegetation: Pondoland-Ugu Sandstone Coastal Sourveld of the Indian Ocean Coastal Belt (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Aptenia cordifolia*, *Cotyledon orbiculata* var. *oblonga*, *Crassula flanaganii*, *C. multicava*, *C. perfoliata* var. *perfoliata*, *Delosperma repens*, *D. tradescantioides*, *Gasteria croucheri*, *Petopentia natalensis*, *Portulacaria afra*, *Rhipsalis baccifera* and *Sarcostemma viminale*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup).

DISTRIBUTION

Plectranthus ernstii is endemic to the sandstone gorges between the Msikaba River (Eastern Cape) and Oribi Gorge (southern KwaZulu-Natal).

RELATED SPECIES

Plectranthus ernstii is related to both *P. saccatus* and *P. strigosus* (section *Plectranthus*) of the same region. *Plectranthus saccatus* is a much larger forest and forest margin shrub up to 1 m tall with much larger flowers. *Plectranthus strigosus* is a procumbent coastal forest species without the succulent stems, with white flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact, cluster-forming, 80–150 mm in diameter, stems often rooting where in contact with soil. During the dry season the leaves become purplish green to purplish. The compact cluster-forming growth and slow growth rate, compared to that of other non-cremnophilous *Plectranthus* species, can be seen as an adaptation to the cliff face. The slow growth rate is retained in cultivation and plants can take up to five years or longer to reach maturity, differing from most other level-ground species. Forms from the Msikaba River at the southern end of its distribution tend to be more trailing, with longer elongated branches. *Plectranthus saccatus* subsp. *saccatus* is a related non-cremnophilous, rapid-growing shrubby species.

Size and weight: Clusters small, of medium weight.

Stem: Branches succulent, often moniliform and articulated at nodes. Forms from Sikuba and Msikaba with spreading, subpendent stems rooting where they touch the ground.

Leaves

Orientation: Small, spreading, maximising absorption of light.

Colour: Green, turning purplish under drought stress (production of anthocyanins), a character that can be related to the vertical cliff habitat. This change of colour reduces penetration of light, thus also reducing photosynthesis, and is typical of succulent plants.

Age and persistence: Plants evergreen, but with leaves withering from the base. The fleshy leaves become turgid after rain, but are often in a semi-desiccated state during dry

periods. The fact that the leaves are aromatic can perhaps be interpreted as a chemical defence mechanism against predation by phytophagous insects.

Armament and camouflage: The plants are mechanically unarmed and the conspicuous succulent stems are vulnerable, suggesting a reduction in armament in response to the undisturbed cliff habitat in contrast to the often thorny but grazed surrounding subtropical and thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, short racemes. The conspicuous light mauve to mauve flowers attract insects in the bee family.

Fruit/Seed

Size: Seed (nutlet) rounded, 2 mm in diameter.

Dispersal: Nutlets shaken from the fruiting calyx and locally dispersed.

Time: Nutlets ripening in autumn, coinciding with autumn rainfall. Germination after about 21 days.

Vegetative reproduction: The moniliform, articulated branches root where they touch the soil. The southern forms of *Plectranthus ernstii* have elongated branches rooting at the nodes or where they touch the soil or crevice, establishing new populations. This is a vegetative backup strategy for surviving the harsh cliff-face conditions.

CONSERVATION STATUS

Classified as critically rare (Raimondo *et al.* 2009). Localised and confined to dissected east-flowing river gorges of KwaZulu-Natal Sandstone (Cape Supergroup) where it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens, on embankments or rockeries, in dappled shade (Van Jaarsveld 2010). Outside the habitat, it is best grown in sandy, slightly acidic soil, under controlled conditions in a greenhouse. Seeds have been distributed to growers in Europe and Japan and owing to its small, tree-like habit and ornamental appeal (Oribi Gorge form) it is now popular under the name 'Bonsai Mint'. Propagate from cuttings or seed, trim regularly to keep a neat, compact growth (see Van Jaarsveld 2006a).

VOUCHER

Van Jaarsveld 2196 (NBG).

ILLUSTRATIONS AND MAP

Plate 168, Figures 168a–168e, Map 168.

169. *Plectranthus mutabilis* Codd in Bothalia 11: 404 (1975).

Cremonophyte growth form: Pendent mats (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: Latin *mutabilis*, changeable, pertaining to its variability.

DESCRIPTION AND HABITAT

Prostrate, semisucculent herb. Branches often hanging from cliffs. Leaves ovate to broadly ovate, 15–50 × 15–50 mm, tomentose to glabrescent, glands orange; margin crenate or crenate-dentate with 4–6 pairs of teeth; apex acute or obtuse; base truncate. Inflorescence terminal, racemose, 100–250 mm long, occasionally with a pair of side branches; verticillasters 6–14-flowered. Calyx 2 mm long, elongating to 4 mm after flowering. Corolla 8–15 mm long, purple-blue; tube centrally deflexed, widening towards throat. Nutlets 1 mm long, dark brown.

Phenology: Flowering in autumn (March–April), but also in spring.

Pollinators: Insects.

Habitat and aspect: Cliffs along mountains and river valleys. Plants grow in dry savanna or the fringes of afro-montane forest. *Plectranthus mutabilis* grows in light shade in well-drained, humus-rich soils. The average daily maximum temperature is about 25°C and the average daily minimum about 10°C. Rainfall ranges from 600–1250 mm per annum.

Altitude: 1000–2230 m.

Associated vegetation: Wolkberg Dolomite Grassland, Soutpansberg Summit Sourveld, Mamabolo Mountain Bushveld and Moot Plains Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremonophytes: At Chuniespoort it grows with *Adromischus umbraticola* subsp. *ramosa*, *Aeollanthus buchnerianus*, *Aloe mutabilis* and *Crassula expansa* subsp. *fragilis*.

Geology: Sandstone or dolomite (Sandstone of the Wyllies Poort Formation, Soutpansberg Group) and dolomite of the Malmani Subgroup (Transvaal Supergroup).

DISTRIBUTION

Plectranthus mutabilis is widespread in the Mpumalanga and Gauteng Provinces.

RELATED SPECIES

Characterised by prostrate, free-rooting stems and purple-blue flowers. Related to *Plectranthus aliciae*, *P. madagascariensis*, *P. grandidentatus* and *P. woodii*, all with white flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading, pendent, forming mat-like clusters up to 500 mm in diameter and drooping from the cliff faces. Stems becoming drooping and rooting where in contact with soil.

Size and weight: Clusters small.

Leaves

Orientation: Ascending-spreading, small.

Colour and texture: Green, turning purplish under drought stress (owing to the production of anthocyanins), a character that can be related to the vertical cliff habitat. This change of colour reduces penetration of light, thus also reducing photosynthesis, and is typical of succulent plants. The sometimes hairy nature also helps the plants to deal with drought stress.

Age and persistence: Plants evergreen, but with leaves withering from the base. The fleshy leaves become turgid after rain, but are often in a semi-desiccated state during dry periods. The fact that the leaves are aromatic can perhaps be interpreted as a chemical defence mechanism against predation by phytophagous insects.

Armament and camouflage: The plants are mechanically unarmed, with conspicuous succulent stems.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, short racemes. The conspicuous violet-purple flowers attract insects in the bee family.

Fruit/Seed

Size: Seed (nutlet) rounded, 1 mm in diameter.

Dispersal: Dark brown nutlets shaken from the fruiting calyx and locally dispersed.

Time: Nutlets ripening in summer and autumn, coinciding with the rainfall. Germination after about 21 days.

Vegetative reproduction: The pendent to spreading branches root where they touch the soil, establishing new populations. This is an efficient vegetative backup strategy for continued existence despite the harsh, xeric cliff-face conditions.

CONSERVATION STATUS

Localised and confined to gorges where it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: *Plectranthus mutabilis* is best for dry bushveld or highveld gardens and ideal for steep embankments, grown in partial shade. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from stem cuttings. Effective as a groundcover (Van Jaarsveld 2006a, 2010).

VOUCHERS

Van Jaarsveld 17207, 19777 (NBG).

ILLUSTRATIONS AND MAP

Plate 169, Figures 169a–169d, Map 169.

170. *Plectranthus mzimvubuensis* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Bothalia* 34: 30–32 (2004c).

Cremonphyte growth form: Pendent cluster (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: After the Mzimvubu River where it was first collected. The Xhosa name *Mzimvubu* means ‘the home of the hippo’ (*Hippopotamus amphibius*), but the animals were wiped out in the area more than a century ago.

DESCRIPTION AND HABITAT

Perennial, aromatic shrub up to 1 m tall, 3 m in diameter, scandent, pendent from cliffs. Roots fibrous to slightly fleshy, bearing distinct oblong to rounded, grey tubers 25–50 × 14–20 mm. Stems herbaceous, semisucculent, 4-angled, terete in older branches and with a succulent basal caudex, 100 mm in diameter. Bark smooth, grey. Leaves broadly ovate-deltoid to subrotund, 25–50 × 28–50 mm; surface covered with slightly sunken translucent gland dots (becoming yellowish brown in dried specimens); margin serrate-dentate with 6–10 pairs of teeth; apex acuminate, with short drip-tip; base truncate to subcordate, occasionally slightly decurrent on petiole, thin-textured; petiole 10–20(–30 mm) long, reddish purple. Inflorescence a short terminal raceme (30–)70–90(–120) mm long, sometimes with a pair of side branches at base; rachis sparsely strigose, bearing scattered, sessile glands, yellowish brown. Flowers in sessile, 1–3-flowered cymes forming 2–6-flowered verticillasters, the latter 6–12(–18) mm apart. Calyx up to 4 mm long, accrescent, lengthening to 10–11 mm in fruit, 2-lipped. Corolla pink; tube straight, 9–10 mm long, laterally compressed, 3 mm deep, slightly deflexed forming a swollen saccate base, 2-lipped; upper lip 4-lobed, 8 mm high, becoming reflexed when stigma matures, upper lobes bent forward and forming an ascending-spreading 2-spurred hood; lower lip boat-shaped, 6 mm long, soon becoming reflexed. Style 14 mm long, extending up to 20 mm when mature, exposed for 8 mm. Nutlets rounded, 1.3–1.5 mm long, smooth, dark brown.

Phenology: Flowering in late autumn (April–June). Seeds with local non-specialist dispersal strategy.

Pollinators: Insects.

Habitat and aspect: Grows on shady south-facing shale cliffs, where the plants scramble among shrubs. The vegetation consists of Eastern Valley Bushveld (Mucina *et al.* 2005). The climate is subtropical, with hot summers and dry, sunny, frost-free winters, and cool evenings. The average daily maximum temperature is about 24°C and the average daily minimum about 14°C. Rainfall occurs mainly from spring to autumn, 1000–1250 mm per annum.

Altitude: 300–800 m.

Associated vegetation: Eastern Valley Bushveld (Mucina *et al.* 2005).

Associated cremnophytes: *Plectranthus mzimvubuensis* shares its habitat with other succulent plants such as *Adromischus cristatus* subsp. *mzimvubuensis*, *Bulbine natalensis*, *Crassula cordata*, *C. cultrata*, *C. multicava* subsp. *floribunda*, *C. orbicularis*, *Cyanotis speciosus*, *Delosperma tradescantioides* and *Peperomia blanda*. Trees and shrubs in the area include *Bauhinia bowkeri*, *Celtis africana*, *Ficus burkei* and *Euphorbia tirucalli*.

Geology: Beaufort shale, Emakwezeni Subgroup (Karoo Supergroup).

DISTRIBUTION

Plectranthus mzimvubuensis appears to be endemic to the Mzimvubu River in the Eastern Cape.

RELATED SPECIES

Plectranthus mzimvubuensis is distinguished by its scandent growth and short, parallel-sided corolla tube 10 mm long. It appears to be closest to *P. reflexus*, an erect shrub (non-cremnophyte) with a corolla tube of 25 mm long, constricted at the mouth. A further distinction of *P. mzimvubuensis* are the distinct root tubers. *Plectranthus reflexus* has fleshy roots.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Spreading, scandent to pendent nature, forming shrubs up to 2 m tall. Stems becoming drooping. During the dry season the leaves become purplish green. The succulent roots help to conserve water on the dry cliffs. The root tubers are potato-like and 60 mm in diameter, also aiding water conservation. Stems become terete and are longer lived and less herbaceous than in other *Plectranthus* species.

Size and weight: Shrubs 2–3 m high, heavy.

Leaves

Orientation: Ascending-spreading.

Colour: Green, without any obvious adaptation to drought stress.

Age and persistence: Evergreen, but leaves withering from the base. The semisucculent leaves become turgid after rain, but often in a semi-desiccated state during dry periods. The fact that the leaves are aromatic can perhaps be interpreted as a chemical defence mechanism against predation by phytophagous insects. Damaged plants re-sprout from the rootstock.

Armament: Plants unarmed.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, short racemes. The conspicuous pink flowers attract insects in the bee family.

Fruit/Seed

Size: Seeds (nutlets) rounded, 1.3–1.5 mm in diameter.

Dispersal: Nutlets shaken from the fruiting calyx and locally dispersed.

Time: Nutlets ripening in late autumn, coinciding with the rainfall. Germination after about 21 days.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). Localised and confined to gorges where it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens, in dappled shade on embankments. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings in spring or summer (Van Jaarsveld 2006a, 2010).

VOUCHER

Van Jaarsveld, Xaba & Harrower 92e (NBG).

ILLUSTRATIONS AND MAP

Plates 170 & 170a, Figures 170a–170d, Map 170.

171. *Plectranthus purpuratus* Harv. subsp. *purpuratus*, Harvey, Thesaurus capensis 1: 53, t. 83 (1859).

Cremonophyte growth form: Compact, mat-forming leaf succulent (of light weight, cliff hugger).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: The epithet *purpuratus* refers to the dark purplish green leaves.

DESCRIPTION AND HABITAT

Erect to decumbent, spreading, succulent herbs. Stems 30–100 mm long. Leaves often densely packed or imbricate in an almost pseudostem, ovate to broadly ovate, 15–35 × 15–35 mm, succulent, purplish below, densely to sparsely strigose; glands red; margin shallowly crenate; apex rounded or acute; base truncate to cuneate. Inflorescence terminal, racemose, 30–120 mm long, often with a pair of side branches; verticillasters up to 8-flowered. Calyx 3

mm long, enlarging to 5–6 mm after flowering. Corolla 10–11 mm long, white to bluish; tube saccate at base, constricted near middle. Nutlets 1 mm long, light to dark brown.

Phenology: Flowering from spring to autumn but with a peak in autumn (March–April). Seeds with local non-specialist dispersal strategy, dispersed in autumn.

Habitat and aspect: Plants occur mainly on upper south-facing cliffs. The climate is subtropical, with hot summers and dry, sunny, frost-free winters, and cool evenings. The average daily maximum temperature is 25–26°C and the average daily minimum 8–16°C. Rainfall occurs mainly from spring to autumn, ranging from 1000–1250 mm per annum.

Altitude: 460–795 m.

Associated vegetation: Eastern Valley Bushveld (Mucina *et al.* 2005).

Associated cremnophytes: *Aeollanthus parvifolius*, *Aloe arborescens*, *Bulbine natalensis*, *Crassula pellucida* subsp. *brachypetala*, *C. perforata*, *Cyanotis speciosus*, *Scilla natalensis*, *Stenoglottis woodii* and *Tridactyle bicaudata*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup).

DISTRIBUTION

Plectranthus purpuratus subsp. *purpuratus* is endemic to the Pietermaritzburg-Durban region of KwaZulu-Natal, confined to south-facing cliffs (river valleys and mountainous terrain).

RELATED SPECIES

Plectranthus purpuratus subsp. *purpuratus* is immediately distinguished from its two non-cremnophilous relatives (*P. purpuratus* subsp. *montanus* and *P. purpuratus* subsp. *tongaensis*) by its compact growth, with decumbent stems and subimbricate leaves. It is related to *P. strigosus* but distinguished by the corolla tube which is constricted in the centre. The leaves of *P. strigosus* are usually rusty strigose and the corolla tube is constricted at the throat.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants are compact, the leaves subimbricate, very succulent and purplish green, an adaptation the dry vertical habitat. A purplish pigment (anthocyanins) is produced during dry periods, blocking out excessive light.

Size and weight: Dwarf-sized, of light weight.

Leaves

Orientation: Ascending-spreading, subimbricate, can adjust according to the light source and moisture regime.

Colour: Purplish green, an adaptation to dry conditions.

Age and persistence: Evergreen, but leaves withering from the base. The very succulent leaves become turgid after rain, but are often in a semi-desiccated state during dry periods. The fact that the leaves are aromatic suggests a chemical defence mechanism against predation by phytophagous insects.

Armament: Plants unarmed.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, consisting of short racemes. The conspicuous white flowers attract insects of the bee family.

Fruit/Seed

Size: Seed (nutlet) rounded, 1 mm in diameter,.

Dispersal: Dark brown nutlets shaken from the fruiting calyx and locally dispersed.

Time: Nutlets ripening in late autumn, coinciding with the rainfall. Germination after about 21 days.

Vegetative reproduction: The spreading, mat-forming branches root where they touch the soil, establishing new populations. This is an efficient vegetative backup strategy enabling the plants to survive under the harsh, xeric cliff-face conditions.

CONSERVATION STATUS

Localised and confined to south-facing cliffs and river gorges where it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: *Plectranthus purpuratus* subsp. *purpuratus* is easy to grow. Best for subtropical coastal gardens, grown in rockeries or as a pot plant in light shade. Outside its native habitat, it is best grown under controlled conditions in a greenhouse. Propagate from stem cuttings (Van Jaarsveld 2006a, 2010).

VOUCHER

Van Jaarsveld 17042 (NBG).

ILLUSTRATIONS AND MAP

Figures 171a–171e, Map 171.

172. *Plectranthus saccatus* Benth. subsp. *pondoensis* Van Jaarsv. & Milstein, in Van Jaarsveld & Edwards in *Bothalia* 27,1: 4 (1997).

Cremonophyte growth form: Pendent shrub (heavy, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: After Pondoland in the Eastern Cape, its habitat.

DESCRIPTION AND HABITAT

Trailing glutinous succulent herb, becoming pendent on ledges, aromatic, much-branched, succulent shrub with spreading to pendent branches up to 2 m long. Stems obscurely 4-angled; young stems 2–5 mm in diameter, purplish, minutely glandular pubescent, becoming glabrous; older stems striate; internodes 6–40 mm long. Leaves ovate to broadly trullate, minutely glandular pubescent, 12–27 × 10–28 mm; petiole 5–25 mm long. Racemes secund, 30–50 mm long. Calyx 3–6 mm long, enlarging to 8 mm in fruit; upper lip ascending, ovate, 1 mm long; lower lobes 4, linear-lanceolate, 1 mm long. Corolla saccate; tube 6–20 × 3–7 mm; upper lip 2-lobed, 9–13 × 7–12 mm, erect, lobes folded back; lower lip 8 mm long, horizontal or slightly drooping, blue to pale mauve-pink, inner surface speckled with purple. Stamens 14 mm long, declinate in lower lip, free for 8 mm; anthers purple, bent upwards. Style 11–12 mm long. Nutlets 2 mm long, dark brown.

Phenology: Flowering from spring to autumn but with a peak in autumn (March–April).

Pollinators: Insects.

Habitat and aspect: Mainly south-facing quartzitic sandstone cliffs. Plants are rooted in crevices and on rock ledges. Winters are cool but frost is a rarity or absent. The average daily maximum temperature is 24°C and the average daily minimum 16°C. Rainfall occurs from spring to autumn but occasionally also in winter, ranging from 1000–1250 mm per annum.

Altitude: 300–600 m.

Associated vegetation: Pondoland-Ugu Sandstone Coastal Sourveld of the Indian Ocean Coastal Belt Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Aptenia cordifolia*, *Cotyledon orbiculata* var. *oblonga*, *Crassula flanaganii*, *C. multicava*, *C. perfoliata* var. *perfoliata*, *Delosperma repens*, *D. tradescantioides*, *Gasteria croucheri*, *Petopentia natalensis*, *Portulacaria afra*, *Rhipsalis baccifera* and *Sarcostemma viminale*.

Geology: Quartzitic sandstone of the Natal Group (Cape Supergroup).

DISTRIBUTION

Plectranthus saccatus subsp. *pondoensis* is endemic to the sandstone gorges between the Msikaba River (Eastern Cape) and Oribi Gorge (southern KwaZulu-Natal) in the north.

RELATED SPECIES

Plectranthus saccatus subsp. *pondoensis* is distinguished from the typical subspecies by its distinctly succulent leaves and decumbent to procumbent pendent habit, with flexible (flaccid) stems up to 4 m long. The secondary growth of the species is anomalous, with many broad

collenchymatous rays which impart flexibility (Van Jaarsveld & Edwards 1997). The two subspecies maintain their vegetative characters under uniform cultivation.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Its succulent nature and long, flexible stems suggest an adaptation to the cliff-face environment, ensuring long-term survival in the sheer habitat. During the dry season the leaves become purplish green to purplish. The succulent nature, compared to that of the forest non-cremnophyte (subsp. *saccatus*), can be seen as a adaptation to the cliff environment.

Size and weight: Shrubs of medium weight to heavy.

Leaves

Orientation: Small, spreading, maximising absorption of light.

Colour: Green, turning purplish under drought stress, a character that can be related to the vertical cliff habitat. This change of colour reduces penetration of light, thus also reducing photosynthesis, and is typical of succulent plants.

Age and persistence: Plants evergreen, but with leaves withering from the base. The fleshy leaves become turgid after rain, but are often in a semi-desiccated state during dry periods. The fact that the leaves are strongly aromatic can perhaps be interpreted as a chemical defence strategy against predation by phytophagous insects.

Armament and camouflage: The plants are mechanically unarmed and the conspicuous succulent leaves and stems are vulnerable to larger herbivores.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending, short racemes. The conspicuous mauve-pinkish flowers attract insects.

Fruit/Seed

Size: Seed (nutlet) rounded, 2 mm in diameter.

Dispersal: Nutlets shaken from the fruiting calyx and locally dispersed.

Time: Nutlets ripening in summer and autumn, coinciding with the rainfall. Germination after about 21 days.

Vegetative reproduction: The spreading, mat-forming branches root where they touch the soil, establishing new populations. This is an efficient vegetative backup strategy for surviving the harsh, xeric cliff-face conditions.

CONSERVATION STATUS

Localised and confined to gorges where it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens, grown on steep embankments, balconies, gabions and rockeries in partial shade. Can be used as an effective groundcover on slopes, preventing soil erosion. Outside its native habitat, it is best grown under controlled conditions in a greenhouse. Propagate from stem cuttings (Van Jaarsveld 2006a, 2010).

VOUCHER

Van Jaarsveld 2201 (NBG).

ILLUSTRATIONS AND MAP

Plate 172, Figures 172a & 172b, Map 172.

TETRADENIA Benth.

173. *Tetradenia kaokoensis* Van Jaarsv., in Van Jaarsveld & Van Wyk in *Bothalia* 33,1: 107 (2003c).

Cremnophyte growth form: Erect shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:W:D (r)

Etymology: After Kaokoveld, its native habitat in northwestern Namibia.

DESCRIPTION AND HABITAT

Erect, semisucculent, deciduous shrub up to 600 mm tall. Roots succulent, up to 10 mm in diameter, tapering. Stem terete, 12–20 mm in diameter, succulent, brittle, grey-brown, sparsely longitudinally fissured; young branches densely velvety tomentose, white-green. Leaves crowded, shortly petiolate (base persistent, 2–4 mm long becoming woody with a characteristic cordate abscission scar); blade ovate-lanceolate, ovate to ovate-triangular, 65–140 × 45–115 mm, densely white tomentose on abaxial surface, less so on upper surface; margin crenate-dentate (± 20 pairs of teeth); apex acute to rounded; base cordate; petiole 10–20 mm long, with basal subpetiolar purplish glands (swelling). Inflorescence in lateral or terminal, oblong to pyramidal panicles up to 200 mm long and 120 mm in diameter, appearing with leaves; bracts ovate to triangular, 6–9 mm long, with petiole 1.5–2 mm long; male flower spikes dense, 20–25 mm long; floral bracts broadly triangular-ovate, 0.5 × 1.5 mm, translucent. Flowers in 3-flowered cymes, forming 6-flowered verticillasters. Calyx 1 mm long, 5-lobed, densely hairy; lobes ovate, 0.7–0.5 × 0.3 mm. Corolla white, bilobed, 5-lipped, 3–4 mm in diameter when open, 3 mm long, glabrous on inside, tomentose on outside; lower lip oblong-oval, 1.5 × 0.7 mm, upper lobes ovate, 1 × 0.7 mm. Stamens 5.3 mm long, translucent. Ovary oblong-ovate; disc 2-lobed, bright red, lobes exceeding ovary; stigma 1 mm long, bifid, purplish. Female flowers: gynoecium 2.3 mm long; stigma bifid, 0.8 mm long. Male flowers: anthers white. Seed 0.7–0.8 mm long, oblong-ovoid, brown.

Phenology: Flowering mainly from November–February. Flowers sweetly scented. Seeds wind-dispersed, in summer and autumn.

Pollinators: Insects.

Habitat and aspect: Dolomite, sandstone and granite cliffs, the plants growing mainly on southern aspects (also eastern). Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperature high in summer (up to about 40°C). Winters are cooler and frost is absent. Rainfall is about 200–250 mm per annum and occurs in summer, with a peak in February.

Altitude: 1600–2000 m.

Associated vegetation: Arid savanna.

Associated cremnoophytes: At Otjihipa it has been recorded with the following cliff dwellers: *Aeollanthus haumannii*, *Kalanchoe laciniata*, *Pelargonium vanderwaltii* and *Plectranthus hereroensis*.

Geology: Dolomite (Otavi Group), dark-coloured and rough-textured, also sandstone (Omavanda) and granite (Otihipa).

DISTRIBUTION

Mainly Baynes and Otjihipa Mountains in the Kaokoveld (northwestern Namibia) as well as Iona Peak in Angola.

RELATED SPECIES

Tetradenia kaokoensis is related to the widespread *T. riparia*, which is highly aromatic, has glandular hairs, flowers from late autumn to midwinter, lacks the conspicuous dense white vestiture and the leaves are deciduous at the time of flowering. *Tetradenia kaokoensis* is a smaller, robust species with succulent roots, thick branches, larger leaves and it flowers in summer. The persistent, raised, woody leaf bases (phyllodia) are unique in the genus. *Tetradenia* is endemic to Africa and Madagascar and contains eight species (five in Africa, three in Madagascar).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Long-lived, erect, compact, sturdy, deciduous shrublets.

Size and weight: Shrubs of medium weight to heavy.

Roots: Fleshy, tapering roots suggest an adaptation to the xeric conditions found on the vertical cliffs.

Stem: Branches terete, succulent; young branches grey-white (indumentums) and can be viewed as an adaptation to the xeric cliff-face conditions.

Leaves

Orientation: Ascending-spreading, making the most of the available light in the shady kloof environment.

Colour and texture: Green, soft and fleshy, covered with a dense indumentum, an adaptation to the hot, dry environment. Leaves with flexibility in size (phenotypic plasticity) and can adapt to the availability of light (larger leaves in shade, smaller in exposed areas).

Age and persistence: Becoming deciduous during the dry winter.

Armament: Lacking the very strong aroma of the related *Tetradenia riparia*, suggesting a reduction in chemical defence. The sharp, woody petiole scars perhaps a mechanical defence against predators such as the chacma baboon (*Papio ursinus*) and Kaokoveld rock dassie (*Procavia capensis welwitschii*).

Sexual reproduction

Inflorescence and flowers: Flowering during the rainy season when in leaf (November to February). Dense, conspicuous, white-flowered, lateral or terminal, oblong to pyramidal panicles. The species is dioecious, with male and female flowers on separate plants.

Fruit/Seed

Size: Nutlets of two types: normal type more common, larger, 0.7 mm long, oblong-ovoid; smaller type 0.5 mm long, oblong, longitudinally ridged with 4–7 dark brown ridges.

Dispersal: Mainly by wind. The function of the two types of seed not clearly understood. The smaller type is perhaps more aerodynamic, enabling long-distance dispersal.

Time: Mainly autumn (during the rainy season).

Vegetative reproduction: Absent.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: For dry bushveld (savanna) gardens, in full sun or dappled shade on embankments. Grow under controlled greenhouse conditions outside the habitat. Propagate from stem cuttings in summer. Its very easy growing nature maximises survival rate (Van Jaarsveld 2010).

VOUCHER

Van Jaarsveld 16617 (NBG).

ILLUSTRATIONS AND MAP

Figures 173a–173c, Map 173.



MESEMBRYANTHEMACAEAE

Carruanthus (Schwantes) Schwantes

174. *C. peersii* L.Bolus

Conophytum N.E.Br.

175. *C. auriflorum* Tischer subsp. *turbiniforme* (Rawe) S.A.Hammer
176. *C. bolusiae* Schwantes subsp. *bolusiae*
177. *C. carpianum* L.Bolus
178. *C. danielii* Pavelka
179. *C. ernstii* S.A.Hammer subsp. *ernstii*
180. *C. francoiseae* (S.A.Hammer) S.A.Hammer
181. *C. fulleri* L.Bolus (Pella form)
182. *C. hanae* Pavelka
183. *C. luckhoffii* Lavis
184. *C. marginatum* Lavis subsp. *haramoepense* (L.Bolus) S.A.Hammer
185. *C. marginatum* Lavis subsp. *littlewoodii* (L.Bolus) S.A.Hammer
186. *C. obscurum* N.E.Br. subsp. *sponsaliorum* (S.A.Hammer) S.A.Hammer
187. *C. quaesitum* (N.E.Br.) N.E.Br. subsp. *densipunctum* (L.Bolus) S.A.Hammer
188. *C. quaesitum* (N.E.Br.) N.E.Br. subsp. *quaesitum* var. *rostratum* (Tischer) S.A.Hammer
189. *C. ricardianum* Loesch & Tischer subsp. *ricardianum*
190. *C. stephanii* Schwantes subsp. *stephanii*
191. *C. tantillum* N.E.Br. subsp. *amicorum* S.A.Hammer & Barnhill
192. *C. taylorianum* (Dinter & Schwantes) N.E.Br. subsp. *ernianum* (Loesch & Tischer) de Boer ex S.A.Hammer
193. *C. taylorianum* subsp. *rosynense* S.A.Hammer

Delosperma N.E.Br. emend Lavis

194. *Delosperma* sp. A
195. *Delosperma* sp. B
196. *D. esterhuyseniae* L.Bolus
197. *D. knox-daviesii* Lavis
198. *D. laxipetalum* L.Bolus
199. *D. nubigenum* (Schltr.) L.Bolus
200. *D. saxicola* Lavis
201. *D. subpetiolatum* L.Bolus
202. *D. tradescantioides* (A.Berger). L.Bolus
203. *D. velutinum* L.Bolus
204. *D. waterbergense* L.Bolus
205. *D. zoutpansbergense* L.Bolus

Drosanthemum Schwantes

206. *D. anemophilum* Van Jaarsv. & S.A.Hammer
207. *D. expersum* (N.E.Br.) Schwantes
208. *D. inornatum* (L.Bolus) L.Bolus

Erepsia N.E.Br.

209. *E. heteropetala* (Haw.) Schwantes

Esterhuysenia L.Bolus

210. *E. stokoei* (L.Bolus) H.E.K.Hartmann

Jensenobotrya A.G.J.Herre

211. *J. lossowiana* A.G.J.Herre

Lampranthus N.E.Br.

212. *L. affinis* L.Bolus

Machairophyllum Schwantes

213. *M. brevifolium* L.Bolus

Oscularia Schwantes

214. *O. cremnophila* Van Jaarsv., Desmet & A.E.van Wyk

Ruschia Schwantes

215. *R. knysnana* (L.Bolus) L.Bolus

216. *R. promontorii* L.Bolus

Scopelogenia L.Bolus

217. *S. bruynsii* Klak

218. *S. verruculata* (L.) L.Bolus

CARRUANTHUS (Schwantes) Schwantes

174. *Carruanthus peersii* L.Bolus, Notes on Mesembryanthemum and allied genera 3: 4 (1936).

Cremnophyte growth form: Pendent clusters (of medium weight, cliff hugger).

Growth form formula: E:F:P:Els (vb) (r)

Etymology: After its collector, V.S. Peers (1874–1940), Australian collector of plants who settled in South Africa, just after the Anglo-Boer War (Gunn & Codd 1981).

DESCRIPTION AND HABITAT

Plants with heads dividing and forming small, dense, mat-like clusters up to 300 mm in diameter, becoming pendent, with stems up to 500 mm long, with about 10–25 heads, each head with 6–8 functional green leaves withering and becoming deciduous basally. Roots fibrous. Branches up to 5 mm in diameter, greyish brown, with remnants of old dried leaf bases; older branches up to 10 mm in diameter. Leaves crowded or with short internodes up to 10 mm long, decussate and slightly connate at base, oblong trigonous-clavate (linear-oblongate viewed from the top), 30–60 × 15 mm (lateral compression at apex 10 mm in diameter), somewhat dorsiventrally compressed, keeled below; surface grey-green, smooth, becoming wrinkled and purplish green during drought; apex obtuse to acute, somewhat laterally compressed. Flowers in dichotomous cymes, only opening in late afternoon, pedicellate, yellow, 25–50 mm in diameter; axillary flower often suppressed in autumn;

pedicels terete, 2 mm in diameter, thickened to 4 mm (10–)20–30(–42) mm long, with 1 or 2 pairs of small leaf sheaths; bracts trigonous, 5–6 mm long, keel decurrent on pedicel. Petals numerous in 2 series, linear-lanceolate, 10–22 × 1–1.5 mm, radiate and incurved. Stamens erect, 7–9 mm long, white at base, numerous and crowded at first in a column. Ovary inferior, with raised, ridged, conical centre up to 2 mm high, glands 5, linear, 1.3 × 0.5 mm, separate, greenish yellow; stigmas 5 mm long, filiform, apices becoming coiled outward. Fruiting capsule 10 × 10 mm, opening hygrochastically, bowl-shaped, covering membranes rudimentary (0.5 mm ledge) and almost absent. Seed oval, 0.5 × 0.9 mm, light brown.

Phenology: Main flowering season in spring (August–October) and can be flowering sporadically throughout the year.

Pollinators: Insects (generalist).

Habitat and aspect: Plants are confined to east- and west-facing cliffs, growing in crevices and on ledges of the lower and upper slopes, in ample soil. The climate is hot and dry, with rainfall in summer and winter. The average daily maximum temperature is about 25°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall occurs in winter and summer (cyclonic cold fronts and thunder showers), 200–300 mm per annum.

Altitude: 800–1200 m.

Associated vegetation: Gamka Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other cremnophytes observed at Toorwaterspoort include *Adromischus subdistichus*, *Albuca tortuosa*, *Bulbine* sp., *Cotyledon woodii*, *Crassula capitella* subsp. *thyrsiflora*, *C. cotyledonis*, *C. muscosa* var. *muscosa*, *C. pellucida* subsp. *marginalis*, *C. perfoliata* var. *minor*, *C. pubescens* var. *radicans*, *C. rupestris*, *C. velutina*, *Cyrtanthus montanus*, *Drimia uniflora*, *Haemanthus albiflos*, *Haworthia decipiens* var. *decipiens*, *H. viscosa*, *Lampranthus affinis* and *Senecio talinoides*.

Geology: Witteberg Quartz (Cape Supergroup).

DISTRIBUTION

Toorwaterspoort (between the Slypsteenbergrivier to the west and Groot Swartberg to the east, Eastern Cape).

RELATED SPECIES

Related to *Carruanthus ringens* and *Bijlia tugwelliae*. *Carruanthus peersii* is immediately distinguished from *C. ringens* by its toothless (or almost toothless), oblong, trigonous-clavate leaves and pendent, mat-forming clusters. It is confined to conglomerate and quartz (quartzitic sandstone) and grows on level or hilly terrain, the leaves with numerous pairs of teeth and clustered growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous pendent clusters up to 300 mm in diameter and up to 500 mm long.

Size and weight: Clusters medium-sized.

Stem: Up to 500 mm long.

Leaves

Orientation: Ascending-spreading. The leaves have no teeth, suggesting a moisture strategy that differs from that of other species of *Carruanthus*. In the related *C. ringens*, the leaves have teeth, possibly a ‘dew trap’ or ‘fog trap’ on flat areas. Leaf margins in *C. peersii* are smooth (or with only faint remnants of teeth), suggesting a different strategy and the subsequent loss of teeth.

Colour: Glaucous, green to dirty green, plants becoming purplish green (production of anthocyanins) during drought, thus reducing penetration of light from the sun.

Age and persistence: Plants slow-growing, long-lived perennials.

Armament and camouflage: Plants without armament or camouflage properties.

Sexual reproduction

Flowers: Melittophilous (Hartmann 1991).

Fruit/Seed

Size: Seed 0.5×0.75 mm, light brown, ovoid, the small seeds easily becoming wedged in crevices, ideal for establishment of seedlings.

Dispersal: Hydrochory (ombrohydrochory). Hygrochastic capsules opening with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have no covering membranes. Rain fills the bowl-like cavity of the capsule and the seeds are washed or splashed out. This dispersal strategy would ensure local dispersal on the cliff, the seeds becoming wedged in crevices, ideal for establishment.

Time: Seeds released in autumn and winter, coinciding with autumn or winter rains, thus during the cool season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense mats or clusters, with active vegetative growth and rooting where they come into contact with soil, an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Little-known species, not threatened owing to the remote, safe habitat.

ADDITIONAL NOTES

Horticulture: Best for thicket and succulent karoo gardens, grown on rockeries, embankments or containers. Very easily cultivated. Propagate from cuttings, division or seed. Grow in full sun or light shade. Water sparingly in winter and summer.

VOUCHER

Van Jaarsveld 17412 (NBG).

ILLUSTRATIONS AND MAP

Plate 174, Figures 174a–174c, Map 174.

CONOPHYTUM N.E.Br.

175. *Conophytum auriflorum* Tischer subsp. *turbiniforme* (Rawe) S.A.Hammer in *Cactus and Succulent Journal* (U.S.) 52: 231 (1993).

Cremonophyte growth form: Clustered, mat-forming growth (of light weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: The specific epithet *auriflorum* pertains to the yellow flowers.

DESCRIPTION AND HABITAT

Plants forming compact, mat-like, globose clusters. Roots fibrous. Leaves fused into turbiniform, obconical bodies, each body 10–18 × 38 × 3–8 mm, truncate or convex; epidermis glabrous, pale whitish green to reddish green, spotted, translucent at fissure; fissure 1–3 mm long; summer sheath white to pale brown. Flowers yellow, up to 20 mm in diameter. Petals numerous, in 2 or 3 series, spatulate, 8–10 × 2 mm. Fruiting capsule very fragile, 4-locular, 3 × 4 mm, opening hygrochastically. Seed 0.55–0.70 × 0.45–0.55 × 0.25–30 mm, tuberculate, dark brown. (Description based on Hammer 1993, 2002.)

Phenology: Flowering in autumn. Flowers diurnal, scentless, conspicuous, in profusion.

Pollinators: Insects.

Habitat and aspect: Confined to cliffs of the western escarpment margin, growing in crevices, fissures and on ledges, on various aspects, but more in sheltered, shady spots. This region is subject to occasional fog. The average daily maximum temperature is about 19°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall mainly in winter (cyclonic cold fronts), 100–200 mm per annum.

Altitude: 540–860 m.

Associated vegetation: Namaqualand Klipkoppe Shrubland of the Succulent Karoo (Mucina *et al.* 2005).

Associated cremonophytes: Associated cremonophytes include *Adromischus* sp. and *Ficus ilicina*.

Geology: Quartz of the Bushmanland Group, Khurisberg Subgroup.

DISTRIBUTION

Confined to the escarpment mountains in the Spektakel Pass region, southwest of Springbok (Northern Cape).

RELATED SPECIES

Distinguished from related species by its small turbiniform bodies, translucent fissure and yellow flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Inconspicuous globose to mat-forming clusters in fissures along ledges and crevices.

Size and weight: Clusters small (of light weight).

Stem: Short to medium length, branched and usually unexposed.

Leaves

Orientation: Fused into obconical to turbinate bodies, truncate, with a smooth epidermis and translucent fissure, maximising exposure to light.

Colour: Green to reddish green.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in spring, remaining older leaves recycled and forming a protective sheath for successive newly formed leaves.

Armament and camouflage: Plants without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Yellow, up to 20 mm in diameter, diurnal. The rich flowering and floriferous nature can be seen as an adaptation to the cliff environment, maximising visibility.

Fruit/Seed

Size: Seed $0.55\text{--}0.70 \times 0.45\text{--}0.55 \times 0.25\text{--}30$ mm.

Dispersal: Hydrochory as in other *Conophytum* species. Tuberculate surface of seed ideal for establishment in crevices.

Time: Hygrochastic capsules releasing seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense mats or clusters, with active vegetative growth and rooting where they come into contact with soil, an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009). However, not threatened owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best for greenhouses, grown under controlled conditions. Propagated from seed or by division (Hammer 1993). Resting in summer, active in winter. Grow in partial shade, in small containers, in a sandy, well-drained mixture. Plants grow rapidly, forming dense clusters.

VOUCHER

Van Jaarsveld 21125 (NBG).

ILLUSTRATIONS AND MAP

Figures 175a & 175b, Map 175.

176. *Conophytum bolusiae* Schwantes subsp. *bolusiae*, Schwantes in Die Gartenwelt 33: 25 (1929).

Cremonophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: After Louisa Bolus (1877–1970) of the University of Cape Town, well-known authority on mesembs.

DESCRIPTION AND HABITAT

Plants forming globose to mat-like clusters of 10 to 200, sometimes with long trailing stems and forming groups of up to 600 mm in diameter. Roots fibrous. Leaves fused into turbiniform obconical bodies, each body 10–25 × 8–12 × 8–12 mm, truncate at top to slightly convex; epidermis densely papillate, glaucous; summer sheath white to yellowish white. Flowers magenta, up to 25 mm in diameter. Petals numerous, in 2 or 3 series, up to 10 × 2 mm. Fruiting capsule 4–6-locular, 2 × 4 mm, opening hygrochastically, very fragile. Seed 0.7 × 0.55 × 0.45 mm, densely tuberculate. (Description based on Hammer 2002.)

Phenology: Flowering in spring or early summer. Flowers diurnal, scentless, conspicuous, in profusion.

Pollinators: Insects.

Habitat and aspect: Plants are confined to sheer east-facing shady cliffs, growing in crevices and on ledges of the upper slopes in ample soil, on southern aspects in the fog belt. Summers are hot and dry but plants are ‘misted’ by regular fog from the Atlantic Ocean (some 30 km from the coast). Average daily maximum temperature is about 19°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall occurs mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 500–750 m.

Associated vegetation: Vyftienmyl se Berge Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other cremnophytes observed at Vyftienmyl se Berge include *Bulbine vitrea*, *Adromischus montium-klinghardtii*, *Conophytum stephanii*, *Crassula muscosa* var. *muscosa*, *C. velutina*, *Haworthia arachnoidea*, *Kleinia cephalophora*, *Tylecodon bodleyae*, *T. buchholzianus*, *T. rubrovenosus* and *T. similis*.

Geology: Rough quartz of the De Hoop Subgroup (Gariiep Supergroup).

DISTRIBUTION

Confined to the Vyftienmyl se Berge (Oograbies Mountains).

RELATED SPECIES

Distinguished from related level-ground *Conophytum* species by its large, conspicuous, globose clusters. Related species from non-cliff habitats usually smaller and less conspicuous (camouflage), often with a sunken growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose to mat-forming clusters up to 600 mm in diameter, rooting along ledges and crevices.

Size and weight: Clusters of medium weight.

Stem: Short to medium length, branched and usually unexposed.

Leaves

Orientation: Fused into obconical to turbinate bodies, truncate at the top to slightly convex, with a white to yellowish white summer sheath.

Colour and texture: Green to glaucous green. Densely papillate epidermis, an adaptation trapping fog, often associated with fog belt mesembs such as *Conophytum stephanii*.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in spring, remaining older leaves recycled and forming a protective sheath for successive newly formed leaves.

Armament and camouflage: Plants without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Conspicuous, magenta, up to 25 mm in diameter (same diameter as leaf body), opening towards late afternoon; petals numerous in 2 or 3 series, up to 8–10 mm long, when in flower bodies hardly visible. The rich flowering and floriferous nature can be seen as an adaptation to the cliff environment, maximising visibility.

Fruit/Seed

Size: Seed $0.7 \times 0.55 \times 0.45$ mm, densely tuberculate.

Dispersal: Hydrochory. Hydrochastic capsules, 2×4 mm, opening with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988), indicating local dispersal. Remaining on the cliff is vital to survival. The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large, tuberculate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices (compared to other *Conophytum* species). *Conophytum bachelorum*, a non-cremnohyte of section *Wettsteinia* with solitary bodies (well-camouflaged) and smaller dark pink flowers, has finely tuberculate seeds. Most other facultative cremnohytes have finely tuberculate seed.

Time: Hydrochastic capsules releasing seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense mats or clusters, with active vegetative growth and rooting where they come into contact with soil, an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Although classified as rare (Raimondo *et al.* 2009), it is not threatened owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Very easily cultivated compared to other level-ground species, its adaptability in cultivation and growth vigour viewed as maximising survival. Hammer (1993) reports clusters becoming so large that they fall to the ground. Easily propagated from seed or by division (Hammer 1993). Resting in summer, active in winter. Best grown in partial shade, in small containers. Dividing annually and rapidly forming dense clusters.

VOUCHERS

Hall 23032, Van Jaarsveld 23062 (NBG).

ILLUSTRATIONS AND MAP

Figures 176a–176d, Map 176.

177. *Conophytum carpianum* L.Bolus, Notes on Mesembryanthemum and allied genera 3: 264–265 (1954).

Cremnophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: After Bernard Carp of Cape Town, lover of succulent plants who sponsored many of Harry Hall's expeditions.

DESCRIPTION AND HABITAT

Plants forming dense cushions of many bodies. Roots fibrous. Leaves fused into subcylindrical bodies, each body 6–15 × 4–8 × 3–4 mm, leaf tips free, keeled; epidermis minutely papillate (velvety surface), greyish green; fissure, spotted, gaping; sheath greyish brown to whitish. Flowers white. Petals in 2 series, 2–6 × 1 mm. Fruiting capsule 4-locular, 2 × 2 mm. Seed 0.85 × 0.55 × 0.40 mm, tuberculate. (Description based on Hammer 2002.)

Phenology: Flowering in autumn. Flowers nocturnally scented.

Pollinators: Night-flying insects.

Habitat and aspect: Confined to exposed granite domes, among lichens. Plants are subject to regular fog from the Atlantic Ocean. The average daily maximum temperature is about 25°C and average daily minimum about 10°C. Rainfall mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 900–1160 m.

Associated vegetation: Goarieb Mountain Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Crassula garibina* and *C. macowanii*.

Geology: Granite of the Kuboos-Bremen Suite (Kuboos Pluton Subgroup, Gariep Supergroup).

DISTRIBUTION

Confined to the upper slopes of the Ploegberg near Kuboes (Richtersveld, Northern Cape).

RELATED SPECIES

Related to *Conophytum quaesitum* and *C. hians*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Globose clusters rooting in narrow crevices among lichens and moss.

Size and weight: Clusters small to medium weight.

Stem: Short, branched and unexposed.

Leaves

Orientation: Fused into subcylindrical bodies.

Colour: Greyish green.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in late spring, remaining older leaves recycled and forming a protective sheath for the successive newly formed leaves.

Armament and camouflage: Plants without conspicuous armament.

Sexual reproduction

Flowers: White, nocturnal.

Fruit/Seed

Size: Seed up to 0.85 mm in diameter, tuberculate.

Dispersal: Hydrochory. Hydrochastic capsules opening with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988), thus also a strategy for local dispersal.

Time: Hydrochastic capsules releasing seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009), but well protected in the habitat, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum carpianum* is easily cultivated compared to other level-ground species, according to Hammer (pers. comm.) a ‘great drinker’, rapidly swelling with moisture and making the most of the dry cliff terrain. Its adaptability in cultivation and growth vigour can be viewed as maximising survival. Best grown in partial shade, in small containers.

VOUCHER

Van Jaarsveld 22302 (NBG).

ILLUSTRATIONS AND MAP

Figures 177a–177c, Map 177.

178. *Conophytum danielii* Pavelka in *Kaktusy* 35,1: 1–32 (1999).

Cremonophyte growth form: Clustered, mat-forming growth (of light weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (ft) (r)

Etymology: After Daniel Pavelka, father of Petr Pavelka.

DESCRIPTION AND HABITAT

Plants forming tight, dome-shaped cushions. Roots fibrous. Leaves fused into cylindrical, shortly bilobed bodies, up to 20 mm long; epidermis papillate, pale green to yellowish green; sheath sometimes spotted with brown dots. Flowers diurnal (initially nocturnal), pink, white or cream, in 2 or 3 series, up to 7×1.52 mm. Fruiting capsule 4- or 5-locular, whitish, opening hygrochastically. Seed up to 0.86 in diameter, with rounded papillae.

Phenology: Flowering in late autumn. Flowers initially nocturnal, scented.

Pollinators: Insects.

Habitat and aspect: Confined to low, shady cliffs. Summers are hot and dry but plants may benefit from occasional thunder showers in spring and autumn. The average daily maximum temperature is about 26–27°C and average daily minimum about 10–11°C, with frost absent or light. Rainfall is mainly in winter, spring and autumn (cyclonic cold fronts and thunder showers), ranging from 100–200 mm per annum.

Altitude: 1000–1150 m.

Associated vegetation: Kamiesberg Mountains Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremonophytes: Associated plants include species of *Crassula* and mesembs.

Geology: Banke granidiorite (Spektakel Suite).

DISTRIBUTION

Confined to a single formation.

RELATED SPECIES

Related to the mat-forming *Conophytum marginatum*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous small, dome-shaped clusters.

Size and weight: Clusters small.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into cylindrical, shortly lobed bodies.

Colour and texture: Epidermis pale green, papillate.

Age and persistence: Plants long-lived perennials.

Armament and camouflage: Plants fragile, without conspicuous armament or camouflage properties, an adaptation to the largely undisturbed habitat.

Sexual reproduction

Flowers: Pink, white or cream, diurnal.

Fruit/Seed

Size: Seed up to 0.86 mm in diameter, densely tuberculate.

Dispersal: Hydrochory. Hydrochastic fruiting capsules 4- or 5-locular, white, opening hydrochastically and seed locally dispersed ('wash-out dispersal', Hartmann 1988). The fairly large tuberculate seeds indicate adaptation to the cliff habitat where they become wedged in crevices, providing anchorage for seedlings in the quartz crevices.

Time: Hydrochastic capsules releasing seeds only in the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Threatened owing to its unique fragile habit. Little-known species.

ADDITIONAL NOTES

Horticulture: Best under controlled conditions in a greenhouse. Easily cultivated but should be given ample shade. Its adaptability in cultivation and growth vigour can be viewed as maximising survival. Best grown in sandy soil in small containers and, as for most other species of *Conophytum*, allow for a summer resting period.

VOUCHER

Pavelka 962 (PRC).

ILLUSTRATIONS AND MAP

Map 178.

179. *Conophytum ernstii* S.A.Hammer subsp. *ernstii*, Hammer in Cactus and Succulent Journal (U.S.) 60,6: 262–263 (1988).

Cremnophyte growth form: Clustered, mat-forming (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r) (ft)

Etymology: After Ernst van Jaarsveld (1953–), horticulturist at Kirstenbosch National Botanical Garden.

DESCRIPTION AND HABITAT

Plants forming globose clusters of 10 to 60 bodies and up to 120 mm in diameter. Roots fibrous. Leaves fused into turbiniform bodies, each body 12–15 × 10–18 × 10–18 mm, truncate at top to slightly concave; epidermis densely papillate, glaucous; summer sheath greyish brown, well-spotted, elevated at margins. Flowers pale pink to pink, up to 34 mm in diameter. Petals numerous, in 2 or 3 series, up to 15 × 3 mm. Fruiting capsule 2 × 2 mm, opening hygrochastically. Seed 0.7 × 0.45 × 0.35 mm, densely papillate.

Phenology: Flowering in late autumn. Flowers conspicuous, in profusion, diurnal.

Pollinators: Insects.

Habitat and aspect: Confined to south-facing cliffs (Violsdrif Suite) of hills overlooking the Orange (Gariep) River, growing in crevices and on ledges of the upper slopes in ample soil in the fog belt. Summers are hot and dry but plants are ‘misted’ by regular fog from the Atlantic Ocean (some 80 km from the coast). The average daily maximum temperature is about 20°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 400–1200 m.

Associated vegetation: Richtersveld Sheet Wash Desert, Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other cremnophytes observed at Sandberg include *Adromischus alstonii*, *Conophytum rostratum*, *Crassula garibina*, *C. muscosa* var. *muscosa*, *C. velutina* and *Haworthia tessellata*.

Geology: Rough quartz of the Rosyntjieberg Formation (Orange River Group).

DISTRIBUTION

Confined to the Sandberg region of the Richtersveld Transfrontier National Park (Northern Cape) and adjacent hills in Namibia, and within the fog zone.

RELATED SPECIES

Distinguished from related level-ground *Conophytum* species by its large, conspicuous, globose clusters. The other level-ground *Conophytum* species usually well camouflaged and often with sunken growth. *Conophytum ernstii* subsp. *cerebellum* is slightly smaller (clusters and leaves).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters up to 120 mm in diameter, rooting in narrow crevices.

Size and weight: Clusters of light to medium weight.

Stem: Short, branched and unexposed.

Leaves

Orientation: Fused into turbiniform bodies, truncate at the top to slightly concave;

Colour and texture: Glaucous; epidermis densely papillate; summer sheath greyish brown, well-spotted, elevated at margins. Densely papillate epidermis, an adaptation trapping fog, often found in fog belt with mesembs such as *Conophytum stephanii*.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in spring, remaining older leaves recycled and forming a protective sheath for the successive newly formed leaves.

Armament and camouflage: Plants without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Pale pink to pink, up to 34 mm in diameter (same diameter as leaf body), opening towards late afternoon; petals numerous, in 2 or 3 series, up to 15 × 3 mm, when in flower, bodies hardly visible. The rich flowering and floriferous nature can be seen as an adaptation to the cliff environment, maximising visibility.

Fruit/Seed

Size: Seed 0.7 × 0.45 × 0.35 mm, densely papillate.

Dispersal: Hydrochory. Hygrochastic capsules 2 × 2 mm, opening with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988), thus also a strategy for local dispersal.

Time: Seeds released during the rainy season in winter, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Classified as rare (Raimondo *et al.* 2009) but well-protected within the Richtersveld Transfrontier National Park and also by the cliff-face habitat. A little-known species, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum ernstii* is best grown under controlled conditions in a greenhouse. Very easily cultivated compared to other level-ground species, the growth vigour viewed as maximising survival. Propagate from seed, cuttings or by division. Allow for a summer rest. Best grown in partial shade, in small containers. Dividing annually and rapidly forming dense clusters. Cultivated by mesemb enthusiasts.

VOUCHER

Van Jaarsveld 8512 (NBG).

ILLUSTRATIONS AND MAP

Figures 179a–179e, Map 179.

180. *Conophytum francoiseae* (S.A.Hammer) S.A.Hammer, Dumpling and his wife: new views of the genus *Conophytum*: 133 (2002).

Cremonophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: After Françoise Williamson, wife of Graham Williamson, botanist and expert on the Richtersveld.

DESCRIPTION AND HABITAT

Plants forming rounded clusters up to 60 mm in diameter (15–25 bodies). Roots fibrous. Leaves fused into turbiniform, obconical bodies, concave at apices, each body 8–15 × 9–15 × 8–13 mm; epidermis smooth, glaucous, faintly green-spotted; summer sheath pale to dark brown. Calyx tube 8 mm long, bearing 4–6 green sepals. Flowers magenta, up to 30 mm in diameter. Petals numerous, in 1 or 2 series, up to 15 × 1.5 mm. Fruiting capsule obovate, soft, 4–6-locular, 2 × 4 mm, opening hygrochastically. Seed 0.60 mm in diameter, pustulate. (Description based on Hammer 2002.)

Phenology: Flowering in early spring. Flowers diurnal, scentless.

Pollinators: Insects.

Habitat and aspect: Confined to sheer, shady, south-facing cliffs, in crevices and on ledges of the upper slopes in ample soil, in the fog belt. Summers are hot and dry but plants are ‘misted’ by regular fog from the Atlantic Ocean (some 30 km from the coast). Average daily maximum temperature is about 19°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 250–350 m.

Associated vegetation: Vyftienmyl se Berge Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Conophytum meyeri*, *C. obscurum*, *Crassula pseudohemisphaerica*, *Mitrophyllum grande*, *Tylecodon bodleyae*, *T. buchholzianus* and *T. similis*.

Geology: Quartz of the De Hoop Subgroup (Gariep Supergroup).

DISTRIBUTION

Confined to northern portion of Vyftienmyl se Berge (northeast of Port Nolloth).

RELATED SPECIES

Distinguished from *Conophytum wettsteinii* by its greyish blue clusters.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous rounded clusters up to 60 mm in diameter, rooting along ledges and crevices.

Size and weight: Clusters of medium weight.

Stem: Short to medium length, branched and usually unexposed.

Leaves

Orientation: Fused into turbiniform, obconical bodies, concave at the apices.

Colour: Glauous; epidermis smooth, glauous, faintly green-spotted.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in spring, remaining older leaves recycled and forming a protective sheath for the successive newly formed leaves.

Armament and camouflage: Plants without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Conspicuous, rich magenta, up to 30 mm in diameter (same diameter as leaf body), opening towards late afternoon; petals numerous, in 1 or 2 series, up to 15 mm long, when in flower bodies hardly visible. The rich flowering and floriferous nature can be seen as an adaptation to the cliff environment, maximising visibility.

Fruit/Seed

Size: Seed 0.6 mm long, densely tuberculate.

Dispersal: Hydrochory, as in other *Conophytum* species.

Time: Hygrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, rooting and forming dense mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Not threatened owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Very easily cultivated compared to other level-ground species. Its adaptability in cultivation and growth vigour can be viewed as maximising survival. Best grown in partial shade, in small containers. Dividing annually and rapidly forming dense clusters.

VOUCHER

Van Jaarsveld 23076 (NBG).

ILLUSTRATIONS AND MAP

Figures 180a–180d, Map 180.

181. *Conophytum fulleri* L.Bolus, Notes on Mesembryanthemum and allied genera 2: 62 (1929).

Crempophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: After E.R. Fuller, succulent plant enthusiast and postmaster at Kakamas and Pofadder.

DESCRIPTION AND HABITAT

Plants forming small, rounded mats of interlocking, very fragile bodies. Roots fibrous. Leaves fused into obconical bodies, each body 6–20 × 5–18 × 5 mm, truncate to convex at top; epidermis yellowish green to green, papillate, shiny, spotted with translucent dots; summer sheath whitish to pale yellowish; fissure small, up to 2 mm long. Flowers pink, up to 35 mm in diameter. Petals numerous, in 2–4 series, up to 15 × 2 mm. Fruiting capsule 4- or 5-locular, 2 × 4 mm, opening hygrochastically. Seed 0.6 × 0.5 × 0.35 mm, papillate.

Phenology: Flowering in late autumn. Flowers diurnal, conspicuous.

Pollinators: Insects.

Habitat and aspect: Confined to shady south- or east-facing cliffs. Summers are hot and dry. The average daily maximum temperature is about 27°C and the average daily minimum about 14°C. Rainfall occurs mainly in spring, winter and autumn (thunder showers and cyclonic cold fronts), 50–100 mm per annum.

Altitude: 980–1150 m.

Associated vegetation: Eastern Gariiep Rocky Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated plants include *Adromischus diabolicus*, *Aloe dabenorisana* and *Bowiea gariiepensis*.

Geology: Quartz of the Hom Formation (Bushmanland Group).

DISTRIBUTION

Confined to the mountains of the Orange River (Pellaberg), Pofadder region.

RELATED SPECIES

Distinguished from the related level-ground *Conophytum ectypum* by its large, conspicuous, translucent spots.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous clusters of interlocking bodies.

Size and weight: Clusters small.

Stem: Short to medium length, branched and usually unexposed.

Leaves

Orientation: Fused into obconical bodies, truncate or convex at the top.

Colour: Green; epidermis very fragile, green, with large, translucent, darker dots; summer sheath yellowish brown.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in late spring, remaining older leaves recycled and forming a protective sheath for the successive newly formed leaves.

Armament and camouflage: Plants fragile, without conspicuous armament or camouflage properties, an adaptation to the largely undisturbed habitat.

Sexual reproduction

Flowers: Conspicuous, up to 35 mm in diameter, pink, attractive. Hammer (2002) describes it as honey-scented.

Fruit/Seed

Size: Seed up to 0.6 mm long, papillate.

Dispersal: Hydrochory. Hydrochastic capsules opening with rain, seeds locally dispersed by ‘wash-out dispersal’ (Hartmann 1988).

Time: Hydrochastic capsules releasing seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Not threatened and within the limits of a national park.

ADDITIONAL NOTES

Horticulture: *Conophytum fulleri* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade or full sun, in sandy soil in small containers.

VOUCHER

Van Jaarsveld 1452/28 (BOL).

ILLUSTRATIONS AND MAP

Figures 181a–181c, Map 181.

182. *Conophytum hanae* Pavelka in *Kaktusy* 35,1: 1–32 (1999).

Cremonophyte growth form: Clustered, mat-forming growth (of medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: After Hanna, wife of Petr Pavelka, author of this taxon.

DESCRIPTION AND HABITAT

Plants forming small, dome-shaped clusters up to 80 mm in diameter, consisting of many heads. Roots fibrous. Leaves fused into soft, compressed, obconical body; apices 2-lobed; lobes rounded, 10–16 × 8–10 × 3–4 mm; epidermis glabrous, green; margins reddish. Flowers slightly scented, about 30 mm in diameter, magenta. Petals in 1 or 2 series, up to 15 × 2 mm. Fruiting capsule 5- or 6-locular, 3–4 × 4–5 mm, truncate to pointed at apex. Seed 0.7 × 0.5 × 0.3 mm, tuberculate.

Phenology: Flowering in early autumn. Flowers scentless, diurnal.

Pollinators: The architecture of the large bright flowers suggests a diurnal flying insect.

Habitat and aspect: Confined to south-facing cliffs. The plants grow in shady crevices (all aspects) in association with other succulent plants. Summers are hot and dry and the average daily maximum temperature is about 26°C and average daily minimum about 7°C, with occasional frost. Rainfall occurs in spring, autumn and winter (cyclonic cold fronts and thunder showers in late summer and autumn), 100–200 mm per annum.

Altitude: 1000–1300 m.

Associated vegetation: Kamiesberg Mountains Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other succulents observed at its habitat at Ramkop include *Adromischus filicaulis* var. *filicaulis*, *Crassula garibina* and *Othonna cakilifolia*.

Geology: Gneiss of the Bitterfontein Subgroup (Bushmanland Group).

DISTRIBUTION

Known only from the eastern Kamiesberg, on cliffs of similar geological formations.

RELATED SPECIES

Distinguished from related level-ground species by its more conspicuous, rounded clusters of softer bodied leaves (with reddish margins). The related level-ground species are usually well camouflaged among the quartz gravel flats or outcrops.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dome-shaped clusters.

Size and weight: Clusters of medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into soft, compressed obconical body, the apices 2-lobed; lobes rounded.

Colour: Epidermis glabrous, green, margins reddish; summer sheath yellowish brown, papery.

Age and persistence: Long-lived perennials.

Armament and camouflage: Conspicuous mounds of soft-leaved bodies and compared to level-ground species that are well camouflaged (*Conophytum marginatum* var. *marginatum*, *C. marginatum* var. *littlewoodii* and *C. herreanthus*), this reduction in camouflage can be seen as an adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Magenta, about 30 mm in diameter, slightly scented, diurnal; petals in 2 series, up to 15×2 mm.

Fruit/Seed

Size: Seed $0.7 \times 0.5 \times 0.3$ mm, tuberculate.

Dispersal: Hydrochory. Fruiting capsules 5- or 6-locular, $3\text{--}4 \times 4\text{--}5$ mm, truncate to pointed at the top, fragile, opening hygrochastically with rain but seeds dispersed by 'wash-out dispersal' (Hartmann 1988). The capsules broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The papillate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices.

Time: Hygrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Common in the habitat, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum hanae* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade or full sun, in sandy soil in small containers.

VOUCHER

Pavelka 1369 (PRC).

ILLUSTRATIONS AND MAP

Figures 182a–182d, Map 182.

183. *Conophytum luckhoffii* Lavis, in Bolus, Notes on Mesembryanthemum and allied genera 2: 291–292 (1931). (*Conophytum edwardsiae* variant.)

Cremnophyte growth form: Clustered, mat-forming growth (of light weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: After Dr James Luckhoff, succulent plant enthusiast.

DESCRIPTION AND HABITAT

Plants forming small to large, dome-shaped clusters up to 150 mm in diameter. Roots fibrous. Leaves fused into elongate-cordiform bodies; apices with sharply keeled, ornamented lobes, each body 8–15 × 4–8 × 2–5 mm; epidermis greyish green to purplish green, glabrous. Flowers diurnal, strongly scented, about 35 mm in diameter, magenta to carmine. Petals in 2–4 series, up to 15 × 2 mm. Fruiting capsule 4- or 5-locular, 2 × 4 mm, angular, fragile. Seed 0.9 × 0.5 × 0.4 mm, tuberculate-wrinkled.

Phenology: Flowering in early autumn. Flowers scentless, suggesting a night-flying pollinating insect.

Pollinators: The architecture of the large bright flowers suggests a diurnal flying insect.

Habitat and aspect: Confined to the Cape Fold Belt mountains where it grows on west-facing cliffs, occasionally also on other accessible sandstone pockets. The plants occur in crevices in association with other succulents. Summers are hot and dry but plants are occasionally ‘misted’ by fog from the Atlantic Ocean. Average daily maximum temperature about 23°C and average daily minimum about 12°C, with frost absent. Rainfall mainly in winter (cyclonic cold fronts), late summer and autumn (thunder showers), 400–500 mm per annum.

Altitude: 100–980 m.

Associated vegetation: Piketberg Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnohytes: Other succulents observed at Piekenierskloof Pass include *Adromischus hemisphaericus*, *Crassula montana* subsp. *montana*, *C. atropurpurea* var. *watermeyeri*, *C. rupestris* and *Tylecodon paniculatus*.

Geology: Quartzitic sandstone of the Graafwater Subgroup (Table Mountain Group, Cape Supergroup).

DISTRIBUTION

Piketberg, Citrusdal and northwards to Clanwilliam.

RELATED SPECIES

Distinguished from related level-ground species in the section *Minuscula* by its slightly larger bodies, but not much different. The related level-ground species are usually well camouflaged among the lichen and moss-filled stone pockets.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dome-shaped clusters.

Size and weight: Clusters small to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into elongate-cordiform bodies, apices with sharply keeled and ornamented lobes.

Colour: Epidermis glabrous, greyish green to purplish green; summer sheath papery, whitish.

Age and persistence: Plants long-lived perennials.

Armament and camouflage: The fused, soft-leaved bodies are without conspicuous armament or camouflage properties and in comparison to level-ground species that are well camouflaged (*Conophytum phoeniceum* and *C. depressum*), this reduction in camouflage can be seen as an adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Magenta to carmine, about 35 mm in diameter, strongly scented, diurnal, flowering in early autumn; petals in 2–4 series, up to 15 × 2 mm.

Fruit/Seed

Size: Seed 0.9 × 0.5 × 0.4 mm, tuberculate-wrinkled.

Dispersal: Hydrochory. Fruiting capsules 4- or 5-locular, 2 × 4 mm, angular, fragile, opening hygrochastically with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). Capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large, tuberculate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings.

Time: Hygrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Common in the habitat, not threatened.

ADDITIONAL NOTES

General: *Conophytum luckhoffii* is not an obligate cremnophyte when its distribution as a whole is taken into account. However, the form from Piekenierskloof was described as *C. edwardsiae*, an obligate cremnophyte.

Horticulture: Plants of *Conophytum luckhoffii* are best grown under controlled conditions in a greenhouse. Very easily cultivated, their growth vigour viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade or full sun, in sandy soil in small containers.

VOUCHER

Van Jaarsveld 22794, Luckhoff 2488/30 (BOL).

ILLUSTRATIONS AND MAP

Figures 183a–183e, Map 183.

184. *Conophytum marginatum* Lavis subsp. *haramoepense* (L.Bolus) S.A.Hammer, Dumpling and his wife: new views of the genus *Conophytum*: 181 (2002).

Cremonophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: The specific epithet *marginatum* refers to its reddish margin and the subspecific epithet to a farm, Haramoep, in Bushmanland, Northern Cape.

DESCRIPTION AND HABITAT

Plants forming small, dome-shaped clusters to large mats 200 mm in diameter, consisting of many heads (20–200). Roots fibrous. Leaves fused into soft, oblong to obconical body; apices compressed, with purplish, ornamented lobes or fused; lobes rounded, 10–16 × 4–8 × 4 mm; epidermis glabrous, yellowish green to pinkish green; fissure papillate; sheath pale grey to opaque. Flowers diurnal, slightly scented, about 35 mm in diameter, magenta to pale rose. Petals in 1–3 series, 15 × 2 mm. Fruiting capsule 5- or 6-locular, 2 × 4 mm, obtrullate, pointed. Seed 0.65 × 0.4 × 0.3 mm, distinctly tuberculate.

Phenology: Flowering in early autumn. Flowers faintly scented.

Pollinators: The architecture of the large bright flowers suggests a diurnal flying insect.

Habitat and aspect: Confined to south-facing cliffs. Plants grow in sheltered crevices (all aspects) in association with other succulent plants. Summers are hot and dry and the average daily maximum temperature is about 28°C and average daily minimum about 13°C, with frost absent from the habitat. Rainfall occurs in spring, autumn and winter (cyclonic cold fronts and thunder showers in late summer and autumn), 50–100 mm per annum.

Altitude: 940–1200 m.

Associated vegetation: Eastern Gariiep Rocky Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other succulents observed at its habitat at Groot Pellaberg include *Adromischus trigynus*, *Aloe dabenorisana*, *Bowiea gariepensis*, *Crassula exilis* subsp. *sedifolia*, *C. garibina* and *Tylecodon sulphureus* var. *armianus*.

Geology: Metaquartzitic gneiss of the Hom Formation (Bushmanland Group).

DISTRIBUTION

Known only from northern Bushmanland, on cliffs of similar geological formations (Naip se Berg to Pofadder).

RELATED SPECIES

Distinguished from related level-ground species by its more conspicuous, rounded clusters of softer bodied leaves (with purple apices). The related level-ground species are usually well camouflaged among the quartz gravel flats or outcrops.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dome-shaped clusters.

Size and weight: Clusters of light to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into soft, oblong to obconical body, the apices compressed, with purplish ornamented lobes or fused; lobes rounded.

Colour: Epidermis glabrous, yellowish green to pinkish green; fissure papillate; summer sheath whitish, papery.

Age and persistence: Plants long-lived perennials.

Armament and camouflage: Plants growing in conspicuous mounds of soft-leaved bodies and in comparison to level-ground species that are well camouflaged (*Conophytum marginatum* var. *marginatum*, *C. herreanthus* and *C. regale*), this reduction in camouflage can be seen as an adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Magenta to pale rose, about 35 mm in diameter, slightly scented, diurnal; petals in 1–3 series, up to 15 × 2 mm.

Fruit/Seed

Size: Seed $0.7 \times 0.4 \times 0.3$ mm, papillate.

Dispersal: Hydrochory. Fruiting capsules 5- or 6-locular, 2×4 mm, angular, fragile, opening hygrochastically with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The papillate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices.

Time: Hygrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Common in the undisturbed habitat, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum marginatum* subsp. *haramoepense* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers. Under moist conditions the reddish colour of the leaves is lost (see Figure 184b).

VOUCHER

P. van Heerde 10774 (BOL).

ILLUSTRATIONS AND MAP

Figures 184a–184d, Map 184.

185. *Conophytum marginatum* Lavis subsp. *littlewoodii* (L.Bolus) S.A.Hammer, Dumpling and his wife: new views of the genus *Conophytum*: 181 (2002).

Cremonophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: After Roy Littlewood (1924–1967), collector of succulent plants.

DESCRIPTION AND HABITAT

Plants forming small, dome-shaped clusters to large mats 200 mm in diameter, consisting of many heads (20–50). Roots fibrous. Leaves fused into soft, elongated, heart-shaped bodies; apices lobed, somewhat diverging, grey- to olive-green, with purplish, ornamented lobes, 10–15 × 5–9 × 4–7 mm; epidermis glabrous, dotted with large green idioblasts; fissure papillate; sheath pale grey to opaque. Flowers diurnal, slightly scented, about 35 mm in diameter, magenta to carmine. Petals in 1–3 series, 22 × 2 mm. Fruiting capsule 5- or 6-locular, 2 × 4 mm, obtrullate, pointed. Seed 0.60 × 0.4 × 0.3 mm, distinctly tuberculate.

Phenology: Flowering in early autumn. Flowers faintly scented.

Pollinators: The architecture of the large bright flowers suggests a diurnal flying insect.

Habitat and aspect: Mainly confined to south-facing cliffs, in sheltered crevices in association with other succulents. Summers are hot and dry, the average daily maximum temperature about 28°C and average daily minimum about 13°C, with frost absent from the habitat. Rainfall occurs mainly in spring, autumn and winter (cyclonic cold fronts and thunder showers in late summer and autumn), 50–100 mm per annum.

Altitude: 750–1200 m.

Associated vegetation: Eastern Gariiep Rocky Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: Habitat not seen.

Geology: Metaquartzitic gneiss of the Hom Formation (Bushmanland Group).

DISTRIBUTION

Known only from Naroep in northern Bushmanland, on cliffs (Northern Cape).

RELATED SPECIES

Distinguished from related level-ground species in its more conspicuous, rounded clusters of softer bodied leaves (with purple apices). The related level-ground species are usually well camouflaged among the quartz gravel flats or outcrops.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dome-shaped clusters.

Size and weight: Clusters of light to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into soft, elongated, heart-shaped bodies, the apices lobed, somewhat diverging.

Colour: Epidermis glabrous, greyish green, dotted with large green idioblasts; fissure papillate; lobes purplish ornamented; summer sheath whitish, papery.

Age and persistence: Plants long-lived perennials.

Armament and camouflage: Plants growing in conspicuous mounds of soft-leaved bodies and in comparison to level-ground species that are well camouflaged (*Conophytum marginatum* var. *marginatum*, *C. herreanthus* and *C. regale*), this reduction in camouflage can be seen as an adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Magenta to carmine, about 35 mm in diameter, slightly scented, diurnal; petals in 1–3 series, up to 22 × 2 mm.

Fruit/Seed

Size: Seed 0.65 × 0.4 × 0.3 mm, distinctly tuberculate.

Dispersal: Hydrochory. Fruiting capsules 5- or 6-locular, 2 × 4 mm, angular, fragile, opening hydrochastically with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The distinctly tuberculate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices.

Time: Hydrochastic capsules release the seeds only in the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Common in the habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best grown under controlled greenhouse conditions. Very easily cultivated, its growth vigour possibly maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers.

VOUCHER

Van Jaarsveld 711/59 (BOL).

ILLUSTRATIONS AND MAP

Map 185.

186. *Conophytum obscurum* N.E.Br. subsp. *sponsaliorum* (S.A.Hammer) S.A.Hammer, Dumpling and his wife: new views of the genus *Conophytum*: 212 (2002).

Cremnophyte growth form: Clustered, mat-forming (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: The epithet *sponsaliorum* refers to a betrothal, a marriage or a spouse and honours the married.

DESCRIPTION AND HABITAT

Plants forming small dwarf mats (2–10 bodies). Roots fibrous. Leaves fused into obconical bodies, each body 4–12 × 3–8 × 3–8 mm, truncate at top; epidermis glabrous, shining, pale bluish green to dark green, spotted; fissure short, inconspicuous; summer sheath white, foveate. Flowers pinkish, up to 18 mm in diameter. Petals numerous, in 1 or 2 series, up to 8 × 1 mm. Fruiting capsule 4-locular, 1.5–2.0 × 2.0–2.5 mm, opening hygrochastically. Seed 0.65–0.42 × 0.32 mm, dark brown, covered with small ring- or crescent-shaped bumps. (Description based on Hammer 2002.)

Phenology: Flowering in autumn. Flowers diurnal, scentless, conspicuous.

Pollinators: Insects.

Habitat and aspect: Confined to quartz cliffs where the plants grow in sheltered crevices and on ledges (various aspects), often in shade and subject to occasional fog. The average daily maximum temperature is about 19°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 680 m.

Associated vegetation: Kahams Mountain Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: Species of *Adromischus*, *Crassula* and *Tylecodon*.

Geology: Quartz of the Stinkfontein Subgroup (Gariiep Supergroup).

DISTRIBUTION

Known only from the type locality at Skimmelberg, Richtersveld (Northern Cape).

RELATED SPECIES

Distinguished from related subspecies by its bright green bodies and very dwarf-sized, depauperate stature.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Inconspicuous mat-forming dwarf-sized clusters in fissures along ledges and crevices.

Size and weight: Clusters very small, up to 20 mm in diameter.

Stem: Very short and unexposed.

Leaves

Orientation: Fused into obconical bodies, truncate at the top, with a smooth epidermis.

Colour: Bluish green to dark green.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in spring, remaining older leaves recycled and forming a protective sheath for the successive newly formed leaves.

Armament and camouflage: Plants without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Light pink, up to 20 mm in diameter, diurnal.

Fruit/Seed

Size: Seed with large humps, efficient for establishment in crevices

Dispersal: Hydrochory, as in other *Conophytum* species.

Time: Hygrochastic capsules releasing the seeds only in the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, rooting and forming dense mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Not threatened owing to the cliff habitat.

ADDITIONAL NOTES

Horticulture: Best grown under controlled conditions in a greenhouse, in a sandy, well-drained soil mixture. Keep in dappled shade and dry in summer. Propagated from seed or by division. Introduced into ornamental horticulture by S.A. Hammer in 1995.

VOUCHER

S. Hammer 1437 (BOL).

ILLUSTRATIONS AND MAP

Map 186.

187. *Conophytum quaesitum* (N.E.Br.) N.E.Br. subsp. *densipunctum* (L.Bolus) S.A.Hammer, The genus *Conophytum*: a conograph: 238 (1993).

Cremnophyte growth form: Clustered, mat-forming growth (of light weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb)

Etymology: The epithet *densipunctum* pertains to the densely spotted leaves.

DESCRIPTION AND HABITAT

Plants forming dense cushions or mats. Roots fibrous. Leaves fused into a laterally compressed, obovate body, bilobed, lobes keeled, 15–25 × 12–15 × 8–10 mm; epidermis finely papillate, pale yellowish green, densely spotted; sheath white, densely spotted. Flowers milky white, 15 × 2 mm. Fruiting capsule 5-locular, 2 × 5 mm, opening hygrochastically. Seed 0.70 × 0.5 × 0.3 mm, densely tuberculate. (Description based on Hammer 2002.)

Phenology: Flowering in autumn. Flowers initially nocturnally scented.

Pollinators: Insects.

Habitat and aspect: Confined to the higher mountains of the Sperrgebiet (Lower Orange River Valley) in southwestern Namibia, the plants growing on shady cliffs in the fog belt. Summers are hot and dry but plants are ‘misted’ by fog from the Atlantic Ocean. The average daily maximum temperature is about 20–22°C and average daily minimum about 10–12°C, with frost absent from the habitat. Rainfall occurs mainly in winter (cyclonic cold fronts), 25–50 mm per annum.

Altitude: 1050–1200 m.

Associated vegetation: Succulent Karoo Biome.

Associated cremnophytes: Habitat not seen.

Geology: Quartzitic sandstone, gneiss.

DISTRIBUTION

Widespread in the higher mountains of the Sperrgebiet (southern Namibia).

RELATED SPECIES

Distinguished from related level-ground species by its conspicuous dome-shaped, mat-forming growths and soft bodies. The other related level-ground *Conophytum* species are usually well camouflaged, often with sunken growth and mat-forming.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dome-shaped to mat-forming clusters.

Size and weight: Clusters of light to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into a laterally compressed, obovate body, bilobed, lobes keeled.

Colour: Epidermis finely papillate, pale yellowish green, densely spotted; sheath white, densely spotted.

Age and persistence: Long-lived perennials.

Armament and camouflage: Fragile, without conspicuous armament or camouflage properties, an adaptation to the largely undisturbed habitat.

Sexual reproduction

Flowers: Scented, milky white, flowering in late autumn,

Fruit/Seed

Size: Seed $0.70 \times 0.5 \times 0.3$ mm, densely tuberculate and ideal for small establishment in crevices.

Dispersal: Hydrochory. Fruiting capsule 4–6-locular, 2×3 mm, opening hygrochastically with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large tubercles on the seed surface indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices.

Time: Hygrochastic capsules releasing the seeds only in the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Little-known species, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum quaesitum* subsp. *densipunctum* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers.

VOUCHER

Erni 2027/27 (NBG).

ILLUSTRATIONS AND MAP

Map 187.

188. *Conophytum quaesitum* (N.E. Br.) N.E. Br. subsp. *quaesitum* var. *rostratum* (Tischer) S.A.Hammer, The genus *Conophytum*: a conograph: 261 (1993).

Cremnophyte growth form: Clustered, mat-forming growth (of light weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb)

Etymology: The epithet *quaesitum*, rare or special, pertains to the plants, although they are quite common in certain regions; *rostratum*, a beak, refers to the beaked lobes of the leaves.

DESCRIPTION AND HABITAT

Plants forming dense cushions or mats. Roots fibrous. Leaves fused into a cylindrical, lobed body; lobes keeled, 25–40 × 8–15 × 8–10 mm; epidermis finely papillate, dull to bluish green, spotted or immaculate. Flowers white, straw-coloured, yellowish. Petals 8 × 2 mm. Fruiting capsule 2 × 6 mm, opening hygrochastically. Seed 0.65 × 0.5 × 0.3 mm, densely tuberculate. (Description based on Hammer 2002.)

Phenology: Flowering in late autumn. Flowers initially nocturnally scented.

Pollinators: Insects.

Habitat and aspect: Confined to the higher mountains of the Lower Orange River Valley, the plants growing on shady cliffs in the fog belt. Summers are hot and dry but plants are 'misted' by fog from the Atlantic Ocean. The average daily maximum temperature is about 20–22°C and average daily minimum about 10–12°C, with frost absent from the habitat. Rainfall occurs mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 700–1200 m.

Associated vegetation: Noms Mountain Desert and Richtersveld Mountain Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated plants include *Aloe meyeri*, *Crassula garibina*, *C. sericea* var. *hottentotta* and *Gasteria pillansii* var. *pillansii*.

Geology: Quartzitic sandstone, gneiss (Namaqua Metamorphic Complex) and quartz and conglomerate of the Stinkfontein Formation (Gariiep Supergroup).

DISTRIBUTION

Widespread in the higher mountains of the northern Richtersveld (Northern Cape).

RELATED SPECIES

Distinguished from related level-ground species by its conspicuous dome-shaped, mat-forming growths and soft bodies. The other related level-ground *Conophytum* species are usually well camouflaged, often with sunken growth and mat-forming.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dome-shaped to mat-forming clusters.

Size and weight: Clusters of light to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into broadly obovoid to almost cylindrical, lobed bodies, acutely keeled to round at apex.

Colour and texture: Epidermis finely papillate, dull to grey-green or yellowish green, spotted or immaculate; summer sheath white to pale yellow to brown, maculate. The soft texture can be viewed as a response to the undisturbed habitat.

Age and persistence: Plants long-lived perennials.

Armament and camouflage: Plants fragile, without conspicuous armament or camouflage properties, an adaptation to the largely undisturbed habitat.

Sexual reproduction

Flowers: Scented, white, straw-coloured, yellow to rose-pink, flowering in late autumn.

Fruit/Seed

Size: Seed $0.65 \times 0.5 \times 0.3$ mm, densely tuberculate and ideal for establishment in crevices.

Dispersal: Hydrochory. Fruiting capsules 4–6-locular, 2×3 mm, opening hygrochastically with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large tubercles on the seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices.

Time: Hygrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Little-known species, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum quaesitum* subsp. *quaesitum* var. *rostratum* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers.

VOUCHER

Van Jaarsveld 19944 (NBG).

ILLUSTRATIONS AND MAP

Figures 188a & 188b, Map 188.

189. *Conophytum ricardianum* Loesch & Tischer subsp. *ricardianum*, Loesch & Tischer *Monatsschrift der Deutschen Kakteen-Gesellschaft* 4: 74–76 (1932).

Cremnophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r) (ft)

Etymology: After nurseryman Richard Graessner of Perleberg.

DESCRIPTION AND HABITAT

Plants forming dense mats of 10–60 bodies and up to 120 mm in diameter. Roots fibrous. Leaves fused into turbiniform bodies, each body 20 mm in diameter, truncate at top; epidermis pale green, glabrous, very fragile, soft; fissure very small; summer sheath vertically fluted, pale yellowish brown, well-spotted. Flowers milky white, up to 34 mm in diameter. Petals numerous, in 2 or 3 series, up to 15 × 3 mm, spatulate. Fruiting capsule 3 × 3 mm, opening hygrochastically. Seed 0.8 × 0.45 × 0.35, pale brown, pustulate. (Description based on Hammer 2002.)

Phenology: Flowering in late autumn. Flowers conspicuous, diurnal, in profusion.

Pollinators: Insects.

Habitat and aspect: Confined to south-facing cliffs (reddish sandstone) of hills overlooking the Orange (Gariep) River, the plants growing in crevices and on ledges of the upper slopes in ample soil in the fog zone. Summers are hot and dry but plants are ‘misted’ by regular fog from the Atlantic Ocean (some 80 km from the coast). The average daily maximum temperature is about 20°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 400–1200 m.

Associated vegetation: Richtersveld Sheet Wash Desert of the Desert Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other cremnophytes observed at Kuamsib include *Aloe pavelkae*, *Conophytum quaesitum* var. *rostratum*, *Crassula velutina*, *Gasteria pillansii* var. *ernesti-ruschii* and *Tylecodon torulosus*.

Geology: Rough quartz of the Rosyntjieberg Formation (Orange River Group).

DISTRIBUTION

Confined to the Lorelei in the west, to the Kuamsib Mountains in the east and mountains of the Richtersveld Transfrontier National Park (Northern Cape and Namibia) and adjacent hills in Namibia, and within the fog zone.

RELATED SPECIES

Distinguished from related level-ground *Conophytum* species (*C. wettsteinii* group) by its large, conspicuous, very soft, fragile mats. The other level-ground *Conophytum* species usually have firm bodies.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters up to 120 mm in diameter, rooting in narrow crevices.

Size and weight: Clusters of light to medium weight.

Stem: Short, branched and unexposed.

Leaves

Orientation: Fused into turbiniform bodies, turbinate and truncate at the top.

Colour: Green. Epidermis smooth, very fragile; summer sheath vertically fluted, pale yellowish brown, well-spotted.

Age and persistence: Plants slow-growing, long-lived perennials, becoming dormant in spring, remaining older leaves recycled and becoming a protective sheath for the successive newly formed leaves.

Armament and camouflage: Plants with very fragile bodies, without conspicuous armament or camouflage properties.

Sexual reproduction

Flowers: Milky white, up to 34 mm in diameter (same diameter as leaf body), opening towards late afternoon; petals numerous, in 2 or 3 series, up to 15×3 mm, when in flower, bodies hardly visible. The rich flowering and floriferous nature can be seen as an adaptation to the cliff environment, maximising visibility.

Fruit/Seed

Size: Seed $0.8 \times 0.45 \times 0.35$ mm, densely pustulate.

Dispersal: Hydrochory. Hygrochastic capsules 3×3 mm, opening with rain but seeds dispersed by 'wash-out dispersal' (Hartmann 1988), thus also a strategy for local dispersal.

Time: Seeds released during the rainy season in winter, maximising establishment.

Vegetative reproduction: Increasing vegetatively, forming small, dense mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Well-protected within the Ai-Ais Richtersveld Transfrontier National Park and also by the cliff-face habitat. A little-known species, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum ricardianum* is best grown under controlled conditions in a greenhouse. Very easily cultivated compared to level-ground species; the growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Allow for a summer rest. Best grown in partial shade in small containers. Dividing annually and rapidly forming dense clusters. Cultivated by mesemb enthusiasts.

VOUCHER

Van Jaarsveld 21087 (NBG).

ILLUSTRATIONS AND MAP

Plate 189, Figures 189a–189c, Map 189.

190. *Conophytum stephanii* Schwantes subsp. *stephanii*, Schwantes in Die Gartenwelt 33: 25 (1929).

Cremonophyte growth form: Clustered, mat-forming growth (of light weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (ft) (r)

Etymology: After Paul Stephan, who was Curator of the succulent plant collection of the Hamburg Botanical Gardens.

DESCRIPTION AND HABITAT

Plants forming many-headed, dome-shaped clusters up to 50 mm in diameter. Roots fibrous. Leaves fused into subglobose bodies, each body 7–15 × 4 – 8 × 4 mm; apices convex or somewhat truncate; epidermis olive-green to reddish brown, very hairy owing to dense, tapering, translucent white papillae up to 1.5 mm long. Flowers about 6–8 mm in diameter, reddish, reddish yellow to bronze. Fruiting capsule 3–5-locular, 3 × 4 mm, globose, fragile, hairy. Seed 0.7 × 0.5 × 0.4 mm, finely pustulate. (Description based on Hammer 2002.)

Phenology: Flowering in early autumn. Flowers nocturnal, strongly scented, suggesting a night-flying pollinator.

Pollinators: The nocturnal flowers (becoming diurnal) suggest a night-flying insect.

Habitat and aspect: Confined to quartz cliff faces, the plants growing on shady southern aspects. Summers are hot and dry but plants are occasionally ‘misted’ by fog from the Atlantic Ocean. The average daily maximum temperature is about 26°C and average daily minimum about 10–12°C, with frost absent from the habitat. Rainfall mainly in winter (cyclonic cold fronts), late summer and autumn (thunder showers), 25–50 mm per annum.

Altitude: 600–1169 m.

Associated vegetation: Rosyntjieberg Succulent Shrubland and Namaqualand Klipkoppe Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnoophytes: Associated succulents observed on the Rosyntjieberg include *Aloe meyeri*, *Crassula garibina*, *C. sericea* var. *hottentotta*, *Trachyandra aridimontana* and *Tylecodon ellaphieae*.

Geology: Quartzitic sandstone, gneiss (Namaqua Metamorphic Complex) and quartz of the Stinkfontein Formation (Gariiep Supergroup).

DISTRIBUTION

Confined to Vyftienmyl se Berge (Oograbies Mountains) near the Port Nolloth coast (Northern Cape).

RELATED SPECIES

Distinguished from related level-ground species in the section *Barbata* (*Conophytum depressum* and *C. phoeniceum*, larger sized, solitary or little branched) by its conspicuous globose clusters of densely hairy bodies. These related level-ground species are usually well camouflaged, often with sunken growth or inconspicuous dwarf-sized mats.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dome-shaped clusters.

Size and weight: Clusters medium-sized.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into subglobose bodies, the apices convex or somewhat truncate.

Colour and texture: Epidermis olive-green to reddish brown, very hairy owing to the dense, tapering, translucent white papillae up to 1.5 mm long. The densely hairy nature of the plant bodies and the habitat that receives regular fog indicate a moisture-trapping adaptation. Summer sheath whitish, densely papillate, perforate, an adaptation to the long, dry summers.

Age and persistence: Long-lived perennials.

Armament and camouflage: Plants bodies are soft, without conspicuous armament or camouflage properties as opposed to level-ground species that are well camouflaged (*Conophytum phoeniceum* and *C. depressum*). This reduction in camouflage can be seen as an adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Reddish, reddish yellow to bronze, about 6–8 mm in diameter, strongly scented, flowering in early autumn, nocturnal, suggesting a night-flying specialist pollinator (insect).

Fruit/Seed

Size: Seed $0.7 \times 0.5 \times 0.4$ mm, finely pustulate.

Dispersal: Hydrochory. Fruiting capsules 3–5-locular, 3×4 mm, globose, fragile, hairy, opening hygrochastically with rain, but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large, tuberculate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices.

Time: Hygrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Increasing vegetatively, forming small, dense mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

A little-known species, not threatened owing to the inaccessible habitat and some of the population being within the Richtersveld Transfrontier National Park.

ADDITIONAL NOTES

Horticulture: *Conophytum stephanii* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers.

VOUCHER

Van Jaarsveld 19130 (NBG).

ILLUSTRATIONS AND MAP

Plate 190, Figures 190a–190e, Map 190.

191. *Conophytum tantillum* N.E.Br. subsp. *amicorum* S.A.Hammer & Barnhill in *Bradleya* 15: 42–43 (1997).

Cremonophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: According to Hammer (2002), subsp. *amicorum* was named by two of the four ‘amis’ who found it simultaneously.

DESCRIPTION AND HABITAT

Plants forming dome-shaped clusters up to 80 mm in diameter. Roots fibrous. Leaves fused into narrow obcordate bodies; apices bearing blunt keels, slightly curved, ornamented, each body 15–20 × 8–10 × 5–7 mm; epidermis pale greyish green with a few scattered dots, papillate; sheath light brown, spotted. Flowers diurnal, about 20 mm in diameter, golden yellow. Petals in 1 or 2 series, up to 8 × 2 mm. Fruiting capsule 4- or 5-locular, 2 × 2 mm, angular, fragile. Seed 0.7 × 0.5 × 0.3 mm, pustulate.

Phenology: Flowering in early autumn. Flowers scentless, suggesting a night-flying pollinating insect.

Pollinators: The architecture of the bright flowers suggests a diurnal flying insect.

Habitat and aspect: Confined to the western escarpment fringe where it grows on inaccessible cliffs but occasionally also on other accessible sandstone pockets. The plants occur in association with other succulent plants on sheltered south-facing aspects. Summers are hot and dry but plants are occasionally ‘misted’ by fog from the Atlantic Ocean. The average daily maximum temperature is about 24°C and average daily minimum about 9°C, with frost absent from the habitat. Rainfall occurs mainly in winter (cyclonic cold fronts), late summer and autumn (thunder showers), 150–250 mm per annum.

Altitude: 850 m.

Associated vegetation: Umdaus Mountains Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: Other succulents in the habitat include *Adromischus alstonii*, *Crassula atropurpurea* var. *watermeyerii* and *Tylecodon paniculatus*.

Geology: Quartzitic cliffs of the Kuibis Subgroup (Nama Group).

DISTRIBUTION

South of Steinkopf, Richtersveld (Northern Cape).

RELATED SPECIES

Distinguished from related level-ground species in the section *Minuscula* by its slightly larger, conspicuous bodies. The related level-ground species are usually well camouflaged among the lichen and moss-filled stone pockets.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous dense clusters.

Size and weight: Clusters of light to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into narrow, obcordate bodies, the apices with blunt keels, slightly curved and ornamented.

Colour and texture: Epidermis pale greyish green, with a few scattered dots, papillate.

Age and persistence: Plants long-lived perennials.

Armament and camouflage: Plants are soft-leaved bodies without conspicuous armament or camouflage properties and in comparison to level-ground species that are well camouflaged (*Conophytum swanepoelianum*, *C. minusculum*, *C. rubrolineatum*), this reduction in camouflage can be seen as an adaptation to the largely undisturbed cliff-face habitat.

Sexual reproduction

Flowers: Scentless, about 20 mm in diameter, diurnal, flowering in early autumn; petals in 1 or 2 series, up to 8×2 mm.

Fruit/Seed

Size: Seed $0.7 \times 0.5 \times 0.3$ mm, pustulate.

Dispersal: Hydrochory. Fruiting capsule 4- or 5-locular, 3 × 2 mm, angular, fragile, opening hygrochastically with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large, pustulate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices.

Time: Hygrochastical capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Common in the habitat, not threatened.

ADDITIONAL NOTES

Horticulture: *Conophytum tantillum* subsp. *amicorum* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers.

VOUCHER

Barnhill, Hammer, Rogerson & Tribble 2296 (BOL).

ILLUSTRATIONS AND MAP

Figures 191a & 191b, Map 191.

192. *Conophytum taylorianum* (Dinter & Schwantes) N.E.Br. subsp. *ernianum* (Loesch & Tischer) de Boer ex S.A.Hammer, *The genus Conophytum: a conograph*: 240 (1993). (Hohenzollern obligate cremnophilous form.)

Cremonophyte growth form: Clustered, mat-forming (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: The species was named after the British mesemb enthusiast Edward Taylor (1848–1928); the subspecific epithet honours Franz Sales Erni (1878–1952) from near Aus, Namibia.

DESCRIPTION AND HABITAT

Plants forming dense mats up to 400 mm in diameter. Roots fibrous. Leaves fused into laterally compressed, obcordate, bilobed, soft bodies, each body 15–35 × 12–20 × 10–14 mm,

lobes diverging at apex, unequal and chin-like, with sharp, sinuate, pinkish keels; epidermis grey-green, glabrous to finely papillate; summer sheath white, spotted. Flowers diurnal, up to 30 mm in diameter, bright rosy magenta. Petals numerous, in 2 or 3 series, up to 15×2 mm. Fruiting capsule 5-locular, 4×6 mm, depressed obovate, opening hygrochastically. Seed $0.8 \times 0.5 \times 0.4$ mm, tuberculate, dark brown. (Description based on Hammer 2002.)

Phenology: Flowering in autumn. Flowers slightly scented, conspicuous.

Pollinators: Insects.

Habitat and aspect: Confined to shady south-facing cliffs of the Hohenzollern Mountain where the plants grow in the fog belt. Summers are hot and dry but plants are 'misted' by fog from the Atlantic Ocean. The average daily maximum temperature is about 20°C and average daily minimum about 9°C , with frost absent from the habitat. Rainfall occurs mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 600–1200 m.

Associated vegetation: Succulent Karoo.

Associated cremnophytes: Associated plants include *Conophytum angelicae* and *Crassula ausensis*.

Geology: Hard sandstone (Nama Group).

DISTRIBUTION

Conophytum taylorianum subsp. *ernianum* has a fairly wide distribution from the Sperrgebiet along the coast to Hohenzollern in the east.

RELATED SPECIES

Distinguished from related level-ground *Conophytum* species by its conspicuous globose clusters. The other level-ground *Conophytum* species are usually well camouflaged, often with sunken growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters in quartz crevices.

Size and weight: Clusters of light to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into laterally compressed, obcordate, soft, bilobed bodies, the lobes diverging at the apex, unequal and chin-like with sharp sinuate pinkish keels.

Colour and texture: Epidermis grey-green, glabrous to finely papillate; summer sheath white, spotted.

Age and persistence: Plants slow-growing, long-lived perennials.

Armament and camouflage: Plants fragile, without conspicuous armament or camouflage properties, an adaptation to the largely undisturbed habitat.

Sexual reproduction

Flowers: Bright rosy magenta, up to 30 mm in diameter, diurnal; petals numerous, in 2 or 3 series, up to 15×2 mm.

Fruit/Seed

Size: Seed $0.8 \times 0.5 \times 0.4$ mm, tuberculate, dark brown.

Dispersal: Hydrochory. Hygrochastic capsules depressed obovate, 2×3 –4 mm, opening with rain but seeds dispersed by ‘wash-out dispersal’ (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large, tuberculate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices (compared to other *Conophytum* species).

Time: Hygrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

A little-known species, not threatened owing to the sheer cliff habitat and its distribution within the Richtersveld Transfrontier National Park.

ADDITIONAL NOTES

Horticulture: *Conophytum taylorianum* subsp. *ernianum* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers.

VOUCHER

Van Jaarsveld 21032 (NBG).

ILLUSTRATIONS AND MAP

Plate 192, Figures 192a–192d, Map 192.

193. *Conophytum taylorianum* (Dinter & Schwantes) N.E.Br. subsp. *rosynense* S.A.Hammer, The genus *Conophytum*: a conograph: 265 (1993).

Crempnophyte growth form: Clustered, mat-forming growth (of light to medium weight, cliff hugger).

Growth form formula: A:S:Lar:Lf (vb) (r)

Etymology: The species was named after the British mesemb enthusiast Edward Taylor (1848–1928), and the subspecies after the Rosyntjieberg in the Richtersveld, Northern Cape.

DESCRIPTION AND HABITAT

Plants forming rounded clusters up to 80 mm in diameter. Roots fibrous. Leaves fused into laterally compressed, obcordate, bilobed, soft bodies, each body 10–25 × 12–18 × 10–12 mm, lobes diverging at apex, unequal, chin-like, with sharp, sinuate, reddish keels; epidermis grey-green, finely papillate; summer sheath pale brown. Flowers diurnal, up to 45 mm in diameter, bright rosy magenta. Petals numerous, in 2 or 3 series, 12–22 mm long. Fruiting capsule 5-locular, 2 × 3–4 mm, depressed obovate, opening hygrochastically. Seed 0.8 × 0.5 × 0.4 mm, tuberculate. (Description based on Hammer 2002.)

Phenology: Flowering in midsummer. Flowers slightly scented, conspicuous.

Pollinators: Insects.

Habitat and aspect: Confined to shady south-facing cliffs of the Rosyntjieberg, the plants growing in the fog belt. Summers are hot and dry but plants are ‘misted’ by fog from the Atlantic Ocean. The average daily maximum temperature is about 20°C and average daily minimum about 9°C, with frost absent from the habitat. Rainfall occurs mainly in winter (cyclonic cold fronts), 50–100 mm per annum.

Altitude: 600–1200 m.

Associated vegetation: Rosyntjieberg Succulent Shrubland of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated crempnophytes: Associated plants include *Aloe meyeri*, *Conophytum angelicae* subsp. *tetragonum*, *C. stephanii*, *Ficus ilicina* and *Trachyandra aridimontana*.

Geology: Hard quartz of the Rosyntjieberg Formation (Orange River Group).

DISTRIBUTION

Confined to the Rosyntjieberg Mountains north of the Richtersveld.

RELATED SPECIES

Distinguished from related level-ground *Conophytum* species by its conspicuous globose clusters. The level-ground *Conophytum* species are usually well camouflaged, often with sunken growth.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous globose clusters in quartz crevices.

Size and weight: Clusters of light to medium weight.

Stem: Short, usually unexposed.

Leaves

Orientation: Fused into laterally compressed, obcordate, soft, bilobed bodies, the lobes diverging at the apex, unequal and chin-like with sharp, sinuate, reddish keels.

Colour and texture: Epidermis grey-green, finely papillate; summer sheath pale brown.

Age and persistence: Plants slow-growing, long-lived perennials.

Armament and camouflage: Plants fragile, without conspicuous armament or camouflage properties, an adaptation to the largely undisturbed habitat.

Sexual reproduction

Flowers: Conspicuous, bright rosy magenta, up to 45 mm in diameter, diurnal. The rich flowering and floriferous nature can be seen as an adaptation to the cliff environment, maximising visibility.

Fruit/Seed

Size: Seed $0.8 \times 0.5 \times 0.4$ mm, tuberculate.

Dispersal: Hydrochory. Hydrochastic capsules depressed obovate, $2 \times 3-4$ mm, opening with rain but seeds dispersed by 'wash-out dispersal' (Hartmann 1988). The capsules have broad rectangular valve wings, no covering membranes. Rain fills the saucer-like cavity of the capsule and the seeds are washed out and down the cliffs, succumbing to gravity until they become wedged in a crevice. The large, tuberculate seeds indicate adaptation to the cliff habitat and this method of dispersal, providing good anchorage for seedlings in the quartz crevices (compared to other *Conophytum* species).

Time: Hydrochastic capsules releasing the seeds only during the rainy season, maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming small, dense, tight mats or clusters, the active vegetative growth an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

A little-known species, not threatened owing to the sheer cliff habitat and its occurrence within the Richtersveld Transfrontier National Park.

ADDITIONAL NOTES

Horticulture: *Conophytum taylorianum* subsp. *rosynense* is best grown under controlled conditions in a greenhouse. Very easily cultivated and its growth vigour can be viewed as maximising survival. Propagate from seed, cuttings or by division. Keep dry from late spring to summer. Best grown in partial shade, in sandy soil in small containers.

VOUCHER

Van Jaarsveld 5518 (NBG).

ILLUSTRATIONS AND MAP

Plate 193, Figures 193a–193e, Map 193.

DELOSPERMA N.E.Br. emend Lavis

194. *Delosperma* sp. A

Cremonophyte growth form: Pendent to procumbent mats, rooting at nodes (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb) (r)

DESCRIPTION AND HABITAT

Plants mat-forming and pendent from cliff faces, with stems up to 500 mm long forming loose clusters. Roots fibrous. Branches 1.8–2.0 mm in diameter, soft, brittle, terete, at first reddish green, becoming grey-green; nodes 12–15(–30) mm apart; surface glabrous, or with scattered hairs when young. Leaves fleshy, dorsiventrally compressed, ovate, narrowly ovate to linear-ovate, occasionally elliptic to linear-oblongate, slightly cymbiform and with obscure keel, 25–35 × 7–12 mm, spreading to slightly recurved; surface smooth, shiny green, occasionally hairy when young becoming glabrescent; margin entire to ciliate, reddish towards apex; apex acute, with green to reddish mucro. Flowers axillary, solitary, 20–25 mm in diameter; pedicels 8–10 mm long. Receptacle cup-shaped, 3 mm deep, 10 mm in diameter, bearing 2 outer ovate sepals 7–8 × 4 mm and 3 smaller obovoid sepals 3 × 2.5 mm, with membranous margins and pointed apices, with scattered hairs. Petals magenta, mauve or yellow, in 2 series, the outer linear-lanceolate, up to 15 × 1.3–1.5 mm, the inner shorter and narrower, 5 × 0.2 mm. Stamens in 3 series, 3–5 mm long, at first overtopping stigmas; filaments white to light mauve, hairy; anthers 0.7–1.0 mm, yellowish. Ovary elevated to about 2 mm, 5-lobed; stigmas 5, lanceolate, 2 mm long, papillate; nectaries dark green, 2 × 0.3 mm. Capsule top-shaped, 8–10 mm in diameter, grey, with old petals persistent and becoming blackish; covering membranes lacking, valve wings present, closing bodies absent. Seed pear-shaped, 0.5 × 0.4 mm, tuberculate, pale brown.

Phenology: Flowering from spring to autumn with a peak in midsummer, but occasionally at other times of the year.

Pollinators: Insects.

Habitat and aspect: Sheltered cliffs, from coastal rivers to sunny kloofs (mainly eastern, southern and western aspects). Plants tend to root at the nodes and extend their range by runners. Temperatures are moderate and subtropical. Winters are cool but frost is absent. The average daily maximum temperature is about 24°C and the average daily minimum temperature is about 16°C. Rainfall occurs mainly in summer but at times also in winter, ranging from 1000–1250 mm per annum.

Altitude: 200–250 m.

Associated vegetation: Pondoland-Ugu Sandstone Coastal Sourveld.

Associated cremnophytes: At Mzamba (Eastern Cape), the habitat is shared with *Aloe arborescens*, *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula orbicularis*, *C. perfoliata* var. *minor*, *C. perforata* and *Gasteria croucheri*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Natal Formation (Cape Supergroup).

DISTRIBUTION

Delosperma sp. A is confined to the coastal quartzitic sandstone gorges in southern KwaZulu-Natal (Mtamvuna region) and the northeastern extreme of the Eastern Cape (Mzamba River).

RELATED SPECIES

Delosperma sp. A is at once distinguished from *D. rogersii* by its procumbent growth, with larger, dorsiventrally flattened leaves and larger flowers of 20–25 mm in diameter. *Delosperma rogersii* form loose mats with decumbent, sturdy branches, oblong, triquetrous leaves 10–20 × 7 mm and smaller flowers about 19 mm in diameter. *Delosperma rogersii* is a widespread species common in the dry river valleys of the Eastern Cape such as the Bashee and Kei Rivers (shale and occasionally sandstone), and is especially common on cliffs and steep, exposed, rocky terrain. It also occurs in light shade of short shrubby vegetation. The associated vegetation is thicket and the plants are variable in leaf hairiness and flower colour. The leaves are sometimes densely arranged, almost imbricate, especially in exposed habitats. The flowers are mainly yellow, but pink- and mauve-flowered populations are also found. *Delosperma rogersii* is also cultivated locally as a ground cover. It is a long-lived perennial and is drought tolerant.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants bearing long, pendent, leafy stems, a habit that is retained in cultivation. A rapid-growing, fairly long-lived perennial.

Size and weight: Plants small.

Rootstock: Roots fibrous, no specialised features.

Stem: The internodes of the long, pendent branches are 12–30 mm long, an adaptation to the vertical cliff face without much competition or predation. Stems and leaves soft and fragile.

Leaves

Orientation: Spreading, sometimes somewhat recurved.

Colour and texture: Green, sometimes shiny, fleshy, soft, becoming turgid after rain, but withered during dry periods, an adaptation to the extreme, dry habitat. Leaves are hairy or glabrous, sometimes only the margin fringed with hairs.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: The plants have no obvious armament.

Sexual reproduction

Flowers: Mauve, pink or yellow, simple, axillary produced, conspicuous, with conspicuous yellow stamens, maximising visibility for successful pollination in the vertical cliff environment. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed 0.5×0.4 mm, pear-shaped, tuberculate, the size ideal for establishment in crevices.

Dispersal: Pale brown seeds locally dispersed by rainwater ('wash-out dispersal', Hartmann 1991), settling in crevices where they germinate.

Time: Seeds ripening throughout summer and autumn. Germination after 14–21 days.

Vegetative reproduction: Plants increase vegetatively, forming drooping mats rooting at nodes. This active vegetative growth will root when coming into contact with new crevices below, an effective vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens and ideal for embankments, balconies, window sills as well as hanging baskets. Best grown in partial shade. Propagate from cuttings in a sandy mixture. Plants thrive in cultivation. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 19294 (NBG).

ILLUSTRATIONS AND MAP

Figures 194a–194c, Map 194.

195. *Delosperma* sp. B

Cremonophyte growth form: Pendent to procumbent leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

DESCRIPTION AND HABITAT

Plants mat-forming and pendent from cliff faces with stems up to 800 mm long, forming loose clusters. Roots fibrous. Branches 1.8 mm in diameter, soft, brittle, terete, green to grey-green; nodes 12–55 mm apart (leaves crowded towards branch ends); surface hairy; hairs multicellular, translucent, up to 0.5 mm long. Leaves fleshy, dorsiventrally compressed, narrowly elliptic to linear-oblongate, slightly cymbiform and with obscure keel, 20–40 × 5–9 mm, ascending to recurved; surface dull green, densely hairy (velvety), sometimes slightly uneven and wrinkled; apex acute, with green to reddish, sharply pointed mucro. Flowers solitary, 20–25 mm in diameter; pedicels slender, 20–40 mm long. Receptacle cup-shaped, 2 mm deep, 5–6 mm in diameter, bearing 2 outer linear-lanceolate sepals 8 × 3 mm and 3 smaller obovoid sepals 3 × 4 mm, with membranous margins and pointed apices. Petals mauve, in 2 series, the outer linear-lanceolate, up to 12 × 1–1.3 mm, the inner shorter and narrower, 5 × 0.2 mm. Stamens in 3 series, 3–5 mm long, at first overtopping stigmas; filaments light mauve; anthers 0.7 mm long, yellowish. Ovary pointed, 1.8 mm high, 5-ridged; stigmas 5, lanceolate, 2.5 mm long, papillate; nectaries dark green, 1.5 × 0.3 mm. Capsule obconical, 9 mm in diameter; covering membranes lacking, valve wings present, closing bodies absent. Seed pear-shaped, up to 1 × 0.6–0.7 mm, tuberculate, pale brown.

Phenology: Flowering mainly from spring to autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs of narrow shady kloofs (mainly eastern, southern and western aspects). Plants are rooted in crevices and on ledges, drooping over the rock faces. Winters are cool but frost is absent. Temperatures moderate, the average daily maximum about 24°C and average daily minimum about 16°C. Rainfall occurs mainly in summer, but occasionally also in winter, 1000–1250 mm per annum.

Altitude: 150–250 m.

Associated vegetation: Pondoland-Ugu Sandstone Coastal Sourveld of the Indian Ocean Coastal Belt (*Mucina et al.* 2005).

Associated cremnophytes: At Luputana (Eastern Cape), the habitat is shared with *Aloe arborescens*, *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula orbicularis*, *C. perfoliata* var. *minor* and *C. perforata*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Natal Formation (Cape Supergroup).

DISTRIBUTION

Delosperma sp. B is a quartzitic sandstone endemic, as yet known only from the narrow Luputana Gorge (northern Transkei, Eastern Cape).

RELATED SPECIES

Related to *Delosperma* sp. A, *Delosperma obtusum* and *D. tradescantioides*. *Delosperma* sp. B is at once distinguished from *Delosperma* sp. A by its linear-oblongate, densely hairy leaves (surface often mat and wrinkled), slender pedicels 20–40 mm long, slightly smaller flowers of which the petals are 12×1.0 – 1.3 and larger seed of 1×0.6 – 0.7 mm. *Delosperma obtusum* is a much-branched, vigorous, scrambling species with semiterete leaves that grows at higher altitudes along the Drakensberg. *Delosperma tradescantioides* has larger, firmer, triangular-ovate leaves and is widespread in the Eastern Cape.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with long, pendent, leafy stems, a habit that is retained in cultivation. A rapid-growing, fairly long-lived perennial.

Size and weight: Small.

Rootstock: Roots fibrous, no specialised features.

Stem: The internodes of the long, pendent branches are up to 55 mm long, an adaptation to the vertical cliff face without much competition or predation. Stems and leaves soft and fragile.

Leaves

Orientation: Ascending-spreading.

Colour and texture: Pale green, fleshy, soft, becoming turgid after rain, but withered during dry periods, an adaptation to the extreme, dry habitat.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: The unarmed plant is dependent on the protection of the cliff face against larger herbivores.

Sexual reproduction

Flowers: Mauve, simple, axillary produced, conspicuous, with conspicuous yellow stamens, maximising visibility for successful pollination in the vertical cliff environment. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed up to $1 \times 0.6\text{--}0.7$ mm, pear-shaped, tuberculate.

Dispersal: Pale brown seeds locally dispersed by water ('wash-out dispersal', Hartmann 1991).

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Plants increase vegetatively, forming dense mats that soon become pendent, the branches (vegetative growth) rooting where they find new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for subtropical coastal gardens and ideal for embankments, balconies, window sills and hanging baskets. Grow in partial shade. Propagate from cuttings in a sandy mixture. Plants do well in cultivation. Its very easy growing nature maximises its survival rate.

VOUCHER

Van Jaarsveld 16405 (NBG).

ILLUSTRATIONS AND MAP

Figures 195a–195d, Map 195.

196. *Delosperma esterhuyseniae* L.Bolus in *Journal of South African Botany* 25: 259–260 (1959).

Cremonophyte growth form: Pendent loose mats, succulent leaves crowded towards branch ends (of light to medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb) (r)

Etymology: After Elsie Esterhuysen (1912–2006) of the University of Cape Town, very prolific plant explorer, mountaineer and botanist.

DESCRIPTION AND HABITAT

Plants forming dwarf clusters with pendulous stems up to 120 mm long from a lignified semisucculent base up to 15 mm in diameter. Branches up to 3 mm in diameter, becoming corky and thicker with age, usually with 2 pairs of functional leaves at apices, withering from the base. Leaves thick, succulent, laterally compressed, club-shaped viewed from the side, cymbiform, with eccentric keel, up to 36×8 mm; surface minutely papillose, yellowish to purplish green; apex obtuse. Flowers solitary, up to 40 mm in diameter, with white to light pink Stamnodes. Receptacle top-shaped, about 10 mm in diameter, bearing 2 club-shaped sepals 6 mm long and 3 ovate sepals up to 5 mm long. Petals in 6 series, outer linear-lanceolate, up to 22×1.5 mm, inner shorter, narrower. Stamens in 3 series, up to 3 mm long; filaments yellowish green. Stigmas 5, lanceolate, 1.5–3 mm long, papillate. Capsule obconic, 9 mm in diameter; covering membranes lacking, valve wings present, closing bodies absent. Seed up to 1 mm in diameter, pale brown.

Phenology: Flowering mainly from spring to summer.

Pollinators: Insects.

Habitat and aspect: Cliffs of narrow shady kloofs (mainly eastern and western aspects). Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperatures are high in summer and can reach 40°C. Winters are cooler but frost is absent. The average daily maximum temperature is 26–27°C and the average daily minimum about 9–11°C. Rainfall occurs throughout the year but with a peak in spring and summer (thunder showers or cyclonic winter rain), 200–300 mm per annum.

Altitude: 400–1200 m.

Associated vegetation: Kouga Grassy Sandstone Fynbos of the Fynbos Biome as well as Gamka Thicket and Groot Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Gert Smitskloof (Baviaanskloof), the habitat is shared with *Albuca cremnophila*, *Cotyledon tomentosa*, *Crassula perfoliata* var. *minor*, *C. perforata* and *Gasteria rawlinsonii*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup). Plants tightly wedged in cracks, ledges and fissures.

DISTRIBUTION

Delosperma esterhuyseniae is a quartzitic sandstone endemic, confined to the narrow kloofs (north-south orientation) of the Aasvoëlberg northwest of Willowmore, Baviaanskloof and Groot Winterhoek Mountains of the Eastern Cape.

RELATED SPECIES

Related to *Delosperma ecklonis*, a much-branched, vigorous, scrambling dwarf shrub with hairy leaves and smaller flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants firmly rooted in crevices, forming small, tight mats, often becoming drooping and with the soft, fragile leaves apically grouped. This habit is retained in cultivation. A rapid-growing, fairly long-lived perennial.

Size and weight: Heads small and within the miniature size range.

Rootstock: The slightly thickened rootstock grows firmly wedged in crevices.

Stem: The short branches (up to 40 mm) are grey, with older leaves withering. The stems are fibrous and strong.

Leaves

Orientation: Spreading-ascending.

Colour and texture: Pale green, glaucous, very fleshy, soft, becoming turgid after rain, but withered during dry periods, an adaptation to the extreme, dry habitat.

Age and persistence: Leaves becoming deciduous from the base, resulting in apical grouping.

Armament: The soft leaf texture suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Flowers: White to light pink, simple, large for such a small plant, with conspicuous yellow stamens, maximising visibility for successful pollination on the shady vertical cliffs. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed up to 1mm in diameter, an ideal size for establishment in crevices.

Dispersal: Seeds dispersed by rainwater ('wash-out dispersal', Hartmann 1991), settling and germinating in crevices.

Time: Seeds ripening throughout summer and autumn, coinciding with the start of the rainy season. Germination after 14–21 days.

Vegetative reproduction: Plants increase vegetatively, the active vegetative growth rooting where it comes into contact with new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

Not threatened, a local endemic well protected by the habitat and furthermore occurring within a nature reserve.

ADDITIONAL NOTES

Horticulture: Best grown in thicket gardens, in rockeries or containers. Outside its native habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings or seed in a sandy mixture. It does well in cultivation and should preferably be kept in dappled shade. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 7245, 16078 (NBG).

ILLUSTRATIONS AND MAP

Plate 196, Figures 196a–196d, Map 196.

197. *Delosperma knox-daviesii* Lavis in Journal of South African Botany 32: 209–210 (1966).

Cremonophyte growth form: Pendent leafy stems (of light to medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: After Mr C.N. Knox-Davies.

DESCRIPTION AND HABITAT

Plants branched, soft, fragile, procumbent, fast-growing, short-lived, perennial shrublets, sometimes mat-forming on cliffs and becoming pendent, with stems up to 200 mm long; tips of flowering branches often dying back to central clusters. Roots fibrous. Branches glabrous, becoming woody, soft and green at first, terete; internodes on vegetative branches 10–30 mm long, spreading. Leaves decussate, sometimes crowded owing to short internodes, dorsiventrally flattened, linear-elliptic, linear-ob lanceolate to lanceolate-obovate, 15–35 × 6–8 mm; surface glabrous, abaxial surface convex; apex acute, mucronate. Flowers terminal, solitary or in loose apical cymes, 20–24 mm in diameter; pedicels 8–12 mm long. Receptacle top-shaped, 3 mm deep, bearing 2 outer linear-lanceolate sepals 4 × 1.5 mm and 3 much shorter sepals. Petals linear-lanceolate, up to 12 × 2–2.5 mm, mauve, centre white. Staminodes white, linear, overtopping stamens. Capsule top-shaped, up to 6 mm in diameter. Seed pear-shaped, up to 1 × 0.5–0.8 mm, tuberculate, brown.

Phenology: Flowering mainly from spring to summer.

Pollinators: Insects.

Habitat and aspect: Cliffs of the upper eastern escarpment margin (Mpumalanga), on all aspects. Plants are rooted in crevices and on ledges, drooping over rock faces. Temperatures moderate, average daily maximum about 24°C and average daily minimum about 12°C. Winters are cooler, with light frost. Rainfall mainly in summer, 700–800 mm per annum.

Altitude: 1500 m.

Associated vegetation: Northern Escarpment Quartzite Sourveld of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Blyderivierspoort (Mpumalanga), the habitat is shared with *Aeollanthus parvifolius*, *Aloe arborescens*, *A. spicata*, *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula setulosa*, *C. swaziensis*, *Cyanotis speciosus*, *Otiophora cupheoides*, *Scilla natalensis*, *Senecio orbicularis* and *Thorncroftia succulenta*.

Geology: Quartzitic sandstone, Chuniespoort Group (Black Reef Formation, Transvaal Supergroup).

DISTRIBUTION

Delosperma knox-daviesii occurs on the escarpment edge in the Mpumalanga Drakensberg. It is confined to exposed cliffs.

RELATED SPECIES

Related to *Delosperma obtusum* and *Delosperma* sp. A, the former with semiterete leaves and from higher altitudes along the southern Drakensberg. *Delosperma* sp. A is a procumbent species with larger axillary flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming mats and stems becoming pendent, the old flowering branches dying back. A fast-growing, short-lived perennial.

Size and weight: Plants small (200–300 mm in diameter).

Rootstock: Roots fibrous, no specialised features.

Stem: Short to long and sometimes drooping.

Leaves

Orientation: Spreading (shade), to densely crowded (full light).

Colour and texture: Pale to purplish green, soft and fragile, becoming turgid after rain, but withered during dry periods.

Age and persistence: Persistent.

Armament: The soft, fragile nature suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the grazed grassland and subtropical forest.

Sexual reproduction

Inflorescence and flowers: Mainly mauve but also pink or magenta, simple or in terminal cymes, conspicuous, maximising visibility for successful pollination in the cliff and ledge

environment. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed small, $1 \times 0.5\text{--}0.8$ mm, tuberculate.

Dispersal: Dark brown seeds locally dispersed by water ('wash-out dispersal', Hartmann 1991), ideal for establishment in crevices.

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Plants increase vegetatively, forming small, dense mats or clusters, the active vegetative growth rooting where it comes into contact with new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

Widespread and not threatened.

ADDITIONAL NOTES

Horticulture: Best for highveld hardens, grown in rockeries or containers. Outside its habitat, it should rather be grown under controlled conditions in a greenhouse. Plants easily grown from cuttings and thrive in cultivation. Its very easy growing nature maximises survival rate). Introduced to Kirstenbosch in 1934 (285/34).

VOUCHER

Van Jaarsveld 19360 (NBG).

ILLUSTRATIONS AND MAP

Figures 197a & 197b, Map 197.

198. *Delosperma laxipetalum* L.Bolus, Notes on Mesembryanthemum and allied genera 2: 66 (1929).

Cremonophyte growth form: Ascending shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:S/H:Es (vb)

Etymology: The epithet *laxipetalum* refers to the lax floral petals.

DESCRIPTION AND HABITAT

Plants much-branched, compact shrublets up to 300 mm high. Roots fibrous. Branches minutely papillate, becoming woody, terete. Leaves decussate, subimbricate or crowded owing to short internodes, spreading, somewhat trigonous, dorsiventrally flattened, but with

distinct keel, elliptic-obovate, 10–15 × 4–7 mm; surface minutely papillate; apex rounded, apiculate. Flowers solitary (rarely in cymes of up to 3); pedicels short, 1–4 mm long, 12–14 mm in diameter. Receptacle top-shaped. Petals linear, 5–6 × 1 mm, white. Capsule top-shaped, 3–4 mm in diameter. Seed not seen.

Phenology: Flowering mainly from spring to autumn.

Pollinators: Insects.

Habitat and aspect: Vertical cliffs of narrow shady kloofs (all aspects) and river valleys. Plants are rooted in crevices and on ledges. Temperature moderate, the average daily maximum about 25°C and average daily minimum for the region about 15°C. Winters are cool but frost is absent. Rainfall occurs mainly in summer and winter, 400–500 mm per annum.

Altitude: 550–1100 m.

Associated vegetation: Groot Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnoophytes: At Gert Smitskloof (Baviaanskloof), the habitat is shared with *Bulbine natalensis*, *Cotyledon woodii*, *Crassula orbicularis*, *C. perforata*, *C. rupestris*, *Delosperma elsieae* and *Gasteria rawlinsonii*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Delosperma laxipetalum occurs widespread in the Eastern Cape, from the Baviaanskloof and Kouga in the south to the Suurberg in the northeast.

RELATED SPECIES

Related to *Delosperma rogersiae* with mauve or yellow flowers and linear leaves (glabrous or hairy).

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming compact shrublets, well rooted in crevices and on ledges. A slow-growing, long-lived perennial.

Size and weight: Plants of medium weight.

Rootstock: Roots fibrous, no specialised features.

Stem: Becoming woody.

Leaves

Orientation: Spreading in shade, densely crowded and subimbricate when in full sun, triangular in cross section. Very adaptable.

Colour and texture: Pale green to green, fleshy, soft, becoming turgid after rain, but withered during dry periods, an adaptation to the extreme, dry habitat.

Age and persistence: Leaves persistent and long-lived, resulting in densely imbricate grouping.

Armament: No specific adaptation, but heavily grazed in non-cliff sites.

Sexual reproduction

Flowers: White, simple, terminally produced, conspicuous, maximising visibility for successful pollination in the vertical cliff environment. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Not seen.

Dispersal: Seeds locally dispersed by water ('wash-out dispersal', Hartmann 1991), ideal for establishment in crevices.

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Stems of *Delosperma laxipetalum* will root where they come into contact with the soil, a vegetative backup and adaptation to the very dry, harsh conditions on the cliff face.

CONSERVATION STATUS

Widespread and not threatened.

ADDITIONAL NOTES

Horticulture: Best for thicket and succulent karoo gardens, grown on steep embankments, rockeries or balconies. Plants rapid-growing and not shy to flower. Propagate from seed or cuttings. *Delosperma laxipetalum* does well in cultivation but outside its habitat, it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 16074 (NBG).

ILLUSTRATIONS AND MAP

Figures 198a–198c, Map 198.

199. *Delosperma nubigenum* (Schltr.) L.Bolus, in Jacobsen, A handbook of succulent plants 3: 1103 (1960).

Cremonophyte growth form: Pendent to procumbent leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb) (r)

Etymology: The epithet *nubigenum*, cloud-borne, refers to its high-altitude habitat.

DESCRIPTION AND HABITAT

Plants branched, soft, fragile, procumbent shrublets forming mats and drooping from cliffs, with stems up to 500 mm long. Roots fibrous. Branches glabrous, papillate, soft and green at first, terete. Leaves decussate, dorsiventrally flattened, 12–14 × 5–6 mm, pale to bright green; surface glabrous, minutely papillate, abaxial surface convex; apex acute, apiculate. Flowers terminal, solitary, 20–25 mm in diameter, shortly pedicellate. Petals linear-lanceolate, bright yellow; receptacle top-shaped. Capsule top-shaped.

Phenology: Flowering mainly from spring to summer.

Pollinators: Insects.

Habitat and aspect: Cliffs of the eastern escarpment of the central Drakensberg (all aspects). Plants are rooted in crevices and on ledges, drooping over the rock faces. Temperature very low in winter, with snow. An average daily maximum of 18°C has been recorded. The average daily minimum temperature for the region is 5°C. Rainfall occurs mainly in summer, 1000–1500 mm per annum.

Altitude: 3000–3400 m.

Associated vegetation: Drakensberg Afroalpine Heathland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Aloe aristata*, *A. pratensis*, *Cotyledon orbiculata*, *Crassula setulosa*, *Merwillia plumbea* and *Senecio orbicularis*.

Geology: Basalt.

DISTRIBUTION

Delosperma nubigenum occurs on the escarpment edge in the KwaZulu-Natal Drakensberg. It is confined to exposed cliffs.

RELATED SPECIES

Related to *Delosperma obtusum* which has mauve flowers and larger leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants forming mats, with stems becoming pendent. A fast-growing, cold-tolerant species and fairly long-lived perennial.

Size and weight: Plants small.

Rootstock: Roots fibrous, no specialised features.

Stem: Becoming long and drooping.

Leaves

Orientation: Spreading-ascending.

Colour and texture: Bright green, soft and fragile, becoming turgid after rain, but withered during dry periods.

Age and persistence: Persistent.

Armament: The soft, fragile nature suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the grazed grassland.

Sexual reproduction

Flowers: Bright yellow, simple, conspicuous, maximising visibility for successful pollination in the cliff and ledge environment. Flowering time in summer and autumn is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Not seen.

Dispersal: Seeds locally dispersed by water ('wash-out dispersal', Hartmann 1991), ideal for establishment in crevices.

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Plants increase vegetatively, forming dense mats that soon become pendent, the branches (vegetative growth) rooting where they find new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

Not threatened owing to the safe habitat.

ADDITIONAL NOTES

Horticulture: Best for cool temperate to warm temperate gardens, grown in full sun on steep embankments. Its dense mat-like growth is ideal for preventing soil erosion. Propagate from

cuttings in a sandy mixture. Plants thrive in cultivation. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 17000 (NBG).

ILLUSTRATIONS AND MAP

Figures 199a–199e, Map 199.

200. *Delosperma saxicola* Lavis in Journal of South African Botany 35,3: 145–148 (1969).

Cremonophyte growth form: Pendent leafy stems, occasionally spreading, cluster-forming shrublet (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: The epithet *saxicola*, dwelling among rocks, pertains to its habitat.

DESCRIPTION AND HABITAT

Plants much cluster-forming, spreading shrublets up to 250 mm in diameter and 50 mm high. Roots fibrous. Branches minutely hairy at first, becoming glabrescent and grey, woody, 2 mm in diameter; nodes 4–8 mm apart. Leaves very crowded and subimbricate (owing to short internodes), club-shaped (oblanceolate, dorsiventrally viewed), 14–19 × 6–8 mm, trigonous, distinctly keeled, up to 8 mm deep; surface minutely hairy, becoming glabrescent; apex acute, apiculate. Flowers solitary, often monochasial, 20–24 mm in diameter; pedicels 5 mm long. Receptacle obconical. Petals 8 × 1 mm, white, light pink, or apices pinkish. Capsule top-shaped, fragile, 5 mm in diameter. Seed globose, 1 × 0.8 mm in diameter, surface tuberculate.

Phenology: Flowering mainly from spring to summer.

Pollinators: Insects.

Habitat and aspect: Exposed, vertical to near vertical, coastal (sea-facing), quartzitic, sandstone cliffs. The aspect is south-facing. Plants are rooted in crevices and on ledges, occasionally drooping over the rock faces. Temperatures are moderate and an average daily maximum of 25°C has been recorded. The average daily minimum temperature for the region is 12–14°C. Rainfall occurs mainly in winter and summer, ranging from 700–800 mm per annum.

Altitude: 50–100 m.

Associated vegetation: Tsitsikamma Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: At Lotteringriviermond, the following plants have been recorded: *Crassula orbicularis*, *Drosanthemum candens*, *Gazania rigens* var. *leucolaena*, *Lobelia cuneifolia*, *Oedera imbricata* and *Passerina* sp.

Geology: Quartzitic sandstone (Table Mountain Group, Cape Supergroup).

DISTRIBUTION

Delosperma saxicola is endemic to the coastal cliffs just north and south of the Lotteringriviermond of the Tsitsikamma National Park in the Western Cape. Although locally common, it is a rare endemic.

RELATED SPECIES

Related to *Delosperma pattersoniae* to the east and *D. littoralis* to the west. It is immediately distinguished from these two coastal species by its densely (almost imbricate) arranged leaves (short internodes). The others are procumbent, mat-forming (forming much larger mats) and the leaves are much further apart.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Small cluster-forming mats (occasionally with stems becoming pendent). A slow-growing, long-lived perennial.

Size and weight: Plants small (up to 250 mm in diameter).

Rootstock: Roots fibrous, no specialised features.

Stem: Short to long and sometimes drooping.

Leaves

Orientation: Densely crowded (subimbricate), an adaptation to the semi-arid cliff-face environment.

Colour and texture: Green, firm, minutely hairy, becoming turgid after rain, but withered during dry periods.

Age and persistence: Persistent.

Armament and camouflage: No armament or camouflage.

Sexual reproduction

Inflorescence and flowers: Mainly white to light pink or mauve, simple or in a simple terminal monochasium, conspicuous, maximising visibility for successful pollination in the cliff environment. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed small, 1×0.8 mm, tuberculate.

Dispersal: Dark brown seeds locally dispersed by water ('wash-out dispersal', Hartmann 1991), ideal for establishment in crevices.

Time: Seeds ripening throughout summer and autumn. Germination after 14–21 days.

Vegetative reproduction: Plants increase vegetatively, forming dense mats that soon become pendent, the branches (vegetative growth) rooting where they come into contact with new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

Very localised, well protected by the cliff-face environment.

ADDITIONAL NOTES

Horticulture: Best for coastal fynbos gardens, grown in full sun on steep embankments. Does well in containers. Outside its habitat, it should rather be grown under controlled conditions in a greenhouse. Propagate from cuttings in a sandy mixture. Grows best in slightly acid, mineral-poor soil. Plants thrive in cultivation. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 19217 (NBG).

ILLUSTRATIONS AND MAP

Figures 200a–200d, Map 200.

201. *Delosperma subpetiolatum* L.Bolus, Notes on Mesembryanthemum and allied genera 2: 168 (1930).

Cremnophyte growth form: Pendent to procumbent leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb) (r)

Etymology: The epithet *subpetiolatum* (*sub*, almost, and *petiolatum*, bearing a petiole) refers to the very short petiole.

DESCRIPTION AND HABITAT

Plants branched, soft, fragile, procumbent shrublets, mat-forming and drooping from cliffs, with stems up to 500 mm long. Roots fibrous. Branches glabrous, papillate, soft and reddish green at first, terete. Leaves ascending-spreading, decussate, dorsiventrally flattened, $10\text{--}15 \times 5\text{--}8$ mm,

bright green; adaxial surface flat, abaxial surface convex; surface glabrous, minutely papillate; apex acute, apiculate; petiole up to 1 mm long. Flowers terminal, solitary, 18 mm in diameter; pedicels 10 mm long. Receptacle top-shaped. Petals linear-lanceolate, pink. Capsule top-shaped.

Phenology: Flowering mainly from spring to summer.

Pollinators: Insects.

Habitat and aspect: Sheltered cliffs of the Eastern Cape Drakensberg (all aspects). Plants are rooted in crevices and on ledges, drooping over the rock faces. Temperatures are low in winter, with snow. The average daily maximum temperature is about 22°C and average daily minimum 12°C. Rainfall occurs mainly in summer, 1000–1200 mm per annum.

Altitude: 1000–1400 m.

Associated vegetation: Amathole Mountain Grassland of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe maculata*, *Cotyledon orbiculata* and *Crassula nudicaulis*.

Geology: Beaufort shale (Tarkastad Subgroup).

DISTRIBUTION

Delosperma subpetiolatum occurs on the Katberg and adjacent mountains in the Eastern Cape (part of the southern Drakensberg). It is confined to exposed cliffs.

RELATED SPECIES

Related to *Delosperma repens* with white to red flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Forming mats, growing on ledges and fissures and with stems becoming pendent. A fast-growing, cold-tolerant species and fairly long-lived perennial.

Size and weight: Plants small.

Rootstock: Fibrous, no specialised features.

Stem: Becoming long and drooping.

Leaves

Orientation: Spreading-ascending.

Colour and texture: Bright green, soft and fragile, becoming turgid after rain, but withered during dry periods.

Age and persistence: Persistent.

Armament: The soft, fragile nature suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the grazed grassland.

Sexual reproduction

Flowers: Bright pink, simple, conspicuous, maximising visibility for successful pollination in the cliff and ledge environment. Flowering time in summer and autumn is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Not seen.

Dispersal: Seeds locally dispersed by water ('wash-out dispersal', Hartmann 1991), ideal for establishment in crevices.

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Plants increase vegetatively, forming dense mats that soon become pendent, the branches (vegetative growth) rooting when they find new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

Widespread and not threatened.

ADDITIONAL NOTES

Horticulture: Best for highveld gardens, grown in full sun. Suitable for growing in containers and hanging baskets. Plants thrive in cultivation and are easily propagated from cuttings in a sandy mixture.

VOUCHER

Van Jaarsveld 16921 (NBG).

ILLUSTRATIONS AND MAP

Figures 201a–201c, Map 201.

202. *Delosperma tradescantioides* (A.Berger) L.Bolus in *The Flowering Plants of South Africa* 7: t. 261 (1937).

Cremonophyte growth form: Pendent to procumbent leafy stems and loose mats (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: The epithet *tradescantioides* refers to its resemblance to the genus *Tradescantia* (Commelinaceae).

DESCRIPTION AND HABITAT

Plants pendulous from cliff faces, with stems up to 1 m long, forming loose curtains. Roots fibrous. Branches 2 mm in diameter, maroon-green to green when young, glabrous or hairy, becoming grey when mature, terete; nodes 5–30(–40) mm apart. Leaves fleshy, sessile, dorsiventrally flattened, ascending-spreading, ovate to ovate-cordate or ovate-lanceolate, 20–30 × 12–17; surface glabrous or hairy, adaxial surface slightly convex, abaxial surface flat to slightly convex, except for central midrib, rounded; apex acute, mucronate; base subcordate. Flowers solitary, 25–30 mm in diameter; pedicels short, angular, 3–4 mm long, glabrous or hairy. Petals up to 17 × 1.5 mm, bright magenta (rarely red) to white. Sepals fleshy (covering ovary after flowering), 2 outer broad and up to 12 mm long, 3 inner smaller (7 mm long). Capsule 3–4 mm, obconical, 9 mm in diameter; covering membranes lacking, valve wings present, closing bodies absent. Seed pear-shaped, 0.8 × 0.5 mm in diameter, dark brown.

Phenology: Flowering mainly from spring to autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs of river gorges (mainly eastern and southern aspects). Plants are rooted in crevices and on ledges, drooping over the rock faces. Temperatures are moderate, the average daily maximum about 22°C and average daily minimum for the region 14°C. Winters are cool but frost is absent. Rainfall occurs mainly in summer but at times also in winter, ranging from 600–800 mm per annum.

Altitude: 400–1440 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Bulbine natalensis*, *Cotyledon orbiculata*, *Crassula orbicularis*, *C. perfoliata* var. *minor*, *C. perforata* and *Gasteria excelsa*.

Geology: Quartzitic sandstone and shale.

DISTRIBUTION

Delosperma tradescantioides is confined to the coastal river gorges (Kei River and surrounding region) of the Eastern Cape.

RELATED SPECIES

Related to *Delosperma lebomboensis* which differs in leaf shape (also slightly smaller) and lacks indumentums. The latter is widespread in northern KwaZulu-Natal, Swaziland and Mpumalanga (especially the Lebombo Mountains), usually with white flowers.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with long, pendent, leafy stems, a habit that is retained in cultivation. A rapid-growing, fairly long-lived perennial.

Size and weight: Plants forming small mats drooping from the cliff.

Rootstock: Roots fibrous, no specialised features.

Stem: The internodes of the long, pendent branches are reddish purple (grey in older plants) and up to 1 m long, an adaptation to the cliff face where the plants experience little competition or predation. Stems and leaves soft and fragile, a character that can be viewed as an adaptation to a little-disturbed environment.

Leaves

Orientation: Ascending-spreading.

Colour and texture: Pale green and flattened, adapted to grow in shade, thus ideal for the often shady cliff habitats. The fleshy leaves are soft, becoming turgid after rain, but withered during dry periods, an adaptation to the extreme, dry habitat.

Age and persistence: Persistent, long-lived, eventually withering.

Armament: Leaves soft and fragile, without armour.

Sexual reproduction

Flowers: Mauve, reddish or white, simple, axillary produced, conspicuous. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed 0.8×0.5 mm, tuberculate, the size ideal for establishment in crevices.

Dispersal: Dark brown seeds locally dispersed by rainwater ('wash-out dispersal', Hartmann 1991), settling and germinating in crevices.

Time: Seeds ripening throughout summer and autumn. Germination after 14–21 days.

Vegetative reproduction: Plants increase vegetatively, forming dense mats that soon become pendent, the branches (vegetative growth) rooting when they reach new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Plants easily grown from seed or cuttings and thrive in cultivation. Its very easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 7157 (NBG).

ILLUSTRATIONS AND MAP

Plate 202, Figure 202a, Map 202.

203. *Delosperma velutinum* L.Bolus, Notes on Mesembryanthemum and allied genera 2: 39 (1929).

Cremnophyte growth form: Pendent to procumbent leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: The epithet *velutinum* pertains to the velvety indumentum of the leaf.

DESCRIPTION AND HABITAT

Plants compact shrublets, forming longer spreading branches, sometimes pendent from cliff face, with stems up to 300 mm long. Roots fibrous. Branches 2.2 mm in diameter, green when young, with short dense hairs or glabrous, becoming grey when mature, terete; internodes very short. Leaves fleshy, ascending-spreading, crowded at branch tips, subimbricate, subsessile, dorsiventrally flattened, ovate to ovate-lanceolate, 15–22 × 8–12 mm; surface densely hairy (velutinous), adaxial surface slightly convex, abaxial surface keeled; apex acute, apiculate; base cuneate; old leaves persistent. Flowers solitary, 25–30 mm in diameter; pedicels short, angular, 3–4 mm long, glabrous or hairy. Petals up to 14 mm in diameter, white or mauve.

Phenology: Flowering mainly from spring to autumn.

Pollinators: Insects.

Habitat and aspect: Cliffs of the eastern escarpment margin (Kranskop, Thukela), also river gorges (northern aspects). Plants are rooted in crevices and on ledges. Temperatures are moderate, the average daily maximum about 24°C and average daily minimum for the region 12°C. Winters are cool but frost is absent or light. Rainfall mainly in summer but at times also in winter, ranging from 700–800 mm per annum.

Altitude: 100–1550 m.

Associated vegetation: Eastern Valley Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Aloe arborescens*, *Bulbine natalensis*, *Crassula expansa* subsp. *fragilis* and *C. perfoliata* var. *heterotricha*.

Geology: Quartzitic sandstone and shale.

DISTRIBUTION

Delosperma velutinum occurs widespread, from the escarpment margin overlooking the Thukela River basin to Shongweni and Oribi Gorge in coastal and southern KwaZulu-Natal.

RELATED SPECIES

Related to *Delosperma tradescantioides*, with distinctly flat leaves, and *D. echinatum* of the Eastern Cape, the latter with long distinct trichomes and oval to globular leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: A fairly long-lived, perennial shrublet. Plants also producing longer spreading stems, rooting and colonising new crevices.

Size and weight: Plants forming small shrublets firmly wedged in crevices.

Rootstock: Roots fibrous, no specialised features.

Stem: Becoming woody, sturdy shrublets.

Leaves

Orientation: Grouped and almost imbricate, at ends of branches.

Colour: Pale green.

Armament: Leaves soft and fragile, without armour.

Sexual reproduction

Flowers: White to mauve, simple, solitary, axillary, conspicuous. Flowering time is long and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Not seen.

Dispersal: Seeds dispersed by water ('wash-out dispersal', Hartmann 1991).

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Plants increase vegetatively, forming dense mats that soon become pendent, the branches (vegetative growth) rooting when they find new crevices below, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for dry bushveld gardens, on steep embankments and rockeries. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings. Thrives in containers. Its easy growing nature maximises survival rate.

VOUCHER

Van Jaarsveld 18048 (NBG).

ILLUSTRATIONS AND MAP

Figures 203a–203c, Map 203.

204. *Delosperma waterbergense* L.Bolus in Journal of South African Botany 29: 48 (1963).

Cremonophyte growth form: Pendent leafy stems to cluster-forming (of light weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: After its habitat, the Waterberg, Limpopo Province.

DESCRIPTION AND HABITAT

Plants compact shrublets (sometimes becoming pendent) up to 100 mm high. Rootstock swollen. Stems minutely papillate. Leaves ascending, subterete, linear, 25–34(–50) × 2–4 mm, (4 mm at widest point); abaxial surface canaliculate; apex acute. Flowers solitary, 30–40 mm in diameter; pedicels 6–16 mm long. Petals linear-spathulate, up to 22 × 2 mm, pink. Filaments pink. Capsule 5 mm in diameter. Seed pear-shaped, 0.5 × 0.3 mm, tuberculate, dark brown.

Phenology: Flowering mainly in summer.

Pollinators: Insects.

Habitat and aspect: South-facing cliffs of the Waterberg (Limpopo Province) plateau margin. Plants are rooted in crevices and on ledges. Temperatures are moderate, the average daily maximum about 27°C and average daily minimum for the region about 12°C. Winters are cool but frost is absent or light. Rainfall mainly in summer, 700–800 mm per annum.

Altitude: 1500–1800 m.

Associated vegetation: Waterberg Magaliesberg Summit Sourveld of the Grassland Biome (Mucina *et al.* 2005).

Associated cremnophytes: In its native habitat at Marakele National Park, it grows in association with *Aeollanthus buchnerianus*, *A. parvifolius*, *Agapanthus coddii*, *Aloe arborescens*, *Bulbine natalensis*, *Crassula cymbiformis*, *C. sarcocaulis*, *C. setulosa*, *C. swaziensis*, *Lobelia aquamontanus*, *Teedia pubescens*, *Tetradenia brevispicata*.

Geology: Quartzitic sandstone, Matlabas Subgroup (Waterberg Group).

DISTRIBUTION

Delosperma waterbergense is endemic to the Waterberg (Limpopo Province).

RELATED SPECIES

Delosperma waterbergense is related to *D. zoutpansbergense* but is at once distinguished by its compact growth with a swollen rootstock.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: A long-lived, cluster-forming shrublet well anchored in fissures, crevices and ledges.

Size and weight: Plants forming small shrublets firmly wedged in crevices, sometimes becoming pendent.

Rootstock: Roots fleshy, providing anchorage and storage from which damaged branches can perennate.

Stem: Herbaceous, becoming slightly woody.

Leaves

Orientation: Ascending-spreading, crowded, linear, subterete, an adaptation to the dry habitat.

Colour: Green.

Armament: Leaves soft and fragile, without armour.

Sexual reproduction

Flowers: Simple, larger than those of most other *Delosperma* species, thus rich flowering attracting insect pollinators to the cliff-face habitat. Flowering time is in the growing season, fairly long, and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed 0.5×0.3 mm, pear-shaped, tuberculate.

Dispersal: Dark brown seeds dispersed by water ('wash-out dispersal', Hartmann 1991).

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Plants increase vegetatively, forming small mats that become pendent, the branches (vegetative growth) rooting when coming into contact with soil, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for highveld gardens, grown in containers or rockeries. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings. Does well in containers, in dappled shade or full sun. Its ease of growth maximises survival rate.

VOUCHER

Van Jaarsveld 17953 (NBG).

ILLUSTRATIONS AND MAP

Plate 204, Figures 204a–204c, Map 204.

205. *Delosperma zoutpansbergense* L.Bolus in Journal of South African Botany 25: 372 (1959).

Cremonophyte growth form: Pendent to procumbent leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb)

Etymology: After its habitat, the Soutpansberg, Limpopo Province.

DESCRIPTION AND HABITAT

Plants procumbent, mat-forming, up to 30 mm high, without swollen rootstock. Stems with shiny papillae; nodes 20–40(–45) mm apart. Leaves spreading ascending, subterete, linear, 10–50 × 2–4 mm; surface papillate, adaxial surface channelled; apex acute. Flowers solitary, 27–30 mm in diameter; pedicels up to 15 mm long. Petals linear-spathulate, 10–13 × 0.75–1.25 mm, pink. Filaments pink; apices white. Capsule not seen. Seed not seen.

Phenology: Flowering mainly in summer.

Pollinators: Insects.

Habitat and aspect: Upper sheltered south-facing cliffs of the Zoutpansberg (Limpopo Province). Plants are rooted in crevices and on ledges. Temperatures are moderate, the average daily maximum about 25°C and average daily minimum for the region 10°C. Winters are cool but frost is absent or light. Rainfall occurs mainly in summer, 1250–1500 mm per annum.

Altitude: 1500–1730 m.

Associated vegetation: Soutpansberg Summit Sourveld (Mucina *et al.* 2005).

Associated cremnoophytes: *Aeollanthus buchnerianus*, *Aloe arborescens*, *Crassula swaziensis*, *Kalanchoe crundallii*, *Plectranthus mutabilis* and *Thorncroftia succulenta*.

Geology: Protozoic quartzitic sandstone (Soutpansberg Group, Wyllies Poort Formation).

DISTRIBUTION

Delosperma zoutpansbergensis appears to be endemic to the upper south-facing cliffs of the Soutpansberg (Limpopo Province), growing on ledges, in crevices and fissures.

RELATED SPECIES

Related to *Delosperma waterbergense* but is at once distinguished by its smaller flowers and lack of a tuberous base.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: A soft, procumbent, mat-forming plant.

Size and weight: Small, soft, fragile mats firmly wedged in crevices.

Rootstock: Roots fibrous, providing anchorage in crevices.

Stem: Herbaceous, becoming slightly woody.

Leaves

Orientation: Ascending-spreading, soft, linear, subterete, an adaptation to the seasonally dry habitat.

Colour: Pale green.

Armament: Leaves soft and fragile, without armour.

Sexual reproduction

Flowers: Simple but conspicuous, thus rich flowering attracting insect pollinators to the cliff-face habitat. Flowering time is during the growing season, fairly long, and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed 0.5×0.3 mm, pear-shaped, tuberculate.

Dispersal: Dark brown seeds dispersed by water ('wash-out dispersal', Hartmann 1991).

Time: Seeds ripening throughout summer and autumn.

Vegetative reproduction: Plants increase vegetatively, forming small mats that become pendent, the branches (vegetative growth) rooting where they touch the soil, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best for highveld gardens, grown in containers or rockeries. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings. Thrives in containers, in dappled shade or full sun. Its ease of growth maximises survival rate.

VOUCHER

Van Jaarsveld 19776 (NBG).

ILLUSTRATIONS AND MAP

Figures 205a–205d, Map 205.

DROSANTHEMUM Schwantes

206. *Drosanthemum anemophilum* Van Jaarsv. & S.A.Hammer in *Cactus and Succulent Journal* (U.S.) 76,4: 204 (2004).

Cremnophyte growth form: Erect, spindly shrub (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:As:W:Ev

Etymology: The epithet *anemophilum*, wind-loving, pertains to the wind-dispersed seed.

DESCRIPTION AND HABITAT

Erect, virgate, spindly shrubs up to 1.5 m tall, with leaves and fertile parts carried at tips of branches. Main branch up to 18 mm thick, terete, sometimes slightly angular, with smooth purplish brown bark; young branches bubbly papillate, papillae subsiding with age; older branches glabrescent. Leaves opposite, equal, papillate, compressed, 3-angled, $10\text{--}16 \times 2\text{--}2.5 \times 2$ mm, dark dull green, never reddened, ascending-spreading; apices slightly incurved,

obtuse. Flowers diurnal, appearing in late spring and early summer (October to early November), solitary, apical; pedicels 2–8(–15) mm long. Sepals 5, triangular, 3 × 3 mm, margins thin, aging to a dull purple. Petals linear, 10–14 × 0.5 mm, blunt, spreading, in 2 series: a longer outer one and a shorter inner erect one, mauve pink to white, shiny. Filamentous staminodes in a central cone; filaments about 2 mm long, white; anthers 0.3 mm long, white, not overtopping stigmas. Ovary conical, 5-angled, raised to about 2.5 mm, reddish when fresh; stigmas 5, ascending-spreading, lanceolate, 1.5–2 mm long. Capsule globose to top-shaped, 5-locular, placentation parietal, 9–11 × 7–9 mm when fresh, reduced to about 7–8 × 5–8 mm when dried, loculi deep and slightly narrowing to the 4 mm wide apex (vs 5–6 mm at widest point of capsule), hard and bone-like, ivory-coloured when dried, difficult to break open with the fingers, hygroscopic; valves triangular, 2 × 2 mm, without wings, remaining erect once opened; expanding keels contiguous, parallel, loculi deep (4–5 mm), without covering membranes, central axis and loculi roofs raised to almost as high as open erect valves. Seed 1.3 × 0.75 × 0.40 mm, minutely tuberculate, slightly flattened, brownish.

Phenology: Flowering mainly in spring.

Pollinators: Insects.

Habitat and aspect: Steep south-facing aspects, on and below sandstone cliffs, up to altitudes of about 1000 m. Plants rooted in crevices and on ledges. Temperature high in summer, warm with cold nights in winter. Average daily maximum temperature about 29°C and average daily minimum about 14°C. Rainfall in winter and summer, 200–300 mm per annum.

Altitude: 800–1000 m.

Associated vegetation: Western Little Karoo of the Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnoophytes: Associated species at the type locality at Rooinek Pass include *Crassula atropurpurea* var. *purcellii*, *C. brachystachya*, *Othonna triplinervia* and *Senecio articulatus*.

Geology: Quartzitic sandstone, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Drosanthemum anemophilum is a quartzitic sandstone endemic, confined mainly to the south-facing cliffs on the Rooinek Pass, south of Laingsburg (Western Cape).

RELATED SPECIES

Not closely related to any other *Drosanthemum*. See note below.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Erect, very sparsely branched, virgate growth habit up to 1.5 m high.

Size and weight: Plants of medium weight to heavy in large specimens.

Rootstock: With central taproot, thus firmly anchored on cliff faces. Roots fibrous.

Stem: Erect, soon becoming woody.

Leaves

Orientation: Ascending-spreading.

Colour: Pale green.

Age and persistence: Leaves persistent and long-lived, eventually withering.

Armament: No armament.

Sexual reproduction

Flowers: Flowers are solitary at branch ends, conspicuous, maximising visibility for successful pollination in the cliff environment. Flowering time is in spring (October–November).

Fruit/Seed

Size: Seed $1.3 \times 0.75 \times 0.40$ mm, brownish, minutely tuberculate.

Dispersal: Capsule remaining open, the slightly flattened seed dispersed by wind and jactitation (Van der Pijl 1982).

Time: Seeds ripening throughout summer and autumn, in time for winter rains. Germination after 14–21 days.

Vegetative reproduction: Absent.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Note: Not only is it an unusual *Drosanthemum*, it is unique in the Mesembryanthemaceae in several ways. It is unusually tall for a mesemb. The fruit capsules are bone-like in texture, hygroscopic and anemochorous. Their valves lack wings, and the deep loculi have small fragmentary roofs in an erect position. After opening, the valves remain open and in an erect position, allowing easy egress for the unusually large, somewhat flattened seeds, which are dispersed by strong gusts of wind. This is the first record of anemochory in the genus *Drosanthemum*.

Horticulture: Plants easily grown from seed, thriving in cultivation. It has a rapid growth rate and flowers after the third year of sowing.

VOUCHER

Van Jaarsveld 13695 (NBG).

ILLUSTRATIONS AND MAP

Figure 206a, Map 206.

207. *Drosanthemum expersum* (N.E.Br.) Schwantes in Zeitschrift für Sukkulantenkunde 3: 30 (1927).

Crempnophyte growth form: Pendent to procumbent leafy stems (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els (vb) (r)

Etymology: The epithet *expersum*, devoid of, pertains to the capsules, which are without covering membranes.

DESCRIPTION AND HABITAT

Plants much-branched, long-lived, mat-forming, pendulous shrublets from cliff faces, with stems up to 400 mm long forming loose mats. Roots fibrous; main root (taproot) succulent, up to 5 mm in diameter, cylindrical, about up to 120 mm long. Branches 1 mm in diameter, maroon at first, becoming dark purplish brown, soft, brittle, terete; nodes 5–12 mm apart; surface papillate; hairs multicellular, translucent. Leaves fleshy, subterete, linear, papillate, 9–14 × 2 mm, ascending-spreading; surface papillate, green, adaxial surface somewhat flattish; apex obtuse. Flowers solitary, up to 35 mm in diameter; pedicels 18–65 mm long. Receptacle cup-shaped, 2 mm deep, 8 mm in diameter, bearing 2 outer triangular-lanceolate sepals 5 × 3.5 mm and 3 smaller sepals 3 × 2 mm. Petals bright magenta, 10–15 × 0.5–1.5 mm. Ovary pointed; stigmas 5, lanceolate, 4.0–5.5 mm long, papillate; nectaries green. Capsule cup-shaped, 8 mm in diameter (open 12 mm), top pyramidal; covering membranes lacking, valve wings present, closing bodies absent. Younger fruits reddish, 10–12 mm in diameter before desiccating. Seed up to 0.8 mm in diameter, pale brown.

Phenology: Flowering mainly in spring.

Pollinators: Insects.

Habitat and aspect: Sheltered south- and east-facing cliffs of the upper slopes of the central and northern Cape Fold Belt mountains. Plants are rooted in crevices and on ledges, drooping over the rock faces. Temperatures relatively low, with snow in winter. The average daily maximum temperature is about 20°C and average daily minimum about 8°C. Rainfall occurs mainly in winter, estimated to be above 1000–1500 mm per annum.

Altitude: 1200–2000 m.

Associated vegetation: North Hex Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Crassula nudicaulis*, *C. pellucida* subsp. *spongiosa* and *Esterhuysenia drepanophylla*.

Geology: Quartzitic sandstone, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Drosanthemum exspersum is a quartzitic sandstone endemic, confined mainly to south-facing cliffs from Tafelberg (Cold Bokkeveld, Western Cape) to Bobbejaansberg and Matroosberg in the south (Western Cape) and northwards to the Calvinia district (Northern Cape).

RELATED SPECIES

Not closely related to any other *Drosanthemum*. A unique feature setting it apart from most other members of the genus, is the absence of covering membranes and hence its former placement in the genus *Delosperma*. Could perhaps be related to the deciduous cremnophilous *Drosanthemum inornatum* of the Hunsberg in southern Namibia with smaller, puce-coloured flowers and capsules without covering membranes.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with pendent, leafy stems, a habit that is retained in cultivation. A rapid-growing, fairly long-lived perennial, sprouting from the basal portion of the stem.

Size and weight: Plants of medium weight.

Rootstock: With central taproot, thus firmly anchored on cliff face. Roots fibrous. Perennial rootstock long-lived and re-sprouting, thus differing from most other short-lived *Drosanthemum* species.

Stem: Pendent and forming loose mats on ledges. Stems and leaves soft and fragile, a character that can be viewed as a reduction in armament as a result of the undisturbed habitat.

Leaves

Orientation: Ascending-spreading, somewhat recurved.

Colour: Pale green.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: The softer leaf texture suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the grazed grassland and subtropical forest.

Sexual reproduction

Flowers: Flowers simple, borne at branch ends or axillary produced, conspicuous, maximising visibility for successful pollination on the vertical cliffs. Flowering time is in spring.

Fruit/Seed

Size: Seed up to 0.8 mm in diameter, an ideal size for establishment in crevices.

Dispersal: Seeds dispersed by rainwater ('wash-out dispersal', Hartmann 1991), settling and germinating in crevices.

Time: Seeds ripening throughout summer and autumn, in time for winter rains. Germination after 14–21 days.

Vegetative reproduction: Plants increase vegetatively, forming small mats that become pendent, the branches (vegetative growth) rooting where they come into contact with soil, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic well protected in the habitat, not threatened.

ADDITIONAL NOTES

Horticulture: Best for cool fynbos and other temperate gardens, grown in containers or on rockeries. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings. *Drosanthemum expersum* does well in containers, in dappled shade or full sun. Its ease of growth maximises survival rate.

VOUCHERS

Van Jaarsveld 18413, 18621, 19210, 20059 (NBG).

ILLUSTRATIONS AND MAP

Plate 207, Figures 207a–207i, Map 207.

208. *Drosanthemum inornatum* (L.Bolus) L.Bolus in *Journal of South African Botany* 30: 33–44 (1964). (Hunsberg form.)

Crempnophyte growth form: Pendent leafy stems from tuberous roots (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els:D (vb) (eg)

Etymology: The epithet *inornatum* pertains to its generally unattractive features.

DESCRIPTION AND HABITAT

Plants much-branched, long-lived, pendulous (from cliff faces), summer-deciduous shrublets with stems up to 500 mm long forming loose mats. Main branch up to 8 mm in diameter. Roots tuberous (main root or taproot) succulent, up to 5 mm in diameter. Branches 1.8–2.5 mm in diameter, 3.5 mm in diameter (basally up to 4 mm) at swollen nodes, at first green, with

translucent papillate epidermis, becoming brownish, longitudinally fissured, becoming dark purplish brown, slightly articulated at nodes, soft and brittle, terete; nodes 7–25 mm apart. Leaves summer-deciduous, fleshy, green, spreading, pendent, subterete, linear, papillate, 12–18(–25) × 2 mm, drooping; surface papillate, green, adaxial surface somewhat flattish; apex obtuse. Flowers solitary, up to 20 mm in diameter; pedicels 8–10 mm long. Receptacle cup-shaped, 2–3 mm deep, 4 mm in diameter, bearing fleshy sepals with membranous wings. Petals puce, 8 × 1–1.5 mm. Stigmas 5 mm long, papillate; nectaries green. Capsule top-shaped, fragile, 5–6 mm in diameter, about 3–4 mm deep (open 9 mm in diameter, at top); covering membranes lacking, valve wings broad, 2 × 2 mm, closing bodies absent. Seed 0.6 × 0.4 mm, light brown.

Phenology: Flowering mainly in spring.

Pollinators: Bees (Hartmann 1991).

Habitat and aspect: Confined to south-facing cliffs, the plants growing on ledges and crevices. Temperature warm to high in summer and mild to warm in winter, but regularly cooled by fog from the Atlantic. The average daily maximum temperature is about 24°C and the average daily minimum temperature for the region 10°C. Winters are cooler but frost is absent. Rainfall occurs mainly in winter and about 50–75 mm per annum (mainly cyclonic winter rain). Regular fog provides extra moisture.

Altitude: 800–1100 m.

Associated vegetation: Succulent Karoo.

Associated cremnophytes: *Drosanthemum inornatum* shares its habitat at the type locality (at Konsertinaberg) with *Crassula sladenii*, *C. tomentosa* var. *tomentosa*, an undescribed *Hartmanthus* sp., *Tylecodon buchholzianus* and *T. singularis*.

Geology: Dolomite cliffs of the Port Nolloth Zone (Gariiep Supergroup).

DISTRIBUTION

Southern Namibia, east of Rosh Pinah, confined to dolomite.

RELATED SPECIES

Not closely related to any other *Drosanthemum*. A unique feature distinguishing it from most other members of the genus, is the absence of covering membranes. In this respect it is similar to *D. expersum*, another cremnophyte occurring from Nieuwoudtville to Matroosberg in the south. Another unusual feature is the deciduous nature of the plants.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with pendent, leafy stems, a habit that is retained in cultivation.

Size and weight: Plants of medium weight.

Rootstock: Tuberous roots ensure good anchorage and long-term survival.

Stem: Pendent, forming loose mats on ledges. Stems and leaves soft and fragile, young stems with a fleshy, translucent layer, the epidermis covered in papillae, a character that can be viewed as an adaptation to the shady, south-facing cliffs during its cooler growing season. The reduction in armament (fragility) can be viewed as a result of the undisturbed cliff-face habitat.

Leaves

Orientation: Drooping from the drooping stems, an adaptation to the vertical cliff face.

Colour and texture: Bright green, papillate.

Age and persistence: Leaves deciduous towards summer.

Armament: The absence of armament and the soft leaf texture suggest a response to the undisturbed cliff habitat.

Sexual reproduction

Flowers: Simple, in leaf axils. Flowering in winter and spring.

Fruit/Seed

Size: Seed 0.6×0.4 mm, an ideal size for establishment in crevices.

Dispersal: Seeds dispersed by rainwater ('wash-out dispersal', Hartmann 1991), settling and germinating in crevices.

Time: Seeds ripening throughout spring.

Vegetative reproduction: Absent.

CONSERVATION STATUS

A local endemic, not threatened.

ADDITIONAL NOTES

Horticulture: Best grown in containers under controlled conditions in a greenhouse. It has little ornamental value and is grown as a curiosity plant. Propagate from cuttings in sandy soil. Sow seed in autumn. Plants easily grown from cuttings, doing well in cultivation. Its very easy growth maximises survival rate.

VOUCHER

Van Jaarsveld 19915 (NBG).

ILLUSTRATIONS AND MAP

Figures 208a & 208b, Map 208.

EREPSIA N.E.Br.

209. *Erepsia heteropetala* (Haw.) Schwantes in Gartenflora 77: 68 (1928).

Cremnophyte growth form: Pendent, cluster-forming (of medium weight, cliff hanger).

Growth form formula: E:F:As:W:Ev

Etymology: The epithet *heteropetala* refers to the variable length of the petals.

DESCRIPTION AND HABITAT

Plants much-branched, cushion-shaped or pendent shrublets up to 300 mm in diameter. Roots fibrous. Stems reddish brown, up to 4.5 mm in diameter, soft at first becoming woody; nodes 5–30 mm apart. Leaves ascending, fleshy, pale green (margins and leaf tips sometimes reddish), triquetrous, slightly laterally compressed (8 mm wide), falcate to subfalcate, 35(–50) × 7 mm; margin serrate-denticulate; surface smooth, adaxial surface somewhat flat to slightly channelled; apex mucronate, reddish at tips. Flowers solitary or up to 3 in apical cymes, up to 40 mm in diameter; pedicels 6 mm long (in fruit). Petals purplish pink, linear, merging with staminodes. Capsule top-shaped, 15 mm deep, 15 mm in diameter at top; closing body absent, covering membranes present, valves light brown, valve wings narrow. Seed 1.5 × 1.2 mm in diameter, somewhat laterally compressed (0.5 mm) tuberculate, pale brown.

Phenology: Flowering mainly in spring and summer.

Pollinators: Insects.

Habitat and aspect: Mainly south- and west-facing cliffs of the central Cape Fold Belt mountains. Plants are rooted in crevices and on ledges, sometimes drooping over the rock faces. Temperatures are relatively low, with occasional snow in winter. The average daily maximum temperature is about 20°C and the average daily minimum for the region about 10°C. Rainfall occurs mainly in winter and is estimated to be above 1000–1500 mm per annum.

Altitude: 400–1300 m.

Associated vegetation: Hawekwas Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Crassula pellucida* subsp. *alsinoides*, *C. nudicaulis*, *C. pellucida* subsp. *spongiosa*, *Esterhuysenia stokoei*, *Oscularia caulescens* and *O. deltoides*.

Geology: Quartzitic sandstone, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Erepsia heteropetala is a quartzitic sandstone endemic, confined to the south- and east-facing cliffs in the Du Toitskloof and adjacent regions of the southwestern Cape (Western Cape).

RELATED SPECIES

Related to *Erepsia lacera* in shape, colour and size of the leaves, but the latter is an erect shrublet from Paarlberg. Two smaller species, *E. forficata* (Table Mountain) and *E. inclaudens* (Kogelberg), also occur frequently on cliff faces in the Western Cape.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with compact cushion or becoming pendent, this habit retained in cultivation. A rapid-growing, fairly long-lived perennial.

Size and weight: Plants of medium weight.

Rootstock: Fibrous, no specialised features.

Stem: Stems and leaves softer and more fragile than those of the closely related *Erepsia lacera*, a character that can be viewed as a reduction in armament as a result of the undisturbed habitat.

Leaves

Orientation: Ascending-spreading.

Colour: Pale green, somewhat glaucous.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: Plants without obvious armament.

Sexual reproduction

Inflorescence and flowers: Flowers simple or in cymes of 3, at branch ends or axillary produced, conspicuous, thus maximising visibility for successful pollination in the vertical cliff environment. Flowering time is in late spring and summer and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed large, 1.5 mm in diameter, with tuberculate surface ideal for establishment in crevices.

Dispersal: Seeds locally dispersed by rainwater ('wash-out dispersal', Hartmann 1991), but their compressed nature appears to be an adaptation for wind dispersal as well.

Time: Seeds ripening throughout summer and autumn, in time for winter rains.

Vegetative reproduction: Absent.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: Plants easily grown from seed or cuttings, thriving in cultivation. Its very easy growing nature maximises survival rate.

VOUCHERS

Van Jaarsveld 18419, 18421 (NBG).

ILLUSTRATIONS AND MAP

Figures 209a–209e, Map 209.

ESTERHUYSENIA L.Bolus

210. *Esterhuysenia stokoei* (L.Bolus) H.E.K.Hartmann in *Bradleya* 16: 44–91 (1998).

Cremonophyte growth form: Pendent to procumbent leafy stems (of light weight, cliff squatter).

Growth form formula: E:F:P:Els (vb) (r)

Etymology: After Thomas Stokoe (1868–1959), mountaineer and plant collector.

DESCRIPTION AND HABITAT

Plants much-branched, pendulous, glabrous shrublets on cliff faces, with stems up to 300 mm long forming loose mats. Roots fibrous. Branches 1 mm in diameter (main branch up to 5 mm in diameter), yellowish at first, becoming brown, soft, brittle, terete; nodes 5–30 mm apart; surface smooth. Leaves fleshy, trigonous, linear, falcate to subfalcate, grey-green, reddish at tips, 8–14 × 3 mm, ascending-spreading; surface finely papillate, green, adaxial surface somewhat flat; apex mucronate. Flowers solitary, 30–45 mm in diameter; pedicels 10–50 mm long (in fruit). Petals purplish pink, 4–20 × 0.25–2.5 mm. Filaments absent; anthers yellow. Capsule top-shaped, 5 mm deep, 6–8 mm in diameter (open 12–13 mm); closing body absent, covering membranes lacking, but with closing ledges, valves light brown, valve wings narrow. Seed 1.5 × 1.3 mm in diameter, echinulate, dark brown.

Phenology: Flowering mainly in late spring.

Pollinators: Insects.

Habitat and aspect: Mainly sheltered south-facing cliffs. Plants are rooted in crevices and on ledges, drooping over the rock faces. Temperatures moderate in summer, with cold winters and occasional snow. An average daily maximum temperature of about 20°C has been

recorded. The average daily minimum temperature for the region is about 8°C. Rainfall occurs mainly in winter and is estimated to be above 1000–1500 mm per annum.

Altitude: 800–1500 m.

Associated vegetation: North Hex Sandstone Fynbos of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Crassula alsinoides* subsp. *alsinoides*, *C. nudicaulis*, *C. pellucida* subsp. *spongiosa*, *Erepsia heteropetala* and *Oscularia deltoides*.

Geology: Quartzitic sandstone, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Esterhuysenia stokoei is a quartzitic sandstone endemic, confined to south-facing cliffs in the Du Toitskloof and Franschhoek regions of the southwestern Cape (Western Cape).

RELATED SPECIES

Not closely related to any of the other three *Esterhuysenia* species. *Esterhuysenia drepanophylla* also commonly occurs on cliffs in the Western Cape but it is a shrublet with very different leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with pendent, leafy stems, a habit that is retained in cultivation. A rapid-growing, fairly long-lived, perennial.

Size and weight: Plants of light weight.

Rootstock: Central taproot and branches rooting where touching the ground. Roots fibrous, no specialised features.

Stem: Pendent and forming loose mats. Stems and leaves soft and fragile, a character that can be viewed as a reduction in armament as a result of the undisturbed habitat.

Leaves

Orientation: Ascending-spreading.

Colour: Pale green, somewhat glaucous.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: The softer leaf texture (compared to other *Esterhuysenia* species) suggests a reduction in armament in response to the undisturbed cliff habitat in contrast to the surrounding accessible fynbos.

Sexual reproduction

Inflorescence and flowers: Flowers simple, at branch ends or axillary produced, conspicuous, thus maximising visibility for successful pollination in the vertical cliff environment. Flowering time is in late spring and flowers are regularly produced, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed large, 1.5 mm in diameter, the echinulate surface ideal for establishment in crevices.

Dispersal: Seeds dispersed by rainwater ('wash-out dispersal', Hartmann 1991), settling and germinating in crevices.

Time: Seeds ripening throughout summer and autumn, in time for winter rains.

Vegetative reproduction: Plants increase vegetatively, forming small mats that become pendent, the branches (vegetative growth) rooting where they touch the soil, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened owing to the safe, sheer cliff face.

ADDITIONAL NOTES

Horticulture: Best for cool fynbos and other temperate gardens, grown in containers or rockeries. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings. Does well in containers, in dappled shade or full sun. Its ease of growth maximises survival rate.

VOUCHER

Van Jaarsveld 18436 (NBG).

ILLUSTRATIONS AND MAP

Figures 210a–210f, Map 210.

JENSENOBOTRYA A.G.J.Herre

211. *Jensenobotrya lossowiana* A.G.J.Herre in *Sukkulentenkunde* 4: 79 (1951).

Cremonophyte growth form: Pendent clusters (of medium weight to heavy, cliff hanger).

Growth form formula: E:P:F:Els (ft) (vb)

Etymology: First part of genus name honours Emil Jensen, succulent enthusiast of Lüderitz; the Greek *botrys* (a bunch of grapes) refers to the club-shaped leaves, resembling bunches of grapes. The specific epithet honours Otto von Lossow, physician from Luderitz.

DESCRIPTION AND HABITAT

Much-branched, densely leaved shrubs pendent from cliffs or procumbent on ledges up to a 2.18 m in diameter. Roots fibrous. Branches woody, brittle, dark brown to blackish, with flaking, longitudinally fissured bark (bare for up to two thirds of their length in old specimens), 1 m long; main branch up to 70 mm in diameter; younger branches with internodes 5–10 mm long, spongy internodes 5 mm in diameter, brownish at first and with remnants of old persistent leaves. Leaves decussate, crowded, with 1 or 2 functional pairs at each branch end, basally connate, oblong trigonous-clavate (linear-oblongate viewed from the top) to subglobose, somewhat laterally compressed, 20–30 mm long, 15–18 mm in diameter at apex (base 8 mm in diameter); apices faintly keeled; surface grey-, pinkish to purplish green, smooth, turgid; second or third pair withering (as moisture recycled to first pairs); the upper half of older leaves often covered with blackish fungal growth; epidermis flat, stomata not sunken; apex obtuse. Flowers light to dark pink, terminal, solitary, 20–25(–35) mm in diameter when fully opened, ebracteate, buds reddish, opening during the day; pedicel 10 mm long, terete, 3 mm in diameter. Sepals 5, obtuse, 4–5 mm long, reddish purple, inner hyaline. Petals in 2 series, 10–12 × 2 mm. Filamentous staminodes absent; stamens diffuse, numerous, 3–4 mm long, white. Ovary flat or concave; glands annular, in a dark green lophomorphic ring (crenulate); stigmas 5, subulate; placenta parietal. Fruiting capsule 10–12 mm in diameter, funnel-shaped, flat at top, opening hygrochastically, soft and disintegrating soon; valve wings broad, expanding keels contiguous, diverging, ending in coiled tape-like awns, locules 5, covering membranes absent. Seed oval to subglobose, 0.5 × 0.8–1 mm, papillate, reddish brown.

Phenology: Flowering sparsely but continuous throughout year.

Pollinators: Insects (generalist).

Habitat and aspect: The main and best developed stands are found on south- and southeast-facing cliffs at Dolphin Head (Spencer Bay) and northwards to Arkona, at altitudes of 15–200 m. Plants grow in crevices and on ledges of the lower and upper slopes, in ample sandy soil, the branches often covered in lichens. The climate is typical of the southern Namib Desert and rainfall is below 25 mm per annum, but the vegetation is dependent on regular fog from the cold Benguela Current. It remains cool throughout the year except when onshore berg winds cause temperatures to rise above 40°C. The average daily maximum temperature is about 19°C and average daily minimum about 10°C, with frost absent from the habitat. Rainfall occurs mainly in winter (cyclonic cold fronts), 15–20 mm per annum.

Altitude: 15–200 m.

Associated vegetation: Succulent Karoo Biome.

Associated cremnophytes: Other cremnophytes observed at Dolphin Head include *Dicoma spinulosa*, *Pelargonium ceratophyllum*, *P. cortusifolium* and *Tylecodon schaeferi*. At the coastal sandstone ridges at Arkona, plants found in association are *Brownanthus marlothii*, *Capparis hereroensis* and *Drosanthemum luederitzii*.

Geology: Coarse brittle quartzitic sandstone of the Spencer Bay Formation (Nossop Group, Damara Sequence).

DISTRIBUTION

Localised at Dolphin Head and northwards to Arkona, confined to the coast.

RELATED SPECIES

Related to the genus *Delosperma*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Conspicuous pendent, much-branched, fragile, brittle shrubs with pendent clusters of grape-like leaves. The heavy branches are perfectly adapted to a pendent and procumbent growth (on ledges).

Size and weight: Clusters medium-sized to large.

Stem: Up to 1 m long.

Leaves

Orientation: Leaves without teeth, fragile and plants easily damaged. The very succulent, club-shaped leaves remain turgid owing to the regular supply of moisture in the form of fog and are adapted to the dry, almost rainless climate. Like many mesembs adapted to arid conditions, the moisture from the older leaf pair is absorbed (recycled) by the younger pair. Plants were observed during morning fog, the plants and lichens moist, with moisture dripping from the leaf apices. Their turgid nature, even in December when rainfall is least expected, clearly points to their dependency on fog. The leaf epidermis is flat, without sunken stomata (Hartmann 2001b), an indication of a regular fog supply. When covered in moisture, the stomata are able to absorb moisture, a possible explanation for the turgid status of the leaves throughout the year. The thick layer of wax on the epidermis protects the plant from moisture loss under dry berg wind conditions when temperatures can suddenly rise.

Colour: Reddish to greyish green. Plants becoming reddish to greyish green (production of anthocyanins), an adaptation that reduces penetration of light that may be harmful.

Age and persistence. Slow-growing, long-lived perennials; leaves annually replaced.

Armament and camouflage: Plants fragile, extremely brittle and without armament or camouflage properties.

Sexual reproduction

Flowers: Melittophilous (Hartmann 1991). Flowering sparsely but throughout the year, probably because of the regular fog supply and almost seasonless climate.

Fruit/Seed

Size: Seed small, 0.5×0.8 –1 mm, reddish brown to yellowish, ovoid to subglobose.

Dispersal: Hydrochory (ombrohydrochory). Hygrochastic capsules opening with rain but seeds dispersed by ‘wash out dispersal’ (Hartmann 1988). The capsules have no covering membranes. Rain fills the bowl-like cavity of the capsule and seeds are washed or splashed out. This dispersal strategy would ensure local dispersal on the cliffs, the seeds succumbing to gravity and eventually becoming wedged in crevices, ideal for establishment. The papillate surface and small size of the seeds are indications of adaptation and successful dispersal in the cliff habitat where the seeds are washed into crevices, providing good anchorage for the seedlings. According to Burgoyne (1998) the coiled, ribbon-like awns arising from the end of the expanding keels help to remove the seeds from the capsules. As the valves open, the hygroscopic, coiled, ribbon-like awns tear loose from the centre and uncoil, removing some of the seeds from their cavities, thus aiding dispersal.

Time: Seeds released throughout the year but especially in winter, coinciding with autumn or winter rains, thus during the cool season and maximising establishment.

Vegetative reproduction: Plants increase vegetatively, forming dense mats or clusters up to 1 m in diameter and occasionally rooting when coming into contact with soil, an efficient vegetative dispersal backup and adaptation to the cliff face.

CONSERVATION STATUS

Classified as near threatened (Loots 2005). A little-known species, not threatened owing to the safe, remote habitat without disturbances by herbivores or humans.

ADDITIONAL NOTES

The habitat: Today Dolphin Head forms a promontory but it was once an island. The main population of *Jensenobotrya lossowiana* grows on the sheer cliffs and steep slopes but because of a lack of disturbance (even today there are no herbivores), plants are also found on non-cliff sites. Dolphin Head has a breeding colony of the Cape fur seal (*Arctocephalus pusillus*), and the only other larger mammals are black-backed jackal (*Canis mesomelas*) and brown hyena (*Hyaena brunnea*). In my opinion, many of the plants consequently migrated to non-cliff sites owing to a lack of disturbance (no baboons, gemsbok or small game such as hare). However, during times of increased rainfall and an increase in herbivores, the main population will continue their growth on the cliff faces.

Horticulture: Best for cool coastal succulent karoo gardens, ideal for embankments and hanging baskets. Very easily cultivated from cuttings or seed. Grow in full sun or light shade. Water sparingly in winter and summer.

VOUCHER

Van Jaarsveld 21148 (WIND).

ILLUSTRATIONS AND MAP

Plate 211, Figures 211a–211f, Map 211.

LAMPFRANTHUS N.E.Br.

212. *Lampranthus affinis* L.Bolus in Journal of South African Botany 28: 12–14 (1962).

Cremonophyte growth form: Decumbent shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:W:Ev (r)

Etymology: The epithet *affinis* pertains to its close affinity to members of *Lampranthus* section *Haworthia* (*L. stipulaceum*, *L. coralliflorus*, *L. productus* and *L. haworthii*).

DESCRIPTION AND HABITAT

Erect, moderately branched shrublets up to 400 mm high, branched from base and with short, decumbent side branches along erect stems. Roots fibrous. Stems cylindrical, woody, up to 12 mm in diameter, becoming grey; younger leafy branches terete, purplish, 2.5–3 mm in diameter. Leaves numerous, crowded, erect to slightly falcate, ascending, trigonous, terete to somewhat laterally compressed, 35–45 × 3–4 mm; surface smooth, glaucous, covered with powdery bloom, becoming pink when stressed, persistent when dry. Inflorescence cymose, at tips of main branches. Flowers up to 70 mm in diameter, light pink to white, conspicuous. Petals linear-oblongate, 25–30 × 2.5 mm. Staminodes numerous, petal-like; stamens numerous, light yellow, initially covering stigma. Capsule hygroscopic, woody, 8 mm deep, 8–12 mm in diameter, opening once and remaining open, occasionally closing halfway. Seed pear-shaped, slightly depressed, 1–1.3 mm in diameter.

Phenology: Flowering in spring and early summer (October–November). Seeds wind-dispersed.

Pollinators: Insects.

Habitat and aspect: Cliffs in dry river valleys or narrow shady kloofs (all aspects). Plants are firmly rooted in crevices and size often depends on the growing space allowed by the crevice. Temperatures are high in summer and the average daily maximum is about 27°C and average daily minimum about 12°C. Winters are cool but frost is absent. Rainfall occurs throughout the year but with a peak in spring and summer (thunder showers or cyclonic winter rain), ranging from 200–300 mm per annum.

Altitude: 300–1050 m.

Associated vegetation: Mainly Gamka Thicket and Groot Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremonophytes: At Geelhoutboskloof (Baviaanskloof, Eastern Cape), the following plants have been recorded: *Albuca cremonophila*, *Bulbine cremonophila*, *Cotyledon tomentosa*, *Crassula perfoliata* var. *minor*, *C. perforata* and *Gasteria rawlinsonii*.

Geology: Quartzitic sandstone of the Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Lampranthus affinis is a quartzitic sandstone endemic, confined to the narrow kloofs (north-south orientation) of the Baviaanskloof and Swartberg Mountains of the Eastern and Western Cape Provinces (Grootrivierspoort to Seweweekspoort).

RELATED SPECIES

Lampranthus affinis is related to *L. coralliflorus* but is immediately distinguished by the large, rich-flowering inflorescences and by the fruiting capsules that remain open after initially opening. In fact, this character distinguishes it from any other *Lampranthus*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with erect to decumbent stems. A rapid-growing, fairly long-lived perennial. No noticeable vegetative adaptation to the cliff environment.

Size and weight: Plants of medium weight.

Stem: The short branches are grey and covered by persistent old leaves.

Leaves

Orientation: Ascending-spreading to erect, subterete.

Colour and texture: Glaucous (reflecting the light), with powdery bloom. Their slight translucent nature allows light to penetrate deeply, an adaptation enabling the plants to cope with the shady cliff environment. Leaves are soft and fleshy, becoming turgid after rain, but pinkish during dry periods, an adaptation to the extreme, dry habitat. The waxy bloom is another adaptation to the very dry habitat.

Age and persistence: Dry leaves persistent.

Armament: Plants with no conspicuous armament, suggesting a response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading, with large, conspicuous light pink to white flowers (rich flowering). Unlike the flowers of most species of *Lampranthus*, these flowers open in shady positions. This phenomenon together with the conspicuous light-coloured flowers can be related to the shady cliff environment, maximising insect pollination.

Fruit/Seed

Size: Seed 1.0–1.3 mm in diameter, depressed, the size ideal for establishment in crevices.

Dispersal: Capsules initially hygrochastic, but remaining open (occasionally closing again). The seeds are shaken from the capsules and dispersed by water, wind and also by jactitation. This is unlike other *Lampranthus* species, which are mostly rain-dispersed.

Time: Seeds ripening in summer. Germination after 21 days.

Vegetative reproduction: Stems of *Lampranthus affinis* will root where they come into contact with the soil, a vegetative backup strategy for survival under the very dry, harsh conditions on the cliff face.

CONSERVATION STATUS

Locally abundant.

ADDITIONAL NOTES

Horticulture: Best for thicket, dry fynbos and succulent karoo gardens, grown on steep embankments, rockeries or balconies. Plants are rapid-growing and not shy to flower, even in shady positions. Propagate from seed or cuttings. *Lampranthus affinis* thrives in cultivation but outside its habitat it is best grown under controlled conditions in a greenhouse.

VOUCHERS

Van Jaarsveld 16086, 17379 (NBG).

ILLUSTRATIONS AND MAP

Figures 212a–212d, Map 212.

MACHAIROPHYLLUM Schwantes

213. *Machairophyllum brevifolium* L.Bolus, Notes on Mesembryanthemum and allied genera 3: 126 (1938).

Crempnophyte growth form: Rounded cluster (of medium weight, cliff hugger).

Growth form formula: A:Lper:R:C:La (vb) (r)

Etymology: Latin *brevi*, short, and *folium*, leaf, pertaining to the short leaves (shortest in the genus).

DESCRIPTION AND HABITAT

Plants much-branched, round, firm, cluster-shaped, 70 mm high, 120 mm wide. Roots fibrous. Stems short. Leaves ascending, very fleshy, trigonous, slightly laterally compressed (laterally viewed 15 mm wide), falcate to subfalcate, 10–30 × 10–26 mm, with a prominent keel; epidermis whitish green to pale green (margins and leaf tips sometimes reddish); surface smooth, adaxial surface flat to slightly convex; apex mucronate. Flowers solitary; pedicels up

to 15 mm long, 40–45 mm in diameter. Petals lorate, 13–20 × 1–2 mm. Capsule top-shaped, 9–12 mm in diameter, 6-locular; covering membranes present, closing body absent.

Phenology: Flowering in spring.

Pollinators: Insects.

Habitat and aspect: Mainly south-facing cliffs and cliff tops. Plants are rooted in crevices and on ledges. It is warm in summer and colder in winter, with occasional light frost. The average daily maximum temperature is about 32°C and average daily minimum about 15°C. Rainfall occurs mainly in summer and winter and is estimated at 200–300 mm per annum.

Altitude: 500–600 m.

Associated vegetation: Gamka Thicket of the Albany Thicket Biome (Mucina *et al.* 2005).

Associated cremnohytes: Associated species include *Crassula capitella* subsp. *thyrsiflora*, *C. nudicaulis*, *C. perforata* and *C. rupestris*.

Geology: Conglomerate (Enon, Uitenhage Group).

DISTRIBUTION

Machairophyllum brevifolium is endemic to cliffs on the conglomerate hills in the Oudtshoorn district of the Western Cape.

RELATED SPECIES

Immediately distinguished from other *Machairophyllum* species by its short, compact leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with compact, rounded cushions. A slow grower and long-lived perennial.

Size and weight: Small plants (of medium weight).

Rootstock: Fibrous, no specialised features.

Leaves

Orientation: Ascending-spreading.

Colour: Whitish green, somewhat glaucous.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: No armament.

Sexual reproduction

Flowers: Vespertine, like those of its relatives, opening late afternoon, pollinated by insects.

Fruit/Seed

Size: Not seen.

Dispersal: Seeds locally dispersed. Capsules hygrochastic and seeds dispersed by falling rain drops.

Time: Seeds ripening throughout summer and autumn, in time for winter rains.

Vegetative reproduction: Absent.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: Best for succulent karoo gardens, grown in rockeries or containers. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from seed or stem cuttings.

VOUCHER

Van Jaarsveld 15227 (NBG).

ILLUSTRATIONS AND MAP

Figures 213a & 213b, Map 213.

OSCULARIA Schwantes

214. *Oscularia cremnophila* Van Jaarsv., Desmet & A.E.van Wyk in *Bothalia* 35,2: 160–163 (2005c).

Cremnophyte growth form: Pendent leafy stems (heavy, cliff hanger).

Growth form formula: E:F:P:Els (vb) (r)

Etymology: Greek *kremnos*, cliff, and Greek *phileein*, to love, pertaining to its cliff habitat.

DESCRIPTION AND HABITAT

Densely branched, glabrescent, succulent shrub pendent from cliffs, 600–750(–1000) mm tall. Old stems woody, up to 30 mm in diameter, basal portion with rough bark, very corky, with

prominent longitudinal cork ridges (wings), leafless for up to 250 mm, becoming thinner with leaves distally; young stems green at first, soon becoming brown, woody and longitudinally fissured. Leaves sessile, united at base, decussate, crowded (almost touching), entire, ascending, spreading, 2 or 3 pairs (with persistent withered older pair), thick, club-shaped, trigonous, 10–15 × 6–10 mm, pale yellowish grey-green; surface minutely papillate; apex obtuse, mucronate; edges of keel and margin sometimes reddish, keel 7–9 mm deep, falcate. Inflorescences in lax to dense, laterally spreading cymes forming panicles, 40–50 × 25–40 mm, with up to 23 flowers on bibracteate peduncles up to 20 mm long; flowers in 3-flowered cymes of (10–)15–17 mm diameter, central flower opening first, remaining open; bracts leaf-like, club-shaped. Flowers diurnal, pleasantly scented; pedicels 3–5(–8) mm long. Sepals 5, unequal, with translucent margins, outer 2 triangular-club-shaped, 5–7 × 3.0–3.5 mm, inner 3 triangular-lobate, 3.5–4.0 × 3.0 mm. Petals pink, in 1 series, spreading, linear-lanceolate, 6–7 × 1.4–2.0 mm; apices obtuse to subacute. Stamens: staminodes filamentous, in a central cone; filaments 3 mm long, distal third pink, basal two thirds translucent, white, clasping ovary; anthers 0.6–0.7 mm long, yellow, not completely overtopping stigmas. Gynoecium 4 mm in diameter, with 5 raised, obtuse sutures, minutely papillate, pale translucent green, elevated up to 1.2 mm; nectaries narrow, 2 mm long, crenulate, surrounding ovary; placentation parietal; stigmas 5, arising from centre between sutures or lobes, tapering, erect, dark maroon, papillate, not completely concealed by stamens. Capsule 5-locular, hygrochastical, globose to top-shaped, 5 mm in diameter, 6–7 mm deep, top rounded, when open then up to 9 mm in diameter; covering membranes complete, valve wings broad. Seeds pear-shaped, 0.6–0.8 mm in diameter, tapering, minutely tuberculate, brownish.

Phenology: Flowering in early spring (August–September).

Pollinators: Insects.

Habitat and aspect: Coastal cliffs of two quartzitic sandstone inselbergs, mainly east-facing. Plants are rooted in crevices and on ledges, drooping over the rock faces. Temperature moderate, with frequent coastal fog. The average daily maximum temperature is about 20°C and average daily minimum temperature about 12°C. Rainfall occurs mainly in winter and is estimated at about 300–400 mm per annum.

Altitude: 50–100 m.

Associated vegetation: Namaqualand Strandveld of the Fynbos Biome (Mucina *et al.* 2005).

Associated cremnophytes: Associated species include *Crassula alsinoides* subsp. *alsinoides*, *C. nudicaulis* and *C. pellucida* subsp. *spongiosa*.

Geology: Quartzitic sandstone, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Oscularia cremnophila is a quartzitic sandstone endemic, confined to the east-facing cliffs of a single inselberg near Elands Bay (Western Cape).

RELATED SPECIES

Related to *Oscularia vredenburgensis*, a spreading shrub of Saldanha with grey-green leaves not as densely arranged and turgid as those of *O. cremnophila*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with dense, leafy, pendent stems and this habit is retained in cultivation. A long-lived perennial with a medium to rapid growth rate.

Size and weight: Large plants with drooping stems sometimes weigh more than 1 kg, but are firmly wedged in crevices.

Rootstock: Fibrous, no specialised features.

Stem: Base of stem with marked corkification, the function of which is not understood currently.

Leaves

Orientation: Ascending-spreading.

Colour: Pale yellowish green, somewhat glaucous.

Age and persistence: Persistent and long-lived, eventually withering.

Armament: Leaves softer and more fragile than those of the closely related *Oscularia vredenburgensis*, suggesting a reduction in armament as a result of the undisturbed habitat.

Sexual reproduction

Inflorescence and flowers: Flowers in cymes, conspicuous, maximising visibility for successful pollination in the vertical cliff environment. Flowering time is in spring.

Fruit/Seed

Size: Seed 0.6–0.8 mm in diameter, tuberculate.

Dispersal: Brown seeds dispersed by raindrops (ombrohydrochory) (Hartmann 1991).

Time: Seeds ripening throughout summer and ready for dispersal at the onset of autumn rains. Germination within 3 weeks.

Vegetative reproduction: Plants become pendent, the branches (vegetative growth) rooting when coming into contact with soil, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic of which the population is so small that it might become threatened.

ADDITIONAL NOTES

Horticulture: Best for fynbos gardens, grown on steep embankments, balconies, containers or rockeries. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings. Does well in containers, in full sun or dappled shade. Its ease of growth maximises survival rate.

VOUCHER

Van Jaarsveld 19003 (NBG).

ILLUSTRATIONS AND MAP

Plate 214, Figures 214a–214e, Map 214.

RUSCHIA Schwantes

215. *Ruschia knysnana* (L.Bolus) L.Bolus, Notes on Mesembryanthemum and allied genera 1: 146 (1929).

Cremonophyte growth form: Cushion-shaped to pendent or mat-forming, succulent-leaved (of medium weight, cliff squatter).

Growth form formula: E:F:As:W:Ev (vb)

Etymology: After Knysna, Western Cape, where this species occurs.

DESCRIPTION AND HABITAT

Plants much-branched, cushion-shaped or pendent shrublets up to 600 mm in diameter. Roots fibrous. Stems reddish brown at first, becoming grey, up to 2 mm in diameter; nodes 5–15 mm apart. Leaves connate at base, often in compact groups, becoming deciduous on older stems and not persistent, ascending, fleshy, bright green (margins and keels translucent, and leaf tips sometimes reddish), triquetrous, slightly laterally compressed (up to 8 mm wide), subfalcate, 20–30(–40) × 4–6 mm; margin and keel entire except tips sometimes obscurely serrate-denticulate; surface smooth, adaxial surface flat; apex aristate or apiculate. Flowers solitary, 12–15 mm in diameter; pedicels 5 mm long (in fruit). Petals purplish pink, 10 × 0.8 mm, merging with staminodes. Filaments 3–5 mm long, light pink. Anthers 1 × 0.2 mm. Stigmas surrounded by a ring of nectaries. Capsule top-shaped, rounded at top, 7 mm in diameter; closing body absent, covering membranes present, valves light brown, valve wings narrow. Seed pear-shaped, 1 mm in diameter, pale brown.

Phenology: Flowering mainly in spring and summer.

Pollinators: Insects.

Habitat and aspect: Coastal cliffs and steep near vertical slopes (mainly south-facing). Plants are firmly rooted in crevices and size often depends on the growing space allowed by

the crevice. Temperature moderate throughout the year. Winters are cooler but frost is absent. The average daily maximum temperature is about 21°C and average daily minimum about 11°C. Rainfall occurs throughout the year (cyclonic in winter, but also with occasional thunder showers in summer), ranging from 600–700 mm per annum.

Altitude: 50–650 m.

Associated vegetation: Tsitsikamma Sandstone Fynbos and Loerie Conglomerate Fynbos (Knysna) (Mucina *et al.* 2005).

Associated cremnophytes: At Oubosstrand, *Ruschia knysnana* grows with *Bulbine latifolia*, *Crassula nudicaulis* and *C. perforata*.

Geology: Quartzitic sandstone (Cape Supergroup) or Enon Conglomerate.

DISTRIBUTION

Ruschia knysnana is distributed from Knysna (Western Cape) to Oubosstrand (Eastern Cape), growing on coastal cliffs.

RELATED SPECIES

No close relatives.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with compact cushion or becoming pendent and this habit is retained in cultivation. A rapid-growing, fairly long-lived perennial.

Size and weight: Plants of medium weight.

Rootstock: Fibrous, no specialised features.

Stem: No apparent unique cliff adaptation.

Leaves

Orientation: Ascending-spreading.

Colour: Bright green.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: The lack of sufficient armament an apparent response to the undisturbed cliff habitat in contrast to the surrounding accessible fynbos.

Sexual reproduction

Inflorescence and flowers: Flowers simple, occasionally on elongated flowering branches, at branch ends or axillary produced, conspicuous, maximising visibility for successful pollination in the vertical cliff environment. Flowering time is in late spring and summer and flowers are regularly produced, ensuring a long and continual seed supply also coinciding with rainfall in the region.

Fruit/Seed

Size: Seed 1 mm in diameter, an ideal size for establishment in crevices.

Dispersal: Seeds dispersed by rainwater ('wash-out dispersal', Hartmann 1991). The compressed shape is an adaptation for wind dispersal as well, the seeds settling and germinating in crevices.

Time: Seeds ripening throughout summer and autumn, in time for winter rains.

Vegetative reproduction: Absent.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: Best for fynbos gardens, grown on steep embankments, rockeries or balconies. Plants are rapid-growing and not shy to flower. Propagate from seed or cuttings. *Erepsia knysnana* thrives in cultivation, but outside its habitat it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 18658 (NBG).

ILLUSTRATIONS AND MAP

Figures 215a & 215b, Map 215.

216. *Ruschia promontorii* L.Bolus, Notes on Mesembryanthemum and allied genera 2: 121 (1929).

Cremonophyte growth form: Pendent leafy mats (of medium weight, cliff hanger).

Growth form formula: E:F:P:Els:Ev (vb)

Etymology: The epithet *promontorii* refers to the Cape Peninsula, especially Cape Point, a promontory where the plant occurs.

DESCRIPTION AND HABITAT

Plants much-branched, mat-forming, glabrous shrublets becoming pendent from cliff faces, with stems up to 500 mm long forming loose mats, leaves crowded at branch ends (2 or 3 pairs). Roots fibrous. Branches 3.5 mm in diameter (main branch up to 5 mm in diameter), reddish at first, biconvex, becoming mottled grey and woody but remaining flaccid; nodes 15–25 mm apart; surface smooth. Leaves fleshy, trigonous, falcate to subfalcate owing to deep prominent keel (5–7 mm), green to yellowish green, reddish at tips and keels, 10–20 × 5–7 mm (viewed dorsally, triangular-ovate), ascending; surface smooth, adaxial surface somewhat flat; apex acute, bearing prominent mucro. Flowers solitary, up to 30 mm in diameter; pedicels 7 mm long. Petals purplish pink. Anthers yellow. Capsule top-shaped, 7–9 mm in diameter, 5–6 mm deep; closing body absent. Seed pear-shaped, 1.5 × 1 mm, minutely tuberculate, light brown.

Phenology: Flowering mainly in spring, to end of October.

Pollinators: Insects.

Habitat and aspect: Sea-facing cliffs (all aspects, mainly northern). Plants are rooted in crevices and on ledges, drooping over the rock faces. Temperature relatively low throughout the year. The average daily maximum temperature is 20°C and average daily minimum for the region 12°C. Rainfall occurs mainly in winter and is estimated to be above 300–400 mm per annum.

Altitude: 120–400 m.

Associated vegetation: Hangklip Sand Fynbos (Mucina *et al.* 2005).

Associated cremnophytes: Near the light house at Cape Point, *Ruschia promontorii* shares its habitat with *Cotyledon orbiculata* var. *orbiculata*, *Crassula nudicaulis*, *Cussonia thyrsiflora*, *Tylecodon grandiflorus* and *T. paniculatus*.

Geology: Quartzitic sandstone, Table Mountain Group (Cape Supergroup).

DISTRIBUTION

Ruschia promontorii is a quartzitic sandstone endemic, confined mainly to east facing coastal cliffs in the Cape Point Nature Reserve (Western Cape). Outside of the National Park it grows on west-facing cliffs (Scarborough to Chapman's Peak).

RELATED SPECIES

Related to *Ruschia rubricaulis*, a ascending to sprawling shrublet occurring among sandstone outcrops.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with pendent, leafy stems, this habit retained in cultivation. A rapid-growing, fairly long-lived perennial.

Rootstock: Central taproot and branches rooting where touching the ground. Roots fibrous, no specialised features.

Stem: Pendent and forming loose mats. Stems and leaves soft and flaccid, a character that can be viewed as a reduction in armament as a result of the undisturbed habitat.

Leaves

Orientation: Ascending-spreading.

Colour: Bright green to yellowish green.

Age and persistence: Leaves persistent and long-lived, eventually withering and resulting in apical grouping.

Armament: No armament.

Sexual reproduction

Flowers: Flowers are simple at branch ends, conspicuous, maximising visibility for successful pollination in the vertical cliff environment. Flowering time is in winter and spring, ensuring a long and continual seed supply.

Fruit/Seed

Size: Seed large, 1.5 mm in diameter, and minutely tuberculate, a size and surface ideal size for establishment in crevices.

Dispersal: Seeds dispersed by rainwater (ombrohydrochory, Hartmann 1991), settling and germinating in crevices.

Time: Seeds ripening throughout summer and autumn, in time for winter rains. Germination within 3 weeks.

Vegetative reproduction: Plants increase vegetatively, forming small mats that become pendent, the branches (vegetative growth) rooting where they touch the soil, an efficient vegetative dispersal backup and adaptation to the cliff face, ensuring long-term survival.

CONSERVATION STATUS

A local endemic, not threatened (Hilton-Taylor 1996).

ADDITIONAL NOTES

Horticulture: Best for cool fynbos and other temperate gardens, grown in containers or rockeries. Outside its habitat, it is best grown under controlled conditions in a greenhouse. Propagate from cuttings. Does well in containers, in dappled shade or full sun. Its ease of growth maximises survival rate.

VOUCHER

Van Jaarsveld 19954 (NBG).

ILLUSTRATIONS AND MAP

Figures 216a–216c, Map 216.

SCOPELOGENA L.Bolus

217. *Scopelogenia bruynsii* Klak in *Bothalia* 30,1: 35–42 (2000).

Cremnophyte growth form: Decumbent shrublet (of medium weight, cliff squatter).

Growth form formula: E:F:As:W:Ev (vb) (r)

Etymology: The genus name ‘*Scopelogenia*’, Latin, ‘*scopulus*’, a cliff, pertaining to its habitat. After Dr Peter Bruyns, specialist in Asclepiadaceae and succulent plants.

DESCRIPTION AND HABITAT

Decumbent, branched shrublets up to 500 mm in diameter, about 300 mm high, branched from base, with short side branches along stems. Roots fibrous. Stems cylindrical, woody, up to 10 mm in diameter, becoming purplish grey; younger leafy branches terete, purplish, 4 mm in diameter. Leaves crowded, erect to slightly incurved, ascending, subterete to 3-angled, up to 45 × 8 mm, persistent when dry; surface smooth, glaucous, covered with powdery bloom, becoming yellowish when stressed. Inflorescence cymose, at ends of main branches. Flowers up to 18 mm in diameter, yellow to pink or reddish, flowering in masses, conspicuous. Staminodes numerous; petaloid staminodes linear-oblongate, 7 × 1.5 mm; stamens numerous, light yellow. Stigmas 5.3 mm long. Capsule top-shaped, hygrochastic, 5-locular, soft, up to 4.5 mm in diameter, top dome-shaped; covering membranes present. Seed 1 mm in diameter, tuberculate, pear-shaped.

Phenology: Flowering in spring and early summer (September–October).

Pollinators: Insects.

Habitat and aspect: Sheltered south-facing cliffs. Temperatures are high in summer (average daily maximum about 26°C; average daily minimum about 10°C). Winters are cooler but frost is absent. Rainfall occurs mainly in winter (cyclonic winter rain), ranging from 200–300 mm.

Altitude: 120–400 m.

Associated vegetation: Succulent Karoo.

Associated cremnophytes: At Rooiberg, northern Knersvlakte (red flowered population), *Scopelogenia bruynsii* shares its habitat with *Cotyledon orbiculata* var. *orbiculata*, *Crassula pseudohemisphaerica* and *Tylecodon nolteei*.

Geology: Quartzitic sandstone of the Nardouw Subgroup (Table Mountain Group), Witpoort Formation (Witteberg Group), the latter two of the Cape Supergroup and also the Kwanous Formation in the Kamiesberg (Vanrhynsdorp Group).

DISTRIBUTION

Scopelogenia bruynsii is confined to quartzitic sandstone mountains ranging from the Kamiesberg (Northern Cape) to the mountains of the Little Karoo in the Western Cape.

RELATED SPECIES

See differences under *Scopelogenia verruculata*.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with erect to decumbent stems, with a cushion-like growth. A rapid-growing, fairly long-lived perennial. No noticeable vegetative adaptation to the cliff environment.

Size and weight: Plants of medium weight or heavy.

Stem: The short branches are grey and covered by persistent old leaves.

Leaves

Orientation: Ascending, subterete.

Colour and texture: Glaucous (reflecting the light), with powdery bloom. Their slight translucent nature allows light to penetrate deeply, an adaptation enabling the plants to cope with the shady cliff environment. Leaves are soft and fleshy, becoming turgid after rain, but yellowish during dry periods, an adaptation to the extreme, dry habitat.

Age and persistence: Old, dry leaves persistent.

Armament: No conspicuous armament, suggesting a response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading, with conspicuous yellow to pink flowers. The plants are floriferous and flower in masses. Unlike the flowers of most species of *Scopelogenia*, these flowers open in shady positions. This phenomenon together with the conspicuous light-coloured flowers can be related to the shady cliff environment, maximising insect pollination.

Fruit/Seed

Size: Seed 1 mm in diameter, depressed, pear-shaped, the size ideal for establishment in crevices.

Dispersal: Seeds forced out of capsules by water action and then locally dispersed.

Time: Seeds ripening in summer.

Vegetative reproduction: Branches finding a crevice will rapidly root.

CONSERVATION STATUS

Locally abundant.

ADDITIONAL NOTES

Horticulture: Best for dry fynbos or succulent karoo gardens, grown on steep embankments, rockeries or balconies. Plants are rapid-growing and not shy to flower, even in shade. Propagate from cuttings. *Scopelogenia bruynsii* thrives in cultivation, but outside its habitat it is best grown under controlled conditions in a greenhouse.

VOUCHER

Van Jaarsveld 17812 (NBG).

ILLUSTRATIONS AND MAP

Figure 217a, Map 217.

218. *Scopelogenia verruculata* (L.) L.Bolus in Journal of South African Botany 28: 9–11 (1962).

Cremonophyte growth form: Decumbent shrublet (of medium weight to heavy, cliff squatter).

Growth form formula: E:F:As:W:Ev (vb) (r)

Etymology: Latin *verrucula*, a small wart, pertaining to the leaves; Linnaeus cited Dillenius who named this species *Mesembryanthemum foliis verruculiformibus*.

DESCRIPTION AND HABITAT

Decumbent, branched shrublets up to 1 m in diameter and about 200 mm high, branched from base, with short side branches along stems. Roots fibrous. Stems cylindrical, woody, up to 12 mm in diameter, becoming purplish grey; younger leafy branches terete, purplish, 4 mm in diameter. Leaves numerous, erect to slightly falcate, ascending, subterete, up to 40 × 7 mm; surface smooth, glaucous, covered with powdery bloom, becoming yellowish when stressed, persistent when dry. Inflorescence cymose, at ends of main branches, up to 90 mm long, 80 mm in diameter. Flowers up to 18 mm in diameter, yellow, flowering in masses, conspicuous. Staminodes numerous; petaloid staminodes linear-oblongate, 7 × 1.5 mm; stamens numerous, light yellow. Stigmas 5.3 mm long. Capsule hygroscopic, woody, 5 mm deep, 7 mm in diameter, opening once, remaining open. Seed 1.2 mm in diameter, pear-shaped, flat, wind-dispersed.

Phenology: Flowering in spring and early summer (October–November).

Pollinators: Insects.

Habitat and aspect: Mainly sheltered cliffs (mostly south- and east-facing aspects). Plants are firmly rooted in crevices. Temperature relatively low in summer. Winters are cooler but frost is absent. The average daily maximum temperature is about 18°C and average winter temperature 8–10°C. Rainfall occurs mainly in winter (cyclonic winter rain), ranging from 1000–1500 mm per annum.

Altitude: 100–1000 m.

Associated vegetation: Peninsula Sandstone Fynbos (Mucina *et al.* 2005).

Associated cremnophytes: On cliffs on Table Mountain, it grows with the following cliff-dwelling species: *Bulbine lagopus*, *Crassula coccinea*, *C. pellucida* subsp. *alsinoides*, *Lampranthus multiradiatus* and *Oscularia falcata*.

Geology: Quartzitic sandstone (light-coloured and smooth-textured), Peninsula Formation (Cape Supergroup).

DISTRIBUTION

Scopelogenia verruculata is a quartzitic sandstone endemic, confined to rock faces from the Cape Peninsula to Riversdale in the east (Western Cape mountains).

RELATED SPECIES

Related to *Scopelogenia bruynsii*, but differs in the fruiting capsules remaining open, not closing again after initial opening. Related to the genus *Lampranthus* but immediately distinguished by the subterete, linear leaves.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Plants with erect to decumbent stems with a cushion-like growth. A rapid-growing, fairly long-lived perennial.

Size and weight: Plants of medium weight to heavy.

Stem: The short branches are grey and covered by persistent old leaves.

Leaves

Orientation: Ascending, subterete.

Colour and texture: Glaucous, with powdery bloom. Their slight translucent nature allows light to penetrate deeply, an adaptation enabling the plants to cope with the shady cliff environment. Leaves are soft and fleshy, becoming turgid after rain, but yellowish during dry periods, an adaptation to the extreme, dry habitat.

Age and persistence: Old, dry leaves persistent.

Armament: Plants without conspicuous armament, suggesting a response to the undisturbed cliff habitat in contrast to the thorny but heavily grazed surrounding thicket vegetation. Branches are not brittle and, unlike those of many *Lampranthus* species, difficult to detach owing to their strong fibrous nature.

Sexual reproduction

Inflorescence and flowers: Inflorescence ascending to spreading, with conspicuous yellow flowers. The plants are floriferous and flower in masses. Flowering in shady positions together with the conspicuous light-coloured flowers (rich flowering) can be related to the shady cliff environment, maximising insect pollination.

Fruit/Seed

Size: Seeds 1.2 mm in diameter, flat, pear-shaped, the size ideal for establishment in crevices.

Dispersal: Light seeds shaken from the capsules and dispersed by wind. This is unlike other related Mesembryanthemaceae such as members of the genus *Lampranthus* of which the seeds are rain-dispersed, an adaptation to the cliff environment.

Time: Seeds ripening in summer.

Vegetative reproduction: Branches finding a new crevice will rapidly root, filling ledges, a vegetative backup strategy enabling the plants to survive the harsh cliff-face environment.

CONSERVATION STATUS

Locally abundant and not threatened.

ADDITIONAL NOTES

Horticulture: Best for fynbos gardens, grown on steep embankments, rockeries or balconies. Plants are rapid-growing and not shy to flower, even in shade. Propagate from cuttings. *Scopelogenia verruculata* does well in cultivation, but outside its habitat it is best grown under controlled conditions in a greenhouse. Plants easily grown from cuttings. It grows very easily, maximising survival rate.

VOUCHER

Van Jaarsveld 17628 (NBG).

ILLUSTRATIONS AND MAP

Figures 218a–218d, Map 218.

OXALIDACEAE

Oxalis L.

219. *Oxalis pocockiae* L.Bolus

OXALIS L.

219. *Oxalis pocockiae* L.Bolus in Journal of Botany, British and Foreign 68: 75 (1930).

Cremonophyte growth form: Dwarf-sized rosette (of light weight, cliff hugger).

Growth form formula: A:B:D:C:La (vb)

Etymology: After Mary Agard Pocock (1886–1977), botanist who specialised in algae.

DESCRIPTION AND HABITAT

Plants dwarf-sized, semisucculent geophytes up to 140 mm high, with shortly exerted stems from rhizome 40–100 mm long. Bulb narrowly ovoid, with 4 longitudinal wings; tunics numerous, hard, dark brown, the outer adpressed at margins and forming the wings; numerous aerial winged bulbs produced in leaf axils. Leaves basal to loosely imbricate, glabrous or sparsely hairy; petiole up to 25 mm long; leaflets 3, sessile, broadly cuneate-rotund, 3–6 × 5–10 mm, green, often purplish below, the medial usually emarginate. Peduncles extending beyond leaves. Sepals oblong-lanceolate, obtuse, 4.5–7.0 mm long. Corolla 12–24 mm long, rose to white; tube funnel-shaped, yellow. Ovary glabrous or pubescent; styles pubescent. Stamens 9–10. Seed endospermous. (Description based on Salter 1944.)

Phenology: Flowering in winter and spring. Seed wind-dispersed.

Pollinators: Insects.

Habitat and aspect: A chasmophyte occurring in rock crevices, often on vertical sandstone cliffs. The bulbs are firmly rooted in crevices and on rocky ledges. The winters are cool but frost is a rarity or absent. The average daily maximum temperature is about 22°C and the average daily minimum 15°C. Rainfall occurs mainly in winter, occasionally in summer, 750–2000 mm per annum.

Altitude: 350–600 m.

Associated vegetation: Mainly Sandstone Fynbos in Peninsula Sandstone Fynbos, Fynbos Biome (Mucina *et al.* 2005).

Associated cremonophytes: *Aloe succotrina*, *Cotyledon orbiculata*, *Crassula nudicaulis*, *Drosanthemum stokoei* and *Ruschia promontorii*.

Geology: Mainly quartzitic sandstone, Peninsula Formation (Cape Supergroup), also on granite.

DISTRIBUTION

Oxalis pocockiae is confined to quartzitic cliff faces and rocky outcrops in the Western Cape, from Prince Albert in the east to Malmesbury in the west.

RELATED SPECIES

Related to *Oxalis depressa*, but at once distinguished by its winged vegetative bulbils.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact, rosulate growth, the rhizome deeply embedded in rock crevices. The bulb ensures its survival during the long summer droughts. The vegetative winged bulbils are formed near the stem apex, brittle and easily detached.

Size and weight: Dwarf-sized clusters.

Leaves

Orientation: Spreading-ascending.

Colour: Green, often purplish below.

Armament: Absent.

Sexual reproduction

Flowers: Corolla 12–24 mm long, rose to white; tube funnel-shaped, yellow.

Fruit/Seed

Size: Very fine dust diaspores.

Dispersal: Seeds dispersed by wind.

Time: Dispersal in winter and spring.

Vegetative reproduction: *Oxalis pocockiae* regenerates from brittle, winged bulbils that are dispersed by wind, a unique feature among cremnophilous succulent and bulbous succulent plants. When these winged bulbils become detached and fall into adjacent crevices, they will root and establish new plants. This regeneration is a vegetative backup strategy, aiding long-term survival.

CONSERVATION STATUS

Localised and confined to cliffs where it is not threatened owing to the inaccessible habitat.



ADDITIONAL NOTES

Horticulture: Grown as a curiosity plant, with potential to become a weed in succulent collections. Easily grown, but not an ornamental species.

VOUCHER

Van Jaarsveld 19660 (NBG).

ILLUSTRATIONS AND MAP

Figures 219a–219d, Map 219.

PORTULACACEAE

Anacampseros L.

220. *Anacampseros scopata* G. Will.

ANACAMPSEROS L.

220. *Anacampseros scopata* G. Will. in *Cactus and Succulent Journal* (U.S.) 66: 20–23 (1994).

Cremnophyte growth form: Dwarf-sized compact herb, leaf and stem succulent (of light weight, cliff hugger).

Growth form formula: A:S:Lper:Lc:Ca:B (vb) (ft)

Etymology: The epithet *scopata*, densely covered with bristly hairs, pertains to the heads covered in hairs.

DESCRIPTION AND HABITAT

Plants dwarf-sized perennials with flattened tubers, 25 × 12 mm, due to rock fissures. Branches up to 8, arising from tubers, truncate, up to 1.5 mm long, 5 mm in diameter. Leaves numerous, embedded among dense mass of white, woolly hairs (up to 5 mm long); lamina broadly elliptic to narrowly ovate, about 2–3 mm long, fleshy, ascending, glabrous, dark to greenish brown. Peduncles up to 10 mm long, 6 mm in diameter. Flowers apically produced, solitary, white to light pink. Sepals 2.5 × 2.5 mm, hooded, triangular, pink brown, fleshy. Petals: upper petal 2.3 mm long, 3 mm wide, triangular, subacute; lateral petals 2.5 × 2.3, triangular, subacute. Stamens 1.5 mm long, clasping base of ovary. Ovary globose, 1 mm in diameter, bright green; style 1 mm long. Seed obovate, 0.8 mm in diameter, tuberculate, straw-coloured.

Phenology: Flowering in autumn and winter.

Pollinators: Insects.

Habitat and aspect: In fissures of horizontally layered quartz on the eastern cliffs of Vyftienmyl se Berge. Winters cool but frost is a rarity or absent. Average daily maximum temperature is 19°C, average daily minimum 10°C. Rainfall mainly in winter and spring, 25–50 mm per annum. Precipitation in the form of regular fog from the nearby Atlantic Ocean.

Altitude: 350–450 m.

Associated vegetation: Vyftienmyl se Berge Succulent Shrubland, Succulent Karoo Biome (Mucina *et al.* 2005).

Associated cremnophytes: *Conophytum stephanii*, *Crassula muscosa*, *C. pseudohemisphaerica*, *Gasteria pillansii* var. *ernesti-ruschii*, *Haworthia arachnoidea*, *Plectranthus strigosus* and *Tylecodon buchholzianus*.

Geology: Stinkfontein Subgroup (Gariiep Supergroup).

DISTRIBUTION

Anacampseros scopata is known only from east-facing cliffs of the low coastal Oograbies mountain range near Port Nolloth along the Atlantic coast where it is subject to regular fog.

RELATED SPECIES

Anacampseros scopata is related to another dwarf-sized plant, *A. bayeri*, the latter lacking the dense woolly hairs and occurring in shallow pans, not on cliffs.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Compact succulent growth in the horizontal quartz layers ensures a safe, undisturbed habitat (from larger herbivores). Dense, woolly hairs help to trap the low clouds of fog.

Size and weight: Clusters dwarf-sized, of light weight.

Leaves

Orientation: Ascending-spreading.

Colour: Dark to greenish brown, covered in dense, white, woolly hairs.

Armament: Absent.

Sexual reproduction

Inflorescence and flowers: Flowers apically produced, solitary, white to light pink.

Fruit/Seed

Size: Seed small diaspores, 0.8 mm in diameter.

Dispersal: Seeds dispersed by wind.

Time: Winter and spring.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Localised and confined to cliffs where it is not threatened owing to the inaccessible habitat.

ADDITIONAL NOTES

Horticulture: Best for greenhouses, grown under controlled conditions. Keep in light shade, dry in summer, but mist regularly. Plants easily grown in small containers, but need regular attention owing to their minute size. Thrives in a cool desert climate but must be protected from frost.



VOUCHER

G. & F. Williamson 4600 (NBG).

ILLUSTRATIONS AND MAP

Figures 220a–220c, Map 220.

OUTGROUPS (NON-SUCCULENTS)
(Pedaliaceae, Scrophulariaceae)

PEDALIACEAE

Dewinteria Van Jaarsv. & A.E.van Wyk

221. *Dewinteria petrophila* (De Winter) Van Jaarsv. & A.E.van Wyk

DEWINTERIA Van Jaarsv. & A.E.van Wyk

221. *Dewinteria petrophila* (De Winter) Van Jaarsv. & A.E.van Wyk in *Bothalia* 37,2: 198–201 (2007a).

Cremonophyte growth form: Squat, somewhat trailing chasmocremnophyte (of light weight, cliff squatter).

Growth form formula: E:F:As:S/H:Es:De (vb) (r) (fn)

Etymology: Greek *petra*, a rock, and *philein*, to love, after its rock habitat.

DESCRIPTION AND HABITAT

Soft, somewhat trailing, branched, biennial (or annual) plant, up to 200 mm long; most parts covered with mucilage glands; base of stem slightly swollen (semisucculent, somewhat ovate, up to 5 mm in diameter), often compressed owing to narrow crevices. Roots fibrous. Branches 3–4 mm in diameter at base. Specialist branchlets filiform, 0.25 mm in diameter, basally produced, trailing, negatively phototropic, annual, usually dying back after fruiting. Leaves on main branches opposite (internodes 8–14 mm long), broadly cordate to kidney-shaped, up to 40 × 55 mm, grey-green; margin coarsely dentate; petiole 20–60 mm long; axils mostly with paired or solitary extrafloral nectary. Leaves on specialist branchlets (arising as accessory shoots below extrafloral nectary and flower) small, entire, ovate, 2–4 × 0.6–1.7 mm; petiole 3–4 mm long, sometimes becoming slightly longer but then leaves becoming broader and coarsely toothed. Flowers on main branch axillary (mostly solitary, rarely in pairs), conspicuous, trumpet-shaped, 30–70 mm long; pedicel 1.2–4.0 mm long. Calyx slightly zygomorphic, persistent, 5-partite; lobes oblong-triangular, up to 3 mm long. Corolla slightly swollen at base, sparsely covered with mucilage glands, cream-coloured (pale yellow in bud stage) and maroon-purple in throat and tube; lobes 5, broadly ovate, somewhat 2-lipped, lower pair slightly larger than upper 3. Stamens 4, arising from base of corolla tube, with short staminode between the pairs; filaments filiform, slightly flattened, up to 12 mm long, pilose; anthers basifixed. Ovary elongate-conical, 2-chambered, placentation axile, with 3–5 seriate ovules; style up to 23 mm long; stigma capitate, up to 1.5 mm in diameter. Cleistogamous flowers on specialist branchlets 2 mm long, light yellowish green, remaining a reduced bud; pedicel up to 1.5 mm long. Capsules on main branches lanceolate in side view, 18–25 mm long, tapering into curved apex, laterally flattened, dehiscent loculicidally; valves 2, chartaceous. Specialist capsules flattened, ovate to ovate-cordate, 5–8 × 4.0–5.5 mm, brown; both carpels dehiscent loculicidally, false septa nearly completely reduced to small

seams at base of capsule. Seeds of main branch capsules linear-oblong to club-shaped, slightly flattened, 2.0–2.2 mm long, minutely reticulate, brownish. Specialist seeds oblong-obovoid, 2.5–3.0 mm long, fringed. (Description based partly on De Winter 1961.)

Phenology: Flowering in summer (January–April).

Pollinators: The long-tubed white corolla with its distinct maroon-purple centre suggests a specialist insect pollinator.

Habitat and aspect: Rock fissures, cracks and crevices. All aspects of cliffs but more prominent on shady, south-facing cliffs. Temperatures correspond to those of the tropics and it is very hot in summer. Winters are cooler but frost is absent. The average daily maximum temperature is 30–38°C and average daily winter temperature 18–28°C. Rainfall in summer, ranging from 50–150 mm per annum.

Altitude: 600–1500 m.

Associated vegetation: Mosaic of arid mopane savanna (*Colophospermum mopane* dominant) and Namib Desert vegetation.

Associated cremnophytes: *Aeollanthus haumannii* and *Tetradenia kaokoensis*.

Geology: Granite (Fransfontein Granite Suite).

DISTRIBUTION

Otjihipa Mountains, northwestern Kaokoveld, Namibia.

RELATED SPECIES

Related to *Rogeria* but immediately distinguished by its unique atelechorous and anemochorus dispersal strategies. This is a remarkable adaptation and the first of its kind recorded for an obligate cremnophilous species. It is further distinguished from *Rogeria* by its soft fragile growth, soft capsules and small, linear to club-shaped seeds. All *Rogeria* species are annual or biennial, with erect woody growth, and are usually found on disturbed sites. They have very firm, armoured capsules and flattened seed.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Soft, fragile, squat, somewhat trailing growth. It has a flattened, semisucculent, perennial stem base, well wedged in the small rock cracks and well protected from disturbances such as wind or large herbivores. Plants grow in summer when flowering and fruiting takes place, with a resting period in winter and spring. The habitat of small fissures and cracks in boulders presents little competition from other cliff-dwelling plant species.

Size and weight: Usually 100–250 mm in diameter, size also depending on the amount of rain.

Stem: Soft and fragile, sometimes becoming pendent if growing from an overhang. Additionally, the elongating, wandering, filiform accessory stems, which also appear in summer,

are phototropically negative and will grow into any available (adjacent or the same) crevice. Small cleistogamous flowers result in different smaller, ovate seed capsules deeply buried within the crevice and with larger seeds than those produced by the normal aerial capsules.

Leaves

Orientation: Ascending to spreading.

Colour and texture: Glaucous, grey-green, covered with mucilage glands, well adapted to the xeric habitat.

Age and persistence: Weakly perennial, rapid-growing during the short wet periods but dying back to the base under unfavourable conditions.

Armament and camouflage: Plants without conspicuous armament or camouflage properties. The fruiting capsules of the two related *Rogeria* species in the region are very hard and armoured. The extrafloral nectaries attract ants, which provide additional protection against phytophagous insects (plants at Kirstenbosch continually visited by local ants).

Sexual reproduction

Remarkable reproductive biology: *Dewinteria petrophila* displays a remarkable reproductive biology, an adaptation to its arid cliff-face habitat. The safe (ensured) atelechorous (blastochory) cloned seed placement near the mother plant (or adjacent crevices) and aerial anemochorous (dust diaspores) dispersal ensure long-term survival.

Inflorescence and flowers: Flowers axillary, large in comparison to plant size, thus rich flowering ensuring cross fertilisation. The large, tubular, trumpet-shaped standard flowers suggest a specific insect pollinator. The dwarf cleistogamous flowers are 2 mm long, with pedicels up to 1.5 mm long, on slender, negatively phototropic, filiform branches bearing ovate, dwarf-sized, sometimes toothed leaves.

Fruit/Seed

Capsules: Capsules on arboreal branches tapering and flattened, those on specialist accessory branches flattened, much smaller, ovate to ovate-cordate; both capsules dehiscent loculicidally.

Size: Seed from aerial capsules 2.0–2.2 mm long, linear-oblong to club-shaped, slightly flattened, minutely reticulate, brownish (more than 50 per capsule). Seed from smaller capsules on accessory branches 2.5–3.0 mm long, oblong-obovoid, fringed (up to 5 per capsule).

Dispersal: The smaller seeds from the normal aerial capsules are shaken from their capsules by wind (anemochorous). The higher numbers (more than 50) improve chances of seeds landing in a suitable crevice site. The larger seeds from cleistogamous flowers and smaller capsules are locally dispersed (blastochory), the lower number of seeds (less than 5 per capsule) well secured, 'planted' deep in the fissure by the plant itself. Here the seeds remain, germinating when conditions become favourable (with the next good rains), an adaptation that could be compared to a long-term insurance policy. In

this way, the plant can afford to produce fewer but larger, more secure seed but of the exact genetic stock as the mother plant.

Establishment: Mucilage on the surface of the seed may play a role in anchorage of seedlings and in absorption of moisture in both seed types.

Time: Seeds released during the rainy season from summer to autumn.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Plants are fairly common on cliff faces in the habitat and are not threatened.

ADDITIONAL NOTES

Horticulture: An attractive ornamental species that would be excellent for dry desert gardens, grown in rock fissures. Grow from seed, but germination is erratic. Best grown in dappled shade under controlled conditions in a greenhouse. Flowering in summer and autumn.

VOUCHERS

Van Jaarsveld 17520, 19413, 19527, 22102, 22106 (NBG).

ILLUSTRATIONS AND MAP

Plate 221, Figures 221a–221e, Map 221.

SCROPHULARIACEAE

Stemodiopsis Engl.

222. *Stemodiopsis rivae* Engl.

STEMODIOPSIS Engl.

222. *Stemodiopsis rivae* Engl. in *Annuario Reale del Istituto Botanico di Roma* 7: 25 (1897).

Cremonophyte growth form: Trailing chasmophyte (of light weight, cliff hugger).

Growth form formula: E:F:As:S/H:Es:De (vb) (fn)

Etymology: After the Italian botanist Domenico Riva (1856–1895), who collected the type.

DESCRIPTION AND HABITAT

Soft, perennial, branched, trailing herb up to 400 mm in diameter; stems and leaves strigose. Branches somewhat 4-angled. Leaves slightly fleshy; lamina triangular-ovate to ovate, 5–18 × 2–18 mm; margin serrate-dentate with 2–4 teeth; apex acute; base cuneate to subtruncate; petiole 3–12 mm long. Flowers solitary; bracteole up to 1.5 mm, subulate; pedicels 4–9 mm long, becoming decurved in fruiting stage. Calyx lobes subequal. Corolla 2-lipped, up to 10 mm long, white; throat pink to mauve; tube up to 6.5 mm long, 1.5 mm at base, widening to 4 mm at throat, sparsely pilose; upper lip about 3 mm long, triangular-ovate, lower lip 4.0–4.5 mm long, shortly trilobed, minutely pubescent. Capsule 4–5(–9) mm long (including beak), minutely pubescent. Seed oblong, 1 × 0.3 mm, slightly curved, yellowish brown. (Partly based on Philcox 1990.)

Phenology: Flowering in summer (January–April).

Pollinators: Insects.

Habitat and aspect: Rock cracks and crevices. All aspects, but mainly on shady south-facing cliffs. Temperatures correspond to those of the tropics and it is very hot in summer. Winters are cooler but frost is absent. The average daily maximum is 29°C and average daily winter temperature 17°C. Rainfall in summer, ranging from 300–400 mm per annum.

Altitude: 400–1675 m.

Associated vegetation: Soutpansberg Mountain Bushveld of the Savanna Biome (Mucina *et al.* 2005).

Associated cremonophytes: On the farm Little Leigh (near Wyllies Poort), it grows with the following cliff-dwelling plants: *Adromischus umbraticola* subsp. *ramosa*, *Aeollanthus buchnerianus* and *Crassula setulosa*.

Geology: Sandstone of the Wyllies Poort Formation (Soutpansberg Group).

DISTRIBUTION

Restricted to cliffs near Wyllies Poort and also in Zambia, Zimbabwe, Mozambique and Malawi.

RELATED SPECIES

The only *Stemodiopsis* species occurring in South Africa. The negatively phototropic fruit stalks are unique among the family Scrophulariaceae in South Africa.

ADAPTATIONS TO THE CLIFF ENVIRONMENT

Habit: Soft, fragile, trailing perennial growth in narrow crevices, also from the roof of overhanging rocks. It is well wedged in small rock crevices and cracks where it is well protected from disturbances such as wind or large herbivores. Plants grow in summer, when flowering and fruiting takes place, with a resting period in winter and spring. There is little competition from other cliff-dwelling plant species in its habitat of small fissures and crevices in boulders.

Size and weight: Usually 100–400 mm in diameter, size also depending on the amount of rain.

Stem: Soft, fragile, sometimes becoming pendent if growing from an overhang.

Leaves

Orientation: Ascending spreading.

Colour and texture: Green, leathery, somewhat fleshy.

Age and persistence: Plants perennial, rapid-growing during the short wet periods but dying back to the base under unfavourable conditions.

Armament: Plants without armament or camouflage properties.

Sexual reproduction

Inflorescence and flowers: Flowers axillary, small, in 2- or 3-flowered cymes. The flowers suggest a specific insect pollinator.

Fruit/Seed

Capsules: After fertilisation, the sharply rostrate, ellipsoid-conical capsules become recurved or directed downward towards the crevice. The pedicels are negatively phototropic, bending the capsule towards the crevice.

Size: Seed 1 mm long, narrowly oblong, slightly curved.

Dispersal: Yellowish brown seeds are shaken from the small capsules and dispersed by wind (explaining the large number of seeds) but the capsules are directed towards the crevice, thus ensuring a better chance of establishment (blastochory).

Establishment: The small, oblong seeds become wedged in crevices where they germinate when conditions are favourable.

Time: Seeds released during the rainy season from summer to autumn.

Vegetative reproduction: Absent.

CONSERVATION STATUS

Plants are fairly common and widespread and are not threatened.

ADDITIONAL NOTES

Horticulture: No attempt has been made to cultivate the plants.

VOUCHERS

Van Jaarsveld 19763, 19822 (NBG).

ILLUSTRATIONS AND MAP

Plate 222, Figures 222a–222c, Map 222.