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Systematics of *Hypoxis* (Hypoxidaceae) in southern Africa

by

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Declaration:

I, YASHICA SINGH, declare that the thesis, which I hereby submit for the degree PHILOSOPHIAE DOCTOR at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE: ..YSingh……………………………..

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Singh, Y. Systematics of *Hypoxis* L. (Hypoxidaceae) in southern Africa. Department of Plant Science, University of Pretoria. Unpublished thesis. Pages 424, tables 22, figures 117. March 2009. Promoter: Prof. Dr. A.E. van Wyk. **Keywords:** anatomy, descriptions, *Hypoxis*, key, morphology, phytochemistry, phytogeography, seed surface, taxonomy.

Hypoxis is a diverse group of perennial geophytic herbs characterised by hairy leaves and yellow (seldom white) star-shaped flowers. The genus comprises about 70 species with a distribution in the warmer parts of all continents except Europe. With one third of the taxa, the Flora of southern Africa region (South Africa, Swaziland, Lesotho, Namibia and Botswana) is the most species rich for the genus world-wide. A taxonomic revision of the genus in southern Africa was undertaken; 28 species are recognised, one, *H. nivea* having been newly described. Morphological data were gathered through field observations and specimens kept in cultivation as well as herbarium specimens. Habit, leaf dimensions, inflorescence type and distribution of hairs on leaves were found to provide reliable diagnostic characters for species separation. These characters in combination with geographical distribution patterns were applied in drawing up a key to species in the Flora of southern Africa region. The treatment also includes brief notes on diagnostic characters and relationships, distribution and ecology, etymology, red data status and common names for each taxon. Nine species are data deficient due to insufficient collections or type specimens still to be located, and remain unresolved. Evidence from vegetative anatomy, seed micromorphology and preliminary phytochemistry were used to test possible phylogenetic relationships among species inferred from macromorphology. A few members of the southern African *Hypoxis* are of medicinal importance as their rhizomes are a rich source of hypoxoside which in its hydrolysed form has been shown to inhibit the growth of some cancer cells. Based largely on a literature survey, a review of the ethnobotany of the Hypoxidaceae, denoting the food, medicinal and magical value of members of the family is also offered.

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INDEX TO SPECIES AND INFRASPECIFIC TAXA

Accepted names are in **bold** *italics*; synonyms in *italics*
Page numbers refer to main entry in taxonomic treatment

Species insufficiently known

1

INTRODUCTION

1.1 Background

With about 70 species, *Hypoxis* L. is the largest genus in the small family Hypoxidaceae R. Br. within the 'asteloid' clade of the monophyletic order Asparagales (Rudall *et al*. 1998; Fay *et al*. 2000). Nine other genera namely *Curculigo* Gaertner*, Hypoxidia* Friedman, *Molineria* Colla*, Empodium* Salisb., *Heliacme* Ravenna; *Pauridia* Harvey*, Rhodohypoxis* Nel*, Saniella* Hilliard & Burtt and *Spiloxene* Salisb. are included in the family (Nordal 1998). The family is most diverse in the Flora of southern Africa (FSA)[1] region with six genera, *Empodium*, *Hypoxis*, *Pauridia*, *Rhodohypoxis*, *Saniella* and *Spiloxene* (Figure 1.1) comprising about 75 species. All these genera, except *Hypoxis* and *Spiloxene* are endemic to southern Africa. *Hypoxis* occurs in warm parts of all continents except Europe. The genus is widespread in Africa, mainly in the sub-Saharan region and its main centre of diversity and high endemism is in the eastern region of southern Africa, with a smaller centre in tropical Africa. *Hypoxis* is distinguished from the other southern African genera in its combination of hairy leaves, mostly yellow flowers and free tepals that are hairy on the undersurface.

1.2 Geographical range of *Hypoxis*

About 50 species of *Hypoxis* occur in sub-Saharan Africa and its range on the continent is from the Western Cape in South Africa, through central Africa and further north into west Africa and also in Ethiopia, Eritrea and Egypt. With about 30 species, 22 being endemic, southern Africa is the main centre of diversity and high endemism for *Hypoxis*. In southern Africa, the genus is concentrated in the eastern region of South Africa, in the Eastern Cape and KwaZulu-Natal. A secondary centre of diversity and endemism is located in tropical Africa. One species, *H. angustifolia* occurs in Madagascar, Mauritius and Réunion (West Indian Ocean Islands).

Outside of Africa, 14 species of *Hypoxis* occur in the New World, concentrated mainly in south-eastern United States of America and Mexico, and six species occur in Australia. Three species, *H. breviscapa* H.B.K. *H. decumbens* L. and *H. domingensis* Urb. are recorded from South America.

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[1] The FSA region includes South Africa, Botswana, Lesotho, Namibia and Swaziland and is referred to as southern Africa in the dissertation.

Figure 1.—Southern African genera of Hypoxidaceae. A, *Empodium* (with narrow leaves, do not confuse with broad-leafed plant in background); B, *Hypoxis*; C, *Pauridia*; D, *Rhodohypoxis*; E, *Saniella*; F, G, S*piloxene*. Photographs C, E, F, G: Colin Paterson-Jones.

H. decumbens is listed as one of 12 weed species with seeds ending up in forage crops in Brazil (Groth 1988). It has also been recorded as naturalised at three sites in the midlands of KwaZulu-Natal (Hilliard & Burtt 1979). A single species, *H. aurea* Lour. is widespread in southern Asia.

In Africa, *Hypoxis* is a typical component of the afromontane flora. Majority of the species are prevalent in the grassland biome and extend into the neighbouring subtropical dune thickets, savanna or forest biomes. A few taxa are semi-shade dwellers, being restricted to open areas in forest, particularly cliff faces. Within southern Africa, species may be widespread across the region or endemic to a province in South Africa. While some species are spread across habitats from well-drained to moist grassy slopes, forest margins and dune banks, others are restricted to one particular habitat like open grasslands, forest margins or cliff faces.

1.3 Generic nomenclature

Hypoxis was established by Linnaeus in 1759 and the name is derived from the Greek words *hypo* (beneath) and *oxys* (sharp) alluding to the elongated base of the capsule. The word *oxys* could also infer 'sharp' to refer to the somewhat bitter taste of the underground rhizome and roots as opposed to the sweet scented roots of *Acorus* L., as Linnaeus placed *Hypoxis* next to *Acorus* in edition 10 of his *Systema* (Henderson 1987).

1.4 Hypoxidaceae and its classification

The Hypoxidaceae has in the past been treated as a tribe of the family Amaryllidaceae. Hutchinson (1934) was the first to recognise that Hypoxideae should be excluded from the Amaryllidaceae and re-established as the family Hypoxidaceae. Hutchinson (1934) also proposed the Hypoxidaceae as a potential sister group to Orchidaceae. It is now widely accepted that the Hypoxidaceae represent the African branch of the Asparagales, with a close affinity to Asteliaceae Dumortier as proposed by Huber (1969) and this is supported by nucleotide analyses (Rudall *et al*. 1997). The generic circumscription in Hypoxidaceae has also varied considerably. Baker (1878b) recognised four genera in Hypoxidaceae; within *Hypoxis*, he distinguished two subgenera, *Euhypoxis* and *Ianthe* based on presence or absence of hairs, anthers basifixed or versatile, and stigma discrete or concrete. Nel (1914) recognised six genera in the Amaryllidaceae-Hypoxideae. He raised subgenus *Ianthe* of Baker (1878b) to genus as *Janthe*. He also removed the plants with pink and red flowers from subgenus *Euhypoxis* and placed them in a newly described genus *Rhodohypoxis* Nel. Within *Hypoxis*, Nel (1914) recognised 11 formal sections and 83 species in Africa. Early results of this study agree that species in *Hypoxis* can be broadly classified into groups (Singh 2004) as proposed by Nel (1914), however no formal sections were presented due to the study being restricted to the southern African region.

1.5 Economic significance

A few members of the southern African *Hypoxis* are of economic importance. *H. hemerocallidea* Fisch., C.A.Mey. & Avé-Lall. (earlier name *H. rooperi* T. Moore) commonly known as the 'African potato' has become one of the best known medicinal plants in South Africa. Rhizomes of *Hypoxis* are known to the Zulus as 'inkomfe' or 'ilabetheka' and have been used for many generations to treat headaches, dizziness, abdominal pains and mental disorders (Hutchings 1996). Aqueous extracts of rhizomes of *H. hemerocallidea* were used by white farmers in southern Africa to treat symptoms of prostate cancer (Van Staden 1981) and this gave rise to pharmacological interest in the species. These rhizomes are a rich source of hypoxoside (Drewes *et al.* 1984, Bayley and Van Staden (1990), a phenolic glycoside that hydrolyses to form its aglycone called rooperol which is active in inhibiting the growth of cancer cells (Drewes & Khan 2004). The popularity of the genus as an alternative remedy has resulted in unsustainable harvesting of rhizomes from the wild. Exploitation of rhizomes of target and related species has also expedited the need for correct species names and data on species.

Two species, *H. hemerocallidea* and *H. angustifolia* Lam. are largely used as garden ornamentals in the summer rainfall regions in South Africa. Species like *H. obtusa* Ker Gawl. and *H. sobolifera* Jacq., although floriferous are not widely used in horticulture. *H. stellipilis* would also be an excellent ornamental. The leaves of this species are neatly arranged in three ranks, are dark green above and white on the undersurface, making the species unique and attractive.

1.6 Taxonomic difficulties

The taxonomy of *Hypoxis* offers an extraordinary challenge to systematists. *Hypoxis* plants are easily recognised by their geophytic, erect habit, usually hairy leaves, star-shaped, yellow flowers (white in a few taxa), free tepals and anthers and tepals with hairy backs. However, it is difficult to distinguish between species due to the lack of diagnostic morphological characters. The fairly uniform flower structure in the genus means that greater emphasis is placed on vegetative characters, mainly the leaves, and often these characters overlap between closely related species. Separation of species is also hampered by the changing appearance of leaves during the growing season; younger flowering plants often appear very different to mature plants and may not match the descriptions. The main reason for the complex taxonomy is polymorphism caused by genetic abnormalities arising from hybridization, polyploidization and apomixis. Hybrids, polyploids and apomicts derived through these processes end up with variable chromosome sets that cause morphological variation. The derived character sets of these forms start to obscure species limits and the forms no longer align with the original parent species. Variation in morphology makes it difficult for taxonomists to construct workable keys for *Hypoxis* and species identification usually requires the expertise of a specialist familiar with the group.

The present state of knowledge on biology, ecology and phytogeography for species of *Hypoxis* is inadequate. New species are sometimes described based on an understanding of the morphology of the species in a particular region, and without critical assessment of its morphological variation and distribution range. Such studies, including the current one are often based on attempts at regional floras. From the time of Nel (1914), descriptions of new species have led to a large number of synonyms being in current use. In fact, *Hypoxis* phenotypes are either lumped into a single taxon or split into distinct taxonomic units. Geerinck (1971) for instance, reduced four species to synonymy under *H. angustifolia* in Central Africa, which Wiland (1997a) more recently resurrected as distinct species, the morphological species concept being applied by both authors. Based on a survey of morphological characters, Nordal *et al*. (1985) and Zimudzi (1996) adopted the approach of creating species complexes for the Floras of Tropical East Africa and Zambesiaca regions. On the whole, the genus still appears to be evolving and the predicament that taxonomists face is how to deal with individuals that show morphological variation within a species concept: to create synonymy, or to recognise distinct species or species complexes?

1.7 Study objectives

The aims of this study were

- to undertake a survey of macromorphological characters, determine their absence, presence and infraspecific variation in southern African *Hypoxis* and evaluate their diagnostic value in delimiting species and infraspecific taxa.
- to provide a taxonomic revision of the genus *Hypoxis* in southern Africa based on the morphological (character-based) species concept and combine these with geographical distribution patterns in an identification key to the species.
- to use data from leaf anatomy, preliminary phytochemical studies of rhizomes and seed micromorphology to comment on the possible phylogenetic relationships of species surmised mainly from macromorphology.
- to highlight southern African members of *Hypoxis* of uncertain taxonomic status and in need of further study.

1.8 Lay-out of thesis

The information in the thesis is presented as Chapters, with each chapter addressing a discipline investigated. The thesis starts with a review of the historical circumscription of the family Hypoxidaceae and the genus *Hypoxis* in Chapter 2. A summary of nucleotide analyses by botanists working on the phylogenetics of the Asparagales and Orchidaceae over the past 12 years is included in this chapter. In Chapter 3, the medicinal, horticultural and magical properties of *Hypoxis* are described. As the focus of this study is to clarify the taxonomy of *Hypoxis*, it merely offers a synthesis of information on the ethnobotanical uses of the Hypoxidaceae that already exists in published literature. The materials and methods used in accumulating data on macromorphology, leaf anatomy, phytochemistry and phytogeography are consolidated and presented in Chapter 4. As part of the study, diagnostic characters for species were recorded from field work in South Africa and plants kept in cultivation as well as from the study of numerous herbarium specimens. Vegetative, flower and fruit characters and their value in classifying species are discussed in Chapters 5 and 7 respectively. The anatomy of most species of *Hypoxis* in southern Africa was studied by examining transverse sections of leaves and additional information was gathered from leaf surface scans. Chapter 6 provides an illustrated account of the anatomy of leaves for the genus. A preliminary investigation of the phytochemical compounds in rhizomes of 15 species of *Hypoxis* was undertaken. The results from the investigation are reported in Chapter 8. Chapter 9 discusses the geographical distribution and ecology of *Hypoxis* in southern African biomes. An integration of morphology, vegetative anatomy and ecological data has led to a better understanding of the phylogeny of species and this data is synthesised in Chapter 10. Also in this chapter, a discussion is offered on the grouping of species and the possible driving forces behind the evolutionary diversification of species in southern Africa. Conclusions drawn from the discussion are summarised in Chapter 11. The thesis is concluded by a taxonomic treatment of *Hypoxis* (Chapter 12) in the format of *Bothalia* where a key to species based on macromorphology and distribution patterns is presented. Finally, publications emanating from this study are included as Appendices 1 and 2.

2

TAXONOMIC HISTORY

2.1 Introduction

Family placement of the Hypoxidaceae fluctuated from being part of the Amaryllidaceae or Liliaceae s.l. to being treated as a family on its own depending upon the author and the context in which they were working. In the mid-1980s, it became widely accepted that the Hypoxidaceae is a natural family within the order Asparagales, a relationship that was proposed earlier by Huber (1969). This agreement is possibly due to a number of publications after 1970 on angiosperm classification by Dahlgren (1975, 1980, 1983) and on monocotyledon evolution by Dahlgren & Rasmussen (1983) and Dahlgren *et al*. (1985). Hutchinson (1934) considered the Hypoxidaceae to be a sister group to the Orchidaceae. Chase *et al*. (1993) found that the Hypoxidaceae forms a monophyletic group positioned near the base of the Asparagales. Further nucleotide sequencing in the Asparagales (Rudall *et al* 1997; Pires *et al.* 2006) satisfactorily resolved that the Hypoxidaceae represent the African branch of Asparagales with a close relationship to Asteliaceae as proposed by Huber (1969). Recent *rbc*L nucleotide sequence studies in the Asparagales (Rudall *et al*. 1997; Pires *et al.* 2006) and Orchidaceae (Chase *et al*. 1995a; Cameron *et al*. 1999) confirm this. Generic delimitation within the Hypoxidaceae has also varied considerably over the years, the most recent treatment is offered by Nordal (1998). While the history of the family dates back to 1814 when it was first described as Hypoxideae by Robert Brown, the history of the genus *Hypoxis* goes back even earlier to 1759. In his *Species Plantarum*, Linnaeus (1759) established the genus *Hypoxis* and in it he placed three species, all described by himself. This chapter traces the phyletic placement of the Hypoxidaceae and gives an account of the history of *Hypoxis* from Linnean times to the modern molecular period.

2.2 Taxonomic position of the Hypoxidaceae

The Hypoxidaceae was described by Robert Brown in 1814 and has often been treated as a subfamily or tribe within the Amaryllidaceae on account of its inferior ovary. Earlier, Brown (1810) established the Amaryllideae in which he placed *Hypoxis* and *Curculigo*. According to Brackett (1923), Brown wrote in his *General Remarks on the Botany of Australia* (1814) that it is better to consider *Hypoxis* and *Curculigo* in a family separate from Amaryllidaceae and he proposed the name Hypoxideae. Sixty four years later, Baker (1878b) prepared the first synopsis of

Hypoxidaceae, where he detailed differences between Hypoxidaceae and Amaryllidaceae, and presented a description for Hypoxidaceae. Bentham & Mueller (1873) treated the family as tribe Hypoxideae of the family Amaryllidaceae. This delimitation was adopted by Bentham & Hooker (1883), Baillon (1895), Baker (1896, 1898), Nel (1914), Phillips (1926) and Hilliard & Burtt (1978). Pax (1889) raised the tribe to subfamily level as Hypoxidoideae and divided the subfamily into 4 tribes: Alstroemerieae, Conanthereae, Conostylideae and the Hypoxideae. Bessey (1915), Pax & Hoffman (1930) and Emberger (1960) followed Pax's arrangement for the Hypoxideae. Hutchinson (1934) demarcated 14 orders in Division II, Corolliferae of the subphylum Monocotyledons. Among the orders, he included the Liliales with six families, Amaryllidales with only the typical family and the Haemodorales with six families including the Hypoxidaceae. The families included in these orders and the characters used by Hutchinson (1934) to define the orders are summarised in Table 2.1. The Orchidales which also belongs to Corolliferae is included in the comparison as Hutchinson (1934) considered the Orchidaceae to have evolved from the Hypoxidaceae through *Curculigo*.

Table 2.1.—Summary of families and characters used by Hutchinson (1934) to define the orders Liliales, Amaryllidales, Haemodorales and Orchidales

Liliales	**Amaryllidales**	**Haemodorales**	**Orchidales**
Liliaceae Tecophilaceae Trillaceae Pontederiaceae Smilacaceae Ruscaceae	Amarylliadaceae	Haemodoraceae Hypoxidaceae Velloziaceae Apostasiaceae Taccaceae Philydraceae	Orchidaceae
Herbs with rhizomes, corms or bulbs, rarely climbing	Scapigerous herbs with bulbous rootstock and radical leaves	Rootstock a rhizome or rarely a corm	Terrestrial, epiphytic or saprophyti
Perianth corolla-like, the two series similar and often fusing together into one tube	Flowers showy in 1 to many umbels, subtended by one or more spathaceous bracts; corona often present	Perianth-segments becoming valvate	Flowers strongly zygomorphic; perianth segments in 2 whorls, usually petaloid, variously modified
Stamens often 6	Stamens 6	Stamens numerous to 6; free or in bundles	Stamens 2 or 1; pollen from granular to waxy and in masses
Ovary superior or rarely semi-inferior	Ovary superior or inferior	Ovary superior to inferior; 3-celled with axile, or 1-celled with parietal placentas	Ovary inferior
Fruit	Not recorded	Not recorded	Fruit usually a capsule, mostly opening laterally by 3 or 6 longitudinal slits
Seeds with copious endosperm	Endosperm present	Seeds mostly numerous	Very numerous and minute, without endosperm

More recently, Geerinck (1968) also considered Hypoxidaceae to be distinct from Amaryllidaceae, a view based on leaf and floral characters. Regardless of Baker's (1878b) and Geerinck's (1968) contributions, some authors still preferred to place the Hypoxidaceae as a subfamily or tribe in Amaryllidaceae or even as part of the Liliaceae s.l. Taxonomists like Bentham & Hooker (1862–1883) and Heywood (1993) have treated it as part of Amaryllidaceae while Cronquist (1981) and Thorne (1983) retained it in the Liliaceae. Hypoxidaceae was included in the order Haemodorales by Hutchinson (1959, 1973), Liliflorae by Engler (1887–1909), Liliales by Takhtajan (1969) and Asparagales by Dahlgren (1975, 1983). Heywood *et al*. (2007) recognised the Hypoxidaceae as part of the Asparagales based on the Angiosperm Phylogeny Group II System, that is in turn based on analyses in Chase *et al*. (2000) and Fay *et al*. (2000). A table with comparison between the orders Asparagales and Liliales is provided by Dahlgren *et al*. (1985) who largely follow Huber (1969) in listing the differences as well as in the grouping of families in the orders. These authors further offered the view that the Asparagales forms a large fairly homogeneous complex of families that may have evolved in parallel to the Liliales and Dioscoreales.

The phylogenetic associations of the Hypoxidaceae within the Asparagales have also been clarified over the past 15 years. Both Hutchinson (1959) and Takhtajan (1969) placed the Hypoxidaceae close to the Orchidacaeae. Based on seed anatomy in *Curculigo* and *Hypoxis*, Huber (1969) considered the Hypoxidaceae to represent the African branch of Asparagales, close to the Asteliaceae. Dahlgren & Clifford (1982) pointed out that the phytomelan crusts of the seeds in Hypoxidaceae did not support its close relationship to the Orchidaceae, although there were a few notable similarities (epigyny, lack of septal nectaries and rarely nuclear endosperm formation) between the families. However, the association of Hypoxidaceae with Asteliaceae by Huber (1969) and Blandfordiaceae Dahlgren & Cifford is supported by *rbc*L data on Asparagales (Chase *et al.* 1995a; Rudall *et al.* 1997). Rudall *et al*. (1998) explained the phylogenetic associations in the asteloids that comprise the families Hypoxidaceae, Asteliacaeae, Lanariaceae and Blandfordiaceae and considered the asteloid group as the first-branching clade of the Asparagales. Recent *rbc*L analyses of the Lilianae (Chase *et al*. 1995a) and Orchidaceae (Cameron *et al.* 1999) further support Huber's (1969) association of the Hypoxidaceae to the Asteliaceae. These authors also discussed the affinities of the Boryaceae, Blandfordiaceae Asteliaceae and Hypoxidaceae as outgroups to the Orchidaceae. In proposing an orchid ancestor, Cameron (1999) suggested a plant with most characters from different genera in the Hypoxidaceae combined with simultaneous microsporogenesis as in Asteliaceae. A useful summary of the position of the Hypoxidaceae within the Aparagales based on research by various groups is also provided by Judd (2000) in his treatment of the Hypoxidaceae in southeastern United States. In this publication, Judd annotated the findings reported in literature in the references. Evidence from nucleotide sequences may assist in resolving the phylogeny of genera in Hypoxidaceae, and its relation to the Orchidaceae. Such a study is presently being led by Alec Kocyan based at the Jodrell Laboratory, Royal Botanic Gardens, Kew. The study will hopefully clarify the generic limits in Hypoxidaceae using morphology, anatomy and *rbc*L techniques.

2.3 History of *Hypoxis*

Linnaeus established the genus *Hypoxis* in 1759 and in it he placed three species, *H. erecta* L., *H. decumbens* L. and *H. fascicularis* L. *Hypoxis erecta* [= *H. hirsuta* (L.) Coville] and *H. decumbens* L. are retained in the genus while *H. fascicularis* is a synonym of *Colchicum montanum* L. (Family Colchicaeae). The type species of the genus is the American *H. hirsuta* (L.) Coville (= *H. erecta* L., an illegitimate name based on the type of *Ornithogalum hirsutum* L.). Following Linnaeus (1759), eleven years later, *H. villosa* was the first southern African species to be described by the younger Linnaeus (1781). Table 2.2 summarises the authors of species and the year in which southern African and west Indian ocean islands taxa were described. The remaining African taxa are included in a list provided by Singh (2006) [Appendix 1.1]. Taxonomic treatments of *Hypoxis* were prepared by Baker (1878b) and Nel (1914) in their synopses of Hypoxidaceae. Between 1874 and 1904, Baker described 38 species of *Hypoxi*s in Africa, 21 being endemic to southern Africa. Based on herbarium studies, Nel described 45 new species of *Hypoxis* in Africa, 13 from southern Africa. Only one of Nel's species, *H. interjecta* is upheld in this study and the species, *H. exaltata* and *H. sagittata* remain ambiguous due to the paucity of specimens. Baker (1896) offers the last published key to all known species in South Africa, where he recognised 41 species including nine belonging to *Spiloxene* and two to *Rhodohypoxis*.

Taxonomic work done on *Hypoxis* in southern Africa since Baker's (1896) account in Flora Capensis is fragmentary. Noteworthy contributions on the genus were made by Wood (1976) on *Hypoxis* in Natal (now KwaZulu-Natal) and Heideman (1979) studied *Hypoxis* on the Witwatersrand (part of the South African Highveld, covering much of the present-day Gauteng Province) and both these studies exist as unpublished masters theses. In 1995, Bruce-Miller presented a preliminary study on *Hypoxis* in the Eastern Cape Province based on herbarium material at GRA, as a project for her BSc. degree. Apart from Heideman's (1983, 1987) list of species on the Witwatersrand and contribution to the Hypoxidaceae in the Flora of the

Table 2.2.—Summary of names proposed for the southern Africa and west Indian ocean islands taxa in *Hypoxis* (Accepted species names are in **bold**, synonyms in *italics* and and insufficiently known species in normal font).

Taxon	**Author**	**Year described**
		1781–1799
villosa	L.f.	1781
angustifolia	Lam.	1789
decumbens = **villosa**	Lam.	1789
tomentosa = **villosa**	Lam.	1789
obliqua	Jacq.	1796
sobolifera	Jacq.	1796
		1800–1899
obtusa	Burch. ex Ker Gawl.	1816
stellipilis	Ker Gawl.	1822
scabra = **villosa**	Lodd.	1824
filifolia = **longifolia**	Eckl.	1827
hemerocallidea	Fisch., C.A.Mey. & Avé-Lall	1842
abyssinica = **villosa**	Hochst	1844
simensis = **villosa**	Hochst.	1844
multiceps	Buchinger	1845
canescens = **sobolifera** var. **sobolifera**	Fisch.	1845
microsperma = **villosa**	Lallem.in Fischer & Meyer	1845
krebsii = **sobolifera** var. **sobolifera**	Fisch.	1846
petitiana = **villosa**	A. Rich.	1851
rooperi = **hemerocallidea**	T.Moore	1852
latifolia = **colchicifolia**	Hook.	1855
elata = **hemerocallidea**	Hook.f.	1868
longifolia	Baker ex Hook.f	1873
pannosa = **sobolifera** var. **pannosa**	Baker	1874
biflora = **angustifolia**	Baker	1876
ludwigii	Baker	1876
arnottii = **rigidula** var. **pilosissima**	Baker	1877
angustifolia var. **angustifolia**	Baker	1878b
angustifolia var. **buchananii**	Baker	1878b
argentea var. **argentea**	Harv. ex Baker	1878b
argentea var. **sericea**	Baker	1878b
costata	Baker	1878b
decumbens β & γ = **sobolifera**	Thunb. ex Baker	1878b
filiformis	Baker	1878b
gerarrdii	Baker	1878b
iridifolia = **obtusa**	Baker	1878b
jacquinii	Baker	1878b
kraussiana	Buchinger ex Baker	1878b
longifolia var. *thunbergii* = **longifolia**	Baker	1878b
membranacea	Baker	1878b
pannosa = **sobolifera** var. **pannosa**	Baker	1878b
parvula	Baker	1878b
rigidula	Baker	1878b
rigidula var. **pilosissima**	Baker	1878b
rigidula var. **rigidula**	Baker	1878b
rooperi var. *forbesii* = **hemerocallidea**	Baker	1878b
sericea = **argentea** var. **sericea**	Baker	1878b
sericea var. *dregei* = **argentea** var. **sericea**	Baker	1878b
sericea var. *dregei* = **filiformis**	Baker	1878b
sericea var. *flaccida* = **argentea** var. **sericea**	Baker	1878b
setosa	Baker	1878b

Table 2.2.—cont.

Taxon	**Author**	**Year described**
villosa L.f. var. *scabra* = **villosa**	(Lodd.) Baker	1878b
villosa var. *canescens* = **sobolifera** var. **sobolifera**	(Fisch.) Baker	1878b
villosa var. *obliqua* = **obliqua**	(Jacq.) Baker	1878b
villosa var. *pannosa* = **sobolifera** var. **pannosa**	Baker	1878b
villosa var. *sobolifera* = **sobolifera** var. **sobolifera**	(Jacq.) Baker	1878b
villosa var. δ = **longifolia**	Thunb. ex Baker	1878b
zeyheri	Baker	1878b
acuminata	Baker	1889
colchicifolia	Baker	1889
oligotricha = **colchicifolia**	Baker	1889
woodii = **angustifolia** var. **buchananii**	Baker	1889
floccosa	Baker	1894
villosa var. *schweinfurthii* = **sobolifera**	Harms	1895
brevifolia = **parvula** var. **parvula**	Baker	1896
flanaganii	Baker	1896
galpinii	Baker	1896
parvifolia	Baker	1896
		1900–1999
caespitosa = **filiformis**	Baker	1901
ecklonii = **floccosa**	Baker	1901
junodii = **gerarrdii**	Baker	1901
longifolia (nom. illeg.) = **rigidula** var. **rigidula**	Baker	1904
longipes	Baker	1904
mollis	Baker	1904
nigricans	Baker	1904
beyrichii	Nel	1914
cordata = **rigidula** var. **rigidula**	Nel	1914
dinteri = **argentea** var. **sericea**	Nel	1914
distachya = **colchicifolia**	Nel	1914
dregei = **argentea** var. **sericea**	(Baker) Nel	1914
elliptica = **rigidula** var. **rigidula**	Nel	1914
exaltata	Nel	1914
gilgiana = **colchicifolia**	Nel	1914
interjecta	Nel	1914
lata = **angustifolia**	Nel	1914
obconica = **hemerocallidea**	Nel	1914
obliqua Jacq. var. *woodii* = **angustifolia** var. **buchananii**	(Baker) Nel	1914
oblonga = **rigidula**	Nel	1914
obtusa var. *chrysotricha* = **obtusa**	Nel	1914
patula = **hemerocallidea**	Nel	1914
sagittata	Nel	1914
sobolifera var. *accedens* = **sobolifera var. sobolifera**	Nel	1914
sobolifera var. **pannosa**	(Baker) Nel	1914
sobolifera var. **sobolifera**	(Jacq.) Nel	1914
stricta = **galpinii**	Nel	1914
villosa var. *fimbriata* = **villosa**	Nel	1914
neliana = **kraussiana**	Schinz	1926
uniflorata	Markötter	1930
volkmanniae = **rigidula** var. **rigidula**	Dinter	1931

Table 2.2.—cont.

Taxon	**Author**	**Year described**
nitida = **obtusa**	I.Verd	1949
obtusa var. *nitida* = **obtusa**	(I.Verd.) Heideman	1983
tetramera	O.M.Hilliard & B.L.Burtt	1983
limicola = **parvula** var. **parvula**	B.L.Burtt	1988
parvula var. **albiflora**	B.L.Burtt	1988
angustifolia var. **luzuloides**	(Robyns & Tournay) Wiland	2002
angustifolia var. **madagascariensis**	Wiland	2002
nivea	Y. Singh	2007

Witwatersrand, no other taxonomic treatment on southern African *Hypoxis* has been published since Baker's (1896) revision. Burtt (1986, 1988) and Hilliard & Burtt (1983) through their extensive field work mainly in the Drakensberg (Uhkhlamba) Mountains updated much of the taxonomy and nomenclature of individual species. In a recent conspectus of the Cape Flora, Snijman (2000) reviewed Hypoxidaceae, in which she records seven species of *Hypoxis* for the Cape winter-rainfall region of South Africa. Snijman & Singh (2003) and Snijman & Singh (2006) offered lists of species of Hypoxidaceae in southern Africa and South Africa respectively. As part of this study, Singh (2006) [Appendix 1.1] presented a list of species and infraspecific names in *Hypoxis*, including manuscript names. A useful key to infrageneric taxa in *Hypoxis* is offered by Compton (1976) for the Flora of Swaziland where he recognises 12 species, all of which also occur in South Africa. Compton applied macromorphological characters that are easily observable in the field such as habit, leaf shape and width, abundance of flowers on the inflorescence and density of hairs on the leaves. In this communication, he also indicated that it is impossible to construct a simple key to *Hypoxis* and that his key may fail in practice, thus emphasising the difficulty in applying suitable diagnostic characters in keys to members of the group.

For Tropical Africa, small contributions to the taxonomy of *Hypoxis* were made between 1930 and 1990 mainly through Flora work. These were based on the morphological species concept. Hutchinson & Dalziel (1931) presented a treatment of the genus for the Flora of West Tropical Africa where they recognised five species. Hepper (1968) updated the Hypoxidaceae for the Flora of West Africa and provides a key to three species for the region. He commented that several species described by Nel can hardly be maintained as distinct in this confusing genus. He noted that the appearance of the plants change as the leaves develop and further suggested that field workers should note variation within populations and this will help to determine the taxonomic worth of characters. Geerinck (1971) writing on the Flora of Congo, Rwanda and Burundi, upheld two species in Central Africa namely *H. angustifolia* and *H. subspicata* Pax. Champluvier (1987) recognised three species, *H. angustifolia*, *H. kilimanjarica* Baker and *H. obtusa* in the Flora of Rwanda. The first comprehensive work on *Hypoxis* in tropical Africa was provided by Nordal *et al*. (1985) for the Flora of Tropical East Africa. The authors offered a general discussion on the morphology and complex cytology of the genus. For the sub-region, they recognised five species and one species complex and used seed and leaf characters to delimit taxa. This was followed by a revision of Hypoxidaceae for the Flora of Cameroon by Nordal & Iversen (1987) where four species were recognised in *Hypoxis*.

More recently, taxonomic initiatives in *Hypoxis* in tropical Africa has led to an improved understanding of the genus on the continent and its taxonomy is slowly becoming settled. Zimudzi (1993) presented a doctoral thesis on his studies on the family Hypoxidaceae (*Hypoxis* and *Curculigo*) in South Central Africa with emphasis on variation patterns in the genus. The study contributed to a synopsis of the family in the *Flora Zambesiaca* region (Zimudzi 1996) and to the publication of a treatment of the family by Nordal & Zimudzi (2001) for the region. In the former publication, eight species were upheld and in the latter treatment, the authors recognised 14 species, seven of which also occur in southern Africa. In 1998, Wiland completed a doctoral thesis on *Hypoxis* and *Curculigo* in Central Africa (Zaire, Rwanda and Burundi) in Polish. Following on from her studies, Wiland (1997a & b) published seven new species of *Hypoxis* for the region. In 2001, she published a treatment of the genus in Central Africa recognising 20 species, three in Rwanda, five in Burundi and 19 in Congo-Kinshasa, seven being endemic to the region. In the treatment, Wiland-Szymańska (2001) provided scanning electron micrographs of seed surfaces for most species. This was followed by Wiland-Szymańska & Adamski's (2002) contribution to the taxonomy and morphology of *H. angustifolia* from Africa and the West Indian Ocean Islands. Wiland-Szymańska & Nordal (2006) provided a much needed treatment for the diverse Flora of Tropical East Africa region, where they recognised 15 species. Five southern African species namely *H. angustifolia, H. filiformis*, *H. galpinii*, *H. obtusa* and *H. rigidula* are recorded as being present in East Africa.

Zimudzi (1996), Nordal & Zimudzi (2001), Wiland (1997a & b) Wiland-Szymańska (2001) and Wiland-Szymańska & Adamski (2002) used macromorphological characters of the leaf, inflorescence and seed character to delimit *Hypoxis* species in Africa. Their contributions are largely revisionary and based on the morphological species concept.

Outside Africa, *Hypoxis* has received attention from Henderson (1987) for the Flora of

Australia where he recognised two sections, *Hypoxis* with six species and *Ianthe* with four species. According to Manning *et al*. (2002) consider species in *Ianthe* to be closely allied to the southern African *Spiloxene* and proposed their transfer to *Spiloxene*. Henderson (1987) placed *H. marginata* R.Br., *H. nervosa* R. Henderson, *H. arillacea* R. Henderson, *H. exilis* R. Henderson, *H. hygrometrica* Labill. (3 varieties) and *H. pratensis* R. Br. (2 varieties) in Section *Hypoxis*. He used a combination of characters namely pubescence, venation, seed morphology, rhizome length and shape and number of flowers per inflorescence to separate species.

The American members of *Hypoxis* were first studied by Brackett (1923) who recognised 15 species and her key is based primarily on seed morphology. Later, Britt (1967) provided a revision of *Hypoxis* in the United States and Canada as a doctoral thesis in which he proposed a single polymorphic species, *H. hirsuta* (L.) Coville with four varieties for all *Hypoxis* plants in the region. He reduced most species to the typical variety. Herndon (1992b) produced a treatment of *Hypoxis* found in Florida where he reognised five species namely *H. juncea* Sm., *H. leptocarpa* (Engelmann & Gray) Small, *H. rigida* Chapman, *H. sessilis* L. and *H. wrightii* (Baker) Brackett. His treatment includes distribution and ecological observations for each species. Herndon (1992b) found density of leaf hairs, leaf cross-sectional shape and width, texture, pedicel relative to bract and flower length, anther and 'sepal' lengths as well as seed colour and ornamentation to be useful for species separation. More recently, Judd (2000) prepared an account of Hypoxidaceae for the Generic Flora of the southeastern United States in which he traced the generic circumscriptions by various authors based on morphology, anatomy and *rbc*L sequences. He also provided a comprehensive description of *Hypoxis* and recognised seven species in the United States of America and Canada. These include *H. curtissii* Rose, *H. juncea*, *H. hirsuta*, *H. mexicana* Schultes & Schultes f., *H. rigida*, *H. sessilis* and *H. wrightii*. Judd's delimitation of species is along the lines of Brackett (1923) and Herndon (1988, 1992a, 1992b) where he adopts the distinguishing characters suggested mainly by these authors.

2.4 Generic affinities in Hypoxidaceae

Generic circumscription in Hypoxidaceae has varied over the years and it is now generally accepted that the family comprises ten genera, nine as proposed by Nordal (1998) and *Heliacme* described by Ravenna (2003). In his synopsis, Baker (1878b) recognised four genera in Hypoxidaceae namely *Hypoxis*, *Molineria*, *Curculigo* and *Pauridia* (Table 2.3). He divided *Hypoxis* into two subgenera, *Ianthe* Salisb. and *Hypoxis* Baker and described the *Ianthe* as having plants totally glabrous, anthers linear, basifixed and stigma about discrete. In contrast, plants of

Table 2.3.—Summary of genera and subgenera in Hypoxidaceae in four different classifications

Baker (1878b)	**Nel (1914)**	**Hilliard & Burtt (1978)**	**Nordal (1998)**
Hypoxis subgenus *Hypoxis* subgenus *Ianthe*	*Hypoxis*	*Hypoxis*	*Hypoxis*
Molineria	*Molineria*	*Molineria*	*Molineria*
Curculigo	*Curculigo*	*Curculigo*	*Curculigo*
Pauridia		*Pauridia*	*Pauridia*
	Rhodohypoxis	*Rhodohypoxis*	*Rhodohypoxis*
	Forbesia (= *Empodium*)	*Empodium*	*Empodium*
	Janthe (Ianthe) (= *Spiloxene*)	*Spiloxene*	*Spiloxene*
		Saniella	*Saniella*
			Hypoxidia

subgenus *Hypoxis* are hairy, the ovary is nearly always covered in setose, dense hairs and the leaves are pilose. In these species, the anthers are nearly always versatile with the base sagittate and the stigma is 'concrete' (Nel 1914).

Nel (1914) recognised six genera in the tribe Hypoxideae in Amaryllidaceae, among these were *Hypoxis* and *Curculigo* as in Baker (1878b). To these genera, he added *Forbesia* Eckl. with six species. He revived *Ianthe* Salisb. (as *Janthe*, a German transliteration misspelling) including *Spiloxene* Salisb. as distinct from *Hypoxis*. Further, he removed two species with pink or red flowers from Baker's subgenus *Hypoxis* and placed them in a new genus, *Rhodohypoxis* Nel, retaining the yellow-flowered species in *Hypoxis*. Within *Hypoxis*, Nel (1914) classified 83 African species into 11 sections based on morphology mainly the anther apex, leaf dimensions, style to stigma ratio, leaf venation and inflorescence type.

Following Nel's (1914) treatment, five species of *Forbesia* were transferred to *Empodium* (Hilliard & Burtt 1973) while one species was transferred to *Saniella* (Burtt 2000). The use of the generic names *Ianthe* and *Spiloxene* also fluctuated. Previously, Baker (1878b) and Williams (1901) regarded members of the *Ianthe* as different from *Hypoxis* in being glabrous. Fourcade (1934) pointed out that *Ianthe* and *Spiloxene* are congeneric and recognised *Ianthe* as a synonym of *Spiloxene* into which he transferred four species. Garside (1936) accepted this view and transferred a further 16 species from *Ianthe* and *Hypoxis* to *Spiloxene*.

Hilliard & Burtt (1973) helped to clarify the differences between *Curculigo* and *Empodium*, both genera are characterised by the presence of a long beak to the ovary. These authors also discussed floral and fruit differences within *Rhodohypoxis* in the same paper. A few years later, Hilliard & Burtt (1978) presented a taxonomic treatment of *Rhodohypoxis* and described a new genus called *Saniella*. Burtt (2000) elaborated upon the interrelations of *Saniella*, *Spiloxene*, *Empodium* and *Pauridia* and purported that these genera should be maintained until further study. He pointed out that *Spiloxene* needs critical analysis to give a fuller understanding of the genus in addition to Thompson's (1976, 1978) studies. Dr Dee Snijman, based at SANBI's Compton Herbarium is presently revising the genus. In their publication of 1978, Hilliard & Burtt also presented a key to eight genera of Hypoxidaceae. The most recent treatment of the family was by Nordal (1998), who recognised the eight genera of Hilliard & Burtt (1978) and *Hypoxidia* of Friedman (1984) as the ninth genus. In 2003, a tenth genus *Heliacme* Ravenna based on *Hypoxis scorzonerifolia* Lam. (= *Heliacme scorzonerifolia* (Lam.) Ravenna) was added to the family. Morphological differences between the currently accepted genera are tabulated in Table 2.4 and the data is based mainly on the above mentioned studies.

Stamen characters were found to be useful at generic and specific level in the Hypoxidaceae. Nel (1914) resolved that in *Spiloxene* (*Ianthe*), the length of the anthers is uneven between the inner and outer stamens whereas in *Hypoxis*, it is the length of the filaments that are unequal, the outer stamens having longer filaments than the inner ones. Geerinck (1969) pointed out that the terminology used by Nel to describe the attachment of the anther to filament in *Hypoxis* is confusing. Hilliard & Burtt (1978) found the stamens to provide important taxonomic characters at generic level and they illustrated differences in stamen features for seven genera. They broadly classified the stamens into two types based on the point at which the anther is attached to the filament and whether the inner and outer faces of the anther are similar or different. In their classification, *Empodium*, *Molineria*, *Rhodohypoxis* and *Saniella* have stamens where the anther joins the filament low down on the outer surface and the inner and outer anther faces are different, while in *Curculigo*, *Hypoxis*, *Pauridia* and *Spiloxene* the filaments join the anther at midway in the sinus between the basal lobes. In the first group, the cross-section of the anther is asymmetrical and in the second group it is symmetrical. Their grouping is similar to that proposed by Nel (1914) but differs in interchanging the positions of *Rhodohypoxis* and *Spiloxene* between the groups. However, Hilliard & Burtt (1978) cautioned that these characters alone are insufficient to reflect generic affinities. They indicate for instance *Rhodohypoxis* and *Hypoxis* have different stamen types, yet they are closely related, and similarly, the stamens of *Empodium* and *Molineria* are both asymetrical in cross section, yet the two genera are obviously not closely related.

2.5 Conclusions

This account traced the development of the treatment of Hypoxidaceae and confirmation of its relationships with evidence from macromorphology, anatomy and nucleotide sequencing that is becoming available. It also traced the addition of new species in the genus *Hypoxis* from the time of Linneaus (1759) to the present. As various studies on hypoxid genera for the Flora of Southern Africa region are concluded, generic delimitation in Hypoxidaceae will be further clarified. There is no doubt that an integration of characters from morphology, anatomy, phytochemistry and molecular data will benefit the phylogenetic placement of the nine genera in Hypoxidaceae as is being applied for the family by studies at Royal Botanic Gardens, Kew.

Table 2.4.—Summary of morphological characters of currently accepted genera in Hypoxidaceae based on Hilliard & Burtt (1978), Thompson (1979), Nordal (1998), Burtt (2000), Snijman (2000) and Ravenna (2003). Data not shown could not be sourced.

	Hypoxis	*Rhodohypoxis*	*Saniella*	*Empodium*	*Spiloxene*	*Pauridia*	*Curculigo*	*Molineria*	*Hypoxidia*	*Heliacme*
Underground stem Duration	perennial	perennial	annual	annual	annual	annual	perennial	perennial	perennial	perennial
Morphology	rhizome	rhizome	corm	corm	corm	corm	rhizome	rhizome	rhizome	rhizome
Plants Vestiture	hairy	hairy	glabrous	hairy	glabrous/ hairy	hairy	hairy	hairy	hairy	glabrous/ hairy
Hair type	simple, bifurcate, stellate	bifurcate or stellate		simple			bifurcate or stellate			simple
Flowers per nflorescence	1-22	1-2	1	1	1-7	1-2	1-few	10 or more	2-5	1
	bisexual	bisexual	bisexual	bisexual	bisexual	bisexual	unisexual	bisexual	bisexual	
Tepals Number	3+3 (rarely 2+2)	3+3	3+3	3+3	3+3 (-2+2)	3+3	3+3	3+3	3+3	3+3
Fusion	free	united at base into a tube	united at the base into a tube	free	free	united at the base into a tube	free	free	united at the base into a tube	united at the base into a tube
		clawed, inflexed above base and closing mouth of perigone								
Colour	yellow (rarely white)	red, pink or white	whitish, pale yellow at base	yellow	orange, yellow, white (rarely pink) tinged with red or green	white to pale pink	yellow	yellow	red-brown yellowish pink	yellow
Stamens Number	6 (rarely 3, 4, 5)	6	6	6	6	3	6	6	6	6
	uniseriate	biseriate	uniseriate	uniseriate	uniseriate	uniseriate	uniseriate	uniseriate	biseriate	biseriate

Table 2.4.—cont.

	Hypoxis	*Rhodohypoxis*	*Saniella*	*Empodium*	*Spiloxene*	*Pauridia*	*Curculigo*	*Molineria*	*Hypoxidia*	*Heliacme*
Anthers Attachment	filament joins anther medianly in basal sinus	filament joins anther low down on the outer surface	filament joins anther low down on the outer surface	filament joins anther low down on the outer surface	filament joins anther medianly in basal sinus	filament joins anther medianly in basal sinus	filament joins anther medianly in basal sinus	filament joins anther low down on the outer surface	filament joins anther low down on the outer surface	
In cross section	symmetric	asymmetric	asymmetric	asymmetric	symmetric	symmetric	symmetric	asymmetric	asymmetric	
Apical appendages	absent	absent	absent	present	absent	absent	absent	Absent	present	
Pollen grains	monosulcate					bisulcate				
Dehiscence	latrorse	introrse	latrorse	latrorse	latrorse	latrorse	latrorse	latrorse or introrse	latrorse	Introrse
Style length	usually short rarely long	lacking or short	short	short or long	short					
Stigmatic lobes Number	3	3	3	3	3	6	3	3	3	3
Ovary Epigynous beak	absent	present	present	present	absent	absent	present	present or absent	absent	
Locule number	3	3	3	1	3 (rarely 1)	3	3	3	3 (incompletely)	1
Placentation	axile	axile	axile	parietal	axile	axile (rarely pariental)	axile	axile	axile	parietal
Capsules	thin-walled	thin-walled	thin-walled		thin-walled	thin-walled				
Dehiscence	dehiscent, circumscissile longitudinal or indehiscent	dehiscent, circumscissile or rupturing irregularly	dehiscent, rupturing irregularly	indehiscent	dehiscent, circumscissile or indehiscent	indehiscent	indehiscent	indehiscent	indehiscent	indehiscent
Position	aerial	aerial or subterranean	subterranean	aerial or subterranean	aerial	aerial	aerial or subterranean	aerial	aerial	
Seeds Strophiole	absent	absent	absent	present	absent	present	absent	absent	absent	
Testa	smooth or papillate						smooth			papillate

3

ETHNOBOTANY OF HYPOXIDACEAE

3.1 Introduction

More than sixty percent of South Africans use medicinal plants in their health care needs and an estimated 3000 plant species are used in traditional medicines in South Africa (Van Wyk *et al.* 1997). *Hypoxis* is a time-honoured ingredient in some African traditional remedies. The genus is used by ethnic groups in Africa to heal various disorders but is mostly associated with the treatment of abdominal pains, impotency and internal tumours. One species in particular, *Hypoxis hemerocallidea* (*H. rooperi* T. Moore) [Figure 3.1] is a popular 'muthi' among the Zulus and is used as an emetic to treat dizziness and nervous disorders (Hutchings 1996). The species ranks among the top 60 most frequently traded medicinal plants in the Eastern Cape and is noted as 'heavily traded, unsustainably harvested and with a high price at the study sites' (Dold & Cocks 2002) and this implies its obvious exploitation in the wild.

By 1970, white South Africans realised the medicinal potential of *H. hemerocallidea* and this encouraged chemical investigations. A number of patents (Pegel 1973, 1977, 1979; Pegel & Colin 1979; Pegel & Liebenberg 1973; Pegel & Walker 1979) were published describing preparation of the rhizome as a remedy for prostate hypertrophy, gastro-intestinal diseases and urogenital infections. Hypoxoside, a phytosterol glucoside with potential for treating benign prostate hypertrophy (Pegel 1973) was isolated from the rhizomes of *H. hemerocallidea* by Drewes *et al.* (1984). When Drewes *et al.* (1984) isolated hypoxoside, they also showed that the diglucoside when hydrolysed converts to its aglycone which they named rooperol. These authors further ascribed the anti-tumour activity to rooperol. About ten years later, Albrecht *et al.* (1995) reported promising results in mice clinical trials that used rooperol as an oral prodrug for anti-tumour activity. When this finding reached the media in South Africa, the plant was tagged the 'African potato'. *H. hemerocallidea* is also the plant from which the properties of sterols and sterolins were correlated with enhancing the human immune system (Pegel 1997).

The purpose of this Chapter is to give an overview of the uses of members of Hypoxidaceae as medicinal, magical or ornamental plants in Africa and abroad, and this is drawn mainly from published literature and presented in Table 3.1. There has been considerable activity recently concerning the isolation of compounds from species of *Hypoxis* and the overview attempts to introduce these as well.

3.2 Hype around *Hypoxis*

There was national excitement when the potential anti-tumour properties in the rhizomes (Figure 3.2) of *H. hemerocallidea* was made public (Figure 3.3) following the findings by Albrecht *et al*. (1995). The news enthused researchers, chemists, pharmacologists and laypersons alike. Media reports (as in Figure 3.3) alluded to significant results achieved from using *Hypoxis* rhizomes in cancer treatment as well as a booster to the immune system. The latter claim may be connected to the properties of sterols and sterolins in the species, which were correlated with enhancing the human immune system (Pegel 1997). This led the public to try preparations of the *Hypoxis* for immune-related ailments such as the common cold, flu, arthritis, tumours, cancer and HIV/AIDS. A number of over-the-counter products became available; among these were preparations called ‘African potato’, ‘wonder herb’ and ‘miracle cure’.

The popularity of the species further intensified when the South African Health Minister, Manto Tshabalala-Msimang overtly advocated the use of beetroot, garlic, lemon, olive oil and the ‘African potato’ as a supplement for HIV/AIDS patients. The African potato’s AIDS-related fame creates nervousness (Figure 3.4) as it seemingly withdraws the government’s commitment to providing anti-retrovirals in the primary health care system in South Africa. The utterances by the minister are of concern to conservationists as well as such unsubstantiated statements drive a demand for rhizomes and lead to the further depletion of *Hypoxis* populations in the wild. The Minister’s encouragement of use of African potato with vegetables also comes up against the clarification given by Drewes & Horn (1999) on the ‘African potato: myth or muthi’ where the authors caution the use of the “*complex mixture of compounds*” present in the rhizomes, the effects of which are not yet fully understood. The concern is further noted in Drewes & Khan (2004) who indicated that the toxicity of *Hypoxis* compounds to humans remain controversial and recommend a comprehensive toxicity study.

3.3 Economically useful members in the Hypoxidaceae

Curculigo orchioides Gaertn., an Asian species and *Hypoxis hemerocallidea*, the African member are probably the most popular medicinal plants of commercial value in the family. Both species are a potential source of drugs. *C. orchioides* is used in India to treat a variety of ailments including piles, jaundice, asthma, diarrhoea, skin infections, wounds and impotency (Dhenuka *et al*. 1999).

Figure 3.1.—*Hypoxis hemerocallidea* commonly called ‘african potato’.

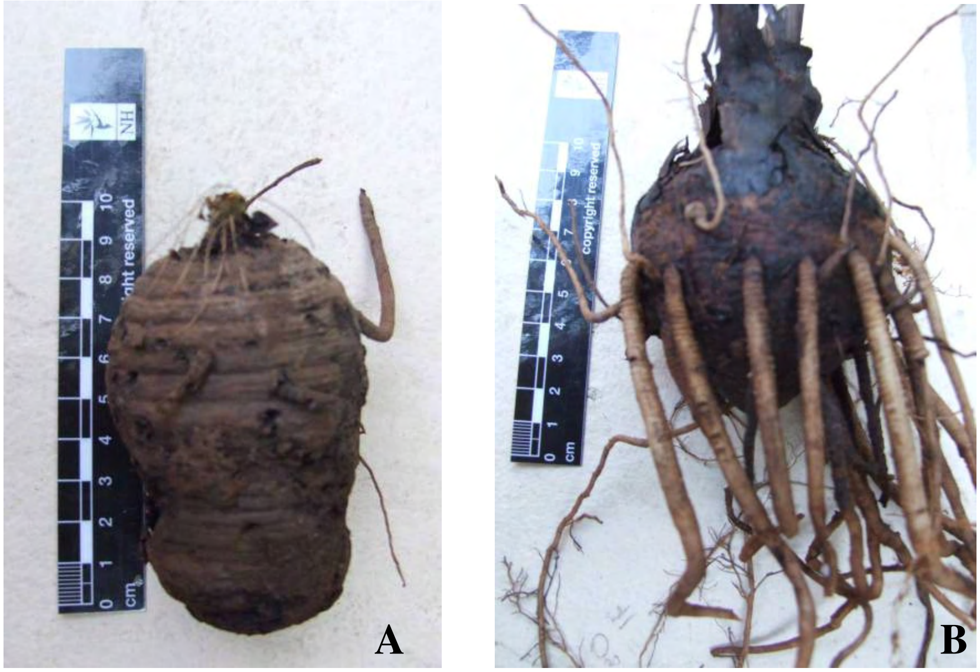

Figure 3.2.—*H*. *hemerocallidea* rhizomes. A, dormant season; B, at start of growing season.

MEDICAL FILE

Centuries-old muti shakes medical world

A tiny yellow flower holds promise for cancer patients, reports TONI YOUNGHUSBAND

An indigenous plant used for hundreds of years by traditional healers is making an unprecedented impact on conventional medicine, and university-trained doctors are battling to cope with patients' demands for treatment.

The six-petalled, star-shaped Hipoxis rooperi, which grows in abundance in KwaZulu-Natal, has shown significant results in cancer treatment and as a booster to the immune system.

Several oncologists have obtained partial registration under regulations laid down by the Medicines Control Council enabling them to treat patients with an extract derived from the plant's bulb.

There are about 100 cancer sufferers currently taking the medication, but hundreds more are on a waiting list.

Doctors hope that within three months amendments to existing legislation will allow them to offer the medication to many more.

The plant is expected to be available as a scheduled drug in tablet form from pharmacies within the next few months.

Dr Carl Albrecht, researcher at the pharmacology unit at Stellenbosch University, says while conventional medicine has only recently appreciated the wonders of what he calls the "star plant", traditional healers have been using it for hundreds of years.

And evidence at archaeological diggings at the Sterkfontein Caves suggests that Hypoxis rooperi was popular among our earliest ancestors. Scratch marks on bone daggers found inside the caves suggest that early man dug the bulbs from between rocks. The plant still grows in the area.

Dr Albrecht said West Street vendors had been selling the plant in its rawest form for years. It was found to be particularly effective against constipation and inflammation.

However, he cautioned against laymen's buying huge quantities of the raw bulb in the hope of finding a cure for cancer. At best, it had shown results in terminal patients, usually prolonging life for 10 to 12 months, particularly in cases of pancreatic cancer where efficacy was easy to determine because there was no other treatment available for this form of cancer.

Cancer patients undergoing chemotherapy have also suffered fewer side effects after taking Hipoxis rooperi.

The plant grows well in summer rainfall areas, particularly in KwaZulu-Natal and in the Eastern Cape, and is found as far north as Kenya.

Dr Albrecht expects the tablets to cost around R180 for 90 when they go on sale.

WONDER PLANT: South Africa's "star plant", Hipoxis rooperi, is being hailed as a medicinal "wonder".
Picture: DIE BURGER

Figure 3.3.—One of the many articles on 'african potato', featured in 'The Saturday' newspaper, 16 March 1997.

Figure 3.4.—Cartoon by John Curtis depicting objection to the South African Health Minister's persistence on including African potato, garlic, beetroot, lemon and olive oil in the diet as a remedy for HIV/AIDS, over anti-retrovirals (from the Cape Argus, 24 August 2006, with permission from the cartoonist).

A related species, *C. pilosa* (Schum. & Thonn.) Engl. that occurs in tropical Africa, is used in West Africa as a purgative and, to treat hernia and swellings (cited in Burkill 1994).

Hypoxis species are used by different cultural groups in Africa to treat a suite of ailments (Watt & Breyer-Brandwijk 1962). In tropical Africa, boiled rhizomes of *H. urceolata* Nel are used as a purgative for new born babies (Wiland-Szymańska 2001). In southern Africa, the two species, *H. colchicifolia* and *H. hemerocallidea* are mostly used in traditional medicine. Their uses include the treatment of impotency, intestinal parasites, stomach pains, headaches, dizziness and mental disturbances (Hutchings 1996). Other species are recorded to have uses for rope making, as food in times of famine or as a charm for protection. The uses of *Hypoxis* and that of other Hypoxidaceae in cultural and medicinal practices are summarised in Table 3.1.

3.4 Hypoxoside

On account of the wide use of *Hypoxis* plants in African traditional medicine and the rising interest in its medicinal properties, the chemistry of a few species was investigated and reported on. The most targeted species in the genus, *H. hemerocallidea*, was used by white farmers in South Africa to treat prostate cancer (Van Staden 1981). The plant was found to have phytosterol glycosides that show activity on benign prostate hypertrophy (Pegel 1973; Pegel & Walker 1979). The diglucoside called hypoxoside that has anti-tumour properties was isolated from *H. hemerocallidea* (Drewes *et al*. 1984). The species is a rich source of this compound and Bayley & Van Staden (1990) reported that the rhizome in the species contain the highest concentration of hypoxoside followed by the roots, whereas the leaves contained neglible levels. Albrecht (1996) indicated that hypoxoside is one of the best studied phytochemicals from an African plant. Hypoxoside is hydrolysed by β-glucosidase to give its aglycone called rooperol (Drewes *et al*. 1984), a compound that has been shown to inhibit specific cancer cells (Drewes & Khan 2004). Albrecht *et al*. (1995) consider rooperol as a promising compound for the treatment of cancer in humans following their results that showed inhibition of melanoma cell growth in mice. Albrecht (1996) reported on the success achieved when hypoxoside was used in a few trials on human patients with cancer, HIV and inflammatory conditions and claims that the diglucoside is a putative, non-toxic prodrug for the treatment of these conditions. He also explained that hypoxoside, a major component of *Hypoxis* plants, is not absorbed in the human gut but is first deconjugated by β-glucurosidase to form rooperol, and it is rooperol that inhibits cancer activity in cells and hypoxoside, although inactive, is a promising prodrug. As the results of such studies became known, a number of products extracted from the rhizomes of *H. hemerocallidea* were manufactured in the form of capsules, tinctures and teas and became available over-the-counter. Drewes & Khan (2004) provided a resourceful review on the usage of these extracts and their chemical constituents. They also reviewed the unravelling of the active compounds in the rhizomes from the 1960s to the present and succinctly covered the biological effect of hypoxoside in treating cancer, HIV, cardiovascular output, hypoglycaemia and ageing. In a recent study, Nair & Kanfer (2008) compared the content of sterols and sterolins in *H. hemerocallidea* rhizomes and some commercially available products. They argued that the quantities of sterol and sterolins in *Hypoxis* and the preparations are too low to have any nutritional or healing effect.

Apart from its use in treating benign prostate hypertrophy, whole extracts of *H. hemerocallidea* rhizomes are being used in antioxidant, anti-convulsant and anti-diabetic agents (Drewes *et al.* 2008). In 2006, Laporta *et al.* analysed hypoxoside from an extract of *H. hemerocallidea* and rooperol derived by enzymatic digestion of hypoxoside, and reported that both compounds showed strong antioxidant activity. They also reported that *H. hemerocallidea* extracts showed higher antioxidant efficacy in comparison to other strong herbal extracts like olive oil and green tea. The results obtained by Laporta *et al*. (2006) indicate that there was no evidence of acute oral toxicity nor adverse effects when *H. hemerocallidea* commercial extracts containing 45% hypoxoside was used at a dosage of 2000 mg/kg. Investigations on the activity of *H. hemerocallidea* extracts on diabetes, convulsions and diarrhoea in rodents are being conducted in the Department of Pharmacology at the University of KwaZulu-Natal, Durban. From these investigations, it was reported that the aqueous extract of *H. hemerocallidea* shows activity against type 2 diabetes (Mahomed & Ojewole 2003), seizures and convulsions (Ojewale 2007) and diarrhoea (Ojewale *et al.* 2008). These studies also suggest the need for further research on the mechanism of the active compounds in *Hypoxis* extracts to confirm its effect on these disorders.

During the present study, it was noted that the two species, *H. hemerocallidea* and *H. colchicifolia*, are sold as 'inkomfe' and 'ilabetheka' respectively at the Warwick Avenue Muthi Market in Durban. These species are used mainly by the Zulu in KwaZulu-Natal to treat mental disorders, heart weakness, impotency and barrenness (Hutchings 1996). In table 3.1, it is noted that both *Curculigo orchioides* and *Hypoxis colchicifolia* are used for treating impotency. As part of this study, a preliminary chemical analysis using Thin Layer Chromatography was undertaken for 14 species of *Hypoxis* in collaboration with Prof. Ben-Erik van Wyk and Dr Alvaro Viljeon at the then Rand Afrikaans University (now University of Johannesburg). The results from the study are reported in more detail in Chapter 8. The five robust species, *H. hemerocallidea*, *H. obtusa*,

Table 3.1.—Traditional ethnobotanical uses of members of Hypoxidaceae

As original literature citing vouchers where not consulted, species names except for known synonyms were not updated. Terms for plant parts are as in literature cited.

Species	**Locality**	**Used by**	**Common names**	**Plant part used**	**Uses**	**Chemical constituents and biological properties**
Curculigo capitulata (Lour.) Kuntze	Tropical Africa Phillipines North Australia				- Ornamental, cultivated in Africa (Wiland 1997)	
C. latifolia Dryand					- Garden ornamental cultivated in the Flora Zambesiaca area for its attractive foliage (Nordal & Zimudzi 2001)	
C. orchioides Gaertn.	Asia	Indians	kali musli (Wala & Jasrai 2003)	rootstock (mainly), roots, leaves	- Used to treat piles, jaundice, asthma diarrhoea (cited in Dhenuka *et al*. 1999) and pimples (cited in Wala & Jasrai 2003) - Used as a poultice to treat itchiness and skin complaints (cited in Dhenuka *et al*. 1999) - Applied as a powder externally to wounds (cited in Dhenuka *et al*. 1999) - Taken as a tonic for impotency (cited in Dhenuka *et al*. 1999)	- Crude extract inhibits replication of Hepatitis B virus DNA and other stages of viral replication such as RNA and protein synthesis (cited in Dhenuka *et al*. 1999). - A new phenolic glucoside called corchioside A was isolated from the species by Garg *et al*. (1989) (cited in Dhenuka *et al*. 1999) - Triterpinoid sapogenins and saponins used as tonic in Chinese medicine (cited in Dhenuka *et al*. 1999) - Curculin, a sweet tasting and taste modifying protein is present in the fruits of *C. latifolia* (cited in Dhenuka *et al*. 1999)
C. pilosa (Schum. & Thonn.) Engl.	Tropical Africa		badia nseka, besakasana, lilanga (Turumbu dialect), fundusjele (Ngwaka dialect) gbalabadoli, mulumba, orangba (Azande dialect) (Wiland 1997a)	roots	- Used in Northern Nigeria as a purgative (Dalziel 1937; cited in Burkill 1994) - Used in Congo-Brazzaville for treating hernia (cited in Burkill 1994) - In the Central African Republic, root reduced to a pulp is applied topically to swellings (cited in Burkill 1994)	

Table 3.1.—cont.

Species	**Locality**	**Used by**	**Common names**	**Plant part used**	**Uses**	**Chemical constituents and biological properties**
	Ghana		ground star, African crocus	rhizome seed capsules	- Used as a remedy for itchiness (Wiland 1997a) - Fresh seed capsules are edible (Dalziel 1937) - Infusion used as an enema for stomach aches (Dokosi 1998)	
C. recurvata Dryand				rootstock		- Isolation of nyasicoside (Chifundera *et al*. 1991)
Empodium plicatum (Thunb.) Garside	South Africa	Zulu	golden star, ploegtydblommetjiesterretjie, isidwa, esincane senkangala (Zulu)	rootstock	- Decoctions taken for chest trouble thought to be caused by evil charms or poison (Hulme 1954) - Eaten raw in Lesotho (Guillarmod 1966). Note the species is not present in Congo, so it could possibly refer to *E. elongatum* (Nel) B.L.Burtt.	
Hypoxis angustifolia Lam.	Africa Swaziland	Shona Masai and Kipsigi	hodo	rootstock	- Fibres removed, washed and eaten raw or grated, boiled or roasted (Tredgold *et al*. 1986) - Flesh of rootstock eaten by children in Kenya (cited in Burkill 1994) - Used for making good luck charm (Adeniji *et al*. 2003)	- Isolation and identification of nyasol, (Z)-1-(4-hydroxyphenyl)-3-(4-hydroxyphenyl)-1,4- Pentadiene, hypoxoside, nyasoside, nyaside and mononyasine A and B (Sibanda *et al*. 1990)
H. argentea Harv. ex Baker	Africa	Sotho	letsikitlane, leihlo-khoma le leholo (Phillips 1917)	rootstock	- Eaten by children in Lesotho (Phillips 1917) - Dried, crushed, mixed with fat, and used to anoint cracks on the teats of cows by the Sotho in Lesotho (Phillips 1917) - Rootstocks are heated to obtain an oil	

Table 3.1.—cont.

Species	**Locality**	**Used by**	**Common names**	**Plant part used**	**Uses**	**Chemical constituents and biological properties**
		Xhosa			which is used to anoint chafes on horses (cited in (Watt & Breyer-Brandwijk 1962) - Eaten in times of famine, roasted or boiled by children (Watt & Breyer-Brandwijk 1962)	
H. colchicifolia including *H. latifolia*	Subsharan Africa	Zulu	ilabetheka, igugu, ingcobo	rootstock	- Reported to be poisonous (cited in Watt & Breyer-Brandwijk 1962) - The Zulu use it as a remedy against barrenness (cited in Watt & Breyer-Brandwijk 1962) and sometimes in a mixture with other roots for barrenness (Bryant 1966). - Plant is regarded by Zulus to produce delirium and is also used by them for treating the condition (cited in Watt & Breyer-Brandwijk 1962) - Plant is used medicinally by the African in Congo (Watt & Breyer-Brandwijk 1962). Note the species is not present in Congo, so it possibly refers to *Curculigo pilosa* with which it may be confused. - Hot infusion of the rootstock is taken as an emetic against dreams disagreeable dreams said to accompany heart weakness (Gerstner, 1938, Bryant 1966) - Boiled rootstock is taken as a emetic (Bryant 1966) - Whole rootstocks are placed in snake holes as traps (Gerstner, 1938, Bryant 1966)	- Plant is said to contain haemanthine and used as a purgative and ascarifuge in unspecified parts of Africa (cited in Watt & Breyer-Brandwijk 1962) - Pentenye-*bis*-glucosidophenol extracted from rhizome (Drewes & Liebenberg 1983)

Table 3.1.—cont.

Species	**Locality**	**Used by**	**Common names**	**Plant part used**	**Uses**	**Chemical constituents and biological properties**
					- Rootstock is ground and placed in food to destroy all small vermin (Bryant 1966) - Used as a diuretic and in the treatment of psychiatric disturbances (Hutchings 1996) - Used for nausea/vomiting and for insect bites (Felhaber 1997). Note in this publication, illustration depicting species matches *H. hemerocallidea* but common names correct for *H. colchicifolia*.	
H. gerrardii Baker	South Africa			rootstock	- Decoction made by pounding and boiling rootstocks used to treat stomach trouble (Riley 1963), such as gripe and dysentery (Hulme 1954)	
H. goetzi Harms	Tropical Africa				- Useful plant with an edible rhizome (Wiland-Symańska 2001)	
H. hemerocallidea Fisch., C.A. Meyer & Avé-Lall. (synonym *H. rooperi*)	Subsaharan Africa	Sotho	mola kharatsa lotsane	rootstock leaf	- Used as a cure for headaches: the rootstock is shaped into a small hollow receptacle in which some blood from the afflicted person's forehead is collected The receptacle is buried and the headache cured (Phillips 1917) - Is a constituent of a medicine used in Lesotho as a charm against thunder and storms (Watt & Breyer-Brandwijk 1962) - Rope made from the leaf is used in the building of huts and reed enclosures and for sewing grain-baskets (Phillips 1917)	- Rootstock contains organic acids (Watt & Breyer-Brandwijk 1962) - Phytosterol glucosides mainly β-sitosterol (Pegel 1973) - Pentenye-*bis*-glucosidophenol extracted from rhizome (Drewes & Liebenberg 1983) - Diglucoside hypoxoside (Drewes *et al*. 1984) - Aglycone rooperol (Drewes *et al*. 1984) - Leaves are not an alternative source to rhizomes for sterols and sterolins. Leaves may be more effective for the

Table 3.1.—cont.

Species	Locality	Used by	Common names	Plant part used	Uses	Chemical constituents and biological properties
					- Pounded decoctions taken for stomach ailments and dysentery (Hulme 1954)	treatment of wounds than rhizomes (Katerere & Eloff 2008).
		Tswana and Kwena		rootstock	- Decoction given as a tonic to weakly children and it works as a purgative (Watt & Breyer-Brandwijk 1962) - Juice from the rootstock is applied to burns (Watt & Breyer-Brandwijk 1962)	
		Zulu			- Infused with Andropogon, Clausena, Ekebergia and Xanthoxylon to treat intestinal parasites, used as a purgative (Bryant 1966) - Infusions used as emetics for dizziness and mental disorders (Hutchings 1996)	
		Afrikaners			- Hot aqueous extracts of fresh or dried rootstocks used by white farmers in southern Africa to treat symptoms of benign prostate hypertrophy (Van Staden 1981)	
	Eastern Cape of South Africa	Xhosa	inongwe, ilabatheka		- Infusion taken orally for kidney pain, high blood pressure, diabetes and arthritis; also taken as a general tonic for good health (Cocks & Dold 2006) - Paste used to treat pimples, acne and skin rash (Cocks & Dold 2006)	
	Swaziland				- Used to treat infective dermatitis (cited in Adeniji et al. 2003)	

Table 3.1.—cont.

Species	Locality	Used by	Common names	Plant part used	Uses	Chemical constituents and biological properties
H. multiceps Buchinger ex Baker	Lesotho	Sotho	molimotsane, morethetho	rootstock	- Mixture of this species and *Ipomoea oblongata* E. Meyer ex Choisy smeared on pegs placed in the ground around a kraal as a charm against lightning (Phillips 1917)	
H. nyasica Baker	Africa	Nyanja		rootstock	- Used as a cough remedy that is said to induce perspiration - Used as an African medicine in the Congo (Watt & Breyer-Brandwijk 1962)	- The plant is said to contain an alkaloid (Watt & Breyer-Brandwijk 1962) - Monoglucoside named nyasicoside was isolated (Galeffi *et al*. 1987) - Mononyasine A and B, glucosides of nyasol and hypoxoside (Messana *et al*. 1989)
H. obliqua Jacq.	South Africa	Xhosa		rootstock	- Water boiled in the scooped-out rootstock is used as a lotion for septic wounds - Resinous material extracted from the rootstock by roasting it has been used for fixing assegai heads on the shaft - The plant is an African medicine in the Congo (Watt & Breyer-Brandwijk 1962)	
H. obtusa	Subsaharan Africa	Karanga children in Zimbabwe		rootstock	- Used in mock bull fights, called 'nhindiri'. A hole is made through the length of the tuber and a forked stick pushed through this. The fork represents the horns of the bull, and the tuber the body. Pairs of boys aim at damaging their opponents bulls (Wild *et al*.1972)	- Isolation of hypoxoside (Marini-Bettolo *et al*. 1982) - Isolation of obtusaside (Msonthi *et al*. 1990)
	Zimbabwe	Shonga	hodzori		- Used to treat abdominal pains, backache and infertility, also as an aphorodisiac taken orally (Gelfand *et al*. 1993)	

Table 3.1.—cont.

Species	**Locality**	**Used by**	**Common names**	**Plant part used**	**Uses**	**Chemical constituents and biological properties**
H. rigidula Baker	Southern Africa	Sotho	tieane	leaf	- In Lesotho, used to make a strong rope (Phillips 1917) - Strong fibrous leaves used by the natives as string or rope and long cords are made by plaiting strands together (Verdoorn 1947)	
				rootstock	- Used as a remedy for gall-sickness in cattle - In the Congo, the plant is a traditional medicine (Watt & Breyer-Brandwijk 1962)	- Rootstocks have given negative tests for haemolysis, alkaloid and organic acid (Watt & Breyer-Brandwijk 1962)
H. urceolata Nel		Narok District, Kenya	chepkimniet (Kipsigis), engaimalasiyai (Masai)	rootstock	- children eat small tubers attached to roots - children fix sticks into rootstocks to make toy wheels - children cut out middle of rootstock to make miniature gourds which they fill with milk and pretend to drink Notes on *Clover, Gwynne & Samuel 614* (EA)	
H. villosa L.f.		Southern Sotho	moli letaha, lehlaba kolobe, khuoa ke maoatle	rootstock	- Used as a charm against thunder	
		Lobedu		leaf	- Sometimes used for making rope but these are weaker and rot sooner than those made from *H. rigidula* (Phillips 1917) - For magical purposes, the rootstock is planted on mounds dedicated to the Gods	

Table 3.1.—cont.

Species	**Locality**	**Used by**	**Common names**	**Plant part used**	**Uses**	**Chemical constituents and biological properties**
					- Sometimes a rootstock is stuck onto a stick and planted outside a kraal to repel witches - Sometimes used to induce diarrhoea in domestic stock (Watt & Breyer-Brandwijk 1962)	
Hypoxis sp.	Malawi					- Rootstock contains haemolytic sapogenin and organic acids (Watt & Breyer-Brandwijk 1962)
Hypoxis sp.				leaf	- Fibre traditionally used for binding on Zulu spears (Cunningham & Terry 2006). The picture in the publication shows *H. obtusa* but does not mention a species.	
Hypoxis sp.	Manyika			rootstock	- Ash prepared from rootstocks are applied to wounds - Decoction given to babies who accidentally drink the milk of a woman who has conceived (Watt & Breyer-Brandwijk 1962)	
		Karanga			- Remedy for vomiting, loss of appetite, abdominal pains and fever - It is used by sprinkling salt on cut surfaces of the rootstock and licking off the bitter juice (Watt & Breyer-Brandwijk 1962)	
		Zulu			- Ingredient of an infusion taken as a purgative and as remedy for internal parasites, also for delirium (Watt & Breyer-Brandwijk 1962)	

Table 3.1.—cont.

Species	**Locality**	**Used by**	**Common names**	**Plant part used**	**Uses**	**Chemical constituents and biological properties**
Molineria capitulata (Lour.) Herb.	Phillippines			leaf	- Fibre of leaves used by hill tribes to make false hair (cited in Burkill 1994) - Used to make fish-nets (Burkill 1994)	
	Borneo			flowers/ fruit	- Fruit is edible (cited in Burkill 1994). - Plant cultivated for its attractive foliage (Burkill 1994)	
	Argentina and Chile				- Widely cultivated in these countries (Ravenna 2003)	
Molineria recurvata (Dryand) Hebbert	India, Himalaya	Apatani		leaves	- to treat body aches (Kala 2005)	

H. rigidula, *H. galpinii* and *H. acuminata* were found to have a similar set of compounds. These species are closely related morphologically. In addition, the rhizomes in these species are large, yellow to orange internally as opposed to the more slender rhizomes that are white to cream-coloured in the smaller species like *H. angustifolia, H. argentea* and *H. filiformis*. With the depletion of the target species, *H. hemerocallidea* and *H. colchicifolia* in the wild, it is likely that the related species will be collected and sold as 'inkomfe' and 'ilabetheka'.

Glucosides were also isolated from *H. obtusa* and *H. nyasica* Baker through the works of Msonthi *et al*. (1990) and Galefi *et al*. (1987, 1989) respectively. Of interest, is the monoglucoside nyasicoside that was first isolated from the rhizomes of *Hypoxis nyasica* (Galefi *et al*. 1987) and then later isolated from the rhizomes of *Curculigo recurvata* Dryand (Chifundera *et al*. 1991). The rhizome of *C. recurvata* is reported to be used orally by the Bashi tribe in Zaire as a treatment for snake bites and arthropod stings (Chifundera *et al*. 1991). Furthermore, hypoxoside was extracted from *H. obtusa* (Marini-Bettolo *et al*. 1982), the species most closely related to *H. hemerocallidea*. Marini-Bettolo *et al*. (1985) isolated hypoxoside and a new glucoside called nyasoside which is biologically related to hypoxoside from *H. nyasica*.

3.5 Commercially available products from rhizomes of *Hypoxis*

Hypoxis fits into a small fraction of plants that is used in African traditional remedies and is also being studied by pharmacologists. It is also a genus from which a number of untested over-the-counter products are manufactured in South Africa by local pharmaceutical companies, by a number of herbalists as well as by home-based entrepreneurs, and has become a commercially viable incentive among some groups. Preparation of the rhizome for ingestion is diverse and range from infusion of chopped rhizomes for use as tea to more sophisticated home-filled capsules containing pulverized rhizomes. A number of commercial products prepared from *Hypoxis* extracts are also available over-the-counter in South Africa (Figure 3.5). One such product is Moducare® that is available in capsule form from health stores and pharmacies. Drewes & Khan (2004) informed of the development of Moducare® based initially on two phytosterol, ß-sitosterol and its glucoside originally obtained from *H. hemerocallidea* rhizomes. However, Moducare® no longer contains *Hypoxis* extracts but those of pine and soya (Drewes & Khan 2004) although the label continues to carry a picture of a *Hypoxis* flower. Drewes & Horn (1999) reported the results of their TLC analysis of Moducare® where they found β-sitosterol and sterols of a structure similar to that in *Hypoxis*. Table 3.2 lists some products, apart from those mentioned in Drewes & Khan (2004) available in South Africa that claim to contain extracts of *Hypoxis*.

Figure 3.5.**—**Examples of over-the-counter products prepared from *Hypoxis* rhizomes. Photograph: A. Rajh.

Table 3.2.—Some products from *Hypoxis hemerocallidea* rhizomes available in South Africa

Trade name	**Form**	**Manufactured by**	**Available at**	**Composition of *Hypoxis***
Moducare®	Capsule	Aspen Pharmacare	Health stores and Pharmacies	20 mg plant sterols and 0.2 mg sterolins per capsule. Research on sterols and sterolins for the product was based on *H. hemerocallidea*. Now pine bark is used instead of *Hypoxis*.
African potato/ *Hypoxis hemerocallidea*	Capsule	NutriGreen-NutriHerb-NutriLife	Health stores	300 mg of dry extract of *H. hemerocallidea,* per capsule
Immunizer	Capsule	Vikeleka Herbal Pharmaceuticals	Pharmacies	Undisclosed amounts of *H. hemerocallidea* and *Aloe vera*
Immuno *Active*	Capsule	Vuselela Herbal Pharmaceuticals	Pharmacies	500 mg of *H. hemerocallidea*. Also contains *Aloe ferox*
Herbal Immune Booster	Tincture	Farmos Health	Pep Store	500 mg of *Hypoxis* and 55 mg plant sterols per 20ml
Hypoxis rooperi	Tincture	Phyto-Force	Health Stores	Undisclosed
African Potato Herbal Tea	Tea	Natural Wonder Healer	Home Industry Outlets	Undisclosed
Die Afrika Aartappel	Tea	Private home based	Flea market	Undisclosed

These products are being used by the public for the treatment of arthritis and cancer, and to get a general boost in immunity to help cope with common ailments like colds and flu. The use of the *Hypoxis*-based products for self medication is mainly promoted through referral by users.

There is at present no formal control in South Africa on the products being manufactured from plants such as *Hypoxis*, and the marketing thereof. This is of concern especially in the absence of clinical evidence of the activity of *Hypoxis* and suitable dosages. The pharmaceutical companies use plants from a cultivated source, however, small home businesses are probably buying the rhizomes off vendors in the muthi market, thereby creating a demand for plants in the wild. Surplus rhizomes that are not sold within a certain period at the muthi market are discarded and replaced by new stock. The problems around harvesting wild source rhizomes are discussed under "What South Africa needs?".

Due to their anti-inflammatory activity (Pegel 1976), lipophilic extracts of *H. hemerocallidea* rhizomes are used to treat prostate problems in Europe (Hostettmann *et al*. 2000). A commercial product from *H. hemerocallidea* of note is Harzol®. The product was launched in 1974 and was used mainly in Germany to treat benign prostate hypertrophy. See Drewes & Khan (2004) for a detailed history of the development of Harzol®. Van Wyk & Gericke (2000) cite Bruneton (1995) and point out that pumpkin (*Cucurbita pepo* L., Cucurbitaceae) oil which contains high levels of phytosterols is marketed in Europe as a remedy for benign prostate hypertrophy. This would be a more suitable source instead of *Hypoxis* as cultivation of the latter requires a longer period.

3.6 *Hypoxis* species as a source of fibre

In a batch of communication in the *Hypoxis* files at the National Herbarium, Pretoria, there are two reports on the fibres in leaves of *Hypoxis rigidula* provided by the Imperial College in London. The first report is a response to a query sent by the Department of Agriculture, Transvaal to the Imperial College about the potential of fibres in *Hypoxis* for commercial use. It is dated 30 September 1906 and gives the results of a chemical comparison of the moisture, ash and cellulose content of *H. rigidula* leaves in comparison to esparto grass (*Stipa tenacissima* L, Poaceae). The report indicates that the fibre of the *Hypoxis* species is dark brown, smooth, stiff and wiry, somewhat lustrous and curly. It mentions that the fibre is resilient, fairly strong but slightly brittle and suggested that it could be used as stuffing material in upholstery.

The second report is dated July 1918 and is in response to a request by the Trades Commisioner's Department in South Africa as to whether there would be a market for fibre from *H. rigidula* and its possible commercial value. The request emanated out of the observation that locals were using the leaves for rope making. Values are presented for the moisture, hydrolyses loss, ash and cellulose contents in the report. The report states that the fibre is fairly resistant due to small losses on hydrolysis, but its low cellulose levels make it brittle and unsuitable for rope making. It advised that due to its extreme brittleness, the fibre is not suitable for commercial purposes.

Later, Watt & Breyer-Brandwijk (1962) mention the use of *H. rigidula* and *H. hemerocallidea* (*H. rooperi*) in rope making used in the building of huts and reed enclosures, and for sewing grain baskets. At the Ecabazini Zulu Cultural Homestead in the Valley Trust centred in the midlands of KwaZulu-Natal, the Zulu use *H. rigidula* (Figure 3.6) and *H. obtusa* fibres to make rope. The process of rope making is illustrated in Figure 3.7A–D. The ropes are used to decorate huts (Figure 3.7D).

Figure 3.6.—*H. rigidula*. A, habit; B, collected for rope making at Ecabazini, Pietermaritzburg, KwaZulu-Natal.

Figure 3.7.—Process of rope making using *H. rigidula* leaves at Ecabazini Zulu Cultural Homestead. A. leaves are plaited tightly over each other. B. close-up of how rope is held between feet and plaited. C. rope rolls stacked for used in hut decorating. D. rope décor on hut roofs. Photographs: Richard Haigh.

3.7 Other uses of *Hypoxis*

Local people in the Estcourt District of KwaZulu-Natal make a black polish from rhizomes of *H. obtusa* (known to them as inkomfe) which they apply to the floor of huts. Making the polish involves boiling sliced rhizomes in water until they are soft and then pouring the discoloured water over fine soil (Fred Smith, Robert Vilakazi of Busmansriver Gifts, pers. comm.). The soil-inkomfe mixture is applied to the floor and from time to time, inkomfe water is sprinkled over the floor to maintain the firmness and shine.

Some taxa of *Hypoxis*, mainly *H. angustifolia* var. *buchananii* and *H. hemerocallidea* are used in horticulture. The genus is suitable as garden plants as the rhizomes are resilient and flower readily in the absence of fire. Inflorescences in many species are produced sequentially throughout the growing season offering colour to beds over many months. A few other species, like *H. obtusa*, *H. acuminata* and *H. sobolifera* are floriferous when grown in clumps. *H. angustifolia* var. *buchananii* and *H. sobolifera* are easily propagated by division of the rhizome. Appleton & Van Staden (1995) offered appropriate methods for propagating *H. angustifolia* var. *angustifolia* for commercial use and to get plants to flower in just eight to ten weeks of transplanting. *H. stellipilis* is unusual in its bicoloured leaves; the upper surface is dark green and the lower surface white due to the density of hairs, raising the potential of this species as an ornamental. Another species of potential value as a pot plant is the dainty single-flowered, *H. parvula*, both white- and yellow-flowered forms may be grown together to create an attractive mass display in containers. The white-flowered *H. membranacea* and *H. nivea* also multiply rapidly like *H. angustifolia* and would be excellent as garden or pot plants. Plants of *Hypoxis* require little care; usually only the dried out shaggy looking leaves and old fruiting heads need to be removed at the end of the growing season. With the features highlighted above, it is clear that more species of *Hypoxis* are worthy of cultivation as garden plants.

3.8 What South Africa needs?

It is inevitable that the exhaustive harvesting of *Hypoxis* plants from the wild will eventually lead to depletion of the resource. Depletion of target species is likely to promote collection of related species. Lack of availability of species in the wild may also influence indigenous practices involving plants in the long term.

Conservation authorities and the Government in South Africa will need to work more rapidly to form partnerships with indigenous communities and develop a plan for achieving sustainable harvesting by a target year. The setting up of such partnerships is challenging as it requires buy-in from collectors, conveyors and vendors of geophytes, like *Hypoxis*. Several community based projects are underway to cultivate medicinal gardens, but their effect is currently minimal in light of the rate at which plants are being removed from the wild in South Africa. There is also the belief among local people that cultivated plants are less potent to those growing naturally and this needs to be considered. In *Science in Africa* (www.scienceinafrica.co.za), Hughes (2002) outlines the basic requirements for small scale sustainable cultivation and techniques for rural communities. He recommends that the approach be based on Afro-ethnic wisdom rather than on a westernised corporate pursuit. Such an approach is completely valid since South Africa, and Africa needs to develop custom made programmes equitable to all stakeholders. A national campaign may be appropriate to bring to an end unsustainable harvesting of our natural resources, but it needs to be initiated at government level immediately.

Through the Department of Botany, University of KwaZulu-Natal, Pietermaritzburg, a number of studies were undertaken on cultivation requirements of *H. hemerocallidea*. These studies include work by Hammerton & Van Staden (1988) on methods for breaking seed dormancy in the species and nutrient and soil requirements for cultivating *H. hemerocallidea* plants with high hypoxoside content by McAlister & Van Staden (1995). The results from these studies are important to increasing yield of plants and hypoxoside content when plants are cultivated for commercial use.

There is evidence that rooperol is active in inhibiting cancer cells (Albrecht *et al*. 1995). What is needed now is support from the Health Department for clinical trials using the prodrug (hypoxoside) on volunteers. It is understandable that the process of clinical trials is complex but the challenge is for immunologists and policy makers to take testing further so that the activity of rooperol as an anti-cancer, anti-HIV and anti-inflammatory becomes accurately known.

Lastly, the diversity in habit, leaves and flowering stalks in *Hypoxis* allows for selection and cultivation of suitable species for the horticultural trade. Since the genus is easy to maintain in gardens and as pot plants, the South African horticultural trade needs to investigate and create a market for these geophytes.

3.9 Conclusions

This Chapter gives an overview of the ethnobotany of Hypoxidaceae with special emphasis on the potential of *Hypoxis* in medicine and horticulture. The robust species in the genus contain the diglucoside, hypoxoside, a bioactive compound which in its hydrolysed form (rooperol) has been shown to slow down the growth of cancer cells. *Hypoxis* therefore holds considerable promise as an anti-tumour drug. The demand for particular species used mainly by the Zulus and now by maverick businessmen is rapidly reducing plant populations in South Africa and is likely to put pressure on related species. National efforts are therefore necessary to promote sustainable harvesting of geophytes for use in traditional remedies from the wild. *Hypoxis* shows great potential as a garden plant and more species should be introduced into horticulture.

4

MATERIALS AND METHODS

4.1 Introduction

The aim of this chapter is to describe the details of the materials and methods used for recording comparative data on morphology, geographical distribution, anatomy and phytochemistry.

4.2 Field studies

The study is based on extensive field work in South Africa. Close to 30 sites were visited in the Eastern Cape, KwaZulu-Natal, Mpumalanga, Gauteng, Free State and North West to observe and collect *Hypoxis* plants. From literature and herbarium sheets, sites with several species were determined and intensive field studies were carried out at these localities. These sites include Mkambati Nature Reserve, Mateku and Stutterheim in the Eastern Cape; Reservoir Hills and Byrne Valley in KwaZulu-Natal; Melville Koppies in Gauteng and Sentinel Peak in the Free State. As *Hypoxis* is plentiful in grasslands in the summer rainfall region of South Africa and is easily accessible, opportunistic collecting was undertaken during general field trips organised by the KwaZulu-Natal Herbarium. In addition, three sites close to Durban, at the coast of KwaZulu-Natal were visited at different seasons each year for three years to record phenology, growth patterns and ecology of the common species *H. hemerocallidea* and *H. angustifolia*. Plants were photographed in the field to record habit, rhizome shape and colour, leaf colour, inflorescence features and mode of fruit dehiscence. Where possible, four plants of a species were collected from a population; two were selected and pressed as herbarium vouchers and lodged at the KwaZulu-Natal Herbarium (NH), Durban, and the remaining two were grown in black plastic bags in open conditions at the NH. Species with short delicate leaves, like *H. flanaganii* and *H. parvula*, were grown in seedling trays for better protection from adverse weather conditions. Vegetative and floral characters were surveyed from observations of plants in the field and those kept in cultivation. Further, plant parts of select species from each trip were preserved in formalin-acetic-acid (FAA) for dissection and anatomical studies.

4.3 Herbarium studies

The study was conducted at the KwaZulu-Natal Herbarium (NH), South African National Biodiversity Institute. Material was obtained on loan from 15 southern African Herbaria [BLFU, KEI, UNIN, WIND, BOL, J, NBG (including SAM), PRE, PRU, BEWS, GRA, NU, NH, Umtamvuna Nature Reserve Herbarium and Ward Herbarium] and 11 herbaria in tropical Africa, Europe and the United Kingdom namely B, BM, BR, EA, GAB, K, LMA, MAL, SRGH, TCD, Z including ZT. Once there was an understanding of species and their diagnostic characters from the study of type specimens and protolgues, non type specimens were reclassified into respective species. A total of about 4000 herbarium specimens were examined. Specimens were also studied and data on macromophology and distribution were acquired through visits to PRE, EA, K, B and POZ. During these visits, specimens of *Hypoxis* from the rest of Africa were studied with the following aims:

- to compare southern African taxa with those in tropical Africa
- to note the southern African species that extend northwards into tropical Africa
- to evaluate variation in taxa occurring in both southern and tropical Africa

4.3.1 Morphological data

Measurements were made of rhizome, pseudostems, leaves, inflorescences and flower parts. Number of veins on leaves and whether veins were prominent or subtle were noted. Using mostly specimens collected by the author and housed at NH, flowers were reconstituted by boiling for one minute in a microwave oven and characters of the stamens and pistil were determined. Anther tip split or entire and style to stigma ratios were recorded to verify their diagnostic value as Nel (1914) placed great emphasis on these characters, as well as on leaf venation.

Macromorphological data obtained from living and herbarium materials were used to compile descriptions for species and the genus. Leaf hairs were studied under an Olympus SZ40 Stereomicroscope at a magnification of 6.7x to 40x. In specimens where hair characters were obscure due to pressing, hairs were scrapped off leaves, placed on a slide and studied under an Olympus CH-2 compound microscope at a magnification of 200x to 400x. Hair characters were also evaluated from scanning electron micrographs, the details of which are provided under anatomical studies.

Throughout the thesis, authors of plant names follow Brummit & Powell (1992) and acronyms of herbaria are according to Holmgren *et al.* (1990). Citation of herbarium specimens in the formal taxonomic treatment is according to the conventions of the SANBI in-house journal, *Bothalia*. Their format is based on the Degree Reference System proposed by Edwards & Leistner (1971). In a citation, where a collector's number is lacking, the herbarium number is recorded, in the absence of which the date of collection is cited. Terminology applied to morphology is mainly according to Stearn (1995), but reference is also made to Dahlgren *et al.* (1985) and Kubitzki (1998). Since plant parts namely rhizome and inflorescence in *Hypoxis* do not strictly match the definitions provided by the literature, the structures are described in detail in Chapters 5 and 7 and appropriate terminology for the genus is suggested.

4.3.2 Distribution data

Once species were determined, the quarter degree square was established for specimens with complete locality details that were not previously georeferenced by the loaning herbarium. For each species, all the grid data was entered into a MS Word document in the format compatible with the MAPPIT Programme (SANBI, Pretoria). Maps were generated using MAPPIT and these were used for checking and editing. Grid data and maps were then supplied to the Data Section of SANBI, Pretoria for overlay of point data over southern African biomes following Rutherford & Mucina (2006).

4.4 Anatomical studies

4.4.1 Leaves

Leaf samples of 20 species of *Hypoxis* were examined by means of light microscopy. Duplicates were included for common taxa to help assess variation. Samples were prepared from plants collected in the wild and fixed in formalin-acetic acid-alcohol (FAA) in the ratio of 1:1:18 (Bridson & Forman 1989). Locality details of samples are recorded in Table 4.1.

Suitable portions of the leaf material were selected about midway up the length of leaves and passed through an alcohol series to dehydrate them. Epidermal leaf scrapes of ad- and abaxial surfaces of all species were prepared using a razor blade. Scrapes were stained with toluidine blue. The glycol methacrylate (GMA) embedding technique for LM (Feder & O'Brien 1968) was used for the study of internal leaf structure. One and a half micrometer (μm) thin sections were cut on a Jung RM2045 ultramicrotome. Sections were stained with the periodic acid-Schiff (PAS) reaction and counterstained with toluidine blue (Feder & O'Brien 1968). Sections were studied on an Olympus BH-2 photomicroscope with an Olympus DP71 digital camera. For SEM studies, leaf material of species (Table 4.2) preserved in FAA was dehydrated through an alcohol series, critical point dried, mounted on stubs, sputter-coated with gold, viewed and photographed using a Jeol JSM 840 SEM at the National Herbarium, Pretoria. For species not available in FAA, leaf samples were selected off herbarium sheets, mainly from the NH Collection. Samples were mounted

Table 4.1.—Specimen details of FAA-preserved collections used in anatomical study of leaves. Vouchers in NH

Species	**Collector**	**No.**
H. acuminata	Singh	286
H. acuminata	Singh & Baijnath	314
H. angustifolia var. *buchananii*	Singh	535
H. angustifolia var. *buchananii*	Singh	583
H. angustifolia var. *buchananii*	Singh	814
H. argentea var. *argentea*	Singh & Baijnath	325
H. argentea var. *argentea*	Singh	626
H. argentea var. *sericea*	Singh	259
H. argentea var. *sericea*	Singh	301
H. colchicifolia	Singh	481
H. colchicifolia	Singh & Govender	435
H. costata	Singh	300
H. costata	Singh	803
H. filiformis	Singh	528
H. filiformis	Singh & Baijnath	418
H. filiformis	Singh & Govender	559
H. flanaganii	Singh	807
H. galpinii	Singh & Baijnath	334
H. hemerocallidea	Singh & Baijnath	227
H. hemerocallidea	Singh, Baijnath & Govender	262
H. interjecta	Singh	280
H. longifolia	Singh	290
H. membranacea	Singh	826
H. multiceps	Singh	279
H. obliqua	Singh	531
H. obtusa	Singh	277
H. obtusa	Singh & Baijnath	337
H. obtusa	Singh, Baijnath & Govender	283
H. parvifolia	Singh	470
H. parvula var. *parvula*	Singh	556
H. rigidula var. *pilosissima*	Singh & Baijnath	318
H. rigidula var. *pilosissima*	Singh, Baijnath & Govender	263
H. rigidula var. *rigidula*	Singh	278
H. rigidula var. *rigidula*	Singh	282
H. rigidula var. *rigidula*	Singh	328
H. rigidula var. *rigidula*	Singh	329
H. rigidula var. *rigidula*	Singh & Baijnath	317
H. rigidula var. *rigidula*	Singh & Baijnath	335
H. sobolifera var. *sobolifera*	Singh	816
H. stellipilis	Singh	621

Table 4.2.—Specimens used in SEM studies of leaf surfaces

Species	**Collector**	**Number**	**Vouchers housed at**
H. angustifolia var. *buchananii*	Singh	303	NH
H. angustifolia var. *buchananii*	Singh	535	NH
H. angustifolia var. *buchananii*	Singh	583	NH
H. argentea var. *sericea*	Singh	295	NH
H. argentea var. *sericea*	Singh	301	NH
H. colchicifolia	Singh	481	NH
H. costata	Singh	300	NH
H. filiformis	Singh	289	NH
H. filiformis	Singh & Baijnath	418	NH
H. filiformis	Singh	462	NH
H. filiformis	Singh	471	NH
H. flanaganii	Singh	628	NH
H. galpinii	Singh & Baijnath	334	NH
H. hemerocallidea	Singh & Baijnath	262	NH
H. hemerocallidea	Singh & Baijnath	321	NH
H. membranacea	Menne	Sn	ex cult.
H. multiceps	Singh	279	NH
H. multiceps	Singh & Baijnath	322	NH
H. multiceps	Singh	615	NH
H. obtusa	Singh	330	NH
H. obtusa	Singh & Govender	563	NH
cf. *H. obtusa x rigidula*	Singh	331	NH
H. parvifolia	Singh	470	NH
H. parvifolia	Burgoyne	7672	PRE
H. parvula var. *parvula*	Singh	465	NH
H. rigidula var rigidula	Singh & Baijnath	317	NH
H. rigidula var. pilossisima	Singh & Baijnath	318	NH
H. rigidula var. *rigidula*	Singh & Govender	435	NH
H. sobolifera var. *sobolifera*	Singh	233	NH
H. sobolifera var. *sobolifera*	Singh	502	NH
H. stellipilis	Singh	621	NH

directly on stubs using double sided adhesive tape and sputter-coated with gold to about 20 nm thickness with a Polaron Sputter Coater and were examined on a JEOL-JSM-840 SEM at the Electron MicroscopeUnit of the University of Pretoria, Pretoria. Scans were photographed using the PC programme Orion Version 6. For both FAA-preserved and herbarium material, leaf samples were removed from about midway the length of the leaves and reduced to roughly 5 x 5 mm sections before mounting on stubs. Both adaxial and abaxial surfaces were mounted for study.

4.4.2 Pollen

Pollen samples representing ten species were obtained from specimens at the KwaZulu-Natal Herbarium for SEM observations. Taxa and specimens are listed in Table 4.3. Pollen grains were

Table 4.3.—Specimen details of collections used in pollen studies. Vouchers in NH, except *Moss 7982* in J

Species	Collector	Number
H. acuminata	*Singh*	*638*
H. angustifolia var. *angustifolia*	*Singh*	*594*
H. colchicifolia	*Singh*	*464a*
H. filiformis	*Singh*	*397*
H. galpinii	*Singh*	*640*
H. gerrardii	*Haygarth*	*76*
H. hemerocallidea	*Singh*	*734*
H. kraussiana	*Moss*	*7982*
H. multiceps	*Singh*	*642*
H. parvula var. *parvula*	*Singh*	*308*

mounted directly on stubs using double sided adhesive tape and sputter-coated with gold to about 20 nm thickness with a Polaron E5200C Sputter Coater. Coated pollen grains were examined on a JEOL-JSM-840 SEM. Scans were photographed using the PC programme Orion Version 6.

4.4.3 Seeds

The materials and methods used in the study of seeds are outlined in a manuscript by Singh & Van Wyk (submitted) (Appendix 1.5). The specimens selected for study are listed in a table included in the manuscript.

4.5 Phytochemical studies

Chemical analysis of selected species of *Hypoxis* was undertaken in the Botany Department at the Rand Afrikaans University (now University of Johannesburg), in collaboration with Professors B-E Van Wyk and A. Viljoen. Chemical compounds in rhizomes of 14 species of *Hypoxis* were accessed using thin layer chromography (TLC) and high performance liquid chromatography (HPLC). Five samples of *H. hemerocallidea* and two for *H. rigidula* var *rigidula* were included to assess variation among populations. Taxa used in the study are listed in Table 4.4. Rhizomes were removed from plants in cultivation and sliced into cubes. Samples were dried in an oven at 40^0C over 48 hours until completely dried. About 0.5 g of rhizome of each species was weighed and ground with a mortar and pestle with some acid washed sand. Powdered samples were transferred into test tubes. To this 20 ml of 96% ethanol was added. Some of the ethanol was used to rinse out the mortar. Test tubes were covered with cotton wool and placed in a water bath at 40^0C for two and half hours. Samples were filtered. The ethanol in the filtrate was evaporated in a Rotavapor. Extracts were washed with methanol and stored in vials overnight. Vials were weighed. Pressure was used to dry the methanol. An equivalent volume of Me was added (5 g = 0.5 ml MeOH *u*l).

The solvent was spotted onto a silica plate and allowed to reach two thirds the plate. The TLC for hypoxoside comprised ethyl acetate: water: methanol (100: 16,5: 13,5). For the phytosterols, the TLC was made up of toluene: ethyl acetate (G:4). Plates were dried in an oven at 80^0C and sprayed with 5% ethanol- H_2SO_4, then 1% EtOH-Vanillin. Spray solution was prepared by dissolving 0.5 g vanillin in 50 ml 37% H_2SO_4.

The HPLC system used was a Column Phenomonex IB-Sil (C15,5µmm, 250 x 4.6 mm). The solvent system consisted of 30–60% linear gradient of methanol in 1% acetic acid-water and run for 20 minutes. Detection: diode array (A: 280±40nm; B: 330±70nm).

Table 4.4.—Details of specimens used in phytochemical studies. Vouchers except *McMaster 40* in NH

Sample Number	**Taxon**	**Collector and number**	**Mass of rhizome (g)**	**Mass of vial (g)**
1	*H. hemerocallidea*	Singh 261	0.5453	4.6090
2	*H. hemerocallidea*	Singh 262	0.5031	4.6527
3	*H. hemerocallidea*	Singh & Baijnath 321	0.5197	4.7096
4	*H. hemerocallidea*	Baijnath s.n.	0.5235	4.6640
5	*H. hemerocallidea*	Singh & Baijnath 265	0.5135	4.7588
6	*H. rigidula* var. *pilosissima*	Singh 326	0.5176	4.6161
7	*H. rigidula* var. *rigidula*	Singh 317	0.5637	4.7381
8	*H. colchicifolia*	Singh 264	0.5466	4.6658
9	*H. galpinii*	Singh 273	0.4987	4.7432
10	*H. obtusa*	Singh 277	0.5695	4.5852
11	*H. setosa*	Singh 233	0.5419	4.6658
12	*H. costata*	Singh 304	0.5342	4.7432
13	*H. multiceps*	Singh s.n.	0.5406	4.5852
14	*H. parvula* var. *parvula*	Singh 308	0.1158	4.5968
15	*H. membranacea*	McMaster 40 (ex cult.)	0.2778	4.6547
16	*H. angustifolia*	Singh 303	0.5083	4.7146
17	*H. argentea* var. *argentea*	Singh 348	0.4214	4.6247
18	*H. acuminata*	Singh 341	0.5680	4.6530
19	*H. filiformis*	Singh 289	0.1385	4.6760
20	*H. rigidula* var. *rigidula*	Singh 337	0.5501	4.6179

5

VEGETATIVE MORPHOLOGY

5.1 Introduction

Members of the Hypoxidaceae display taxonomically significant diversity in their gross morphology. They are variable in growth form, leaves, stamens and pistils and these provide diagnostic characters for recognising genera. Many character states found in *Hypoxis* are also present in other genera and there is no one character that is unique to the genus as is the case for *Empodium* or *Pauridia* (Table 2.4). The genus *Hypoxis* is therefore defined by a combination of characters that include geophytic plants with hairy leaves and scapes, yellow (seldom white) star-shaped flowers with tepals free to the base, anthers basifixed with latrorse dehiscence, ovary trilocular and fruit a pyxis (circumscissile capsule, the top coming off as a lid) with occasional loculicidal dehiscence. Morphologically, *Hypoxis* is most similar to *Rhodohypoxis* but differs from it in its yellow flowers and free tepals. In *Rhodohypoxis*, flowers are white, pink or red and tepals fuse at the base to form a tube.

Hypoxis species are often difficult to differentiate and classify due to the subtle differences in morphological characters. There is a great degree of uniformity in the floral morphology among species and differences in flowers are seen only in size of tepals, shape of anther tips and stigma type. However, even these characters show an overlap in the range among closely related species making it difficult to use them for species recognition. There is therefore much reliance on vegetative morphology for demarcating species within the genus.

Much of the present study is based on morphological data mainly for the purpose of presenting a practical key to identifying species of *Hypoxis* in southern Africa. This chapter presents a summary of the vegetative morphology and defines the terminology used to describe structures. It provides comments on the combination of characters used by previous authors to demarcate species of *Hypoxis* in Africa. For each plant part, the overall structure is described, reference is made to its use in earlier classifications and the diagnostic value is indicated. Finally, the chapter summarises the states of characters that are later combined with floral characters (discussed in Chapter 7) and used in the drawing up of character sets for use in a phenetic analysis in the future (Chapter 10) and the formal taxonomic treatment (Chapter 12).

5.2 Combination of characters used in previous studies on African *Hypoxis*

Characters used by previous workers form a useful basis for assessing their diagnostic value for separating species in *Hypoxis*. This section traces the development in selecting characters for keys presented by various works on the genus in Africa. Baker (1878b) used leaf shape and texture, inflorescence type and flower size to classify 31 species of *Hypoxis* (excluding what is now *Rhodohypoxis*) in Africa. In Flora Capensis that covers mainly the Western Cape, Eastern Cape and KwaZulu-Natal, the latter two provinces having the greatest diversity of species of *Hypoxis* in southern Africa, Baker (1896) recognised 29 species in the genus based on a combination of characters. He employed 'corm' size, leaf shape, texture and width, hairiness of leaves, inflorescence type, pedicel length, flower number, tepal size and hairiness of ovary. In his key, Baker (1896) did not strictly provide couplets with well-defined contrasting characters and it is therefore difficult to apply his key. It is understandable that such a key was inevitable due to the lack of distinct characters and the overlap in range of characters. Nevertheless, the key was used for many years to identify *Hypoxis* species in the region. For the Flora of Tropical Africa region, Baker (1898) recognised 16 species and applied characters similar to those used in his key (1878b) to global species, using single characters throughout the couplets. In this key, he also used relative terms like 'short' and 'long' and 'minute' and 'large' that are difficult to interpret.

Nel (1914) took the approach of classifying 83 species of *Hypoxis* in Africa into sections. In his key to sections he applied a few characters which included anther tips entire or split, leaf width correlated with number of veins, vein thickness, inflorescence type and ratio of style to stigma. Within the sections, Nel applied characters relating to the leaf, inflorescence, flower, gynoecium and androecium. He used lengths of leaves, inflorescences, pedicels, tepals and stamens, as well as the ratio of style to stigma lengths at various points in the keys. Nel further employed texture, hairness, venation of leaves, number of flowers and, bract shape and width in his keys to species.

Common characters used by Baker (1878b, 1896, 1898) and Nel (1914) include leaf shape, texture, width and hairiness; inflorescence type, pedicel length, flower number and tepal size. Baker placed great taxonomic significance on leaf and inflorescence characters while Nel emphasised three characters, namely anther tips entire or split, ratio of style to stigma and number of leaf veins. Discussion on taxonomically significant characters offered by the inflorescence, stamen and pistil structures are given in Chapter 7 on floral and fruiting morphology. Leaf characters including venation, offer reliable attributes for separating species of *Hypoxis*, and these are discussed later in this Chapter.

Anyone attempting to draw up a key to *Hypoxis* is familiar with the failure experienced in finding well-defined differentiating characters. The first key on *Hypoxis* to offer a comprehensive combination of characters for separating species was that of Nordal *et al*. (1985). These authors were also the first to use seed surface characters in their key to species in Africa. Seed characters were used as early as 1923 by Brackett to separate the American species. Nordal *et al*. (1985) also found leaf width, leaf hair density, colour of hairs, flower number, capsule width and pedicel length to be useful for demarcating species in the flora of Tropical East Africa region. Recent treatments of *Hypoxis* in African floras were provided by Zimudzi (1996); Wiland-Szymańska (2001); Nordal & Zimudzi (2001) and Wiland-Szymańska & Nordal (2006), where the approach continued to provide more characters including seed surface features for comparison. Two contributions, both appearing in 2001 by Wiland-Szymańska and Nordal & Zimudzi offer workable keys for identifying tropical African species of *Hypoxis*. Wiland-Szymańska (2001) concluded that for the Central African species of *Hypoxis*, seed surface and leaf indumentum characters were most useful for species delimitation. The advantage of this treatment is that it offers insightful discussion on the diagnostic value of the characters. Nordal & Zimudzi (2001), on the other hand, did not weight particular characters but used a range of characters from growth form, leaf, inflorescence, flower and seed. They provided sufficient detail of characters in their key and this makes interpretation straightforward. The most recent key by Wiland-Szymańska & Nordal (2006) to 15 species of *Hypoxis* in the Flora of Tropical Africa region combines the characters of pseudostem, leaf shape, dimensions and hairiness, seed ornamentation, inflorescence type and tunic form. The key offers comparisons that are mostly easily observable and is workable for the species in the area. The only difficulty with their key is that three sets of couplets offer only seed characters and if plants are collected early in the season, they lack seeds and this poses a problem. Nevertheless, the taxonomy of *Hypoxis* in Africa is no doubt reaching a point of being resolved through the contributions made over especially the past 22 years.

5.3 Taxonomic significance of vegetative morphology

5.3.1 Growth form

Hypoxis are perennial geophytes that generally have synanthous leaves and a life cycle of growth, storage, flowering and dormancy as defined for geophytes by Dafni *et al*. (1981). The genus is predominant in the summer rainfall region in southern Africa, the underground stem (rhizome) thus allowing the plants to perennate in the dry winter months, a time when fire is also a recurring feature. During this study, repeat visits were made to grassland sites in and around Durban to observe flowering in *Hypoxis*. It is concluded that flowering and fruiting take place every year, possibly due to favourable habitats and sufficient reserves in the rhizomes. The genus also has a long season of growth from September to April, following the spring rains. During the growing season, *Hypoxis* plants continue to develop new leaves and inflorescences, and flowering among most species takes place between November and January.

Plants of *Hypoxis* range from robust to delicate and this relates to length and width of rhizomes, leaves and inflorescences. The terms robust, medium-sized and delicate are relative and are applied with difficulty in a key. However, they may be used in combination with other characters. Relative size of plants has been used by Compton (1976) in his key to *Hypoxis* for the Flora of Swaziland. He describes plants as small or robust and defines small plants as those less than 100 mm tall and robust plants being more than 100 mm tall. In general, for the southern African species, using height to determine robustness does work, but poses problems for hysteranthous species when height varies over the season.

In *Hypoxis*, aerial stems are lacking; the leaves arise directly from the rhizome meristem in principally three ranks referred to as trifarious. In a few species, for example *H. argentea*, *H. hemerocallidea*, *H. obliqua*, *H. obtusa*, *H. stellipilis* and *H. villosa* the ranking of leaves is more noticeable than in the rest of the species. However, in some populations of *H. hemerocallidea* and *H. obtusa*, plants were noted to have leaves that are not neatly stacked in three ranks. In this case, type and distribution of leaf hairs are useful in recognising the species. In some species, the bases of leaves wrap around each other tightly to form a column called a false stem (pseudostem). Above the pseudostem, the leaves radiate upwards and outwards. This is discussed in more detail under 5.3.6.2 on leaf arrangement.

Another character that offers confirmatory evidence for classifying species in *Hypoxis* is whether the plants grow solitary or in clumps, the latter resulting from branching of the rhizomes (see 5.3.3). Branching occurs in *H. acuminata*, *H. angustifolia* var. *buchananii*, *H. costata*, *H. galpinii*, *H. multiceps* and *H. sobolifera* and gives rise to many rhizomes and shoots on one plant. Plants of these species may, however, also be found growing singly. In *H. angustifolia* var. *buchananii* and *H. sobolifera*, branching clones are more prevalent in comparison to solitary rhizomes.

5.3.2 Roots

Hypoxis has contractile roots that pull the rhizome firmly downwards into the ground. The roots occur just below the region where new reserves were added in the growing season (Figure 5.1). Root scars from the previous seasons roots can be seen on the lower portion of rhizome. Roots vary from few in the delicate species to about 30 in the robust species. Except for differences in number and size of roots which are proportional to the size of the rhizome, there are no morphological differences in root structure and therefore they are of little diagnostic value.

Figure 5.1.—Solitary rhizome showing roots in A, *H. hemerocallidea*; B, *H. angustifolia* var. *angustifolia*.

5.3.3 Rhizome

5.3.3.1 Structure and terminology

The storage organ in *Hypoxis* is an underground stem that is fleshy with a thin rind. It is an orthotropic (vertical) structure where reserves are added at the apex each season while the opposite end withers gradually upwards. Both the terms 'corm' and 'rhizome' have been used interchangeably to describe the underground stems in *Hypoxis*. Bell & Tomlinson (1980) use the term 'rhizome' to indicate vegetative extension over or within the subtrate by axis elongation and include organs which may be distinguished more precisely as stolons, offsets, or suckers and which may intergrade with tubers and corms. These authors consider rhizomes to be underground or aerial as well as horizontal or vertical (ascending, descending or both). They point out that although it is useful to make a morphological distinction between a ‘rhizome’ being a thickened axis, a ‘corm’ a squat upright axis and a ‘stolon’ an extended axis, there is no precise cicumscription in terms of clone spread. According to Tillich (1998) a rhizome is a creeping shoot (normally underground, but may be aerial) with a storage function as well as for vegetative propagation through branching which could be monopodial or sympodial. He describes very thick rhizomes as 'pachycaul rhizomes' and those that grow vertically downwards as 'positively geotropic rhizomes'. For a corm, Tillich (1998) offers the definition of it being a vertical subterranean shoot with only a few swollen internodes, bears a terminal inflorescence and after flowering, shrivels and decays and is replaced by one or a few new corms that develop in an axillary position. In following the definitions by Bell & Tomlinson (1980) and Tillich (1998), it is concluded that in *Curculigo*, *Molineria*, *Hypoxis*, *Hypoxidia* and *Rhodohypoxis*, the underground stem survives for decades by new reserves being added seasonally to the proximal end while it disintegrates slowly at the distal end; therefore a more appropriate term for the axia in these genera is a ‘fleshy vertical rhizome’. Corms are considered annual perennating organs that are replaced after flowering and are present in *Empodium*, *Pauridia*, *Saniella* (Burtt 2000) and *Spiloxene*. In this study, the term rhizome is used for *Hypoxis* following the definition by Tillich (1998). In the thesis when reference is made to the structure from earlier works, the term applied by the authors is used in inverted commas.

Rhizomes in *Hypoxis* usually grow singly (Figure 5.1) and give rise to one aerial shoot at the apical meristem. However, in a few southern African species, branching of the rhizome through the development of lateral buds occurs. Wood (1976) recognised two types of branching in *Hypoxis*, the first where lateral buds develop from a ‘corm’, each bud remaining attached to the original ‘corm’ forming a ‘plate’ of rhizome material from which many aerial shoots arise. In the second type, being found in *H. angustifolia*, lateral buds develop into slender ‘rhizome-like’ portions at the end of which a ‘corm’ develops. In this type, the ‘rhizome-like’ portion thickens with deposition of food reserves, and the parent rhizome becomes twisted. Heideman (1979) also recorded two types of branching in *Hypoxis*, slightly different to that of Wood (1976). In Heideman’s description, in the first type the apical meristem splits into three to five parts and a shoot arises from each part. In the second type, one large rhizome gives rise to short runners each ending in a rhizome that produces a shoot and this agrees with the first type described by Wood (1976).

Observations made during this study confirm that there are two types of branching in rhizomes of *Hypoxis*. The first is lateral branching where a rhizome gives rise to lateral rhizomes (Figure

5.2A) that are attached to the parent rhizome by reduced stolon-like structures (Figure 5.2B). Each lateral rhizome ends in an erect shoot with scapes. In this case the laterally produced scapes are attached to rhizomes without an associated thickened portion distally. Proliferation by lateral rhizomes gives rise to a number of aerial shoots per plant forming tussocks (Figure 5.3A & B).

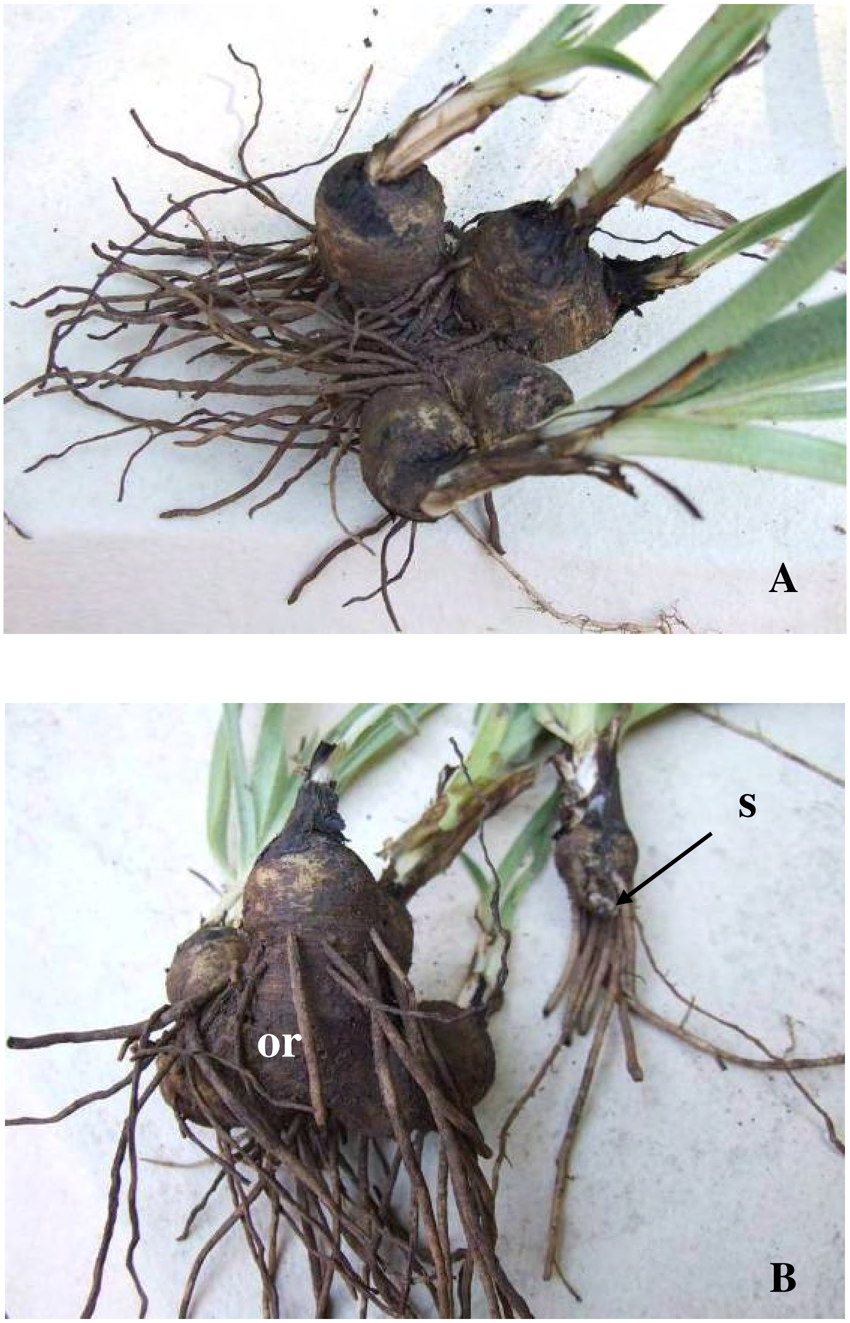

Figure 5.2.—Branching rhizome in *H. sobolifera* var. *sobolifera*. A, four lateral rhizomes produced from an original rhizome; B, original rhizome (or) and reduced stolon-like structure (s).

Figure 5.3.—Rhizomes forming tussocks in A, *H. multiceps*; B, *H. ludwigii;* C, *H. zeyheri*

This occurs in *H. acuminata*, *H. angustifolia* var. *buchananii*, *H. costata*, *H. ludwigii*, *H. galpinii*, *H. multiceps* and *H. sobolifera*. The reduced stolons (Figure 5.2B) are hardly differentiated from the lateral rhizomes. Over a number of years, the original rhizome (Figure 5.2B) which also lengthens by addition of new reserves each year and is usually longer than the lateral rhizomes may become twisted as described by Wood (1976). This definition combines both branching types described by Wood (1976). Twisting of rhizomes occurs more often in species with narrow, elongated rhizomes, namely *H. angustifolia* var. *buchananii* and *H. sobolifera*. These species are suitable for cultivation as they are easy to propagate vegetatively by separation of rhizomes. They also offer a number of flowers per tussock and are ideal for garden beds. In most *Hypoxis* species, damage to the apex of the rhizome induces this type of proliferation, where a number of rhizomes develop around the apex (Figure 5.4 A,B). This happens in the wild through, for example, trampling by cattle or other antelope, and the same damage can be applied in cultivation as a means of increasing number of rhizomes as the rhizomes can be removed and planted out as individual plants.

Figure 5.4.—Rhizomes forming tussocks possibly due to damage to apex in A, *H. rigidula*; B, *H. hemerocallidea*.

In the second type of branching, referred to as vegetative fragmentation, the apical meristem of the rhizome splits into three to five parts (Figure 5.5A) and each of these gives rise to an aerial shoot as described by Heideman (1979). As reserves are added each year to the apex of each fragment rhizome, the rhizomes separate further apart from each other but remain attached to the basal portion of the original rhizome which disintegrates over time (Figure 5.5B). This type of branching has been observed in most robust species like *H. colchicifolia*, *H. galpinii*, *H. hemerocallidea*, *H. obtusa* and *H. rigidula* but is not common.

In both types of branching there is always part of the original rhizome to which the newer rhizomes are attached. The presence of lateral branching is valuable in confirming whether a species belongs to *H. acuminata*, *H. costata*, *H. galpinii*, *H. ludwigii*, *H. multiceps, H. sobolifera* or *H. angustifolia* var. *buchananii*. The second type of branching appears to be due to ecological and biological factors. It is not constant for a species and is therefore unreliable for species identification.

Figure 5.5.—Split in apical meristem in *H. hemerocallidea*. A, splits into three parts (one lying behind the two shown) each giving rise to a rhizome that bears a shoot; B, split deepens but segments are held together by the basal portion of the original rhizome that disintegrates slowly.

5.3.3.2 Shape

Rhizomes are generally subglobose, oblong or turbinate in shape (Figure 5.6A–E) and range from 10 to 100 mm in length and 7 to 60 mm wide. Baker (1896) used size of rhizomes to separate *H. filiformis* from *H. kraussiana*, both of which have subterete leaves. However, due to the overlap in the range of size in rhizomes between the species, the character is not suitable. Leaf hair characters, flower size and filament shape are more useful for separating these species. Size and shape of rhizomes are useful mostly in separating the robust species from delicate species in *Hypoxis* and can be used to confirm a species when used in combination with other characters. Rhizomes in a few species branch through reduced stolons (Figure 5.6E) as discussed in 5.3.3.1.

5.3.3.3 Sap

Rhizomes in *Hypoxis* are fleshy and mucilaginous and when sliced, they exude a slimy juice that turns black through oxidation. In the robust species, *H. colchicifolia*, *H. galpinii*, *H. hemerocallidea* (Figure 5.7A) and *H. rigidula*, the flesh of rhizomes is yellow to deep orange internally. Robust species have large rhizomes and firm leaves. Rhizomes of species with a small stature and soft-textured leaves are white internally (Figure 5.7C). These species include

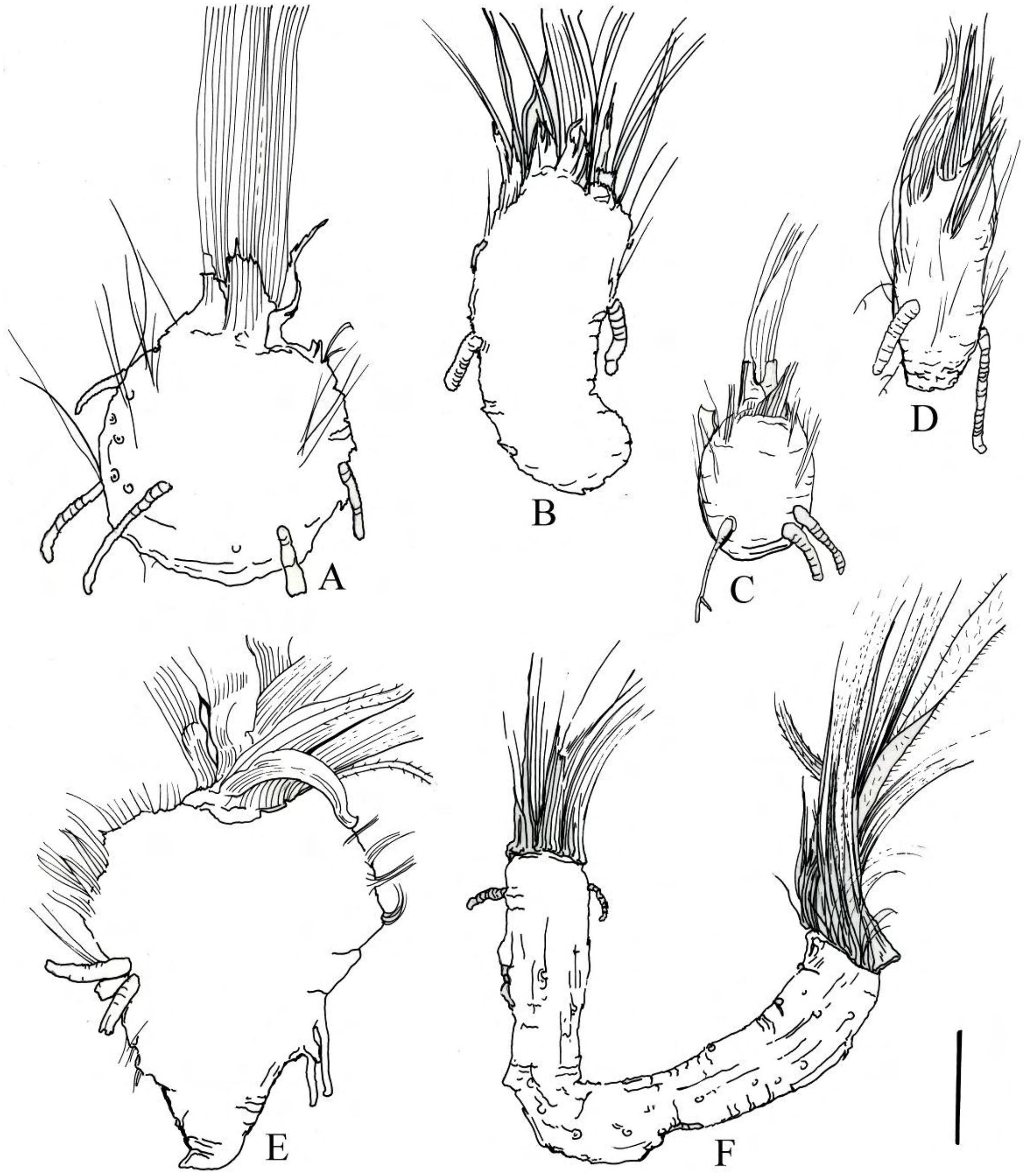

Figure 5.6.—Rhizome shapes in *Hypoxis* A, C, subglobose in *H. rigidula* var. *rigidula*, *Singh 328* (NH) and *H. filiformis, Singh 823* (NH); B, D, oblong in *H. rigidula* var. *pilosissima*, *Singh 326* (NH) and *H. parvula* var. *parvula*, *Singh 308* (NH); E, turbinate in *H. hemerocallidea*, *Singh 649* (NH); F, stoloniferous in *H. sobolifera* var. *sobolifera*, *Singh & Baijnath 233* (NH). Scale bars: A,B, 30 mm; C,D, E,F, 10 mm. A.J. Beaumont.

H. angustifolia, *H. argentea*, *H. filiformis*, *H. flanaganii*, *H. floccosa*, *H. gerrardii*, *H. membranacea, H. parvifolia*, *H. parvula* and *H. tetramera*. Species that fit morphologically in between the robust and the small-statured species (see formal treatment in Chapter 12), namely *H. acuminata*, *H. longifolia*, *H. costata*, *H. interjecta*, *H. muticeps*, *H. obliqua*, *H. sobolifera*, *H. stellipilis*, *H. villosa* and *H. zeyheri* produce rhizomes that are cream or light yellow internally (Figure 5.7B). The yellow-orange colour in robust species is associated with the high amounts of hypoxoside in rhizomes and this is elaborated upon in Chapter 8. Colour of sap, when combined with size of rhizome adds confirmatory value to identifications.

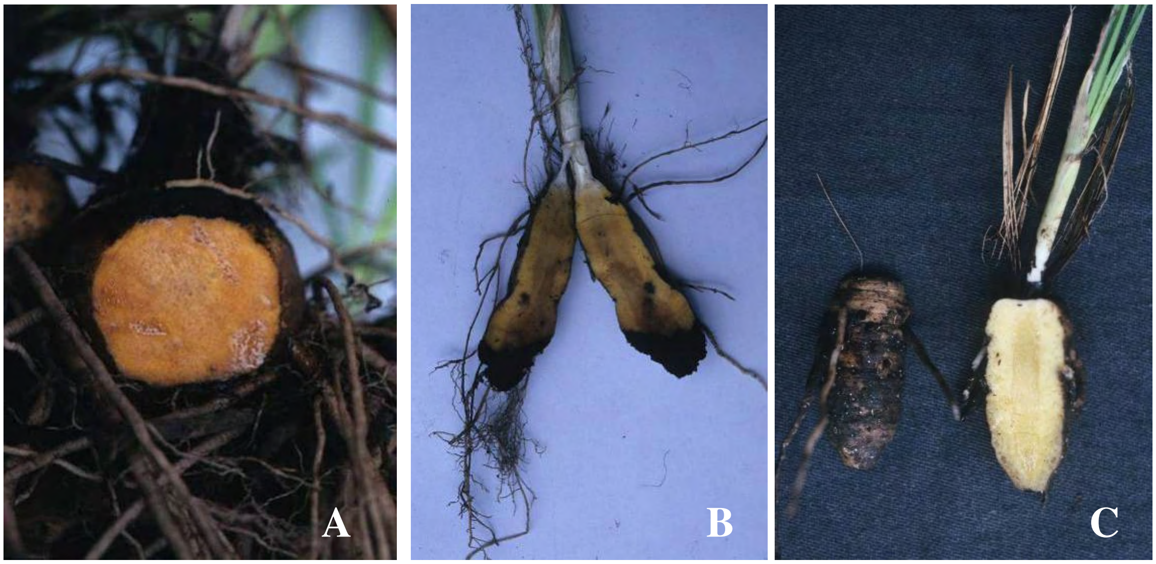

Figure 5.7.—Rhizomes in robust, medium and small-statured *Hypoxis* showing internal colouration. A, *H. hemerocallidea* with orange colouration; B, *H. sobolifera* var. *sobolifera* with yellow colouration; C, *H. angustifolia* var. *angustifolia* with white colouration.

5.3.4 Tunic

In *Hypoxis*, a tunic is present at the leaf bases. It occurs as a white or brown membranous covering that wraps around the leaf bases in species with soft-textured leaves. In the majority of species, the tunic is formed by the persistent veins that remain from the previous season’s leaves and is visible as stiff fibres. Presence of a tunic has not been used much for demarcating individual species except in Wiland-Szymańska (2001) where it is used to separate species with slender leaves and narrow scapes. Wiland-Szymańska (2001) separates *H. filiformis* from *H. canaliculata* on its membranous tunic and slightly narrower leaves. *H. canaliculata* is considered to have a fibrous, stiff tunic. Among the southern African material of *H. filiformis*, specimens were found to have both types of tunics, the fibrous tunic being of varied mass. Some specimens show only a membranous tunic [*McLean 11a* (NH), *Williams 1135* (NH)] which could be due to the fibrous tunic being left behind with the rhizome in the field. Specimens with rhizomes and only few fibrous strands [*Singh 397, 462* (NH), *Ngwenya 420* (NH)] were collected in fields that were recently burned and tunics in these may be reduced due to burning. Examples of specimens of *H. filiformis* that have distinct fibrous tunics of varying masses include *Ross 5*; *Nicholas & Button 1981*, *Singh 443*, *Ngwenya 1468* (all at NH). Wiland-Szymańska & Nordal (2006) used the red colour of tunics in *H. obtusa*, a species widespread in subsaharan Africa to separate it from black tunics of five tropical species.

In summary, the type of tunic is only useful in separating species with membranous leaves from the generally robust species with firm leaves. In southern African species, membranous tunics are associated with membranous leaves while fibrous tunics are found in species with firm to rigid leaves.

5.3.5 Cataphylls

In *Hypoxis*, the outermost leaves are reduced to cataphylls. One to three cataphylls occur in the genus and they vary in length on a plant but are $^1/_3$ to $^1/_{10}$ the length of leaves. They have the same shape as the leaves, either oblong-ovate or linear and are also hairy. Cataphylls wrap around the newly forming leaves, offering them protection. In robust species with distinct three ranks, for example *H. hemerocallidea* and *H. obtusa*, three cataphylls are found to correlate with the position of the ranks and these spread outwards. In robust species with pseudostems like *H. colchicifolia* and *H. rigidula*, two cataphylls wrap tightly around the pseudostem, one larger than other. Cataphylls in the soft-leaved species are usually membranous and fragment as the leaves mature. Most herbarium specimens lack cataphylls as they would have deteriorated with leafing and flowering. Cataphylls differ only in texture but this feature can be assessed in the leaves. They are also similar in related species and are unsuitable for separating taxa.

5.3.6 Leaves

In identifying species of *Hypoxis*, there has been much reliance on leaf characters. Cues to diagnostic value of leaf characters in the genus were pointed out by earlier authors. Baker (1878b) presented a short description of leaves in the genera of Hypoxidaceae and described *Hypoxis* as having sessile, linear or lanceolate and rarely subterete leaves. In the key in this publication, Baker used leaf shape, texture and width to separate species. In the key to species in Flora Capensis, Baker (1896) used the same leaf features but added to it characters of venation and hairiness. Nel (1914) provided discussion on leaf characters in *Hypoxis* and emphasised shape, venation and hairiness. Heideman (1987) used the same leaf characters but also included leaf shape in cross section. Recent taxonomic works on *Hypoxis* in Tropical Africa (Nordal & Zimudzi 2001; Wiland-Szymańska & Adamski 2001 and Wiland-Szymańska & Nordal 2006) give prominence to leaf characters.

Most certainly, leaves offer the largest number of characters that are useful for species identification in *Hypoxis*. Leaf characters of diagnostic importance include arrangement at the base, shape, dimension, texture and leaf indumentum. Leaf length to width ratios are of taxonomic value in separating species into groups (see Singh 2004, Appendix 2.4). They are also useful in demarcating taxa of small stature with corymbose inflorescences. In a few species, bases of leaves wrap around each other to form a false stem (pseudostem) and this is easily distinguished from those where leaves spread upwards and outwards from base. Texture of leaves vary from firm and rigid to soft and flaccid and this is useful in grouping species. Leaf indumentum characters like density, distribution and position relative to the leaf surface and type of hairs are of importance in recognising species. Leaves in the genus may be sparsely, moderately or densely pubescent depending upon the species and a few varieties are recognised based on hair density and distribution. Leaves turn yellow-brown towards the end of the growing season and are marcescent, and depend on external factors like wind for slow obliteration and fire for defoliation. If grasslands are not subjected to burning, the relic of old fibrous leaves remain around the newly forming leaves.

5.3.6.1 Maturation

Members of *Hypoxis* are acaulescent, deciduous herbs and the new flush of leaves arise directly from the apex of the rhizome. Leaves in the genus usually develop with the onset of the new growing season each year, around August-September in southern Africa. This is followed closely by the production of flowers. Most species in the genus are synanthous producing a few leaves at the start of the growing season and continues to produce leaves and flowers simultaneously during the growing season. A few species display hysteranthy where flowers are produced first and then the leaves start to emerge. The term hysteranthy is used as many of the flowers in these plants have passed anthesis by the time the emerging leaves become noticeable (Figure 5.8A). Different degrees of hysteranthy are noted within and among species. It occurs most frequently in *H. multiceps* and *H. interjecta* and occasionally in *H. galpinii* and *H. obtusa*. Due to hysteranthy in *H. multiceps* [*Heideman 98* (J); *Wood 91* (NU); *Stalmans 611* (PRE); *Young A126* (PRE)] and *H. interjecta*, flowers develop with the onset of the growing season (August) and by the time the leaves reach maturity (December), the flowers have been pollinated, and have set fruit and seeds. Towards the end of the growing season, the plants are often with old scapes or without a trace of scapes and flowers (Figure 5.8B). Another feature unique to these species is the pseudopetiolate leaves at the end of the growing season (see 5.3.6.3). The varying facies in *H. multiceps* and *H. interjecta* confuse their identification. Hysteranthy being common and pronounced in these two species can be used to separate them from the rest of the species. Since the two species are similar in their two to five-flowered corymbose inflorescences, leaf characters are necessary for their demarcation. The first few emerging leaves are useful as they are hairy in *H. multiceps* but glabrous in *H. interjecta*. *H. galpinii* and *H. obtusa* are generally synanthous, however if they produce flowers first, then they can be easily separated from *H. multiceps* and *H. interjecta* by their scapes (at least one on a plant) with usually five or more flowers in a raceme and on the type of leaf indumentum explained in 5.3.9.

5.3.6.2 Arrangement

Leaves in *Hypoxis* are arranged in a basal rosette or the bases clasped together to form a false stem (pseudostem). Pseudostems are cylindrical and may form a well-defined column or may be subtle. They are column-like, 80–200 mm tall and diagnostic in *H. colchicifolia*, *H. galpinii*, *H. rigidula* (Figure 5.9A–D) and *H. longifolia*; species with rigid leaves that arise upwards and outwards above the pseudostems. By using the presence of a well-defined pseudostem, these species are easily separated from other robust species like *H. hemerocallidea* (Figure 5.10A) and *H. obtusa* (Figure 5.10B) in which the leaves spread upwards and outwards from base (false stem absent). In the small to medium-statured species, *H. argentea* (Figure 5.11A), *H. sobolifera* (Figure 5.11B, see also 5.7B), *H. angustifolia* (Figure 5.19A) and *H. nivea* (Figure 5.19D), pseudostems are subtle and are concealed by the flexible, arching leaves in these species.

Heideman (1987) begins her key to *Hypoxis* taxa by separating species with pseudostems from those that lack a pseudostem. Wood (1976) used it to separate the robust *H. colchicifolia* from the medium-sized *H. interjecta* which she grouped together on the basis that their leaves being glabrous. No authors working on southern African species prior to Wood (1976) and Heideman (1987) appear to have used this character. Singh (2004) illustrated the states of leaves clasped into a pseudostem in comparison to leaves spreading upwards and outwards from base, and used the character in grouping species. Wiland-Szymańska & Nordal (2006) used the presence of a pseudostem in *H. rigidula*, a species widespread in sub-Saharan Africa to separate it from the remaining 14 species in the Flora of Tropical Africa region. These authors placed *H. galpinii*

Figure 5.8.—Hysteranthy and facies in *H. multiceps*. A, plants showing most flowers pollinated by the time new leaves are noticeable; B, plants in post fruiting with leaves mature.

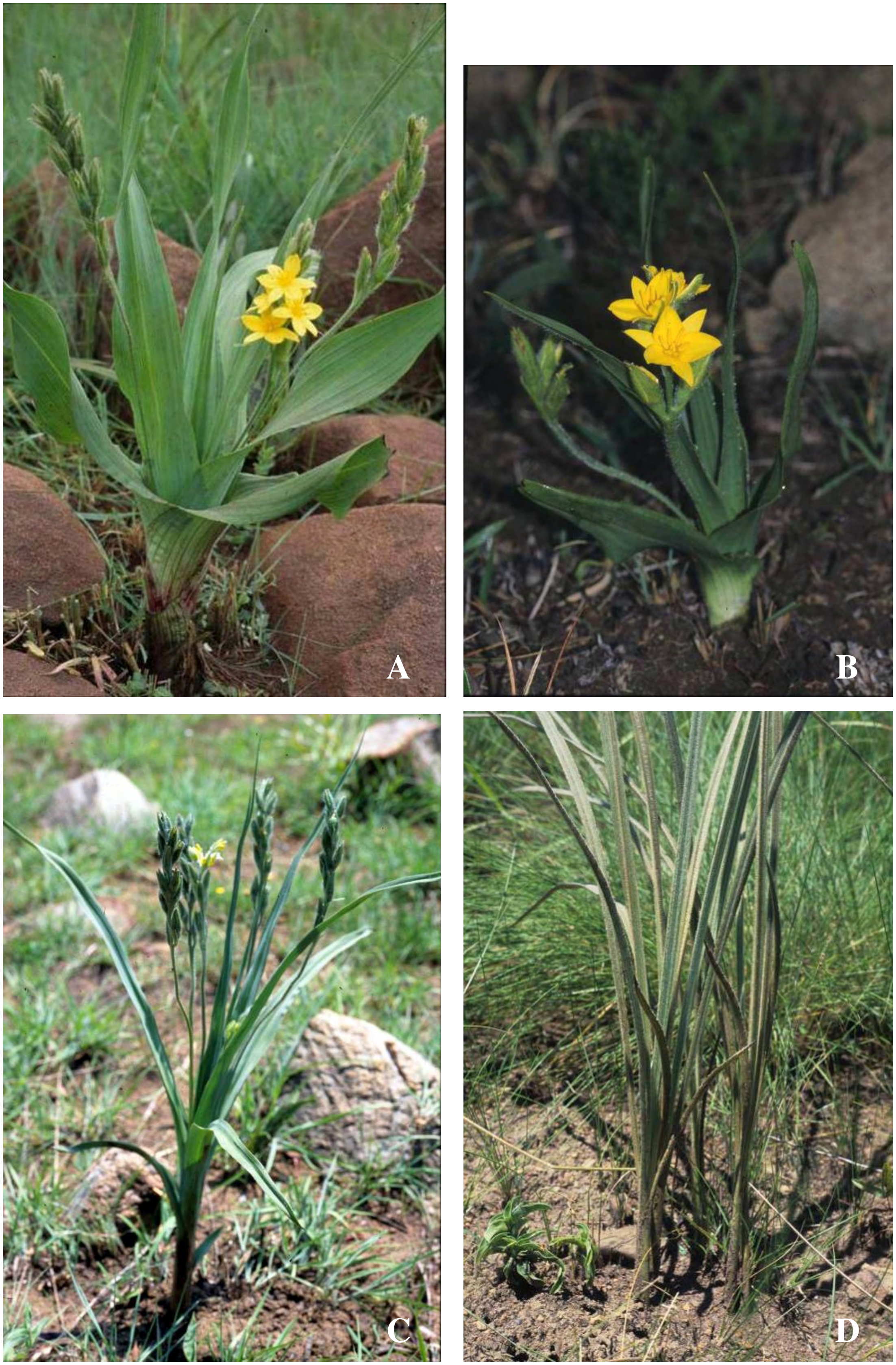

Figure 5.9.—Pseudostem as a distinct column. A, *H. colchicifolia*; B, *H. galpinii*; C, *H. rigidula* var. *rigidula*; D, *H. rigidula* var. *pilosissima*.

Figure 5.10.—Leaves do not wrap at the base into a pseudostem but spread outwards and upwards from the apex of the rhizome in robust species. A, *H. hemerocallidea*; B, *H. obtusa*.

Figure 5.11.—Subtle pseudostems. A, *H. argentea*, a small-statured species; B, *H. sobolifera*, medium-sized species, obscured by the overlapping leaves (see also Figure 5.7B).

among species that lack a distinct pseudostem. In southern Africa, however, *H. galpinii* (Figure 5.8B) has a distinct pseudostem similar to that in its closest relatives *H. colchicifolia* and *H. rigidula*.

The presence or absence of pseudostems is a valuable character for identification of species in southern Africa. The advantage of the character is that it is easily observable and unambiguous in the few species in which it is present.

5.3.6.3 Shape

In *Hypoxis*, leaves are simple, entire and keeled at the midrib with tips acuminate. They are folded together along the length towards the base (conduplicate). Leaf shapes were broadly classified into lanceolate and linear, and used in earlier treatments of *Hypoxis*. Baker (1878b, 1896) placed much emphasis on leaf shape in his keys, often using it as the only character in separating groups of species. However, he only used the character after he separated species on flower size or inflorescence type. Nel (1914) used leaf shape in combination with leaf indumentum and leaf venation. It was also used by Wood (1976) in combination with other leaf characters. Heideman (1987) used many leaf characters except leaf shape. However, she used the outline of leaves in cross section to separate closely related species.

Leaf shape in *Hypoxis* is variable and leaves may appear lanceolate, linear, filiform and ovate in outline (Figure 12A–E). Due to their gradual elongation over the growing season, leaves in the genus start to taper and the shape of mature leaves is different from those at the start of the season. Therefore, the use of leaf shape to separate species is limiting. However, leaf shape is extremely valuable in separating species with distinct shapes. For example, leaves in *H. filiformis* (Figure 5.13A), *H. tetramera*, *H. kraussiana* and *H. longifolia* (Figure 5.13B) are linear and less than 5 mm wide and on these characters they can be separated from the rest of the species. Also, leaves of *H. colchicifolia* are broadly lanceolate (Figure 5.9A, 5.16A) and can be easily separated from the linear leaves of *H. angustifolia* and the filiform leaves in *H. filiformis*.

Generally, leaf shape is not constant in *Hypoxis* and species display different degrees of variation in leaf shape. Leaves of *H. costata*, *H. multiceps* and *H. interjecta* are short and ovate (Figure 5.8A) at the start of the growing season and elongate in post flowering (Figures 5.8B, 5.14A,B, 5.20B), appearing lanceolate later in the season. Mature leaves of *H. costata* exhibit a range in shape between ovate-lanceolate (Figure 5.15B) and linear (Figure 5.15A). The one

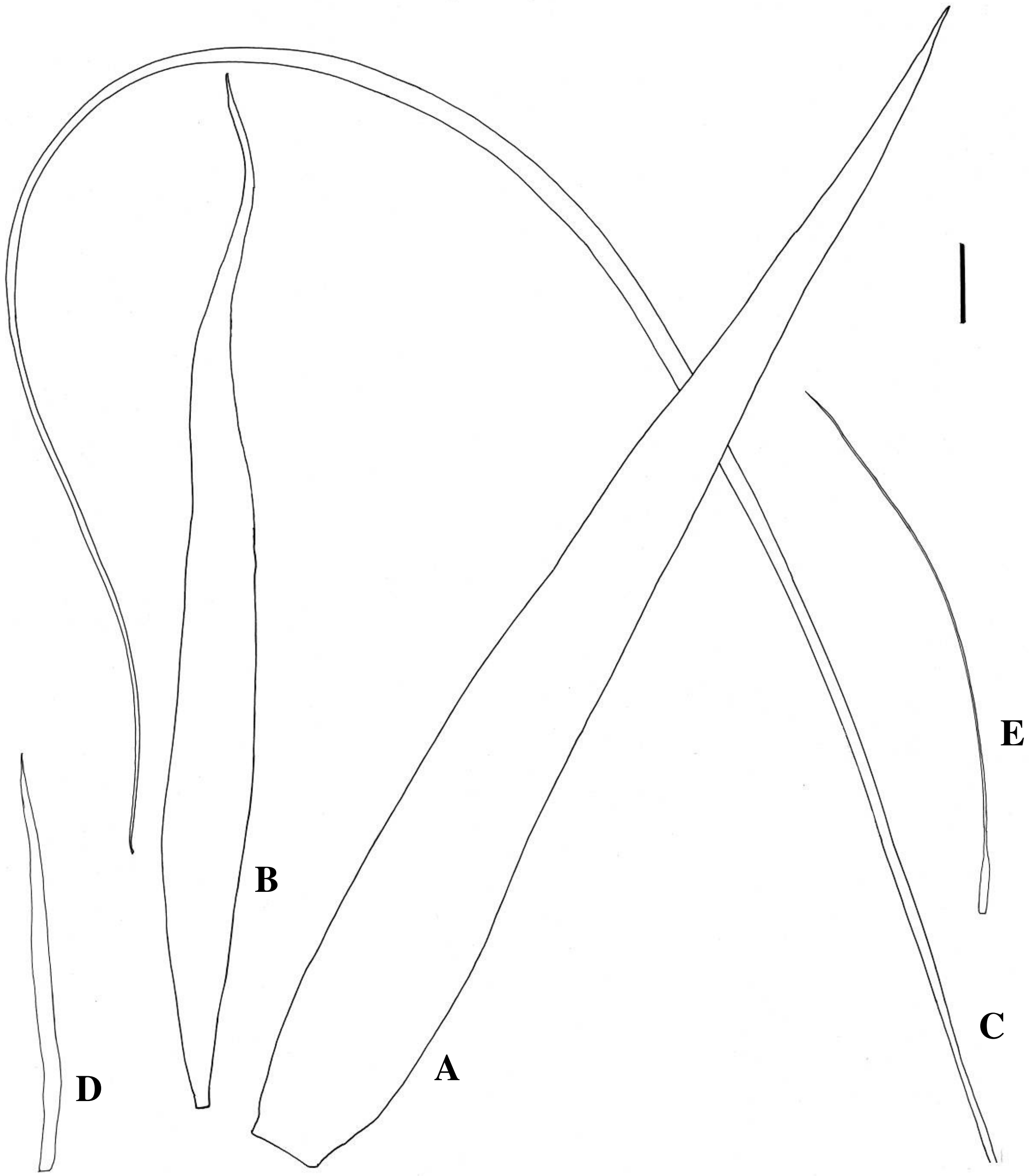

Figure 5.12.—Leaf shapes in *Hypoxis*. A, lanceolate, *H. colchicifolia*, *Singh 294* (NH); B, lanceolate-linear, *H. obtusa*, *Singh 439* (NH); C, linear (long), *H. rigidula*, *Singh 328* (NH); D, linear (short), *H. nivea*, *Singh 874* (NH); E, filiform, *H. filiformis*, *Singh 433* (NH). Scale bar: A–E, 30 mm. A.J. Beaumont.

Figure 5.13.—Leaf shapes. A, filiform, *H. filiformis* (Steenskampberg, Mpumalanga); B, linear, *H. longifolia* (Port Edward, KwaZulu-Natal).

Figure 5.14.—Elongate, pseudopetiolate leaves. A, *H. multiceps*; B, *H. interjecta*.

extreme in range includes plants with broad, stout leaves (Figure 5.15B), while the other extreme includes plants with narrow leaves (Figure 5.15A). The linear leaves are associated with shading caused by tall unburned grass. In some plants of *H. multiceps* (Figure 5.14A) and *H. interjecta* (Figure 5.14B), the bases of leaves narrow to form a pseudopetiole in post flowering and this has also been noticed when plants are growing in between tall grass, usually in unburnt vegetation. Pseudopetioles in *H. multiceps* are observable in specimens *Codd 5912* (PRE); *Coetzee 279* (PRU); *Eckhardt 319* (PRU); *Heideman 116* (J); *Nombekela 117* (NH); *Reid 584* (PRE); *Singh 322*, *609* (NH). *H. interjecta* specimens that show pseudopetioles include *Gilliland s.n.* (J); *Singh 613* (NH); *Smit 877* (PRE); *Strey 3956* (PRE). All specimens cited were collected late in the season between January and July, the start of the growing season being around September. Heideman (1979) gives an account of the stages of seasonal growth pattern in *H. multiceps* and *H. interjecta* which are similar for both species. Pseudopetioles are very likely to be present in *H. costata* as well, but do not appear to be represented in any of the investigated herbarium material.

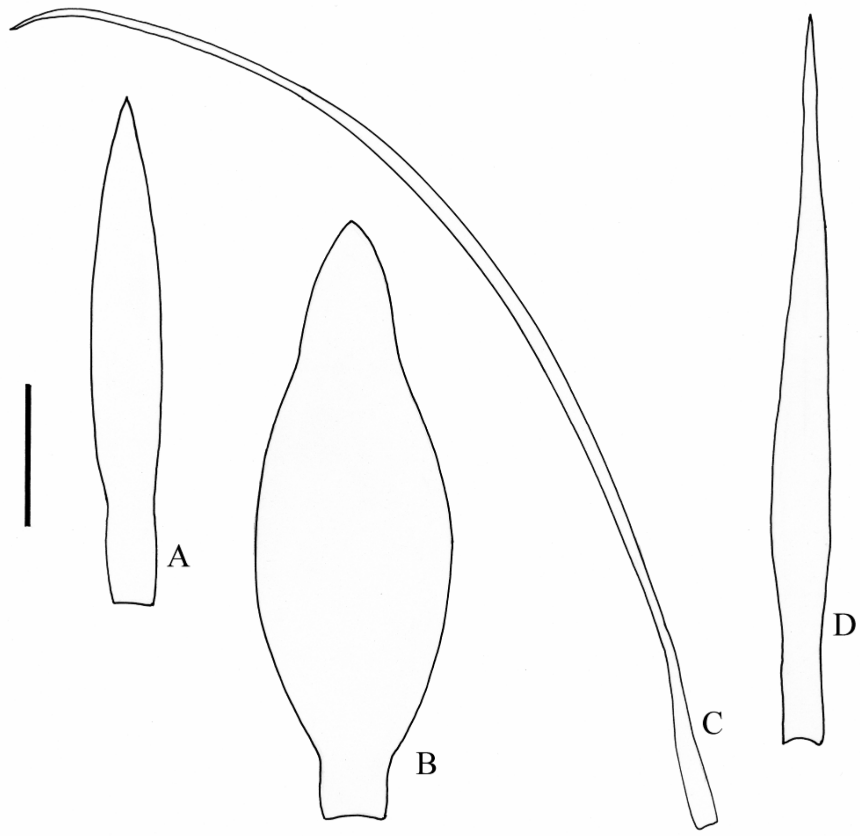

Figure 5.15.—Variable leaf shapes. A, linear, *H. costata Singh 455* (NH); B, ovate-lanceolate, *H. costata Singh 300* (NH); C, linear, *H. gerrardii Singh 448* (NH); D, lanceolate, *H. gerrardii Singh 419* (NH). Scale bars: A, B, 10 mm; C, D, 20 mm. Artist: A.J. Beaumont.

5.3.6.4 Colour

Usually leaves of *Hypoxis* are green on both surfaces and bases are lighter in colour tending towards white. Variation in leaf colouration is useful for recognising some species, mainly live material. In species with small plants like *H. angustifolia*, *H. filiformis*, *H. membranacea*, *H. parvula* and *H. tetramera*, leaf bases are membranous or at least along the margins. Leaf bases may be white (Figure 5.9B) or purple or red-coloured as in *H. colchicifolia* (Figure 5.16). In populations of *H. obtusa* (Figure 5.17), *H. argentea*, *H. angustifolia*, *H. costata* and *H. sobolifera*, leaf bases may be red-tinged. In plants of *H. argentea*, *H. angustifolia* and *H. sobolifera* with red-tinged leaf bases, the scape, pedicel and tepal midribs are also tinged with red. It should be noted that the purple or red colouration is not constant for all populations of these species. However, its presence in these species is helpful in identifying them.

In *H. stellipilis*, leaf colouration is very diagnostic for the species. Leaves are dark green on the upper surface and white on the lower surface (clearly discolourous) (Figure 5.18). The white lower surface is due to the white, stellate hairs that intertwined to form a dense covering. This colouration is constant and unique to the species.

Figure 5.16.—Purple colouration in *H. colchicifolia*. A, all leaf bases purple; B, close up of lower leaf bases.

Figure 5.17.—Purple-red-coloured leaf bases in *H. obtusa*.

Figure 5.18.—Leaves of *H. stellipilis*, green and almost glabrous above, white below formed by tomentose layer of stellate hairs.

5.3.6.5 Length and width

Leaf dimensions are variable among species, ranging from 50 to 600 mm in length and 1.5 to 85 mm in width across the broadest section. The longest leaves in the genus are found in *H. rigidula* reaching 600 mm and the shortest of about 70 mm long is found in *H. floccosa* and *H. flanaganii*. The broadest leaves are found in *H. colchicifolia*, up to 110 mm wide and the narrowest in *H. tetramera* and *H. filiformis* (Figure 5.12E) usually about 2–3 mm.

Baker (1896) used differences in leaf width to separate *H. obtusa* and *H. latifolia* (= *H. colchicifolia*), both of which he considered to have lanceolate or oblong-lanceolate leaves and racemose inflorescences. Based on width of leaves, Baker (1878b) recognised two varieties of *H. angustifolia* Lam. namely var. *angustifolia* and var. *buchananii*. He separated var. *buchananii* in having larger membranous leaves and pedicels about twice as long in comparison to the typical variety. In Flora Capensis, Baker (1896) indicated that this is a shade grown variety with thin textured leaves and long slender pedicels. Nel (1914) used leaf length or width in his keys to species. In his key to sections, he used the ratio of leaf length to width. Both leaf length or width works in Nel’s keys only because he first used floral characters and this grouped species with very varied leaf dimensions together, making the use of the character suitable. Species described by Nel as new on the basis of leaf shape and length, namely *H. cordata*, *H. elliptica* and *H. oblonga* as well as *H. distachya* and *H. gilgiana* have been reduced to synonymy (Singh 2007, Appendix 1.2). Wood (1976) applied ranges in leaf length and width at points in her key but in combination with inflorescence type and flower characters. Heideman (1987) also found it useful to use these characters, again mostly in combination with other leaf and floral features.

Leaf dimensions are valuable in recognising species as well as grouping related species of *Hypoxis*. The character works well for identification of species when used in combination with leaf shape. Species with narrow, linear leaves less than 5 mm wide are easily recognised from those with broad oblong-lanceolate leaves. Both leaf length and width are unsuited for the identification of individual plants in *H. multiceps*, *H. costata* and *H. interjecta* as they display a huge range over the growing season. As seen for leaf shape, the group of species with linear leaves including *H. angustifolia* var. *buchananii*, *H. sobolifera*, *H. stellipilis*, *H. villosa*, *H. zeyheri*, leaf dimensions are similar and therefore unsuitable for separating species. Nevertheless, they confirm a close relationship among these species.

5.3.6.6 Venation

Leaf venation is variable among species in *Hypoxis* and is a good character for recognising some species. In most species, one to four veins close to each margin are thickened and raised on the upper surface while the rest are flush with the leaf surface. Only in a few species, almost all veins are of even thickness and raised on the upper surface.

Nel (1914) emphasised leaf venation characters in demarcating formal sections in *Hypoxis*. He considered total number of veins per leaf, number of thickened veins and whether veins are of equal thickness to be valuable characters for recognising sections. He recorded that the veins in the leaves of some species are noticeably unevenly thickened and described with illustrations the venation patterns covering eight sections in detail from leaf cross sections. Nel used the higher number of veins in Sections *Villosae*, *Orbiculatae* and *Nyassicae* to distinguish them from Sections *Angustifoliae* and *Argenteae*, and Section *Subspicatae* from Section *Recurvatae*. In his key to sections, he used equally or unequally thickened veins to separate Section *Obtusae* from Section *Rigidulae*. *Obtusae* was separated from *Rigidulae* in having uniformly thickened veins while the latter section is defined as having one to three thickened veins on each half of the leaf. Nel used number of veins only once in separating southern African taxa namely *H. obtusa* from his newly described *H. patula*, but the character was used in combination with hairiness and hair type.

The number of veins was found to vary slightly within a species depending on width of leaves. However, number of prominent veins is useful in combination with other leaf characters like leaf shape and indumentum. Number of prominent veins is useful in separating closely related species like *H. colchicifolia*, where all veins are of about the same thickness and equally spaced while in *H. galpinii* only three or four veins close to each margin are thickened. Similarly, veins in *H. obtusa* are prominent and are of almost equal thickness (but not as thick as in *H. colchicifolia*) in comparison to its related species, *H. hemerocallidea* which has veins flush with the leaf surface except two or three veins near each margin are raised on the upper surface. Leaves of *H. multiceps* and *H. costata* are strongly veined and veins are of even thickness in both, except in *H. costata* in which one or two veins close to the margins are of greater thickness and yellow. The character can be used in combination with hair type to separate these species. Number of prominent veins is also useful in recognising species if working with fragments of a leaf.

5.3.6.7 Texture

Previous authors (Brackett 1923; Baker 1878b, 1896, 1898; Nel 1914) used leaf texture to separate species. The states of leaves rigid or flaccid were used. In the Flora Capensis treatment, Baker (1896) applied the terms firm, moderately firm and membranous to separate species with corymbose inflorescences and these terms being relative are applied with difficulty, unless well-understood for the genus.

Texture of leaves in *Hypoxis* varies from soft and membranous to rigid. *H. angustifolia* var. *buchananii*, *H. membranacea*, *H. nivea* and *H. parvula* (Figures 5.19A–D) have thin-texture, almost membranous, flaccid leaves and can be easily separated from the remaining taxa. When dried, the leaves appear membranous. The membranous texture of leaves is associated with semi-shade conditions in cliff forests or provided by rocks and tall vegetation when in open grasslands. This character when combined with the fragile, lax inflorescences in these species is useful for confirming identifications. The remaining species have firm to rigid leaves (Figures 5.9A–D, 5.10A–B, 5.16A, 5.20A–C) and this is correlated with their occurrence in grasslands, most frequently in full sun. Leaves in *H. multiceps*, *H. costata* and *H. intejecta* are short, broad and firm, and are held almost erect in comparison to the soft-textured species. Robust species with rigid leaves include *H. colchicifolia*, *H. galpinii*, *H. rigidula*, *H. obtusa*, *H. multiceps*, *H. costata* and *H. interjecta*. In these species, leaves twist with age (Figures 5.9A, 5.20A–C). As implied by its name, the leaves of *H. rigidula* (Figure 5.9C–D) are rigid. They are also long and slender, and are held erect to about midway where they all bend in one direction or the outer leaves bend backwards on itself. Species with a small stature that have usually rigid, sometimes firm leaves include *H. argentea* (Figure 5.11A), *H. filiformis* (Figure 5.12A) and *H. gerrardii*. There are species that have firm leaves that are not as rigid as those mentioned above and these include *H. hemerocallidea*, *H. flanaganii*, *H. floccosa*, *H. parvifolia*, *H. stellipilis*, *H. sobolifera* and *H. villosa*. In these species, leaves are flexible and are recurved in the first four mentioned species and erect in the latter that have small leaves. Leaf texture is an important diagnostic character and can be used in combination with venation pattern and inflorescence type to identify species in *Hypoxis*.

Figure 5.19.—Soft-textured leaves. A, *H. angustifolia* var. *buchananii* (KwaZulu-Natal, Stainbank Nature Reserve); B, *H. membranacea* (Eastern Cape, Lambazi); C, *H. parvula* var. *parvula* (KwaZulu-Natal, Noodsberg); D, *H. nivea* (KwaZulu-Natal, Umtamvuna).

Figure 5.20.—Rigid leaves showing twist with age. A, *H. obliqua* (Highmoor State Forest Reserve, KwaZulu-Natal); B, *H. costata* (Stutterheim, Eastern Cape); C, *H. obtusa* (Mbidlana, Eastern Cape).

5.3.9 Leaf indumentum

The leaf surface in *Hypoxis* is characterised by a sparse or dense indumentum of non-glandular hairs, usually more dense on the lower surface. Hairs in the genus are non secretory, single, bifurcate or stellate (three to ten arms), and the angle of arms relative to the leaf in horizontal plane may be patent, ascending or appressed (see definitions in Hewson 1988). Differences in distribution of hairs on leaves, density, number and position of arms provide taxonomic characters for separation of species. Hair characters are discussed below and its occurrence in the southern African species of *Hypoxis* is summarised in Table 5.1.

Leaf indumentum was used in many keys to *Hypoxis* species, initially described very coarsely and more recently in greater detail with the aid of Scanning Electron Microscopy techniques. In the first treatment to species in Africa, Baker (1878b) used mainly leaf and inflorescence characters and placed no emphasis on leaf indumentum. In his treatment in Flora Capensis, Baker (1896) used differences in distribution of hairs on leaf surfaces in his key to species. However, Baker (1896) did not find the character very useful in separating the species in Tropical Africa. Nel (1914) used distribution, density, type, colouration and position of leaf indumentum to separate species in Africa. Wood (1976) considered leaf indumentum to be valuable for separating species, and used characters similar to those selected by Nel. Heideman (1987) also applied hair characters to species in the Witwatersrand but less frequently than Wood (1976). Wiland-Szymańska's (2001) key includes distribution of hairs on leaf blades in identifying species in Central Africa. Nordal and Zimudzi (2001) used hair characters similar to those used by Nel in their key to *Hypoxis* in the Flora Zambesiaca region, but applied a number of them in combination with other characters. Wiland-Szymańska & Nordal (2006) found hair type as well as density to be diagnostic for demarcating some species found in the Flora of Tropical east Africa region. Leaf indumentum no doubt offers a suite of characters that are of taxonomic importance in recognising species in *Hypoxis*.

5.3.9.1 Distribution and density of hairs

Hairs may be sparsely scattered in leaves of *Hypoxis* or they may cover the entire leaf surface or may be concentrated only along the veins, margins and midribs (Figure 5.21A–D). The leaves of *H. colchicifolia* and *H. interjecta* are subglabrous and if hairs are present, they are very sparse and distributed mainly on the leaf bases and along margins. The subglabrous state of leaves in *H. colchicifolia* is distinctive and is used to separate it from the closely related species, *H. galpinii* and *H. rigidula* that have bifurcate and stellate hairs in varying density. Subglabrous leaves in *H. interjecta* are easily separated from *H. multiceps* and *H. costata*, species with which it has a close affinity and these have hairs noticeable to the naked eye.

In *H. obtusa* (Figure 5.22D,E) and *H. costata*, hairs form a distinct white band along margins and midribs and this ciliation is unique to these two species. However, apart from other vegetative and floral characters, the species can be separated by the short, appressed hairs in *H. obtusa* and the long, ascending hairs in *H. costata*. In a few species, the distribution of hairs is distinctly dense on the lower surface of leaves. For example, in *H. stellipilis* (Figure 5.7C,D), a species named after its star-shaped hairs (see Figure 6.8D), the hairs form a white tomentose layer on the lower surface of the leaf, while the upper surface is sparsely clothed with hairs. In *H. argentea* var. *argentea* and *H. villosa*, a similar distribution is observed, but in these species, the hairs form a silky white covering over the lower surface as well as along the margins and midribs and the hairs are appressed with arms lying parallel to the length of the leaves. Two varieties are recognised in

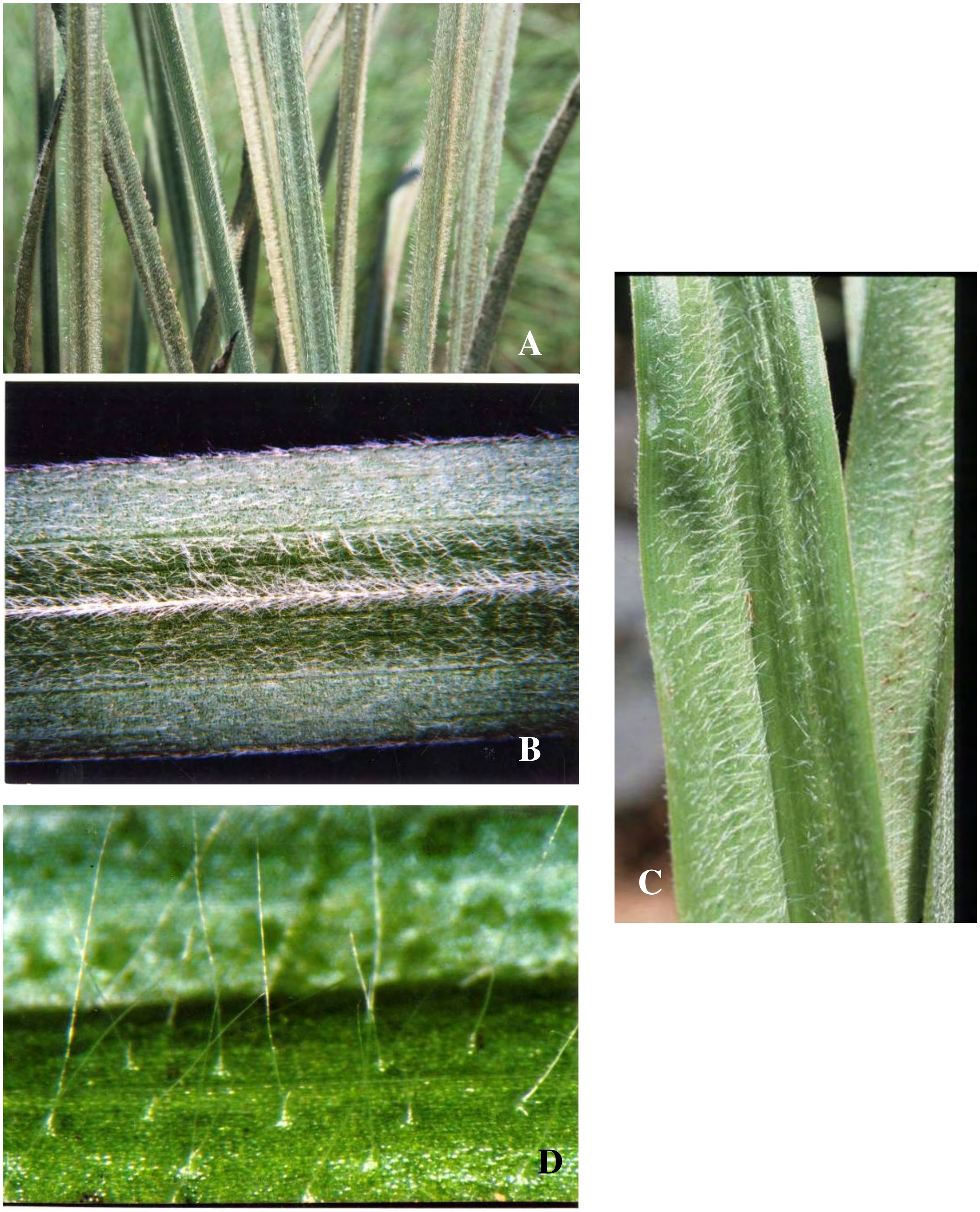

Figure 5.21.—Distribution of hairs on leaves. A, *H. rigidula* var. *rigidula* (ad- and abaxial surfaces), x 1; B, *H. sobolifera* var. *sobolifera* (abaxial surface), x 5; C, *H. hemerocallidea* (adaxial surface), x 0.5; D, *H. membranacea* (abaxial surface), x 20.

H. argentea, *H. rigidula* and *H. sobolifera* based on density of leaf hairs. In *H. argentea* var. *sericea*, hairs are sparsely scattered on the lower surface of the leaf while in *H. argentea* var. *argentea*, hairs are dense on the lower surface giving the leaf a sericeous appearance. The typical varieties of *H. rigidula* and *H. sobolifera* are sparsely hairy on both leaf surfaces and hairs are spaced apart from each other, while in the second varieties in both species, hairs are dense, ascending and overlapping giving leaves a furry appearance.

Newly formed leaves early in the growing season appear more hairy (Figure 5.23A,B) than when they mature and this is due to their distribution across an expanded area in the mature leaves (Figure 5.23C). In a few specimens of *H. hemerocallidea* and *H. sobolifera*, it has been observed that as leaves age and reach marcescens, hairs deteriorate on the lamina, but remain on the margins and midrib.

5.3.9.2 Hair type

Based on number of arms, hairs in *Hypoxis* are classified into simple, bifurcate or stellate types (Figure 5.22 C,J,G,K,L,Q,R). Usually a combination of hair types is present in a species with one type being more predominant. Simple hairs are rare and are present in four species, namely *H. filiformis*, *H. membranacea*, *H. nivea* and *H. parvula*. Such hairs have never been found to occur on their own but in combination with bifurcate and stellate hairs in these three species. Bifurcate and stellate hairs occur widely in the genus, often intermingled with each other (Table 5.1).

In *H. membranacea*, hairs develop on pustules that are observable as dark green dots on the upper surface of the leaf when held against the light (Figure 5.21D). This state is not found in any other species and in the absence of inflorescences and flowers, it can be used to separate the species from *H. angustifolia*, *H. nivea* and *H. parvula* which also have membranous leaves. The use of this character is however, restricted to live material as the feature is lost in dried specimens.

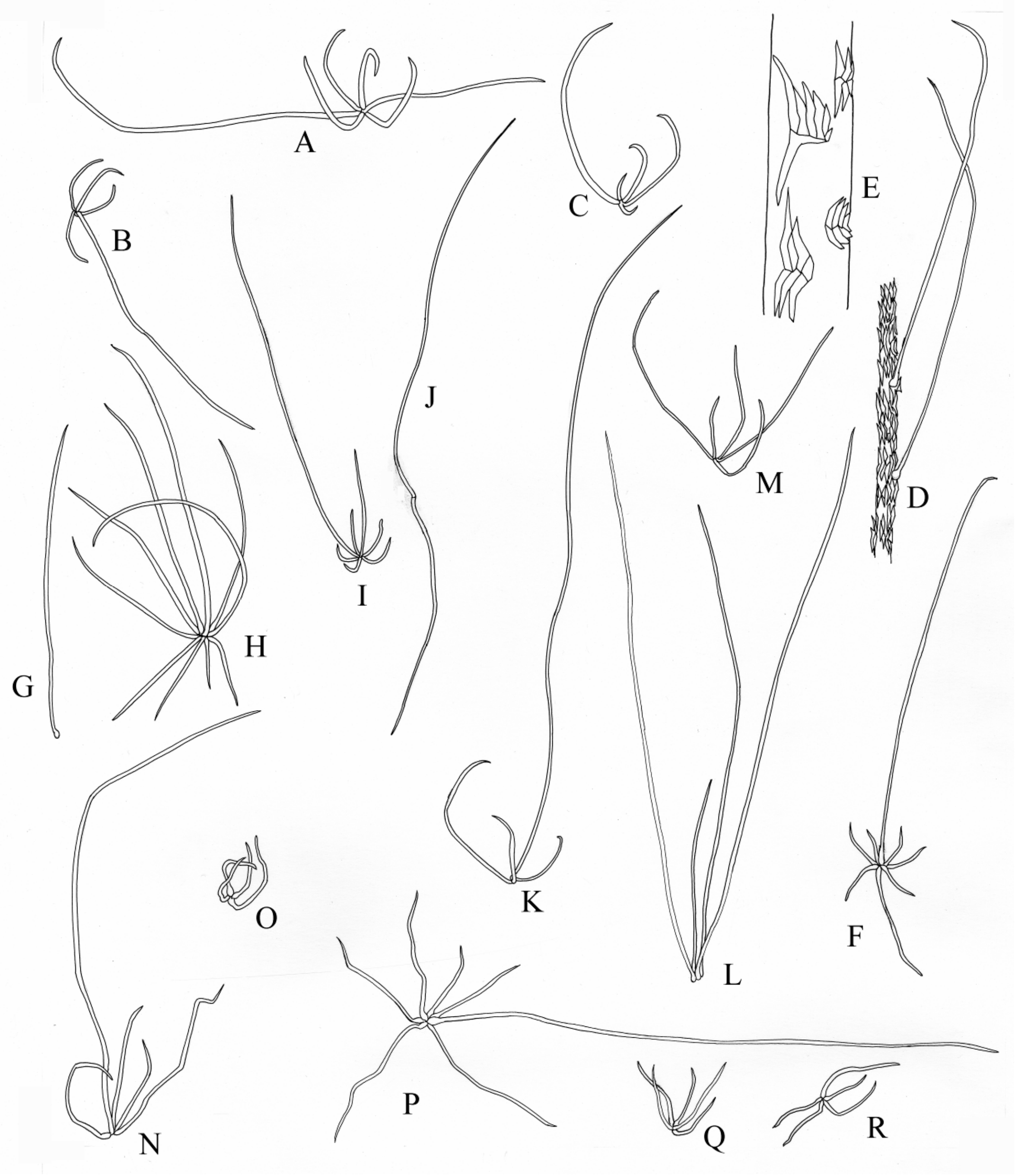

Figure 5.22.—Hair types found in *Hypoxis* A, scape, *H. galpinii Singh 632* (NH), B, tepal surface, abaxial *H. galpinii Singh 632* (NH); C, leaf margin, *H. galpinii Singh 632* (NH); D, E, leaf margin, *H. obtusa Singh 563* (NH); F, tepal surface, abaxial, *H. obtusa Singh 563* (NH); G, bract, *H. sobolifera* var. *sobolifera Singh 233* (NH); H, pedicel, *H. sobolifera* var. *sobolifera Singh 233* (NH); I, tepal surface, abaxial and scape, *H. costata Singh 455* (NH); J, leaf lamina, *H. costata Singh 455* (NH); K, L, leaf lamina, *H. membranacea Singh 826* (NH); M, leaf base; *H. membranacea Singh 826* (NH); N, O, scape, *H. multiceps Singh 642* (NH); P, pedicel, *H. multiceps Singh 642* (NH); Q, R, leaf lamina *H. multiceps Singh 642* (NH).

Figure 5.23.—Leaf hairiness in *H. hemerocallidea*. A, newly formed leaves in young plants with hairy leaves; B, developing leaves hairy; C, mature leaves with hairs beocming spread over a larger surface and less noticelable.

Table 5.1.—Summary of hair characters in southern African species of *Hypoxis*

Taxon	Distribution	Density	Type	Shape of arms	Position of arms	Colour of hairs
acuminata	both surfaces, more dense on lower surface	sparse, dense on margins and midrib	bifurcate or interspersed with stellate	filiform, held in U or V	ascending or patent	white
angustifolia var. *angustifolia*	both surfaces, mainly along veins and margins	sparse	bifurcate or stellate	filiform	ascending	white
angustifolia var. *buchananii*	both surfaces, mainly along veins and margins	sparse	bifurcate or stellate	filiform	ascending	white
argentea var. *argentea*	both surfaces, forming silky covering on lower surface	dense	bifurcate or stellate	filiform	appressed or ascending	white or golden
argentea var. *sericea*	both surfaces, more dense on lower surface	sparse	bifurcate or stellate	filiform	appressed or ascending	white or golden
colchicifolia	absent, if present, then few noticeable in young leaves	sparse	bifurcate or stellate	acicular	ascending	white
costata	mainly veins, margins, midribs	sparse to dense	bifurcate interspersed with stellate	filiform	ascending or appressed	white
filiformis	mainly veins, margins, midribs	sparse	bifurcate or stellate interspersed with simple	filiform	appressed or patent	white
flanaganii	abaxial or both surfaces, margins, midrib	sparse or dense	bifurcate or stellate	filiform	ascending	white, turning brown on drying
floccosa	abaxial or both surfaces, margins, midrib	sparse or dense	bifurcate or stellate	filiform	ascending	white, turning brown on drying
galpinii	along margins, midrib	sparse	bifurcate or stellate	acicular	ascending	white or brown
gerarrdii	abaxial or both surfaces	sparse or dense	bifurcate	filiform, held in U or V	ascending	golden brown
hemerocallidea	evenly on lamina	sparse	bifurcate interspersed with stellate	filiform, held U or V	ascending	white
interjecta	absent, if present, then few noticeable in young leaves	sparse	stellate	acicular	acsending	white
kraussiana	one or both surfaces, margins, midrib	dense	bifurcate interspersed with stellate	acicular, held in a U or V	ascending or patent	white
longifolia	margins, midrib, leaf bases, intercosta	sparse	stellate	acicular	appressed	white or yellow
ludwigii	margins, midrib	dense	stellate	acicular	ascending or appressed	white
membranacea	both surfaces, arises from pustules	sparse	stellate interspersed with simple	filiform	patent	white

Table 5.1.—cont.

Taxon	**Distribution**	**Density**	**Type**	**Shape of arms**	**Position of arms**	**Colour of hairs**
multiceps	even on both surfaces	sparse or dense	stellate	acicular	ascending	yellow to brown
nivea	both surfaces	sparse	bifurcate interspersed with stellate	filiform	ascending	white
obliqua	both, lining midrib and margins on abaxial surface, scattered on veins on upper surface	dense or sparse	stellate	acicular	appressed or acsending	white
obtusa	margins and midrib	dense forming a white band	stellate	acicular	appressed or acsending	white
parvifolia	both surfaces, most on lower surface	sparse or dense	bifurcate or stellate	acicular, held in a U or V	patent	white, yellow or brown
parvula	both surfaces	sparse	bifurcate or stellate interspersed with simple	filiform	ascending	white
rigidula var. *pilosissima*	covering leaf surfaces	dense	bifurcate, stellate	acicular	ascending	white
rigidula var. *rigidula*	lamina, margins, midrib	sparse on lamina, dense on margins and midrib	bifurcate, stellate	acicular or filiform	ascending or appressed	white
sobolifera var. *pannosa*	covering leaf surfaces	dense	stellate interspersed with bifurcate	filiform	ascending	red-brown
sobolifera var. *sobolifera*	abaxial or both surfaces margins, midrib	sparse	stellate or bifurcate	filiform	ascending	white or brown
stellipilis	abaxial surface, light on adaxial surface	dense, forming layer	Stellate	acicular	appressed	white
tetramera	margins and midrib, blade	sparse	bifurcate or stellate	filiform	ascending	white
uniflorata	both surfaces, midrib and veins	sparse, dense on midrib and veins	bifurcate or stellate	filiform	ascending to patent	white
villosa	abaxial or both surfaces, margins and midrib	sparse or dense on margins and midrib	stellate with occasional bifurcate	filiform	appressed or ascending	white
zeyheri	absent, if present only along margins and midrib	sparse	bifurcate or stellate	acicular	ascending or appressed	white or lightly brown

5.3.9.3 Shape of hair arms

The arms of bifurcate and stellate hairs vary in length with one (or two in stellate hairs) more strongly developed than the rest (Figure 5.22C,K,L,Q,R). Based on the shapes of arms, hairs can be categorised into two types in *Hypoxis*. Arms of hairs may be short and acicular (stiff) [Figure 5.24A] or arms long and filiform (lax) [Figure 5.24B]. The acicular arms may be patent, ascending or appressed while filiform arms are mostly ascending and this has an effect on leaf texture. In *H. muticeps*, *H. kraussiana* and *H. parvifolia*, acicular hairs give the leaves a scabrous feel while filiform hairs of *H. argentea* and *H. villosa* create a soft silky covering on the lower surface.

Figure 5.24.—Shape of hair arms in *Hypoxis*. A, U-shaped patent hairs in *H. argentea* var. *argentea*; B, long, filiform arms in *H. angustifolia*.

5.3.9.4 Position of arms relative to the leaf surface

Arms of hairs in *Hypoxis* are patent, ascending or appressed. Most species have ascending hairs. Only two species, namely *H. kraussiana* and *H. parvifolia* have distinctly patent hairs and a few species have appressed hairs [*H. stellipilis*, *H. villosa*]. Leaves of *H. kraussiana* and *H. parvifolia* are distinctive in that they have predominantly bifurcate hairs on blades in a 'U' or 'V' outline (see Figure 6.6C). In *H. angustifolia*, *H. argentea*, *H. acuminata*, *H. gerrardii* and *H. hemerocallidea*, arms may also be held in a 'U', but in these species the arms are filiform (see Figure 6.7B) and have a soft texture. Ascending hairs are associated with long, filiform arms while patent and most appressed hairs are acicular (Table 5.1). In *H. argentea* and *H. villosa*, arms bend at the hair base to lie parallel to the length of the leaf and ascend at the tips, and this aids in recognising these species. The combination of arms being short, acicular and patent or ascending in *H. kraussiana*, *H. parvifolia* and *H. multiceps* give their leaves a scabrous texture. In *H. rigidula* var. *pilosissima* and *H. sobolifera* var. *pannosa*, the dense hairs are ascending giving the leaves a soft, furry texture and this character is used to separate them from the typical varieties. In *H. stellipilis*, hairs are stellate with arms acicular and appressed.

5.3.9.5 Colour of hairs

Hairs in *Hypoxis* are white in the majority of the species, but in a few species they may turn yellow or reddish-brown on drying. In *H. multiceps*, *H. costata* and *H. kraussiana*, hairs on leaves and inflorescences are white or yellow. Often, the inflorescence hairs in these species are yellow and are useful for recognising the species. *H. argentea* can be distinguished by its long silky hairs that appear white or golden yellow giving the leaves a sericeous effect. In *H. sobolifera*, two varieties are recognised based on the density and colour of hairs. *H. sobolifera* var. *pannosa* differs from the typical variety in having a dense indumentum on both surfaces of the leaf and in hairs being red-brown. In the typical variety, hairs are scattered over both surfaces, occur in tufts and are white or pale brown (See Singh *et al*. 2007). In all species, if the previous season's leaves remain on the specimen, the hairs on these leaves turn grey-white when dried even in species with yellow and red-brown hairs, but this is particularly noticeable in *H. sobolifera*.

5.3.9.6 Difficulty in using leaf hair characters in *Hypoxis*

Leaf hairs offer stable characters for identifying species of *Hypoxis*. However, there are a few difficulties that are worth noting. As in seed characters, hairs are minute and their characters are assessed with difficulty using a hand lens in the field. Pressing of specimens for the herbarium also obscures the position of arms relative to the leaves and it becomes problematic to evaluate the character. Newly formed leaves in the growing season are more hairy due to hairs being spread over a smaller area than when they mature. As leaves age, hairs disintegrate leaving the blades glabrous in a few species. This is seen in *H. costata*, *H. hemerocallidea* and *H. sobolifera*. However, in these species, hairs remain on the margins and midrib of the leaves. These changes in distribution of hairs therefore need be noted in plants at various stages of their growth. A combination of leaf hair characters is useful to distinguish some species, for example *H. obtusa* and *H. ludwigii* that have acicular and appressed hairs forming a distinct white band along margins and midribs.

5.3.9.7 Possible function of leaf hairs

Nel (1914) regarded hairiness in *Hypoxis* plants as a protection to reduce excessive transpiration. More recent studies report that leaf hairs are effective in reducing water loss (Ehleringer *et al*. 1976) and in reflecting solar radiation (Johnson 1975). In general, *Hypoxis* species with moderately firm leaves, growing in well drained grasslands, in full sun have leaves with a dense indumentum (*H. sobolifera*, *H. stellipilis* and *H. rigidula* var. *pilosissima*), at least on the lower surface, while those species in semi-shade and wet areas have leaves only lightly hairy, for example *H. flanaganii*, *H. filiformis*, *H. parvula* and *H. nivea*. However, species with almost glabrous leaves like *H. colchicifolia* and *H. interjecta* and those with rigid leaves and varying degrees of hairiness (e.g. *H. rigidula*, *H. galpinii, H. costata*) were found growing sympatrically under the same conditions. It is possible that together with a waxy epidermal layer, the hairs play a role in water retention and reflecting solar radiation while this may not be necessary in species that are adapted to semi-shade and damp conditions.

5.4 Conclusions

This assessment indicates that vegetative characters, especially those of the leaves, are valuable in demarcating species in *Hypoxis*. Rhizome, tunic and pseudostem characters may be used to confirm the identity of a species. Structurally, the star-shaped flowers are fairly uniform and vegetative characters are therefore important for demarcating species. In this chapter, the characters of diagnostic value in the genus were described and illustrated. Due to an overlap in ranges of character states among species and the developmental change in appearance of plants over the growing season, it is concluded that a combination of characters is necessary for reliably identifying infraspecific taxa.

6

LEAF ANATOMY

6.1 Introduction

Leaves in the Hypoxidaceae are rosulate and three-ranked, the outer ones reduced to cataphylls. The foliage leaves are linear or lanceolate and hairy, seldom glabrous. In cross section, the leaves are V-shaped, inversely W-shaped (plicate) or crescentiform, with V-shape being the most common state in the family. In *Hypoxis*, the morphology of the foliage leaves provides a number of characters of taxonomic value. Characters such as leaf venation and indumentum were found to be particularly useful in demarcating species in the genus (Chapter 5).

To assess the potential value of anatomical characters, the leaves of 20 southern African species of *Hypoxis* (see Chapter 4 for a list of species) were studied using Light [LM] and Scanning Electron Microscopy [SEM]. The purpose of this chapter is to report on the leaf anatomical features of the species studied with reference to characters of taxonomic importance. As earlier contributions on the anatomy in the family formed an important framework for the interpretation of the results of the present study, a summary of the key ideas emanating from them is provided at the beginning of the Chapter. The results of the present study are integrated to provide a generic description of the leaf surface and internal anatomy for *Hypoxis*.

Leaf surface characters were found to be of little diagnostic value in separating species in *Hypoxis*. On the contrary, internal anatomy was taxonomically more useful and provided a few characters of diagnostic value. The mesophyll and arrangement of the sclerenchyma making up the inner sheath of the vascular bundles are useful for species identification. Figures depicting anatomical characters in leaves of *Hypoxis* and their variation are included within the generic description. Vouchers of all specimens cited are lodged at NH. A comparison of features from leaf cross sections are presented in Table 6.2. The Chapter concludes with a summary of anatomical characters of diagnostic value in *Hypoxis* and attempts to link them to the associated morphology.

6.2 Literature review

Schnarf (1892) studied the comparative anatomy of roots, rhizomes, leaves and peduncles in the Hypoxidaceae. He used various species of *Hypoxis*, *Curculigo*, *Spiloxene* and *Pauridia* (Table 6.1)

Table 6.1.—Species of Hypoxidaceae used in earlier anatomical studies.
Current names are indicated in brackets.

Author	Roots	Storage organ	Leaves	Peduncle
Schnarf (1892)	*Curculigo sumatrana*	*Curculigo sumatrana*	*Curculigo sumatrana*	
	Hypoxis sp.			*Hypoxis sobolifera* *Hypoxis lanata* (= *H. stellipilis*) *Hypoxis microsperma* (= *H. villosa*)
		Hypoxis linearis (= *Spiloxene serrata* var. *serrata*)	*Hypoxis stellata* (= *S. capensis*)	*Spiloxene capensis*
Nel (1914)			*Hypoxis argentea* *Hypoxis dinteri* (= *H. argentea*) *Hypoxis gerrardii* *Hypoxis obtusa* *Hypoxis recurvata* *Hypoxis subspicata* *Hypoxis villosa*	
Arber (1925)		*Curculigo orchioides*	*Curculigo* sp. *C. recurvata*	
	Hypoxis setosa	*Hypoxis setosa*	*Hypoxis setosa*	*Hypoxis setosa*
Thompson (1976)		*Empodium plicatum*	*Empodium plicatum*	
		Pauridia minuta	*Pauridia longituba* *Pauridia minuta*	
		Spiloxene aquatica *Spiloxene capensis*	*Spiloxene aquatica* *Spiloxene capensis* *Spiloxene flaccida* *Spiloxene minuta* *Spiloxene ovata* *Spiloxene schlechteri* *Spiloxene serrata*	
Heideman (1983)			*Hypoxis acuminata* *Hypoxis argentea* *Hypoxis filiformis* *Hypoxis galpinii* *Hypoxis hemerocallidea* *Hypoxis interjecta* *Hypoxis multiceps* *Hypoxis neliana* (=*H. kraussiana*) *Hypoxis obtusa* *Hypoxis rigidula* *Hypoxis rooperi* (= *H. hemerocallidea*)	

Table 6.1.—cont.

Author	Root	Storage organ	Leaves	Peduncle
Rudall *et al.* (1998)	*Curculigo latifolia* *Curculigo villosa*	*Curculigo latifolia* *Curculigo orchioides* *Curculigo pilosa* *Curculigo villosa*	*Curculigo capitata* *Curculigo latifolia* *Curculigo orchioides* *Curculigo pilosa* *Curculigo recurvata* *Curculigo villosa*	
			Empodium elongatum *Empodium plicatum*	
			Hypoxidia rhizophylla	
	Hypoxis decumbens *Hypoxis hygrometrica* *Hypoxis urceolata* *Hypoxis villosa*	*Hypoxis decumbens* *Hypoxis hygrometrica* *Hypoxis sessiliflora* *Hypoxis urceolata* *Hypoxis villosa*	*Hypoxis angustifolia* *Hypoxis decumbens* *Hypoxis hygrometrica* *Hypoxis obtusa* *Hypoxis rooperi* (= *H. hemerocallidea*) *Hypoxis urceolata* *Hypoxis villosa* *Hypoxis* sp.	
			Molineria latifolia	
			Pauridia longituba	
	Rhodohypoxis baurii		*Rhodohypoxis baurii* *Rhodohypoxis millioides*	
			Spiloxene aquatica *Spiloxene schlechteri* *Spiloxene stellata* (= *S. capensis*) *Spiloxene serrata*	

and provided a detailed anatomical description of the root in *Hypoxis* and *Curculigo sumatrana*. Schulze (1893) mentions *Hypoxis*, *Curculigo* and *Pauridia* in a general discussion under Liliaceae and reports that *Pauridia* cannot be separated anatomically from *Hypoxis*. Schnarf (1892) and Schulze (1893) found that vascular bundles in the peduncle in Hypoxidaceae lie in a ring and are not scattered as in stems of most monocotyledons. Nel (1914) described the morphology of the corms in detail and used it as the main character in grouping species of *Spiloxene*. He found that the leaf anatomy in the genus was of little value in grouping species, as the vascular bundles lie close to the surface and they are hardly distinguishable from each other, appearing almost similar in cross section. In contrast, Nel (1914) reported that the internal leaf anatomy of *Hypoxis* provided good characters for classifying species. He explained the particular usefulness of number, distribution and size of vascular bundles especially those associated with the vein areas. These characters provided support for his infrageneric groupings. He did not, however, give prominence to the shapes of outlines of transverse sections of leaves, a character which is of diagnostic value in other petaloid monocotyledons, for example *Kniphofia* Moench (Baijnath 1980) and *Bulbine* Wolf (Baijnath & Cutler 1993). Figure 6.1 shows cross sections of leaves presented by Nel and a representative of sections he proposed for the African members of *Hypoxis*.

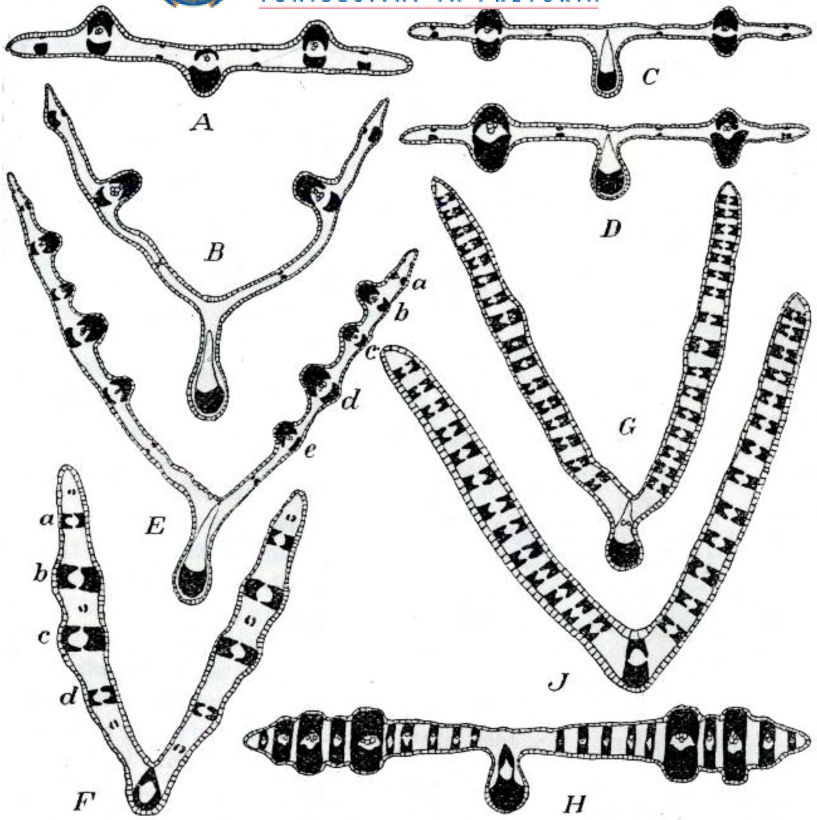

Fig. 2. Blattquerschnitte von *Hypoxis*. *A H. Dinteri* (Angustifoliae); *B H. angustifolia* (Angustifoliae); *C H. argenteae* (Argenteae): *D H. Gerrardi* (Argenteae); *E H. villosa* (Villosae); *F H. recurvata* (Recurvatae); *G H. subspicata* (Subspicatae); *H H. rigidula* (Rigidulae); *J H. obtusa* (Obtusae). — Original.

Figure 6.1.—Cross sections of leaves in *Hypoxis* (sectional names in brackets). Taken from Nel (1914).

H. dinteri (A) and *H. angustifolia* (B) belonging to section *Angustifoliae*, as well as *H. argentea* (C) and *H. gerrardii* (D) of section *Argenteae* are similar in having linear leaves with one lateral vein on each side of the midvein close to the edge that is adaxially prominent. Nel selected *H. dinteri* to represent the two sections and described its anatomy in detail. Using the leaf type in *H. villosa* (E) to represent sections *Villosae*, *Orbiculatae* and *Nyassicae*, Nel described its appearance in cross section. The leaves in these groups are narrowly lanceolate and have about ten veins. Nel pointed out that the higher number of lateral veins (about five) on each half of the leaves, at least three of which are almost uniformly developed in members of these sections, differentiates them from sections *Angustifoliae* and *Argenteae*. Members of *Recurvatae*, represented by *H. recurvata* (F) have four unevenly thickened lateral veins on each half of a leaf. However, all veins are similarly thickened on both sides perpendicular to the leaf surface, with the inner veins *b* and *c* slightly thicker than those in position *a* and *d*. In comparison, the veins in sections *Villosae*, *Orbiculatae* and *Nyassicae* are thicker on the upper surface. In *Subspicatae* (*H. subspicata* = *H. polystachya*, G) and *Obtusae* (*H. obtusa*, J), the leaves have many lateral veins that are almost uniformly thickened and differ little from each other. There are grooves between the veins in these leaves. From Nel's illustrations and descriptions, the leaves in these sections appear very similar and therefore difficult to tell apart. The last leaf type recognised by Nel is that of *Rigidulae* (*H. rigidula*, H). This type differs from *Subspicatae* and *Obtusae* in its strong thickening of one to three lateral veins on each half of the leaf, close to the edge, noticeable to the naked eye. Nel also noted that the cuticle in *H. obtusa*, though variable, is usually thicker than in other species.

Arber (1925) included *Hypoxis* and *Curculigo* in her study of the structure of organs in monocots. She provided a plate (Figure 6.2) with illustrations of transverse sections of root, axis (rhizome), leaf and peduncle in *H. setosa* and uses the transverse sections of leaves in *Curculigo* sp. and *C. recurvata* Dryand. in leaf type comparisons. In trying to understand the mechanism by which root tissue contracts, Arber studied serial sections of the smooth and wrinkled zones in *H. setosa*. She concluded that it is the outer tissues that wrinkled while the central cylinder and inner cortex remained unaffected and she ascribed wrinkling of the whole outermost layer to its increased length in comparison to the inner tissues. With regard to the axis, Arber pointed out the cylindrical rhizome with a depressed growing point in *Hypoxis* (Figure 6.2, viiiB). She further confirmed the observations of Schnarf (1892) and Schulze (1893) that vascular bundles of the peduncle in *Hypoxis* are arranged in a ring (Figure 6.2, viiiE). Thompson (1972) noted that the arrangement was not unexpected as the peduncle is not the main stem or axis, but an axillary structure.

In 1976, Thompson published her studies in the Hypoxidaceae with emphasis on the vegetative morphology and anatomy in *Empodium*, *Spiloxene* and *Pauridia*. She found that the corms of all three genera are very similar anatomically, and that throughout the ground tissue of parenchyma cells, there are mucilage canals. These are not associated with the vascular bundles, but are surrounded by radially flattened cells as in the leaves. She compared the mucilage canals in these genera to Schnarf's (1892) account for *Hypoxis*, where the canals are described to arise schizogenously near the growing point and they have no membrane but are embedded in a ring of smaller cells. She further confirmed that the nature of the corm coverings in *Spiloxene* can be used to recognise the groups established by Nel (1914) for the genus. Using morphology and general anatomy, Thompson (1976) classified the leaves in the genera under study into four groups: carinate, canaliculate, terete and plicate. She found that leaf form is not a good basis for grouping

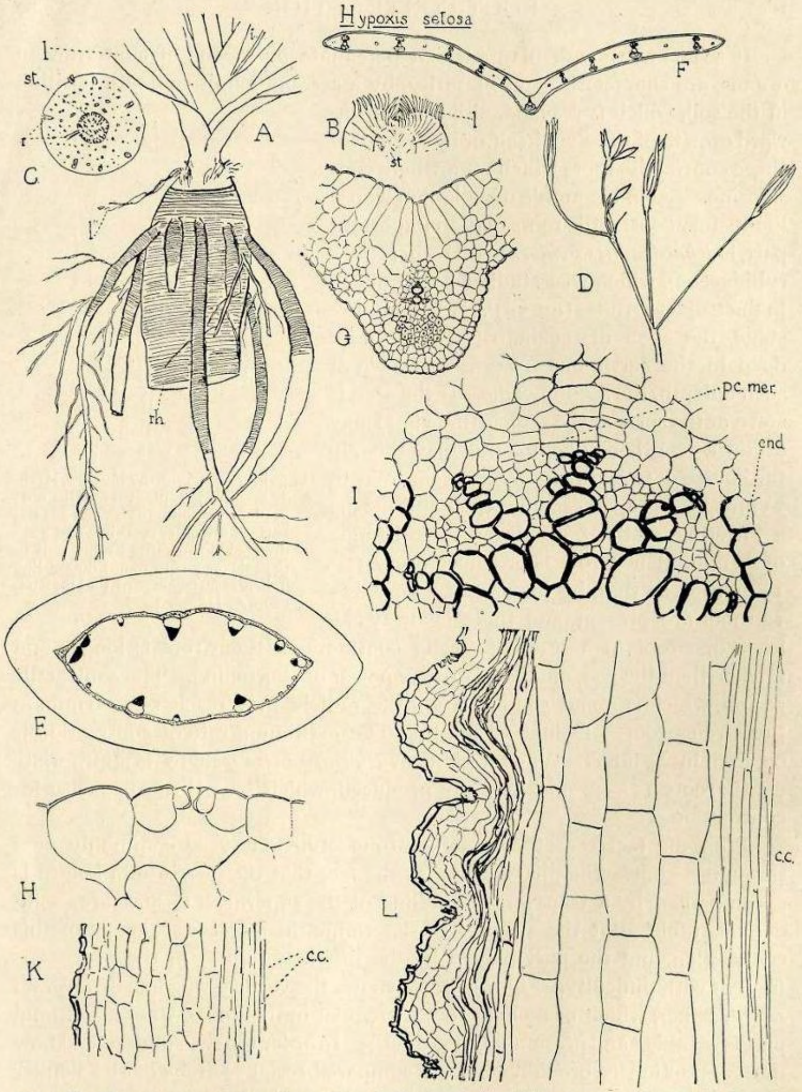

Fig. viii. *Hypoxis setosa*, Baker. Plant from Stellenbosch, S. Africa, grown at Cambridge Botanic Garden, drawn October 5. A, plant (× ½); *l.*, leaves cut off short; *l′.*, remains of old leaves; persistent roots borne on thick vertical rhizome (*rh.*), here cut off at the base; *i.*, one of several lateral inflorescence-axes. B, top of axis cut in half to show sunk growing point; from the stele, *st.*, numerous leaf-traces are seen passing to the crowded leaf-bases, *l.*, (× ½). C, axis cut across (× ½) to show stele, *st.*, roots, *r.*, and mucilage-cavities and bundles in the cortex. D, inflorescence (× ½). E, transverse section of peduncle (× 77). F, transverse section near apex of leaf (× 14). G, transverse section of midrib of leaf (× 77). H, transverse section of stomate from upper surface of leaf (× 318). I, transverse section of part of stele of slender smooth zone of root, to show pericyclic divisions, *pc. mer.*, giving rise to lateral root; *end.*, cuticularised endodermis interrupted opposite origin of lateral root (× 193). K, longitudinal section of cortex of slender smooth zone of root, 12—15 cms. from tip (17—20 cms. from base); *c.c.* position of central cylinder (× 47). L, longitudinal section of cortex of wrinkled zone of root, 2—4 cms. from base (× 47). [A.A.]

Figure 6.2.—Morphology and anatomy of *H. setosa*. Taken from Arber (1925).

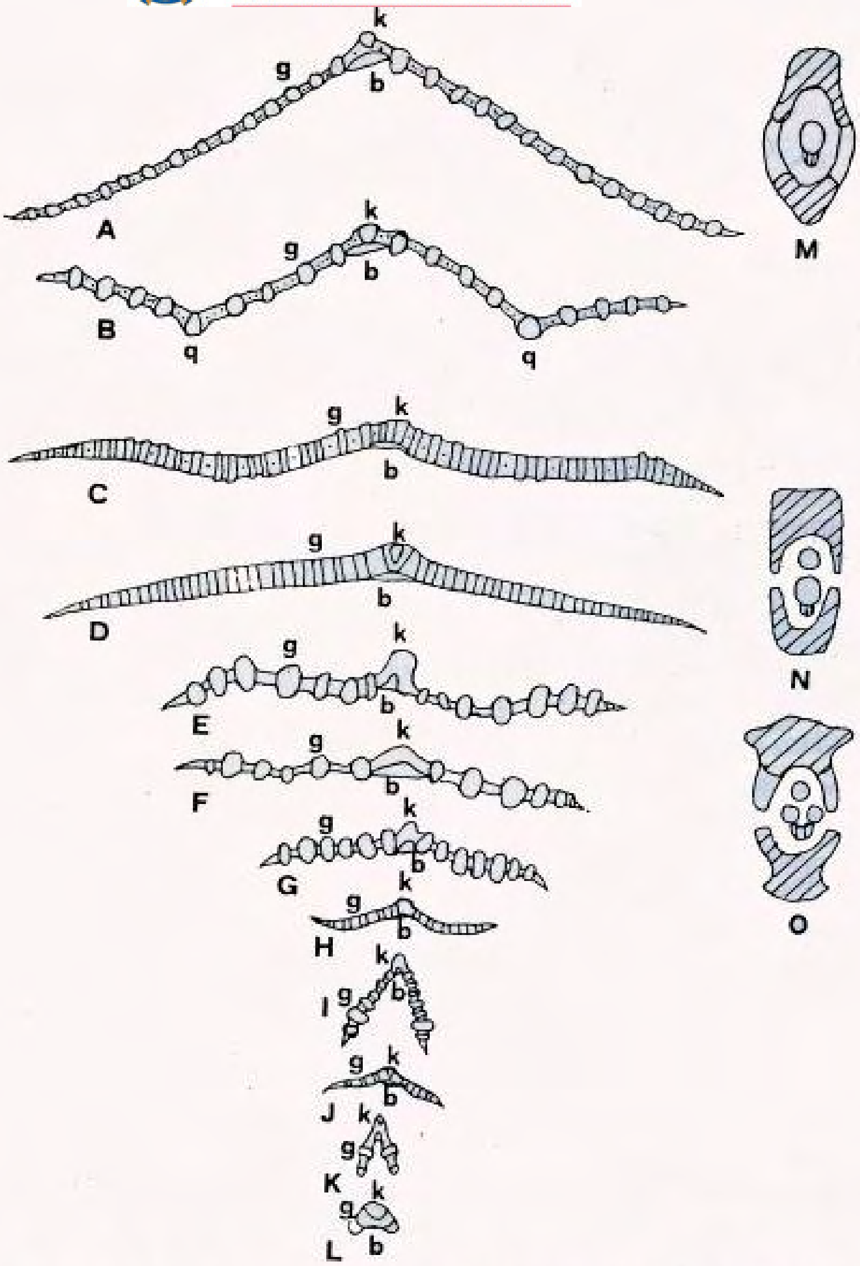

FIG. 3.—Leaf venation. A – L, leaf transections (× 3). A, *H. rooperi*, B, *H. galpinii;* C, *H. obtusa* var. *'nitida'*, D, *H. obtusa* var. *obtusa;* E, *H. rigidula* var. *'hemerocallidea';* F, *H. rigidula* var. *pilosissima;* G, *H. rigidula* var. *rigidula;* H. *H. multiceps* and *H. interjecta;* I, *H. acuminata;* J. *H. neliana;* K, *H. argentea;* L, *H. filiformis*. M–O, fibrous girders (× 30): M, crescent-shaped (in leaves A, B, H); N, crossbar-shaped (in leaves C, D, J, K, L); O, T-shaped (in leaves E, F, G, I).

Figure 6.3.—Cross sections of leaves in *Hypoxis*, classifying them according to girder types. Taken from Heideman (1983).

species in any of the three genera as very dissimilar species could have the same leaf form, and that leaf anatomy was of little taxonomic value.

After Nel (1914), Heideman (1983) paid attention to venation in *Hypoxis* leaves. She studied the leaf sections of eleven species of *Hypoxis* growing on the Witwatersrand and recognised three types of girders among the species: T-shaped, rectangular-(cross-bar) shaped and crescent-shaped (Figure 6.3). She indicated that T-shaped girders protrude as wide prominent ribs (veins) and that the other two types of girders protrude only slightly. According to her, T-shaped girders occur in *H. acuminata* and *H. rigidula*, rectangular girders in *H. argentea*, *H. filiformis*, *H. kraussiana* and *H. obtusa* and crescent-shaped girders in *H. galpinii*, *H. multiceps*, *H. interjecta* and *H. hemerocallidea* (*H. rooperi*). She also classified *H. colchicifolia* (*H. latifolia*) as having crescent-shaped girders. In the same publication, Heideman reported on SEM studies and illustrated leaf hairs in *H. kraussiana* and *H. multiceps* and the stomata in the latter species.

Nordal *et al*. (1985) studied the leaf indumentum in East African *Hypoxis* using LM. These authors broadly classified the hairs into six types based on colouration and distribution, as well as number and position of arms. In Nordal *et al*. (1985), 17 taxa are included as synonyms in the *H. obtusa* complex, and the constituent taxa representing four different hair types. Recent work on the genus in the region by Szymańska & Nordal (2006), however, does not maintain the complex.

Hitherto the most comprehensive study on leaf anatomy of Hypoxidaceae was by Rudall *et al*. (1998). The latter authors provided leaf anatomical descriptions of all genera except *Saniella* based on the study of a number of species (Table 6.1). They included eight species of *Hypoxis*, two being extra-African. In their publication, Rudall *et al*. (1998) presented leaf anatomical data for the asteloid genera and combined them with new rbcL sequence data in analysing the relationship of Asteliaceae and Hypoxidaceae. They confirmed the placement of *Pauridia* in the Hypoxidaceae. The rbcL analysis indicated similarity between *Rhodohypoxis* (a South African genus) and the North American *Hypoxis*, as well as *Spiloxene* (South Africa) and *Hypoxis glabella* (Australia), a species included in section *Ianthe* and has been proposed to belong to *Spiloxene* (Hilliard & Burtt 1978; Manning *et al*. 2002).

6.3 Results

6.3.1 Leaf surface details

The description is based on observations using the SEM and follows the style used in the Anatomy of Monocot Series, Jodrell Laboratory, Kew:

Surfaces plane or ribbed, position of veins (ribs or costae) occupied by largest vascular bundles (Figure 6.4). *Epidermal cells* outline usually distinct, polygonal, mainly hexagonal or axially elongated (Figure 6.5A), rarely elongated transversely (Figure 6.5B); sometimes with distinct costal and intercostal cell arrangement, in general cells of the latter more elongated longitudinally. Position of anticlinal walls denoted by slight depressions, sometimes obscured by wax particles or sheets. *Hairs* bifurcate (Figure 6.6A–D) or stellate (Figure 6.7A–F and 6.8A–D) consisting of two or more unicellular unbranched arms; arms varying in length, central arm often longer and thicker than the rest. *Papillae* absent. *Striae* present in most species, both longitudinal and transverse (Figure 6.9A), often striae spreading transversely from flanks of outer stomatal lips over the subsidiary cells (Figure 6.9B,C). *Stomata* present on both surfaces, more plentiful on abaxial, paracytic; outer stomatal lip (cuticular ledges) level, elliptic in outline (Figure 6.9B). *Wax* usually as sheets on both surfaces, often flaking (Figure 6.9D,E) sometimes particles amorphous (Figure 6.9A) or distinct (Figure 6.9F).

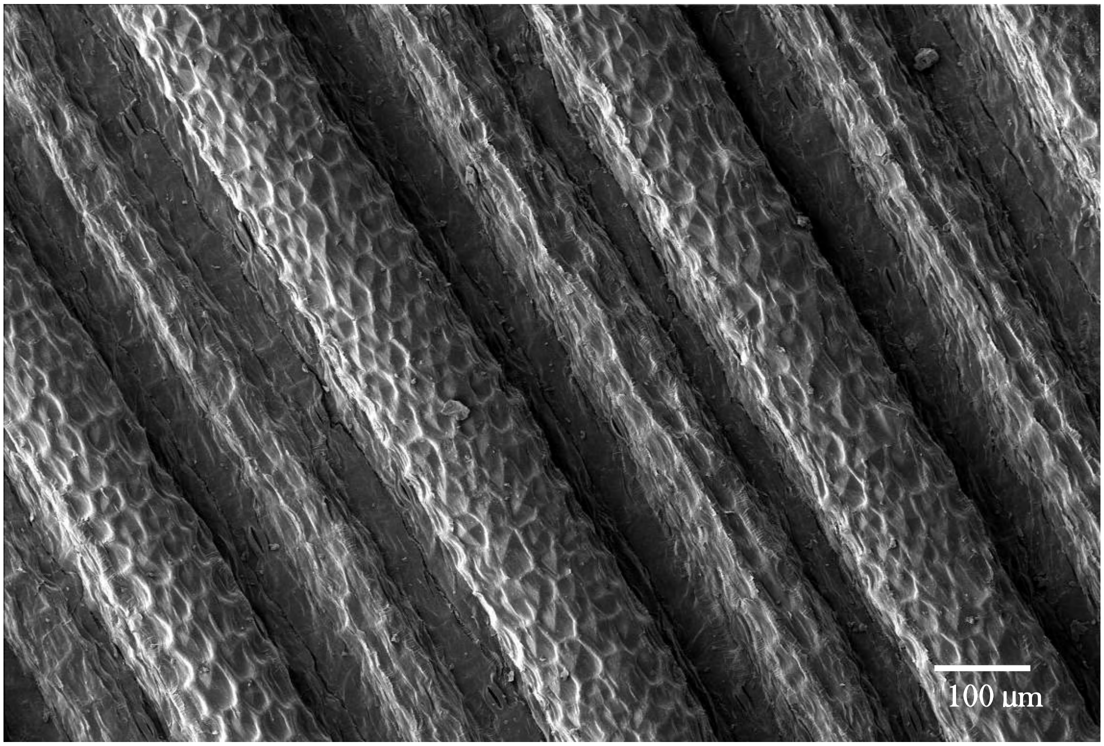

Figure 6.4.—Scanning electron micrograph of upper surface of leaf showing position of veins (ribs) in *H. obtusa* (*Singh 277*), adaxial surface.

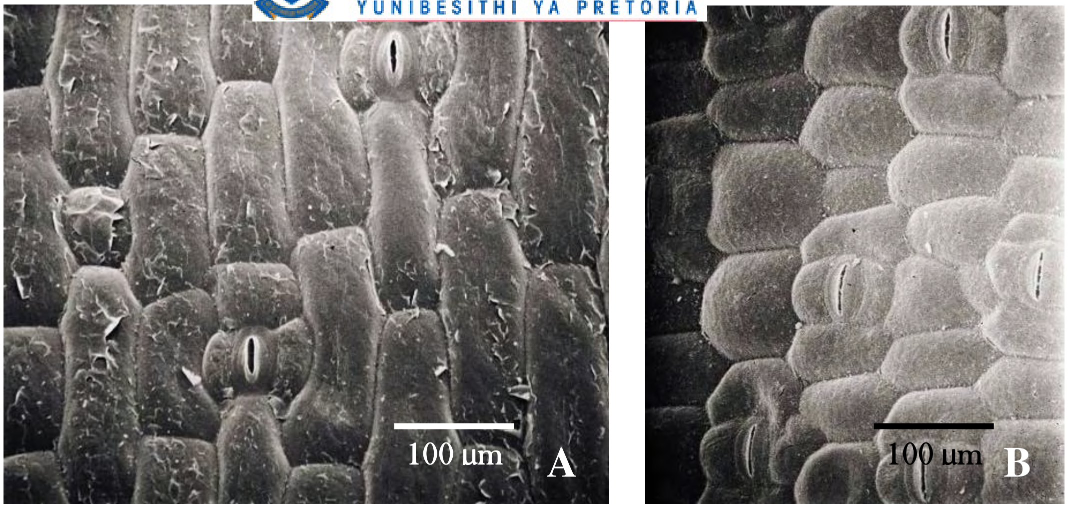

Figure 6.5.—Scanning electron micrographs of leaf surfaces showing epidermis. A, longitudinally elongated cells in *H. longifolia* (*Singh 502*), adaxial surface; B, transversely elongated cells in *H. angustifolia* var. *buchananii* (*Singh 535*), abaxial surface.

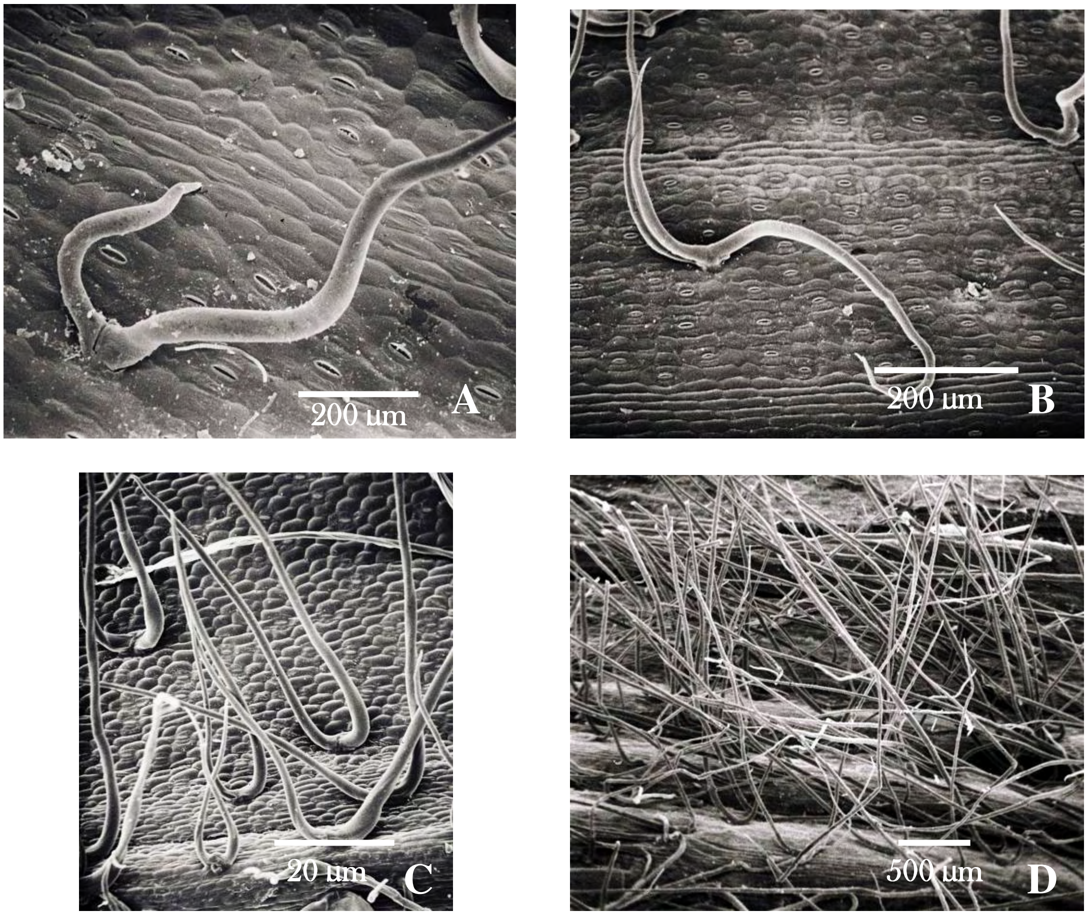

Figure 6.6.—Scanning electron micrographs of leaf surfaces showing bifurcate, ascending hairs. A, *H. hemerocallidea* (*Singh 262*); B, *H. multiceps* (*Singh 322*); C, *H. parvifolia* (*Singh 470*); D, *H. rigidula* var. *pilosissima* (*Singh 318*). A,B,D, adaxial surface; C, abaxial surface.

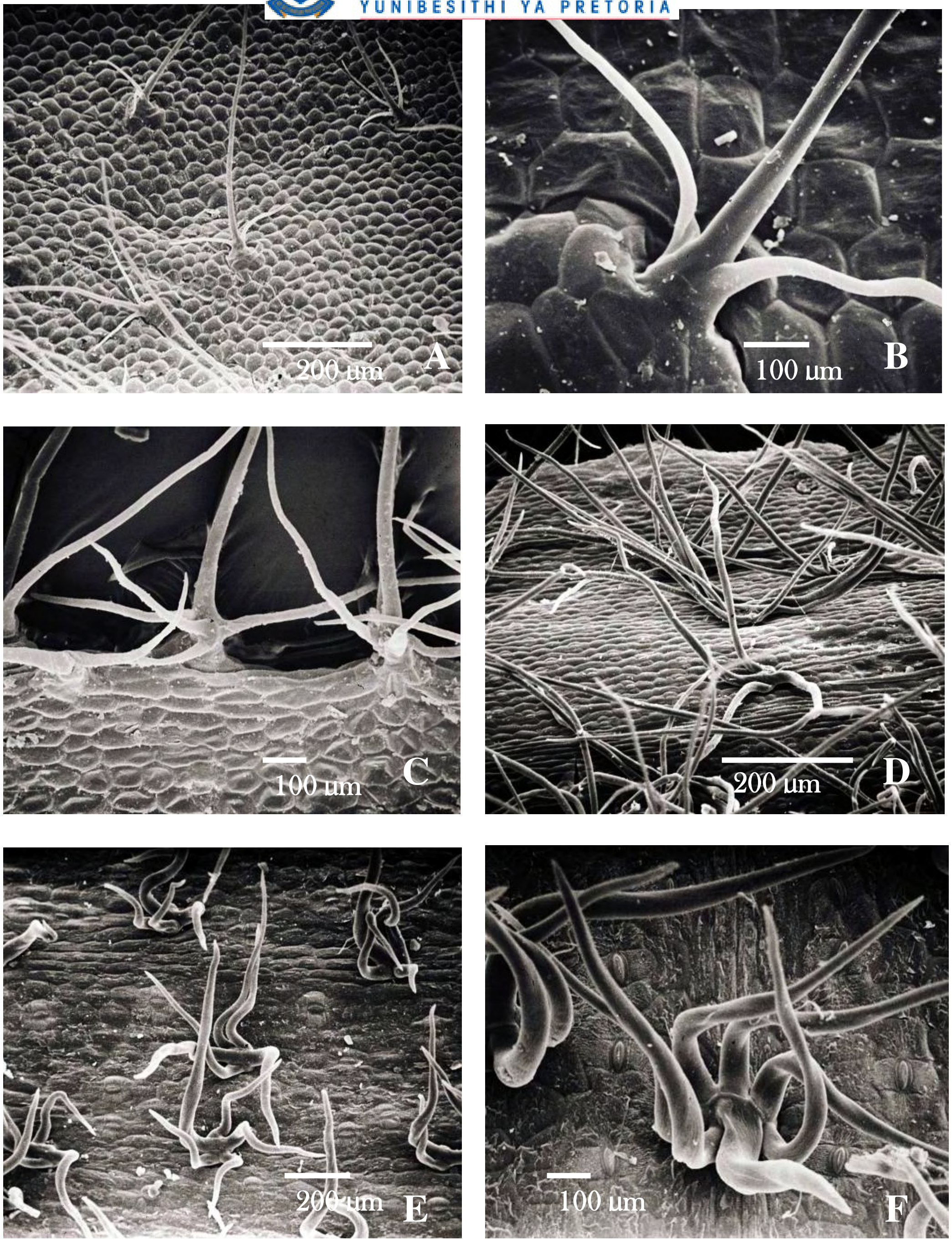

Figure 6.7.—Scanning electron micrographs of leaf surfaces showing stellate, ascending hairs: A–C, *H. parvula* var. *parvula* (*Singh 465*); D, *H. sobolifera* var. *sobolifera* (*Singh 233*); E,F, *H. multiceps* (*Singh 615*). A,B,D,E, abaxial surface; C,F, abaxial surface.

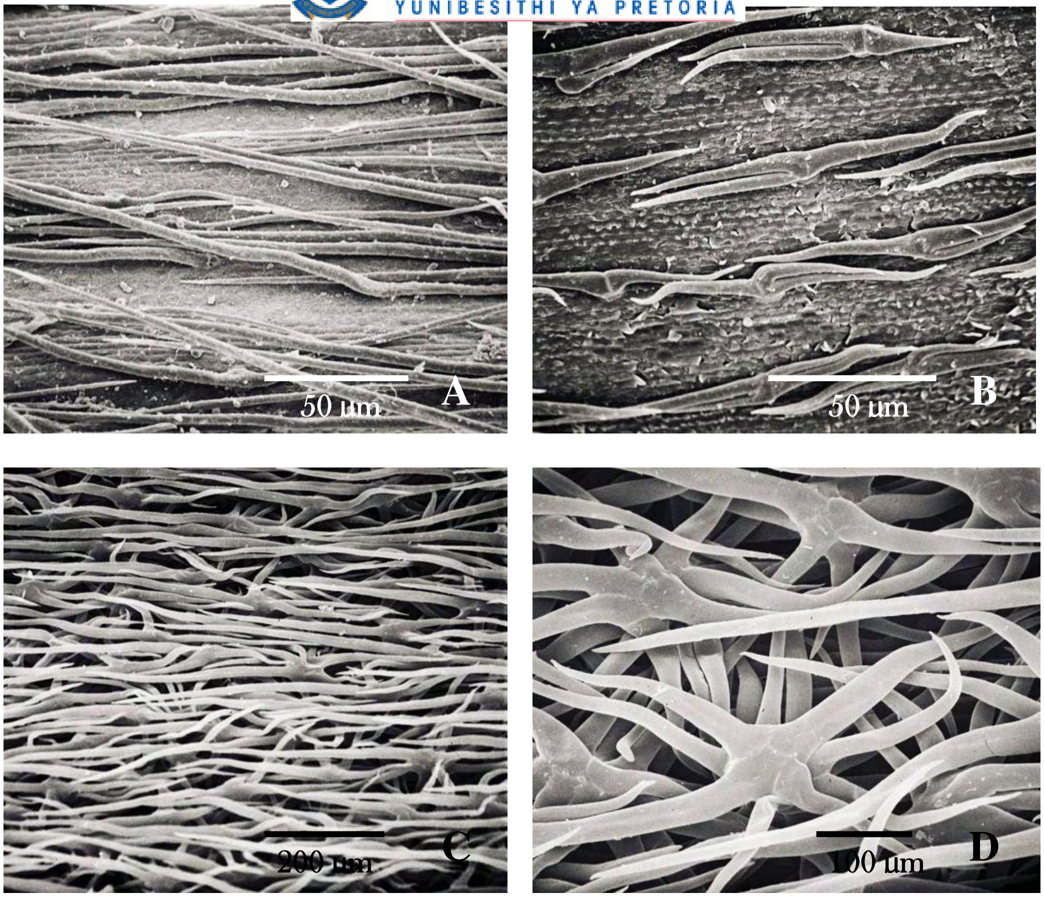

Figure 6.8.—Scanning electron micrographs of leaf surfaces showing stellate, adpressed hairs. A, *H. rigidula* var. *rigidula* (*Singh 317*); B, *H. obtusa* (*Singh 330*); C, D, *H. stellipilis* (*Singh 621*). A, adaxial surface; B–D, abaxial surface.

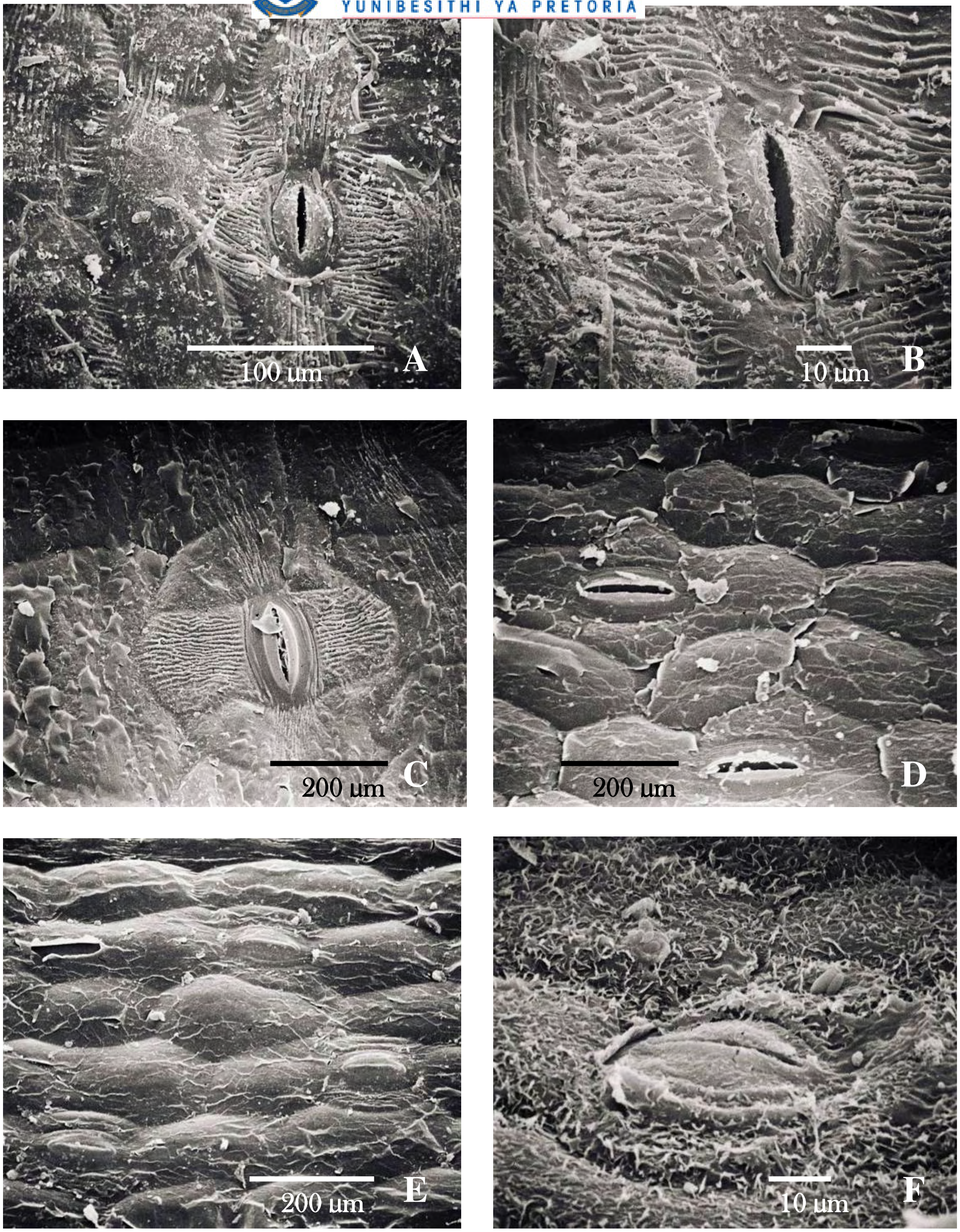

Figure 6.9.—Scanning electron micrographs of leaf surfaces showing cuticular striae, stomata and wax. A, longitudinal and transverse striae in *H. colchicifolia* (*Singh 481*); B, C, transverse striae radiating from flanks of outer stomatal lips over subsidiary cells in B, *H. colchicifolia* (*Singh 481*) and C, *H. multiceps* (*Singh 615*); D, wax as sheet in *H. argentea* var. *sericea* (*Singh 295*); E, wax as sheet in *H. filiformis* (*Singh 418*); F, wax particles in *H. rigidula* var. *rigidula* (*Singh 317*). A, adaxial surface; B–F, abaxial surface.

6.3.2 Internal anatomy of leaf (as seen in transverse section)

Outline dorsiventrally flattened, crescentiform, V-shaped or plicate. *Cuticle* thin on both surfaces, following outer walls of epidermal cells and exposed walls of guard cells. *Epidermis* cells taller than wide, or as wide as tall or wider than tall, cells on adaxial surface usually larger than abaxial (Figure 6.10A–D); bulliform cells present on one or both surfaces (Figure 6.11A, B), sometimes darkly staining due to tanniniferous substances (Figure 6.12A–F). *Hairs* arising from multicellular base; arms circular to square in outline (Figure 6.13A–D). *Stomata* present on both surfaces. *Guard cells* about ⅓ to ½ dimensions of subsidiary cells; outer, poral and inner walls more thickened than epidermal wall; outer stomatal lip (ledge) well-developed, often raised; inner stomatal lip (ledge) obscure or poorly developed; substomatal cavity well-developed; subsidiary cells as tall as or twice as tall as wide (Fig 6.14A–D). *Hypodermis* absent. *Mesophyll* chlorenchymatous, spongy type (Figure 6.15A, B) or sometimes differentiated into palisade (Figure 6.16A, B), 2–11 cells thick, shape and dimensions variable. *Vascular bundles* in a single row with bundle in midrib region usually the largest (Figure 6.17A–F), usually of three sizes (Figure 6.18A–F); large (Figure 6.19A–F), medium (Figure 6.20A–F) and small (Figure 6.21A–D); large bundles alternating with medium and small bundles, commonly with sclerenchyma forming girders (Figure 6.19A–F), occasionally linking to smaller lateral bundles (Figure 6.19B); medium bundles with sclerenchyma as girder and cap at opposite poles (Figure 6.20A–C) or caps at both poles (Figure 6.20D–F) and small bundles with sclerenchyma reduced (Figure 6.21A–D); randomly orientated tiny bundles lacking sclerenchyma present in spaces between large bundles, also single row of tiny bundles at the flanks of largest bundles partially or wholly surrounded by inner sclerenchyma bundle sheath. *Phloem* in abaxial position. *Xylem* in adaxial position. *Margins* without sclerenchyma. *Bundle sheaths* with outer sheath of single layer of parenchyma, inner sheath sclerenchymatous, variously developed. *Crystals* present as raphides in sacs in mesophyll (Figure 6.22A–D), styloids absent. *Mucilaginous canals* absent. *Silica bodies* absent. *Tanniniferous substances* present in epidermal and bulliform cells (Figure 6.12A–F).

6.3.3 Anatomical characters of taxonomic value

The examination of leaf surface characters in this study was limited to SEM. Surface ornamentation in *Hypoxis* was found to be of little value for taxonomy in comparison to other monocot groups, for example *Kniphofia* (Baijnath 1980), *Bulbine* (Baijnath & Cutler 1993) and in *Aloe* and *Gasteria* (Cutler 1972) where striae and papillae provide valuable characters for separating species. Nevertheless, the results of this study proved useful in confirming the distribution and types of hairs discussed in Chapter 5.

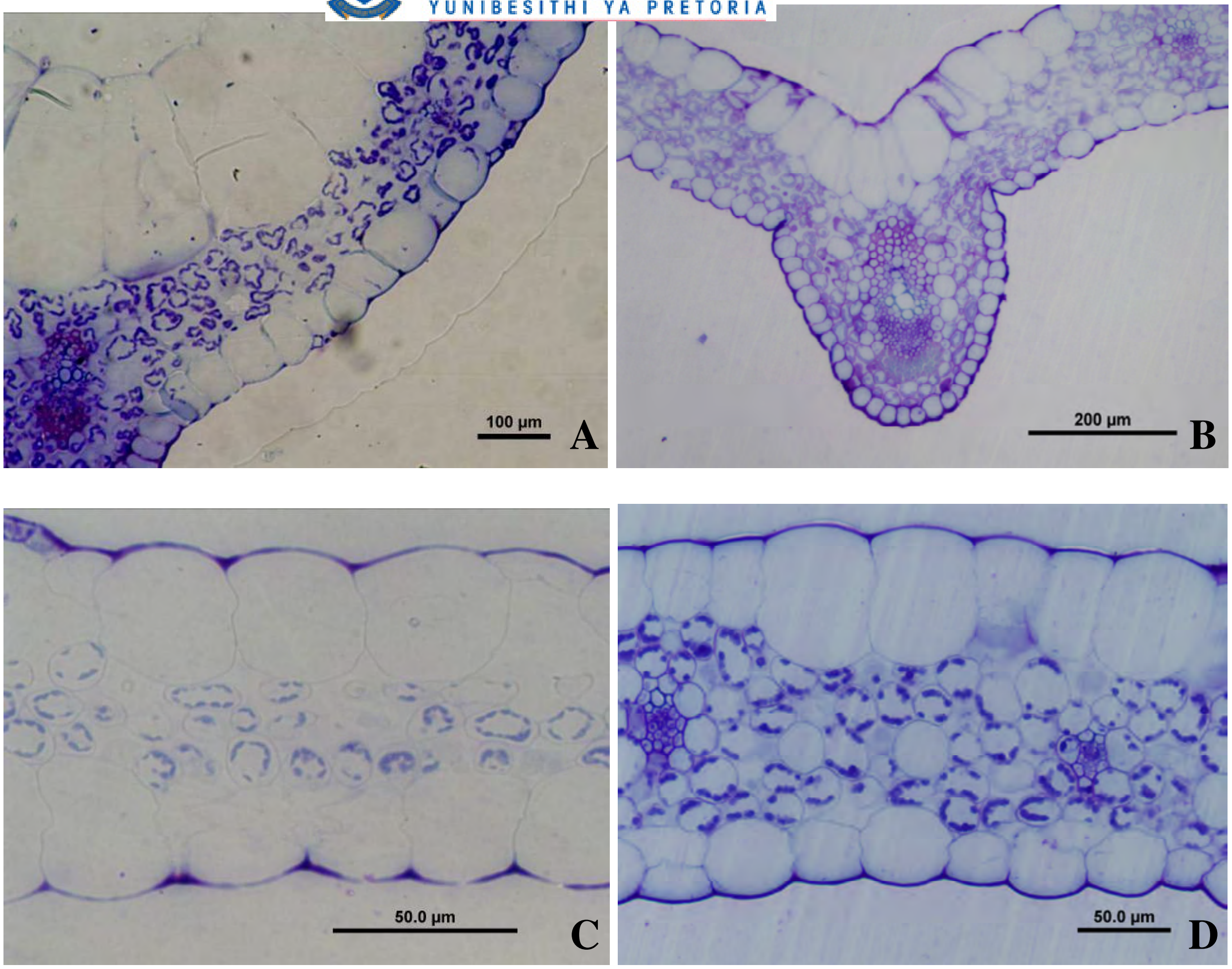

Figure 6.10.—Transverse sections of leaves showing narrow mesophyll. A, *H. parvula* var. *parvula* (*Singh 556*); B, *H. angustifolia* var. *buchananii* (*Singh 814*); C, *H. membranacea* (*Singh 826*); D, *H. flanaganii* (*Singh 807*).

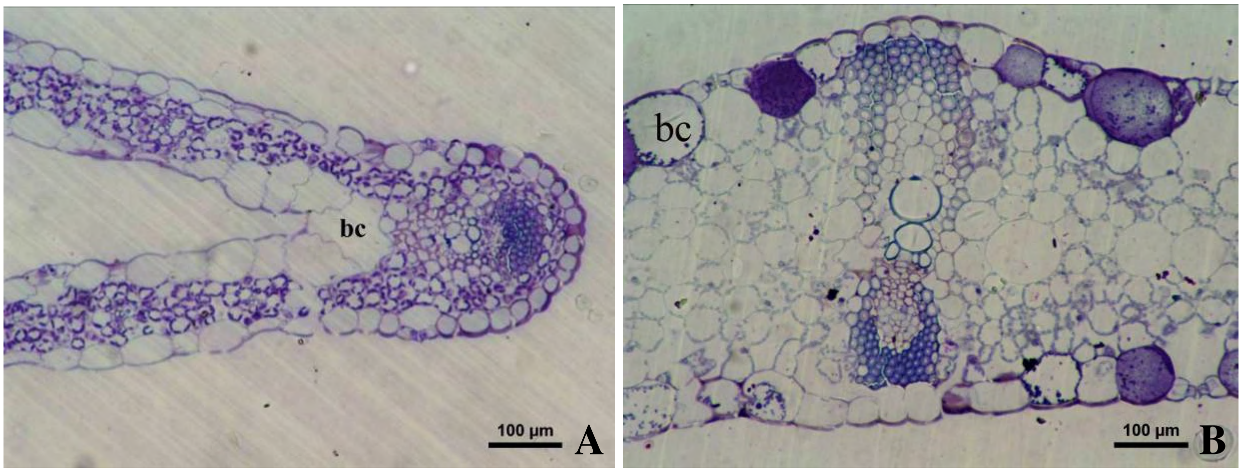

Figure 6.11.—Transverse sections of leaves showing bulliform cells (bc). A, *H. argentea* var. *sericea* (*Singh 259*); B, *H. hemerocallidea* (*Singh 262*).

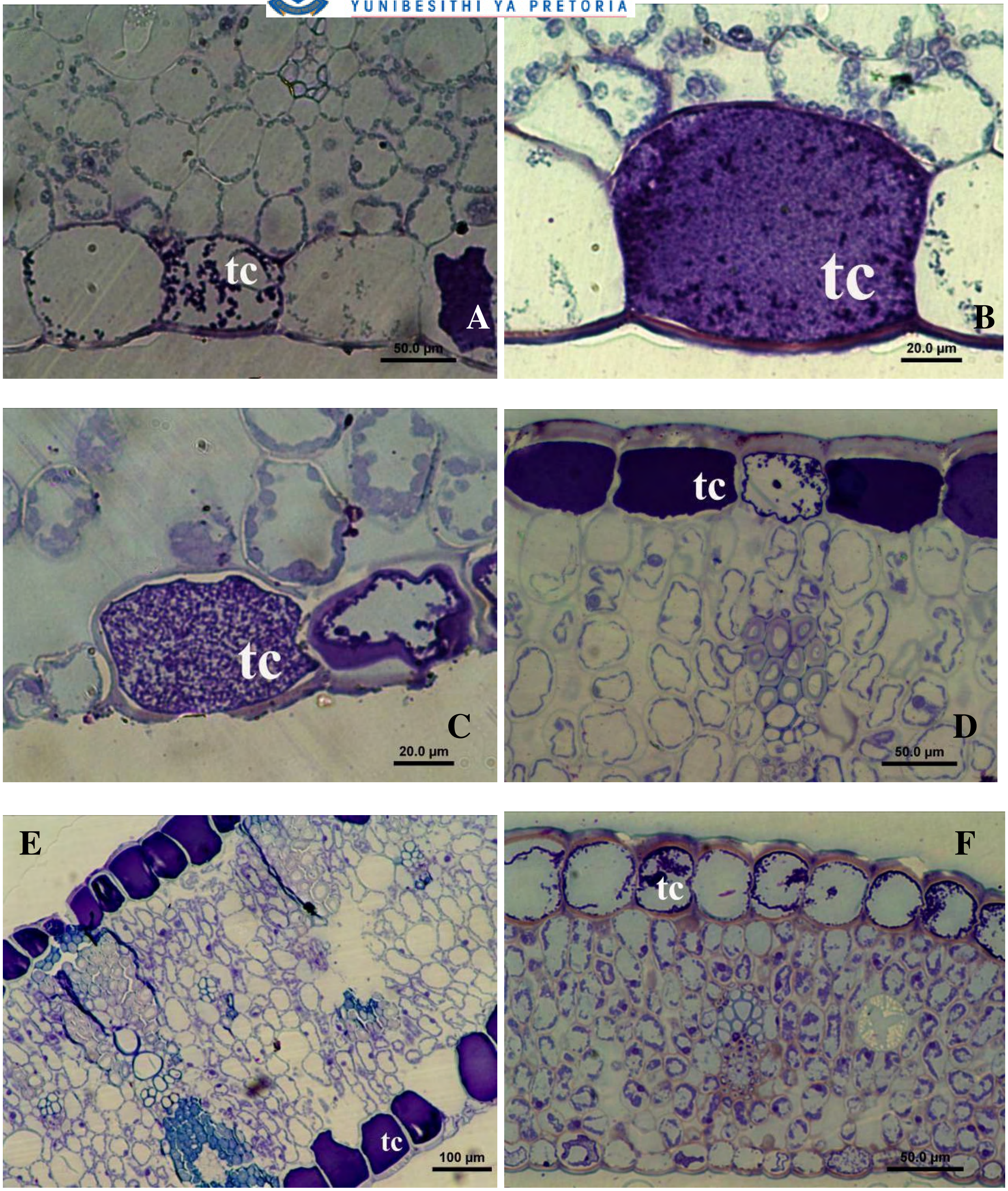

Figure 6.12.— Transverse sections of leaves showing cells with tanniniferous compounds (tc). A, B, *H. hemerocallidea* (*Singh 262*); C, *H. rigidula* var. *pilosissima* (*Singh 263*); D, *H. galpinii* (*Singh 334*); E, *H. obtusa* (*Singh 337*); F, *H. stellipilis* (*Singh 621*).

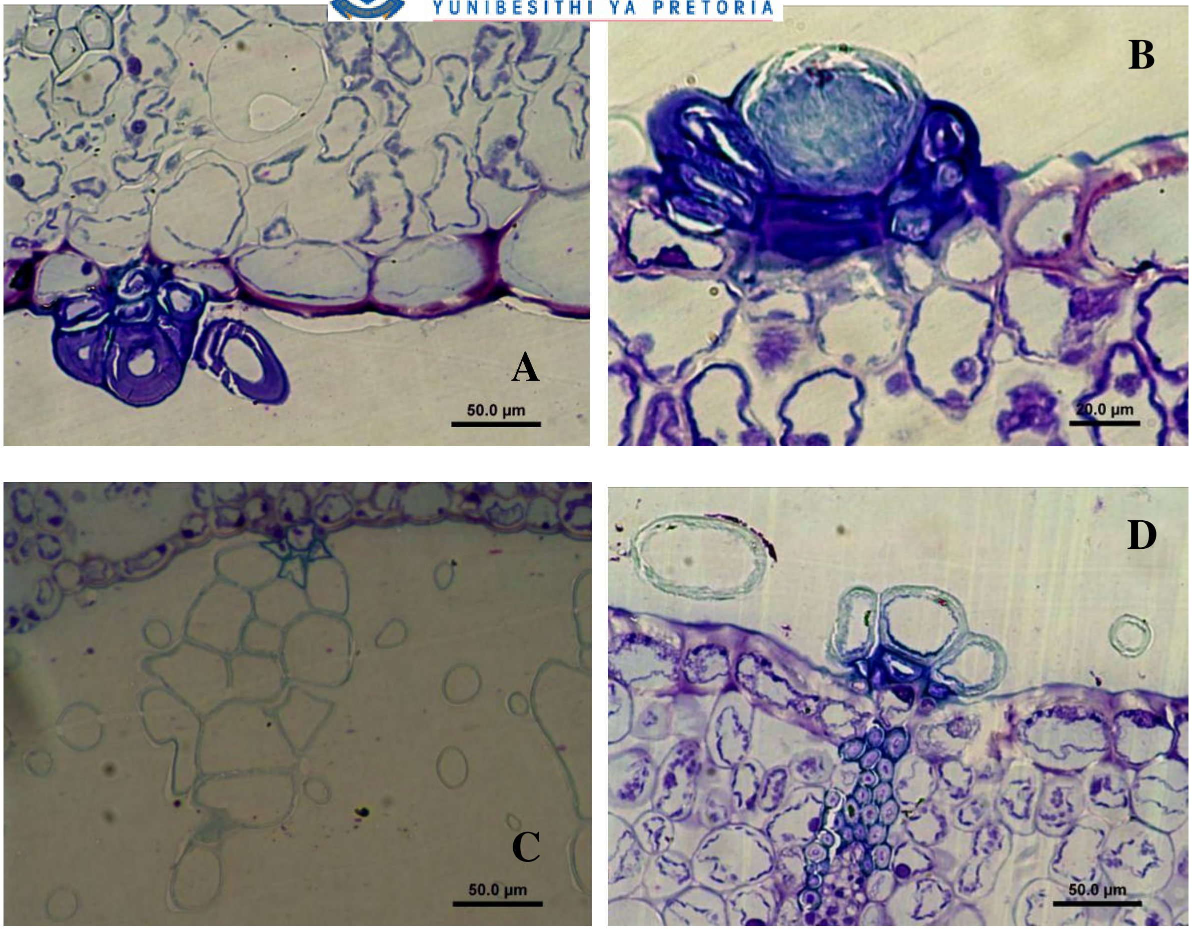

Figure 6.13.— Transverse sections of leaves showing hair attachment and outline. A, *H. multiceps* (*Singh 279*); B, *H. rigidula* var. *rigidula* (*Singh 329*); C, *H. stellipilis* (*Singh 621*); D, *H. obtusa* (*Singh 283*).

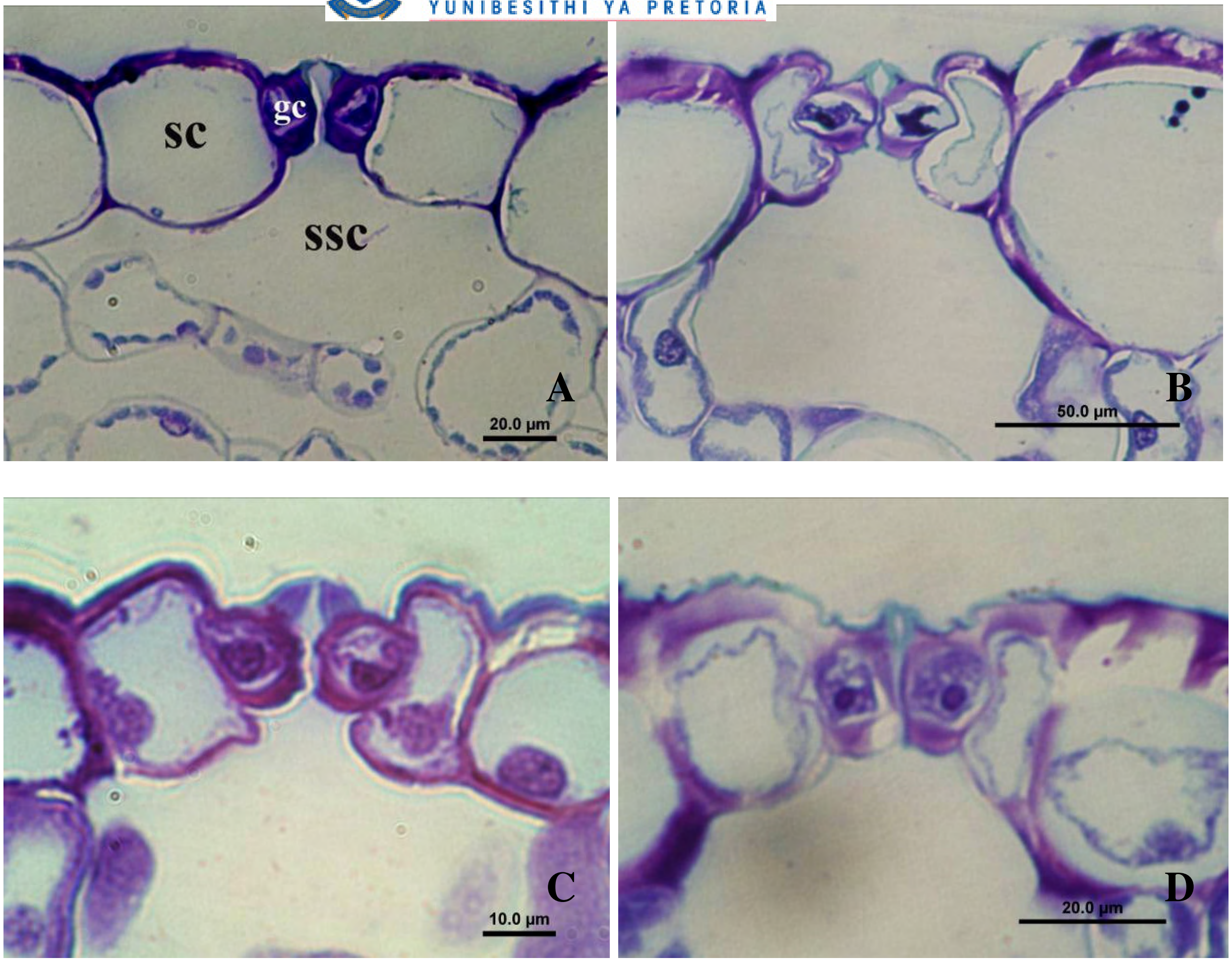

Figure 6.14.—Transverse sections of leaves showing outer stomatal lip. A, *H. costata* (*Singh 803*), sc = subsidiary cavity, ssc = substomatal cavity, gc = guard cell; B, *H. interjecta* (*Singh 280*); C, *H. acuminata* (*Singh 286*); D, *H. rigidula* var. *rigidula* (*Singh 282*).

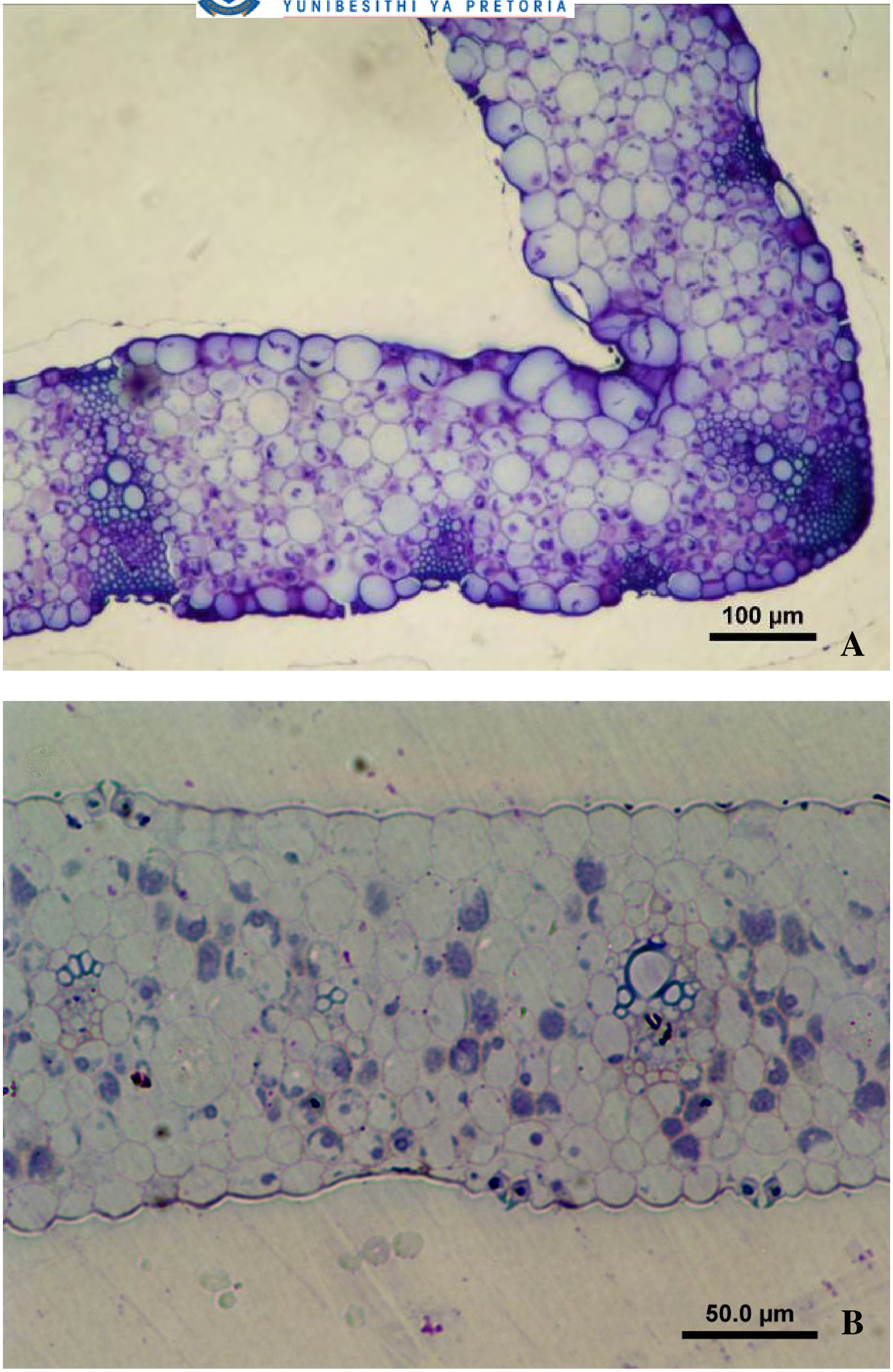

Figure 6.15.—Transverse sections of leaves showing spongy mesophyll. A, *H. filiformis* (*Singh 418*); B, *H. argentea* var. *argentea* (*Singh 626*).

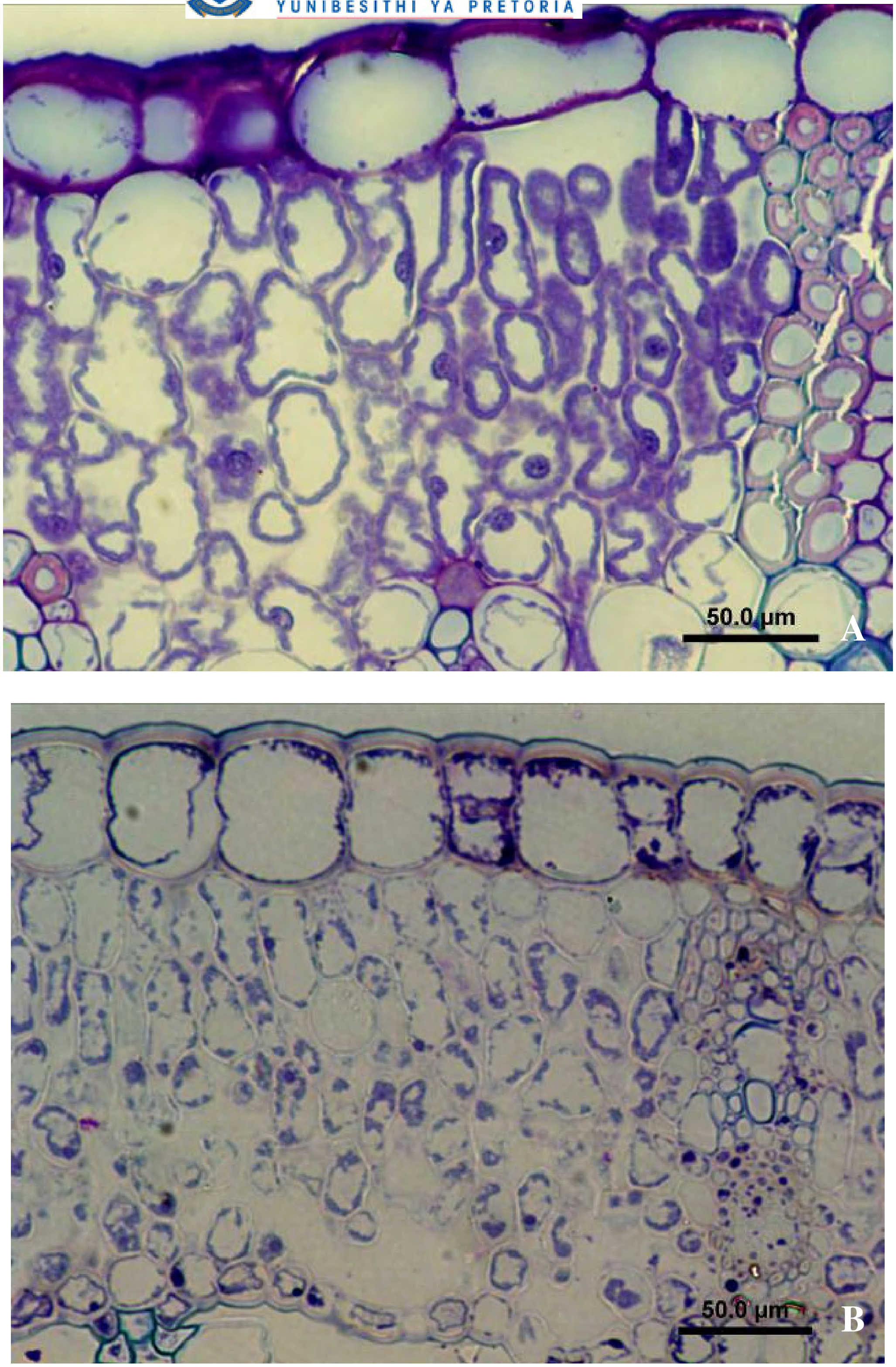

Figure 6.16.—Transverse sections of leaves showing palisade mesophyll. A, *H. obtusa* (*Singh 337*); B, *H. stellipilis* (*Singh 621*).

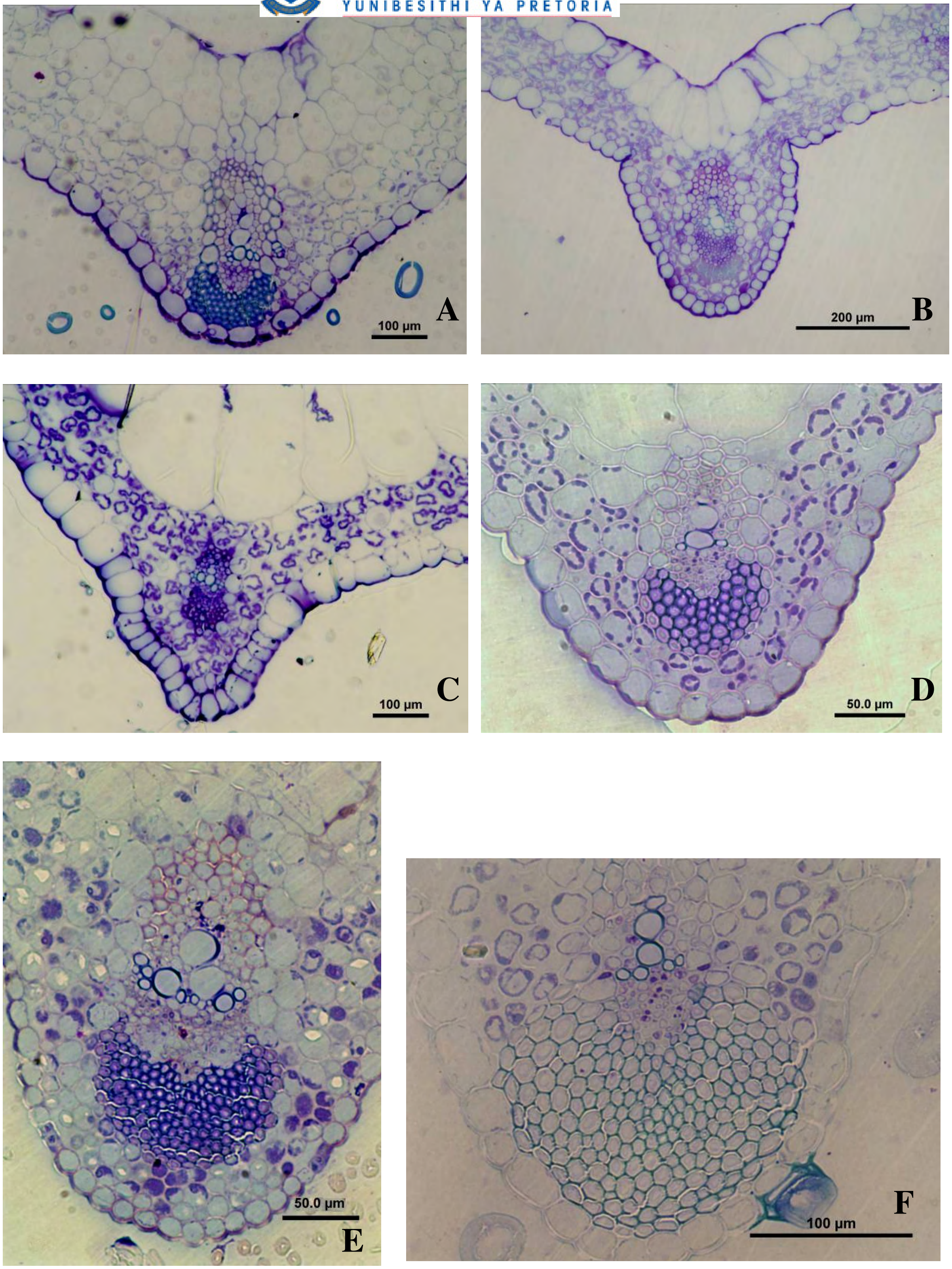

Figure 6.17.—Transverse sections of leaves showing midrib vascular bundle. A, *H. costata* (*Singh 803*); B, *H. angustifolia* var. *buchananii* (*Singh 814*); C, *H. parvula* var. *parvula* (*Singh 556*); D, *H. flanaganii* (*Singh 807*); E, *H. argentea* var. *argentea* (*Singh 626*); F, *H. parviflora* (*Singh 470*).

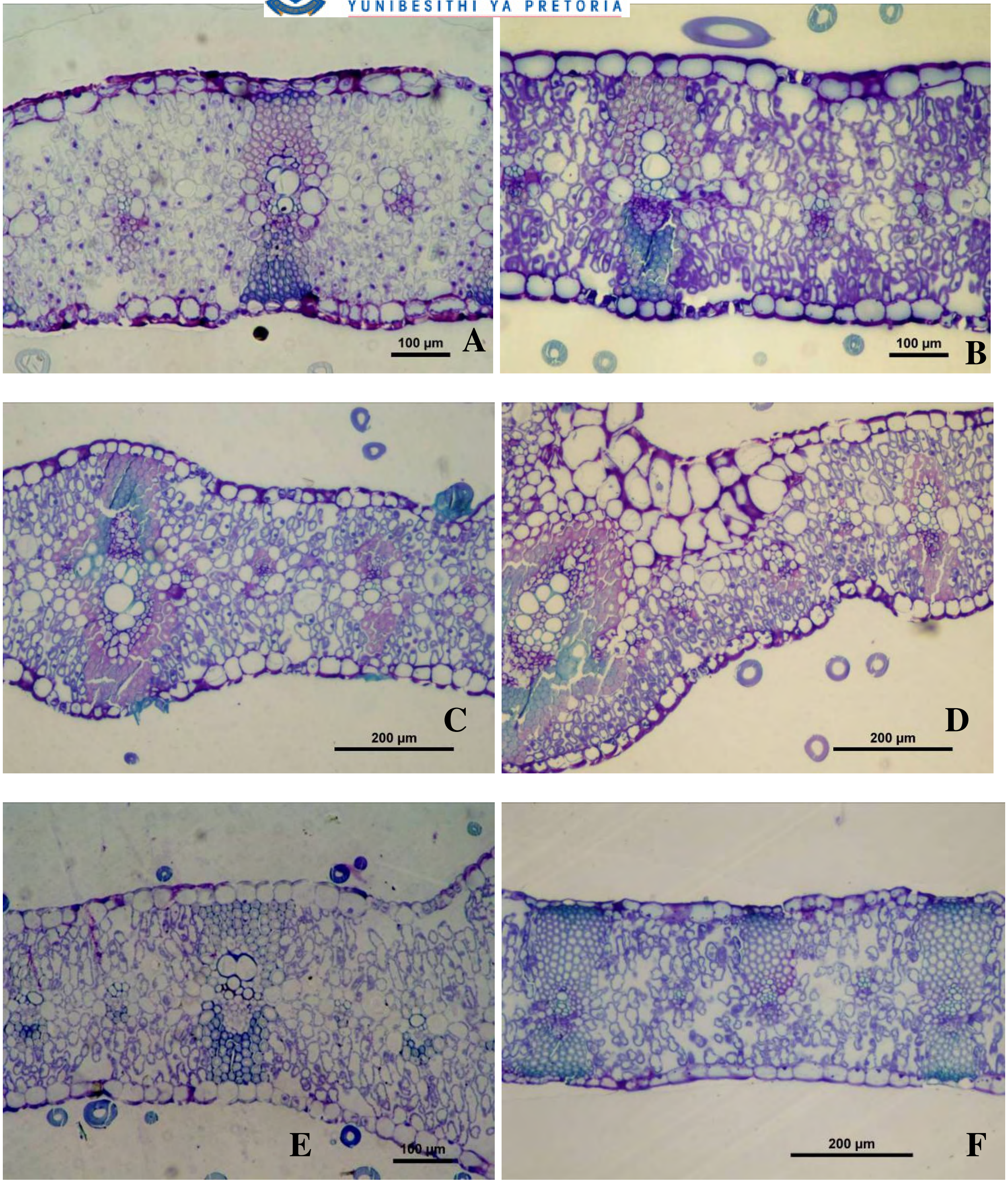

Figure 6.18.—Transverse sections of leaves showing vascular bundles of three sizes arranged in a single row. A, *H. obtusa* (*Singh 277*); B, *H. obtusa* (*Singh 337*); C, *H. rigidula* var. *pilossisma* (*Singh & Baijnath 318*); D, *H. rigidula* var. *rigidula* (*Singh 317*); E, *H. obliqua* (*Singh 531*); F, *H.costata* (*Singh 300*).

7

FLORAL AND FRUITING MORPHOLOGY

7.1 Introduction

Flower characters are valuable in demarcating southern African genera in the Hypoxidaceae (see Chapter 2, Table 2.4). *Pauridia*, a genus endemic to the Western Cape differs in having three fertile stamens while all other genera have six stamens or rarely four. In *Pauridia*, *Rhodohypoxis* and *Saniella*, tepals are fused at the base into a tube and this helps to separate them from *Empodium*, *Hypoxis* and *Spiloxene* that have free tepals. In classifying the genera, Nel (1914) emphasised the taxonomic value of stamens, particularly the way the anthers are attached to the filaments. Hilliard & Burtt (1978) found this character useful to classify the genera of Hypoxidaceae into two groups and they offer an illustrated discussion on the types of anther attachment (discussed under stamens further on).

In *Hypoxis*, the inflorescence is subtended by a leafless scape and bears two (rarely one) to many flowers. The flowers are epigynous, actinomorphic with six (rarely four) petaline tepals in two whorls. Each flower has six (rarely four associated with four tepals) stamens with anthers latrorse, and the pollen grains are single (monads) and monosulcate. The gynoecium is tricarpellate, with a single style, and the stigma is pyramidal or spherical. Placentation is axile and the ovules anatropous. The fruit is a capsule that splits along the circumference and the upper part formed by the persistent tepals drops off as a lid to expose the seeds. Seeds in *Hypoxis* have a black phytomelan crust which is either smooth or papillate and they have a non starchy endosperm. Flowers open for part of the day, each flower once for a single day and are bee-pollinated. Although basic flower morphology in *Hypoxis* is fairly uniform among species, diversity in the genus is reflected by other flowering and fruiting structures including the scapes, flower-bearing axis (rachis), pedicels, capsules and seeds. This Chapter describes the floral and fruiting characters of taxonomic significance in *Hypoxis* and discusses their variation amongst and within taxa.Variation in morphology of these structures, though subtle in some species, is useful in demarcating taxa, especially when used in combination with vegetative characters (discussed in Chapter 5).

7.2 Taxonomic significance of inflorescence and floral characters

7.2.1 Scape

All species of *Hypoxis* produce one or more scapes (leafless peduncles) that arise in the axils of leaves. Generally, scapes are shorter, or about the same length as the leaves except in *H. kraussiana*, *H. parvifolia* and *H. parvula*, where they may be longer than the leaves. Scapes on a plant reach about the same height in most species except in a few robust ones, namely *H. colchicifolia*, *H. galpinii* and *H. rigidula* where their lengths vary. Baker (1898) applied scape length to distinguish among Tropical African species of *Hypoxis*

The scape is generally ancipitous (two-edged) just below the flower-bearing part with sides rounded or flattened (elliptic in cross section). Scapes with rounded sides are found in *H. acuminata*, *H. kraussiana*, *H. longifolia*, *H. rigidula*, *H. stellipilis*, *H. sobolifera* and *H. villosa* while flattened scapes are present in *H. costata*, *H. hemerocallidea*, *H. interjecta*, *H. multiceps* and *H. obtusa*. *Hypoxis filiformis*, *H. longifolia* and *H. tetramera* are distinct in having scapes that are terete and grooved, appearing crescent shaped in cross section. Scapes in the genus are stiff and the upper portion is covered in hairs, in most species more densely so than on the leaves. Indumentum density and colour are diagnostic in few species and add confirmatory value to the identification of a species. For example, in *H. multiceps*, hairs on the scapes are scabrous and yellow, rarely white and this helps to identify the species. Scapes of *H. stellipilis* have a tomentose white indumentum that is distinguishes it from the remaining species with corymbose inflorescences (explained under 7.2.2). The scape is otherwise of little value in classification.

7.2.2 Flower-bearing axis ("Inflorescence")

The scape in *Hypoxis* terminates in few to many flowers borne in a racemose or corymbose arrangement, rarely is there a solitary flower. In inflorescences with more than four flowers, flowers may be arranged in pairs, alternate or opposite to each other or they may have two basal flowers opposite each other and above these, consecutive tiers of two or three flowers.

Baker (1878b) described the scape in *Hypoxis* as bearing a single flower or few flowers in a corymb, or bearing numerous flowers in an acropetal raceme. In his treatment in Flora Capensis, Baker (1896) recognised two main types of inflorescences in *Hypoxis*, racemose and corymbose. Later, in his key to species in Tropical Africa, Baker (1898) used flowers solitary, corymbose or racemose as a significant character for separating species. Nel (1914) provided a full description of the inflorescence in *Hypoxis* where he adopted the states recognised by Baker but used the term 'false umbel' instead of corymbose. He considered species with racemes to bear 8–18 flowers and have pedicels that vary in length; the lowermost flowers being held on longer pedicels than the flowers above. He noted that in some species, pedicels are reduced and the flowers are almost sessile. Nel (1914) described the corymb (false umbel) as bearing 3–7 flowers with the lowermost flowers having significantly longer pedicels than the flowers above. In addition, Nel noted that the varying lengths of pedicels in this type of inflorescence caused all the flowers to be held at almost the same height and therefore his use of the term false umbel. He recorded the presence of a 'false umbel' in four species, namely *H. angustifolia*, *H. stellipilis*, *H. sobolifera* and *H. villosa*. Nel further related Sections *Angustifoliae*, *Argenteae* and *Villosae*, which he considered to have cleft anther tips, with false umbels where the flowers are held at almost same height. He considered that in general the species with entire anther tips may also have false umbels but with flowers not at the same height. Nel described the variations in the false umbel inflorescences in *Hypoxis* based on number of flowers and bracts, and surmised that the variations may be due to reduction or involution of the raceme. He further considered the inflorescence of *H. rooperi* (= *H. hemerocallidea*) to represent the transition from racemose to corymbose. Heideman (1987) adopted the descriptions provided by Nel and illustrated the variation seen in inflorescences in species of the Witwatersrand. Wiland-Szymańska and Nordal (2006) applied inflorescence type as a differentiating character in their key to species in the Flora of Tropical East Africa region.

As recognised by Baker (1878b) and Nel (1914), inflorescence type is a good character for distinguishing groups of species in *Hypoxis*. In the present study, two inflorescence types are recognised in *Hypoxis*, namely a raceme (Figure 7.1) and a corymb (Figure 7.2). In general, racemes consist of (4-)5–17 flowers and corymbs have 4–5(-10) flowers, but in both types reduction in the number of flowers to less than four is noted. The main difference between the raceme and corymb is in the level at which flowers are held along the axes. In the raceme, flowers are borne on short pedicels (usually up to 15 mm) at varied levels on the axes while in the corymb, the lower flowers are elevated on long pedicels (20 mm or more) to lie at the same level as the terminal flowers. Among species with racemose inflorescences, the reduction in pedicel length of all flowers, except the two lowermost ones gives rise to a spike-like raceme and this is found in *H. colchicifolia*, *H. galpinii* and *H. rigidula*, species with a robust habit.

The racemose state is evident when there are more than four flowers on an inflorescence. However, in a few species like *H. hemerocallidea*, *H. obtusa*, *H. longifolia* and *H. ludwigii*, when there are four or less flowers and these arise from a common point and have pedicels of almost

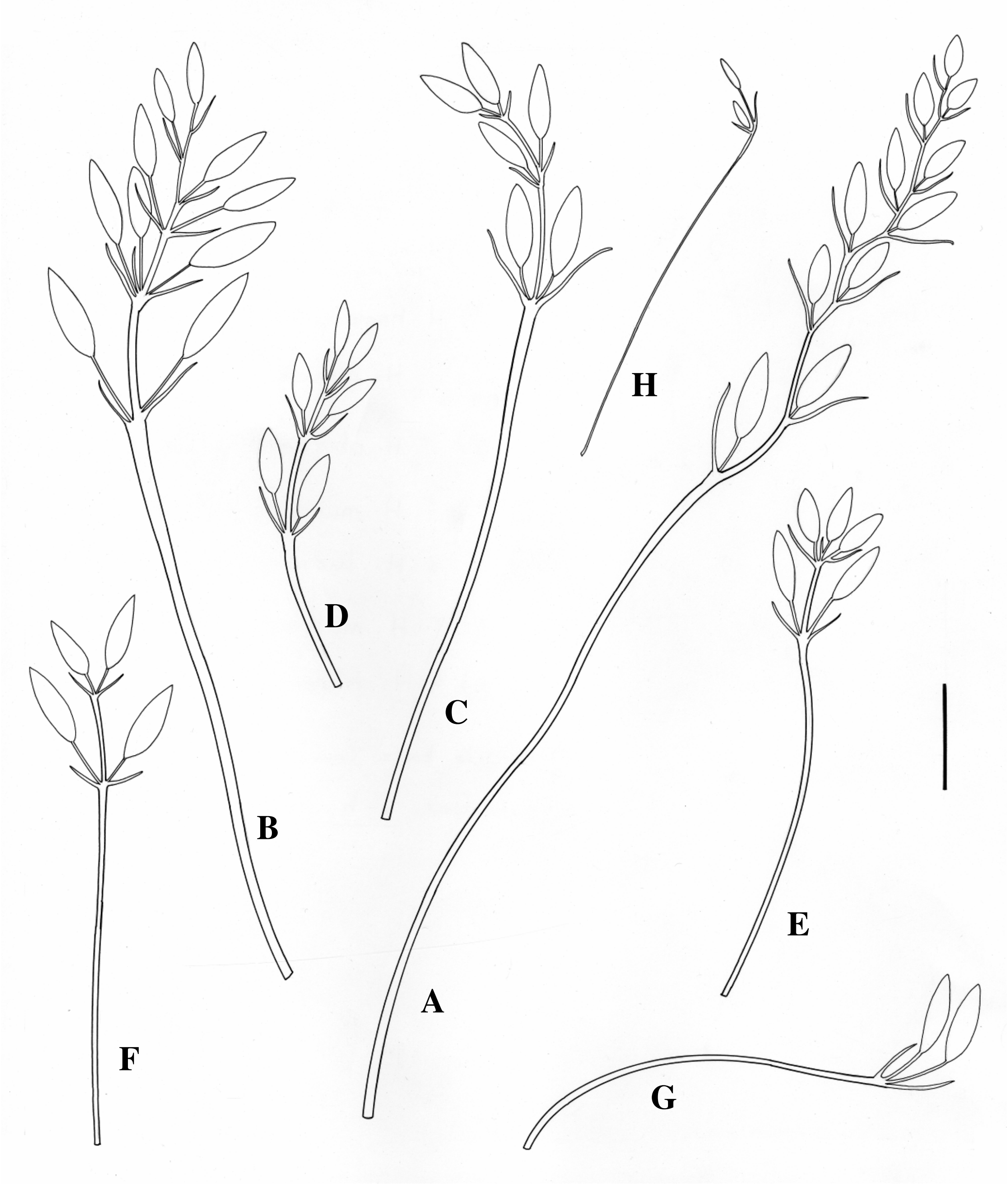

Figure 7.1.—Raceme. A, more than six flowers, *H. rigidula* var. *rigidula*, *Singh 317* (NH); B, more than six flowers, *H. hemerocallidea Singh 321* (NH); C, six flowers, *H, obtusa*, *Singh 583* (NH); D, six flowers, *H. obliqua*, *Cloete 512* (NH); E, five flowers, *H. multiceps*, *Singh 322* (NH); F, four flowers, *H. ludwigii*, *Greene 727* (NH); G, two flowers, *H. multiceps*, *Singh 642* (NH); H, two flowers, *H. filiformis*, *Singh 823* (NH). Scale bar: A–H, 30 mm. Artist: A.J. Beaumont.

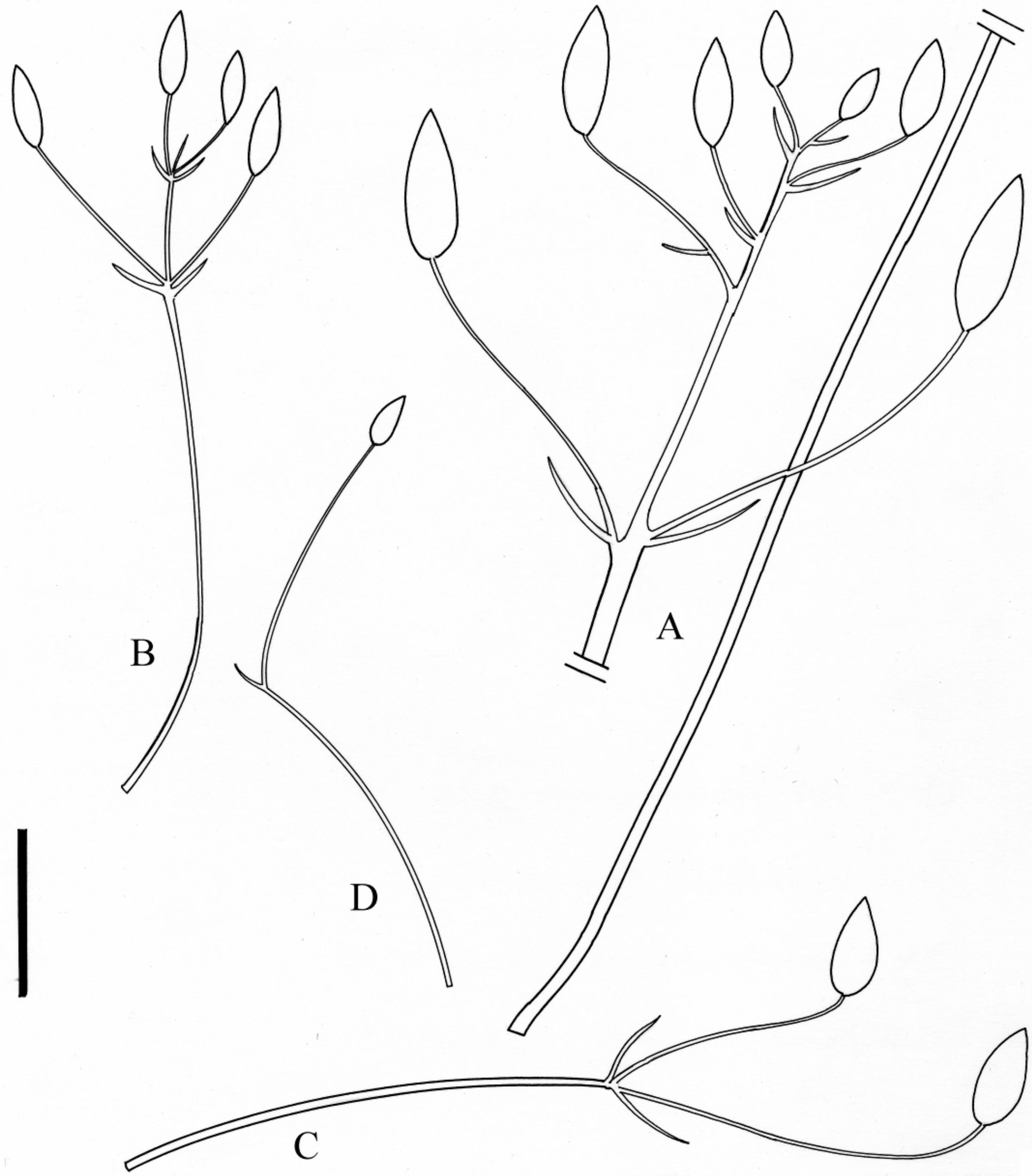

Figure 7.2.—Corymbs. A, seven to eight flowers, *H. sobolifera* var. *sobolifera Singh 233*; B, four flowers, *H. argentea* var. *sericea*, *Singh 498* (NH); C, two flowers *H. membranacea*, *Singh 826* (NH); D, one flower, *H. parvula* var. *parvula*, *Singh 308* (NH). Scale bars: A, B, D, 30 mm; K, 10 mm. Artist: A.J. Beaumont.

equal length, the inflorescence resembles a corymb. In these species, corymb-like inflorescences are occasional and they often occur together with racemes on the same plant. Number of flowers, length of pedicels of the two lowermost flowers and flexibility of pedicels are useful for classifying types of inflorescences in *Hypoxis*. Based on these characters, species can be categorised into groups (Table 7.1). About equal number of species have racemes or corymbs.

Table 7.1.—Distribution of inflorescence types and number of flowers among species

Raceme		**Corymb**	
Pedicels firm and erect, lowermost usually 5–30 mm long Flowers held at varying heights along axis		Pedicels soft and flexible, lowermost usually 10–50 mm long All flowers come to lie almost at the same height	
Flowers 5–17	Flowers 1–5 (rarely 6)	Flowers mostly 4–5(-10)	Flowers 1–2
H. colchicifolia	*H. acuminata*	*H. angustifolia*	*H. flanaganii*
H. galpinii	*H. costata*	*H. argentea*	*H. floccosa*
H. hemerocallidea	*H. filiformis*	*H. gerrardii*	*H. membranacea*
H. longifolia	*H. interjecta*	*H. nivea*	*H. parvula*
H. ludwigii	*H. kraussiana*	*H. stellipilis*	
H. obtusa	*H. multiceps*	*H. sobolifera*	
H. rigidula	*H. obliqua*	*H. villosa*	
	H. parvifolia	*H. zeyheri*	
	H. tetramera		

Inflorescences are produced at the beginning of the growing season, around September and in a few taxa (*H. angustifolia* var. *buchananii*, *H. hemerocallidea* and *H. obtusa*) they are produced continuously throughout the growing season until March. In most species, flowering peaks in October–November after the September rains and/or winter and spring burns. From December onwards, plants reach the fruiting stage and the formation of new inflorescences stops or is reduced.

7.2.3 Flower

In *Hypoxis*, the tepals are free, exposing stamens and style (Figures 7.3 & 7.4). *Hypoxis* flowers are fairly uniform in structure except for slight differences in colour, size and texture of the tepals. In creating sections in *Hypoxis*, Nel (1914) applied two reproductive characters, namely anther apex entire or split, and differences in the relative lengths of style and stigma. These characters were used in combination with the leaf width and number of veins on blades. In her treatment of *Hypoxis* in Central Africa, Wiland-Szymańska (2001) indicated that the gynoecium characters selected by Nel (1914) were not stable for polymorphic species and she cited *H. angustifolia* and *H. hockii* De Wild. as examples. In the following year, Wiland-Szymańska & Adamski (2002) discussed the variation in anther features, and style and stigma ratios in *H. angustifolia*. Comments on these

7.3.—Tepal arrangement. A, *H. hemerocallidea*; B, *H. flanaganii*

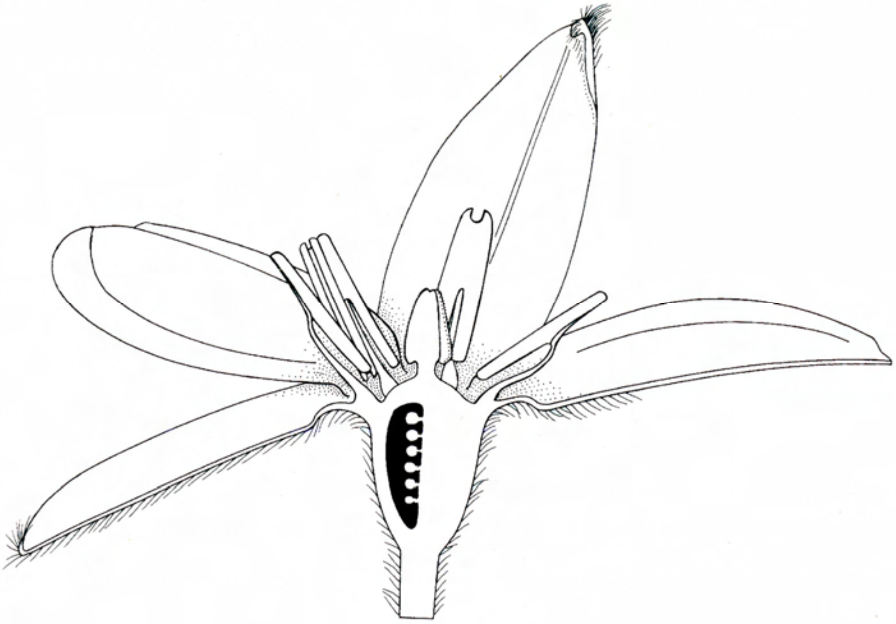

Figure 7.4.—Half flower drawing showing position of stamens relative to tepals in *Hypoxis*. Adapted from Singh (2000).

structures follow under the relevant sections below.

7.2.3.1 Bracts

Each flower in *Hypoxis* is supported by a single bract. In species with single flowers, one or two bracts are present. The presence of the second bract indicates an evolutionary reduction in the number of flowers. The bracts are linear to subulate, acute, keeled and with membranous margins, hairy on the lower surface and range from 4–35 mm in length. In the racemose inflorescences, the bracts are half as long, equal to or longer than the length of the pedicels while in corymbose inflorescences, the bracts are about one third to half as long as the pedicels. The range of the longer bracts in racemes overlaps with the length of bracts in the corymbs, making it difficult to apply the character in sparating species or groups of species. Herndon (1992) found that in the Florida members of *Hypoxis,* the relative lengths of bract and pedicel are useful in demarcating species, but he also cautioned that the character is not very reliable when used on its own. Bracts have not been used on their own or in combination with pedicel lengths in any recent study on the African members of *Hypoxis*.

7.2.3.2 Pedicels

Pedicels in *Hypoxis* are slender and range in length from 10 to 40 mm, being longer in corymbose inflorescences and shorter in racemes. Length of the pedicels has been used by Nel (1914) as a character to separate species. It has also been used in keys by contemporary botanists working on tropical African species of *Hypoxis*. Nordal & Zimudzi (2001), for example, combined length of lowermost pedicels with scape features to distinguish among species in the Flora Zambesiaca region. Wiland-Szymańska and Nordal (2006) also used pedicel length in combination with characters of leaf, scape and inflorescence for species identification. The latter study included five taxa that also occur in southern Africa. Heideman (1987) provided a practical identification key to species of *Hypoxis* on the Witwatersrand. She used pedicel length in combination with leaf, indumentum and flower number to separate *H. filiformis* from *H. argentea*. Further, she described the pedicels of each pair of flowers in *H. filiformis* to be unequal and those of *H. argentea* to be equal. During field work in the Durban area, *H. filiformis* was observed growing with *H. angustifolia* and it was confirmed that the two species can also be separated on the lengths of pedicels, being unequal in *H. filiformis*. Essentially, length of pedicels is an important character for distinguishing between species with racemose and corymbose inflorescences (Table 7.1, Figures 7.1 & 7.2). Pedicels are green in most species but populations of *H. angustifolia* var. *angustifolia*, *H. argentea*, *H. flanaganii* and *H. sobolifera* were found to have red or pink pedicels.

7.2.3.3 Tepals

Flowers in *Hypoxis* have six free tepals arranged in two whorls, the three outer ones alternating with the inner ones in a regular star-shape pattern (Figure 7.3). The tepals are elliptic or ovate-elliptic, with the outer ones slightly narrower with acute tips and the inner tepals with slightly more round tips. In some species, the wider, round tips of the inner tepals gives them an ovate shape. In some plants of *H. filiformis* and *H. tetramera*, tepals may be reduced to four and this was seen mostly in populations of *H. filiformis* growing in bogs. Baker (1878b) recorded the tetramerous state once in an Australian species. Nel (1914) mentioned that he had only seen less than six tepals in *H. saggitata* Nel. Hepper (1968) noted that *H. urceolata* Nel usually has six tepals but four segments do also occur in the species. In *H. angustifolia* and *H. hemerocallidea*, an aberration of eight tepals was recorded during the present study in plants kept in cultivation, but this is extremely rare and clearly an aberration. The stamen number in tetramerous and octamerous plants corresponds to the number of tepals.

Flower colour in *Hypoxis* is yellow except in *H. membranacea* (Figure 5.19B), *H. nivea* (Figure 5.19D) and *H. parvula* var. *albiflora* which have white flowers. All tepals are smooth and bright yellow (seldom white) on the inner (adaxial) surface. The outer (adaxial) surface of outer tepals is green and hairy whereas that of the inner tepals is yellow (with a narrow green band along the midrib) and slightly hairy. Sometimes, the outer surface of tepals in yellow-flowered species is red-keeled and corresponds with red pedicels. This occurs in *H. angustifolia* var *angustifolia*, *H. argentea*, *H. flanaganii* and *H. sobolifera*. In a few specimens of the white-flowered *H. nivea*, the pink colouration is diffused throughout the tepals and flowers are noted as being pink tinged [*Jordaan 952, 1118* (NH)].

In the present study, an association between size and texture of tepals and that of inflorescence types was found. Large (12–20 mm long), thick-textured tepals are found in racemose species while small (4–10 mm long), thin-textured tepals are present in corymbose taxa as well as in taxa with one or two flowers. Nel (1914) also noted that flowers of the corymbose (false umbel) inflorescences are smaller than those in racemes, but did not quantify the differences in flower size. The present study supports Nel's observation on flower size. Wiland-Szymańska (2001) found tepal size to be a diagnostic character and used it on its own to separate species in Central Africa. Nordal & Zimudzi (2001) used flower size in combination with pedicel length to differentiate two closely related taxa with grass-like leaves with width less than 12 mm. In the present, the diameter of open flowers was found to be useful to group species (Singh 2004). In general, *Hypoxis* in southern Africa can be sorted into two groups based on whether the flowers are less than or more than 15 mm in diameter. Flowers less than 15 mm in diameter are associated with corymbose inflorescences while flowers more than 15 mm are found in racemes. However, a few species namely *H. sobolifera*, *H. stellipilis* and *H. villosa* that forms Group 5 (Singh 2004) have corymbose inflorescences but the open flowers are 15–25 mm in diameter, thus overlapping with the size range of flowers from racemose inflorescences. But, in these species, the leaves are flaccid and can be easily distinguished from the stiff leaves of taxa with racemes. In summary, the texture of tepals is difficult to describe for use in a key, but the diameter of open flowers and the length of the tepals are of taxonomic importance in separating species. Flower size, however, cannot be used on its own but only in combination with vegetative and other inflorescence characters.

7.2.3.4 Stamens

Flowers of *Hypoxis* have six stamens, each attached centrally at the base of a tepal (Figures 7.3 & 7.4). The stamens are arranged in two series, the inner three being slightly shorter than the outer three. The two series is not always noticeable in all species, and is less obvious in species with minute flowers like *H. nivea*, *H. flanaganii* and *H. floccosa*. Filaments in *Hypoxis* are subulate except in the *H. filiformis*, *H. membranacea*, *H. nivea* and *H. parvula* in which they are filform. Anthers in *Hypoxis* are linear or lanceolate, sagittate, basifixed or dorsifixed and open by lateral slits (latrorse). Nel (1914) recognised two states for anthers–one with tips entire (Figure 7.5A) and the other with tips split (Figure 7.5B). He used the type of anther tip as a diagnostic character in a key to sections. ‘Entire’ refers to the thecae being fused at the apex and ‘split’ means the thecae are free. According to Hepper (1968), Nel was in error in ascribing split anther tips in *H. ledermanii*. Although anther tips in *H. angustifolia* are split, variation is seen in the degree of split and this is illustrated in Wiland-Syzmańska & Adamski (2002). Nel (1914) claimed that the feature of entire or split anther tips can be seen with the naked eye and that it was more noticeable in some sections e.g. *Angustifoliae* than in others e.g. *Nyassicae*. In the present study, it was found that it is difficult to assess the anther tips especially in species with minute flowers, and that it was not a very useful character for separation of species since taxa with similar vegetative morphology have the same anther attributes. Entire anther tips were found to be associated with species with rigid leaves while split anther tips occur in species with flaccid leaves. However, Nel’s observations on the state of the anther tips are accurate for southern African species except for *H. hemerocallidea*, where the anther tip is either entire or split. Both anther types occur in *H. hemerocallidea*, Nel (1914) placed *H. hemerocallidea* and *H. rooperi* (considered a synonym of *H. hemerocallidea* in the present study) in different sections.

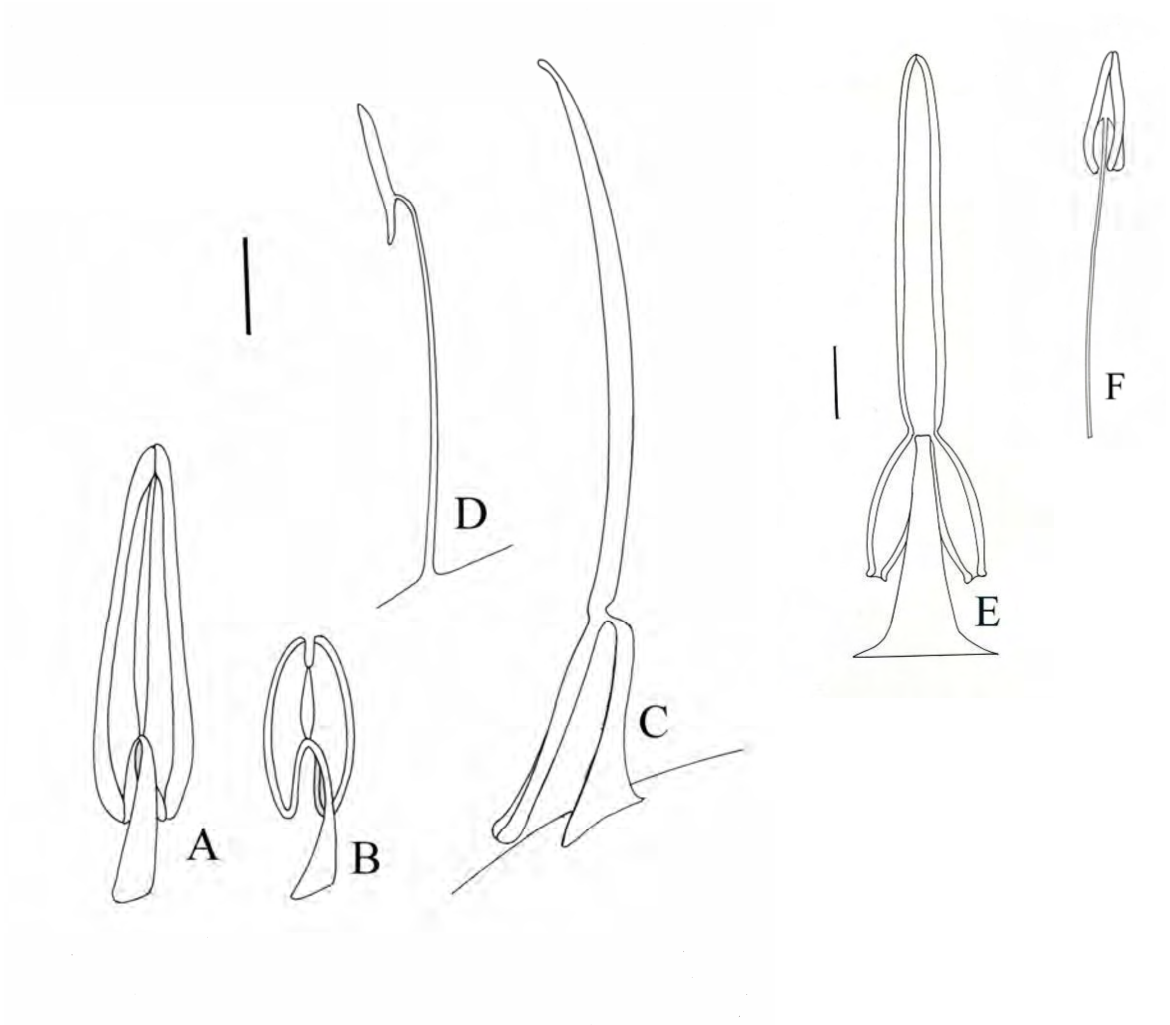

Figure 7.5.—Stamen in *Hypoxis*. A, anther tip entire, *H. hemerocallidea*, *Aubrey s.n.* (NU); B, anther tip spilt, *H. sobolifera* var. *sobolifera*, *Singh & Baijnath 233* (NH); C, stamen showing subulate filament and firm anther attachment, *H. galpinii*, *Singh 632* (NH); D, stamen showing filiform filaments and loose anther attachment, *H. membranacea*, *Singh 366* (NH); E, backview of stamen, *H. galpinii*, *Singh 632* (NH); F, *H. parvula* var. *parvula Singh 366* (NH). Scale bars: A, B, 1 mm; C, D, 2 mm; E, F, 1 mm. Artist: Angela Beaumont.

7.2.3.5 Pollen

Pollen grains in *Hypoxis* are yellow and are quite obvious in the pollen sacs of honeybees (Figure 7.6). Grains in the genus are monosulcate (Figure 7.7A), small, boat-shaped, about twice as long as wide (20–40 x 8–22 µm) and biconvex. The exine is thin and pitted (Figure 7.7B). Pollen grains were found to be similar in all the southern African species of *Hypoxis* and are of no significance for the separation of species.

Figure 7.6.—Pollen collecting bees. A, honeybee visiting flower of *H. galpinii*, pollen sacs filled with yellow pollen; B, solitary bee in flower of *H. colchicifolia*.

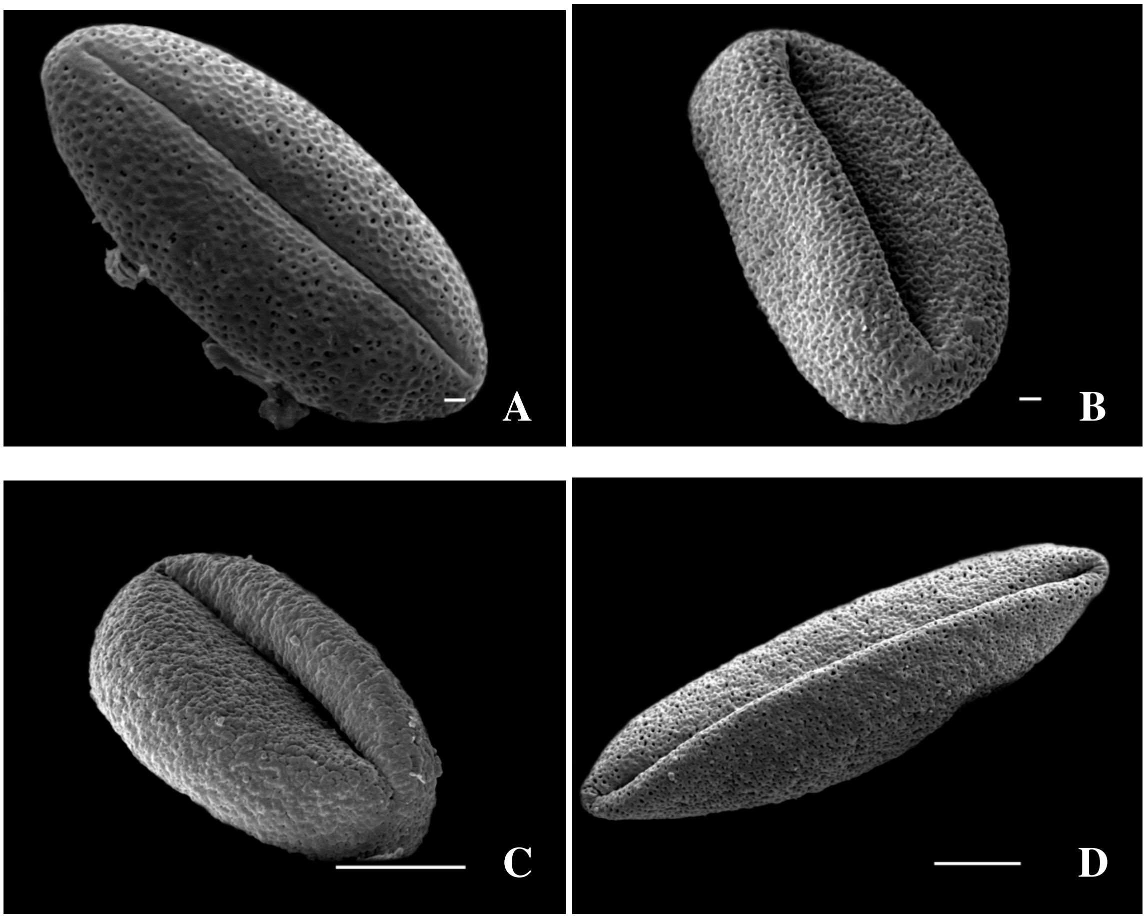

Figure 7.7.—Pollen grains in *Hypoxis* species showing pitted exine, shown in dry state with an infolded furrow. A, *H. galpinii*; B, *H. parvula* var. *parvula*; C, *H. kraussiana*; D. *H. acuminata*. Scale bar: A, B, 1 µm; C, D, 10 µm.

7.2.3.6 Gynoecium

The ovary in *Hypoxis* is inferior, ovate to subglobose 3-locular with axile placentation. Each locule contains 4–16 ovules, biseriately arranged in each locule. The style is well-developed, columnar or filiform; sometimes reduced, then with a broad base and triangular in shape, making the stigma almost sessile. The stigma consists of three concave faces that unite in the shape of a pyramid (Figure 7.8A) and the three free lobes are visible when they become detached from each other, but this is rather uncommon. The stigma in a few species namely *H. membranacea*, *H. nivea* and *H. parvula* and in some specimens of *H. angustifolia* are spherical, but still minutely lobed (Figure 7.8B). The band along the length of the stigma where the lobes unite is papillate (Figures 7.8A & B). Pyramidal stigmas are associated with columnar styles (Figure 7.8A), shorter than or equal to its length, while spherical stigmas are found on filiform styles (Figure 7.8B) that are about 3–5

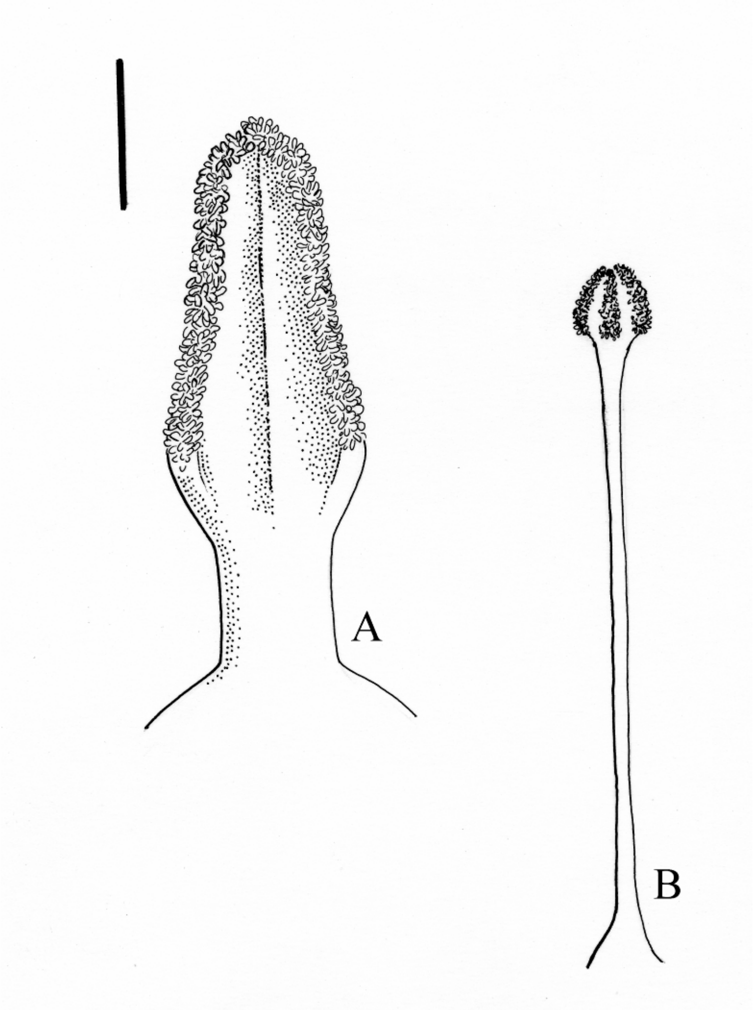

Figure 7.8.—Stigma types in *Hypoxis*. A, pyramidal on columnar style, *H. galpinii*, *Singh 632* (NH); B, speherical on filiform style, *H. parvula* var. *parvula*, *Singh 366* (NH). Scale bar: 1 mm.

times the length of the stigma. Nel (1914) used the spherical stigma on a filiform style to separate *H. membranacea* from the rest of the species. Observations made in the present study confirm that style to stigma ratio is an important character for separating species with filiform styles and minute, spherical stigmas (*H. membrancaea*, *H. parvula*) from those species that have distinct columnar styles and pyramidal stigmas.

7.4 Fruit

The fruit in Hypoxidaceae is either a thin-walled capsule or is succulent to membraneous walled, the latter state referred to as baccate (Nordal 1998). Two types of dehiscence are noted in the thin-walled capsules: (1) circumscissile, where the persistent tepals split open across the carpels and drop off like a lid (pyxis) to expose the seeds and (2) loculicidal, the capsule splits longitudinally (along the carpel walls) into three parts. The 'baccate' fruits are indehiscent, eventually breaking up by disintergration.

Hypoxis fruits are thin-walled capsules (Figure 7.9B) with circumscissile dehiscence (7.9C). In a few of the delicate species namely *H. argentea*, *H. angustifolia*, *H. filiformis* and *H. parvula*, circumscissile dehiscence is followed by longitudinal splitting of the lower part of the capsule (Figure 7.9D). A variation in these types of dehiscence in *Hypoxis* was noted by Hilliard & Burtt (1978) who explained that species growing in damp habitats may lose free dispersal of the seeds and show rather irregular dehiscence. According to them, in these plants, the scape tends to bend downwards after flowering and the fruit being thin-walled is moulded to the shape of the seeds within (Figure 7.10). In the present study, this phenomenon has been observed in plants of *H. angustifolia* and *H. filiformis* growing in the damp habitats. However, not all populations growing in damp conditions show this pattern, for example, capsules of *H. parvula* which grow in moist cliff faces, undergoes circumscissile dehiscence (Figure 7.11).

Capsules in *Hypoxis* are straw-coloured, ovate to round and like the flowers, fruit size varies between the robust and delicate species. In the robust species, capsules are about 7–12 mm x 5–8 mm and in delicate species, they are 3–4 mm x 2–4 mm. Size of capsule can be used in combination with leaf texture and inflorescence type to confirm the identity of a species. Fruit characters are not normally used to define species or groups of species in the genus, probably because they may be lacking on herbarium specimens.

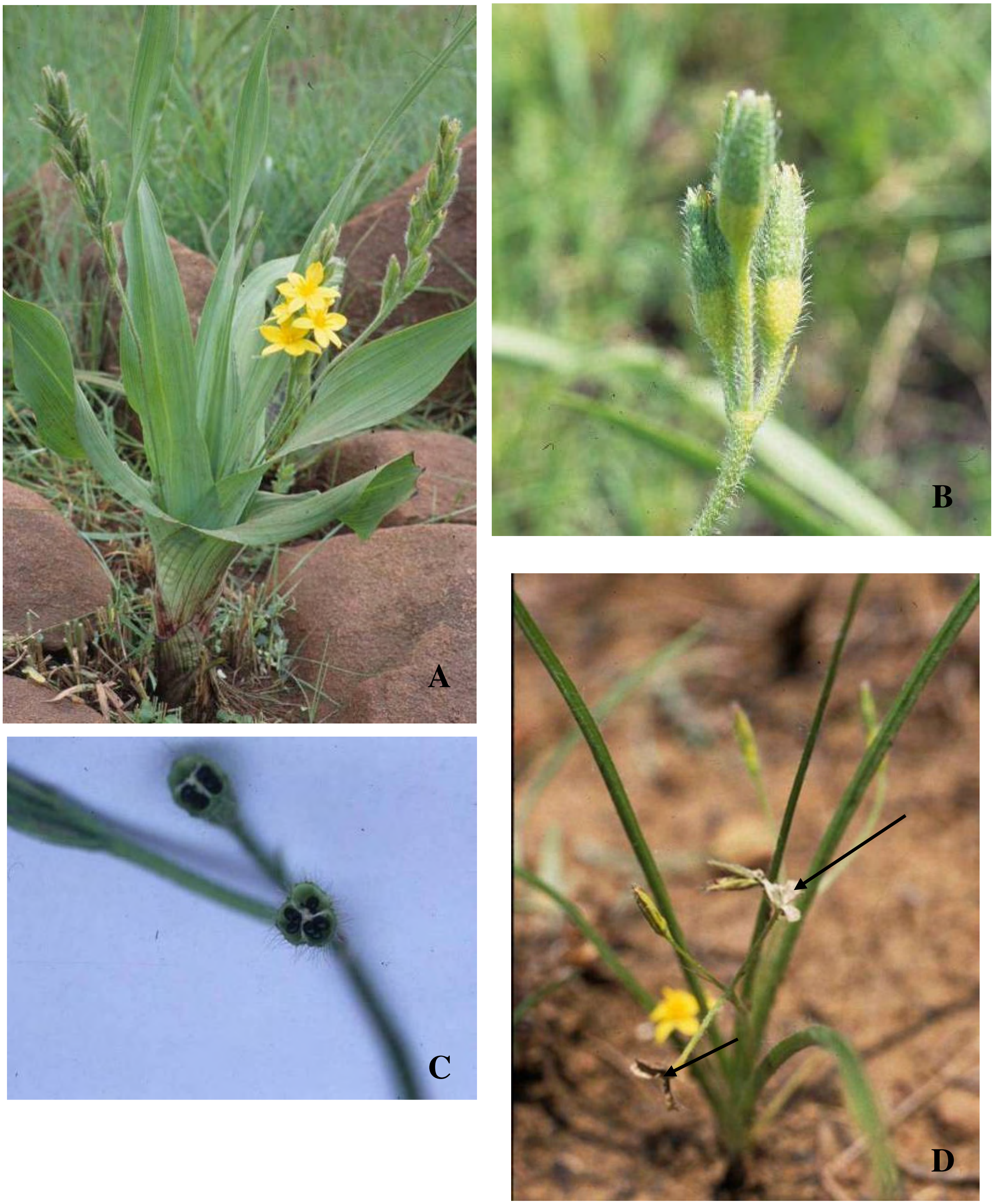

Figure 7.9.—Capsule and dehiscence in *Hypoxis*. A, whole capsules on raceme of *H. colchicifolia*; B, close-up of capsules in *H. longifolia*; C, capsule showing circumscissile dehiscence in *H. angustifolia* var. *buchananii*; D, capsule showing longitudinal dehiscence following circumscissile dehiscence in *H. argentea* var. *sericea* (arrows)

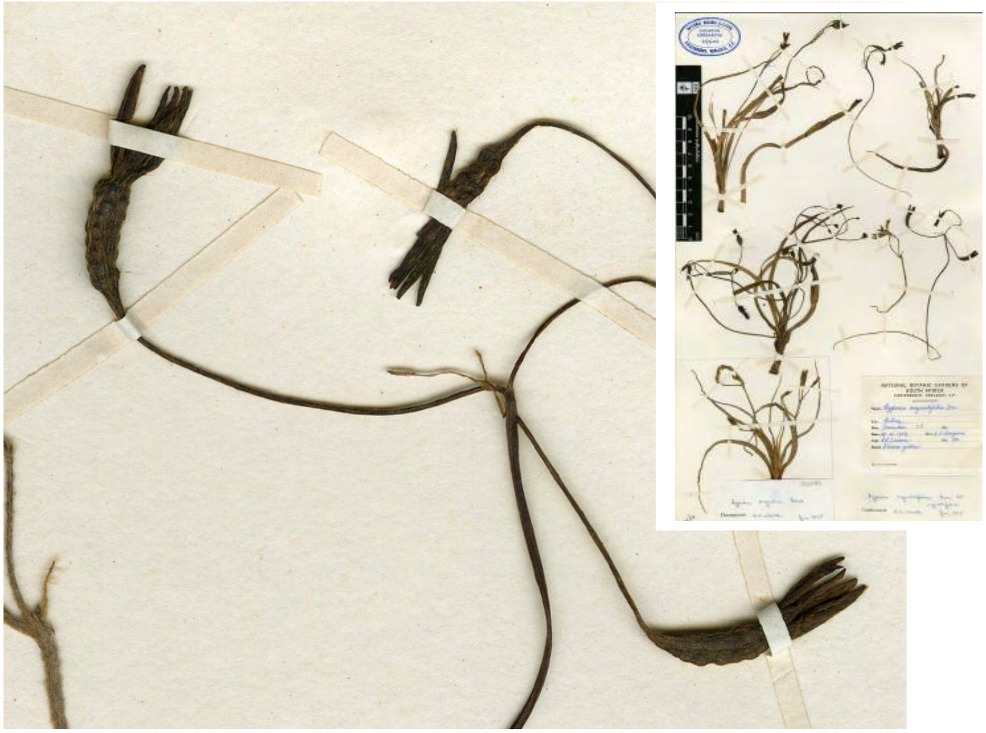

Figure 7.10.—Capsule moulded to shape of seeds in *H. angustifolia* var. *angustifolia* in *Lussem 50* (NBG).

Figure 7.11.—Circumscissile dehiscence in the soft-texture *H. parvula* var. *parvula* (arrows).

7.5 Seed

The Hypoxidaceae is characterised generally by a black (seldom brown), brittle, smooth or papillate phytomelan encrusted seed coat. Phytomelan is one of the prominent characters that differentiate the Hypoxidaceae from the closely related Orchidaceae within the Asparagales (Dahlgren & Clifford 1982). Seed surface characters were found to provide diagnostic characters for species separation in *Hypoxis* in southern Africa. Given the relevance of seed characters to understanding species relationships in the genus, the data on seeds are presented as a separate manuscript (see Appendix 1.5). Much of the data on the seed surface in this study were derived from Scanning Electron Microscopy and although they provide taxonomic evidence for uniqueness or commonality among species, it is not practical to use the character for routine identification in the field or herbarium. Species with unique seed characters like *H. stellipilis* can also be easily separated on vegetative characters. Seed surface characters are useful in confirming relationships among species that were inferred from observations on vegetative morphology and inflorescence and flower characters.

7.6 Conclusions

In this chapter, floral and fruiting features are described, comments on their use by earlier authors are provided and the taxonomic value of characters concluded. Taxonomically, the most informative characters include inflorescence type, filament and style thickness, stigma type and seed surface patterns. In the Discussion presented in Chapter 12, taxonomically significant characters from reproductive morphology are combined with those from the observations on vegetative morphology (Chapter 5) to infer groupings of related species.

8

PHYTOCHEMISTRY

8.1 Introduction

The value of *Hypoxis* as a medicinal plant with potential anti-tumour properties was discussed in Chapter 3 on the Ethnobotany of the genus. Over the past decade considerable interest has been generated in the therapeutic properties of *Hypoxis* in treating prostatic hypertrophy and HIV/AIDS. From the review of the various chemical studies in the genus (included in Chapter 3), the following conclusions are drawn: a) a number of phenolic compounds namely acuminoside, hypoxoside, nyaside, nyasoside, nyasicoside and obtusaside were isolated from *Hypoxis*, b) the compound recognised as having anti-tumour activity is hypoxoside, c) *H. hemerocallidea* (earlier name *H. rooperi*), *H. angustifolia*, *H. nyasica* and *H. obtusa* were reported to contain hypoxoside, d) hypoxoside is concentrated in the rootstocks of the plants and e) hypoxoside has been shown to have activity on immune-related illnesses like cancer, HIV and inflammation.

As part of this project, a preliminary investigation of compounds in the rootstocks of 14 of the 28 southern African species of *Hypoxis* was undertaken. The aim of the study was to investigate the taxonomic value of hypoxoside and other phenolic compounds in rhizomes of southern African species. This chapter discusses the results obtain from thin layer and high performance liquid chromatography and reports on the taxonomic value of chemical patterns in species. Three main fingerprint types are recognised in *Hypoxis*: the *hemerocallidea*-, *filiformis* and *angustifolia* type. The *hemerocallidea* type is present in robust species with rhizomes yellow or orange internally and is the dominant type among the species sampled. Species with white rhizomes have the *filiformis*- or *angustifolia* type profile with hypoxoside absent or subtle in these species. The *angustifolia* type is restricted to *H. angustifolia* which has a unique compound, not present in any other species sampled. From the profiles, relationships of taxa are inferred and these largely confirm the grouping of species based on morphology.

8.2 Materials and method

The materials and methods used for thin layer and high pressure liquid chromatography are described in Chapter 4. The vouchers for the specimens cited in Tables and Figures are presented in Table 4.4 (page 48).

8.3 Results

The results of the thin layer chromatography (TLC) are presented in Figure 8.1 and those of the high performance liquid chromatography (HPLC) are summarised in Table 8.1 and illustrated by the profiles in Figures 8.2, 8.4 & 8.5. The TLC plate (Figure 8.1) gives an overview of the main phenolic compounds in the 20 samples investigated. Three main fingerprint types are evident:

1 The *hemerocallidea*-like type: this is the common pattern detected in 14 of the 20 samples analysed. Hypoxoside (Figure 8.1, arrow) is the main compound with several other minor compounds.

2 The *filiformis*-type: present in *H. argentea*, *H. filiformis*, *H. membranacea* and *H. parvula* (Figure 8.1, tracks 11, 15, 17 & 19). A characteristic unknown compound is noticed at R_f 0.4 and R_f 5.3 minutes (Figure 8.2A–D).

3 The *angustifolia*-type: with a unique combination of compounds. The marker compound is visible as a red spot at R_f 0.4 and R_f 11.3 (Figure 8.5).

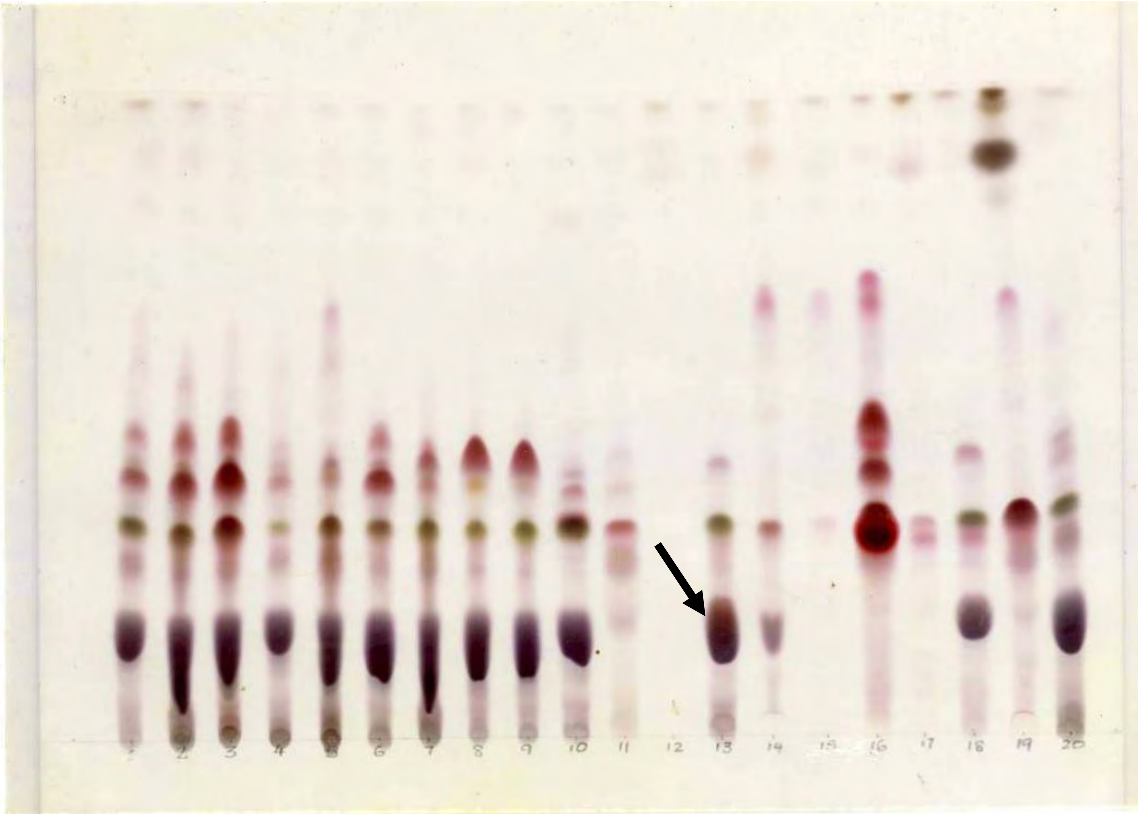

Figure 8.1.—TLC plate showing chemical profiles of 14 southern African species of *Hypoxis*. Species include 1 = *H. hemerocallidea*; 2 = *H. hemerocallidea*; 3 = *H. hemerocallidea*; 4 = *H. hemerocallidea*; 5 = *H. hemerocallidea*; 6 = *H. rigidula* var. *pilosissima*; 7 = *H. rigidula* var. *rigidula*; 8 = *H. colchicifolia*; 9 = *H. galpinii*; 10 = *H. obtusa*; 11 = *H. sobolifera* var. *pannosa*; 12 = *H. costata*; 13 = *H. multiceps* 14 = *H. parvula* var. *parvula*; 15 = *H. membranacea*; 16 = *H. angustifolia* 17 = *H. argentea* var. *argentea*; 18 = *H. acuminata*; 19 = *H. filiformis*; 20 = *H. rigidula* var. *rigidula*. The arrow indicates hypoxoside.

Table 8.1.—HPLC profiles for *Hypoxis*: Retention Time and UV Patterns
+, ++, +++ = relative to the quantity present , tr = trace amounts

	4.34	**7.60**	**5.30**	**5.36**	**10.39**	**12.81**	**10.21**	**12.30**	**11.32**	**6.87**	**16.86**	**16.90**	**17.84**	**18.76**	**21.16**	**8.67**	**5.37**	**11.34**	**12.50**	**17.18**	**10.58**	**4.21**	**13.28**
H. hemerocallidea 1	+						tr						+++	+									
H. hemerocallidea 2																							
H. hemerocallidea 3																							
H. hemerocallidea 4	+	+					tr				+++		+	+									
H. hemerocallidea 5																							
H. rigidula var. *pilosissima*	tr										+++		+	+	+								
H. rigidula var. *rigidula* 1	++							+			+++		+	+	+								
H. colchicifolia	tr							++			+++			++	+								++
H. galpinii											+++		+		+							++	
H. obtusa							tr				+++				+					+++	++		
H. membranacea				+++						+++			+++										
H. sobolifera var. *pannosa*	+++			++									++										
H. costata	+++			+++									+++							+++			
H. multiceps	+				+++									+									
H. parvula var. *parvula*					++								+++			++	++	+++	+				
H. angustifolia	++																						
H. argentea	++																						
H. acuminata	tr			+++																			
H. filiformis	++																						
H. rigidula var. *rigidula* 2	++	+	+++																				

The HPLC profiles confirm relationships of *Hypoxis* species inferred from morphology. Species with delicate, white rhizomes have similar profiles and show a lack of or slight levels of hypoxoside (Figure 8.2A–D). The composition of compounds was found to be uniform among different populations of *H. hemerocallidea* (Figure 8.1, tracks 1 to 5 and Figure 8.3A–C). Similarity between populations was also noted in *H. rigidula* var. *rigidula* (Figure 8.1, tracks 7 and 20). Hypoxoside is the major compound among species with robust, yellow to orange rhizomes (Figure 8.1, tracks 1 to 10, 13, 18 and 20). Its presence is noted in the medicinally important species, *H. hemerocallidea* and *H. colchicifolia* (Figure 8.1, tracks 1–5, 8). The profile of *H. angustifolia* (Figure 8.4) is unique, although morphologically the rhizome in the species is similar to that in members of the *filiformis* type.

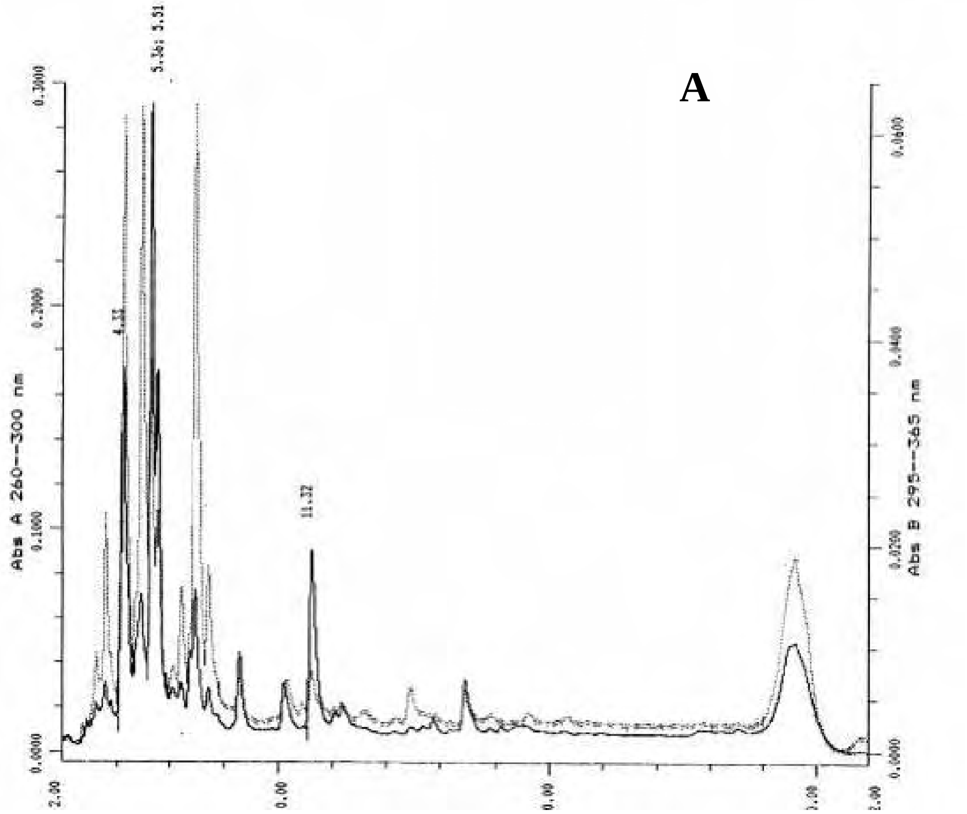

Figure 8.2.—HPLC profiles for species with *filiformis* type fingerprint. A, *H. argentea* var. *argentea*.

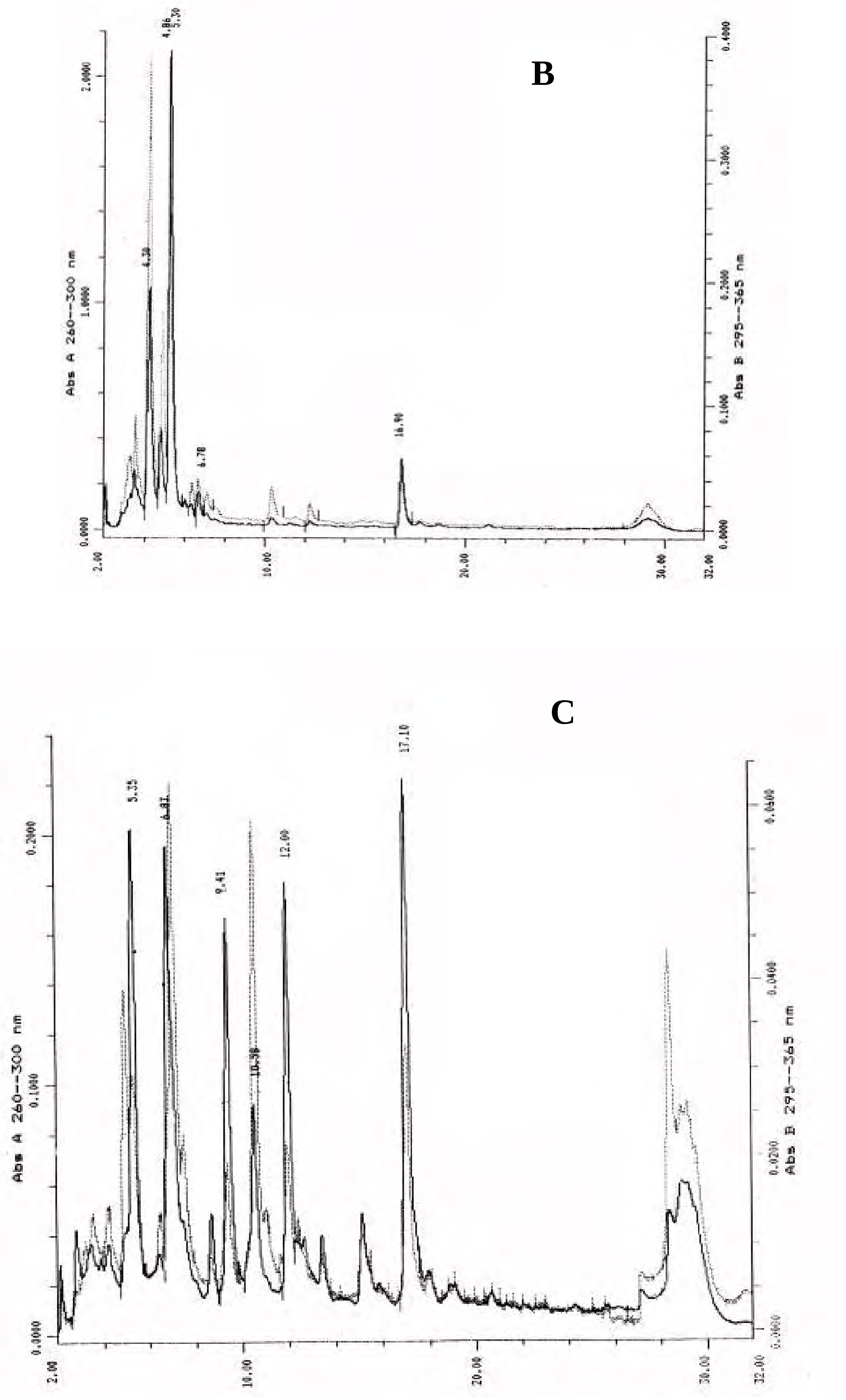

Figure 8.2 cont.—HPLC profiles for species with *filiformis* type fingerprint. B, *H. filiformis*; C, *H. membranacea.*

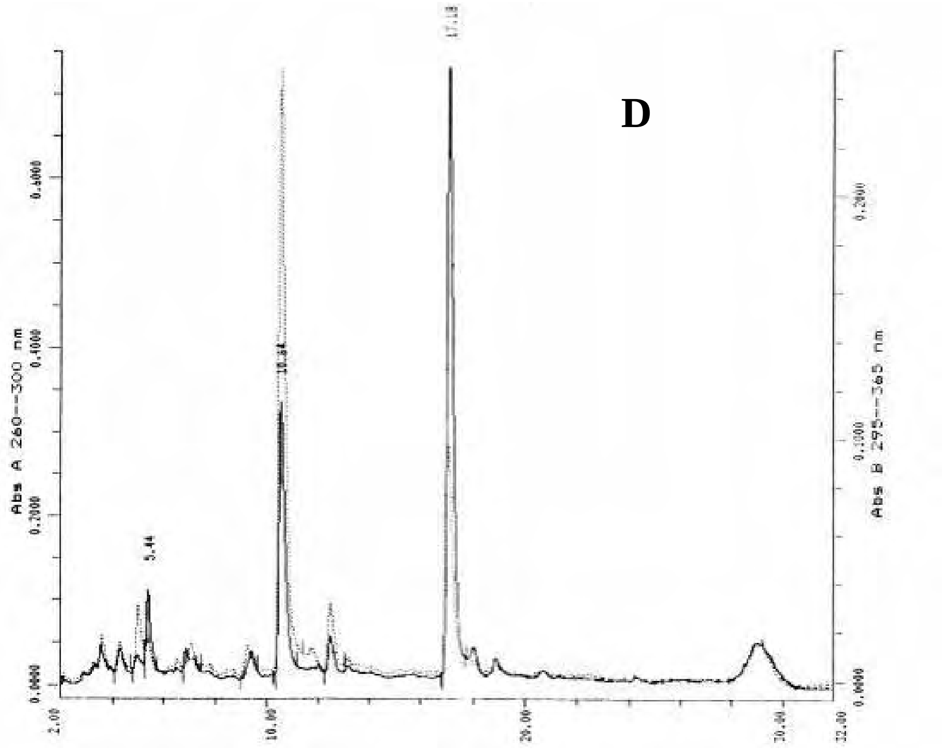

Figure 8.2 cont.—HPLC profiles for species with *filiformis* type fingerprint. D, *H. parvula*.

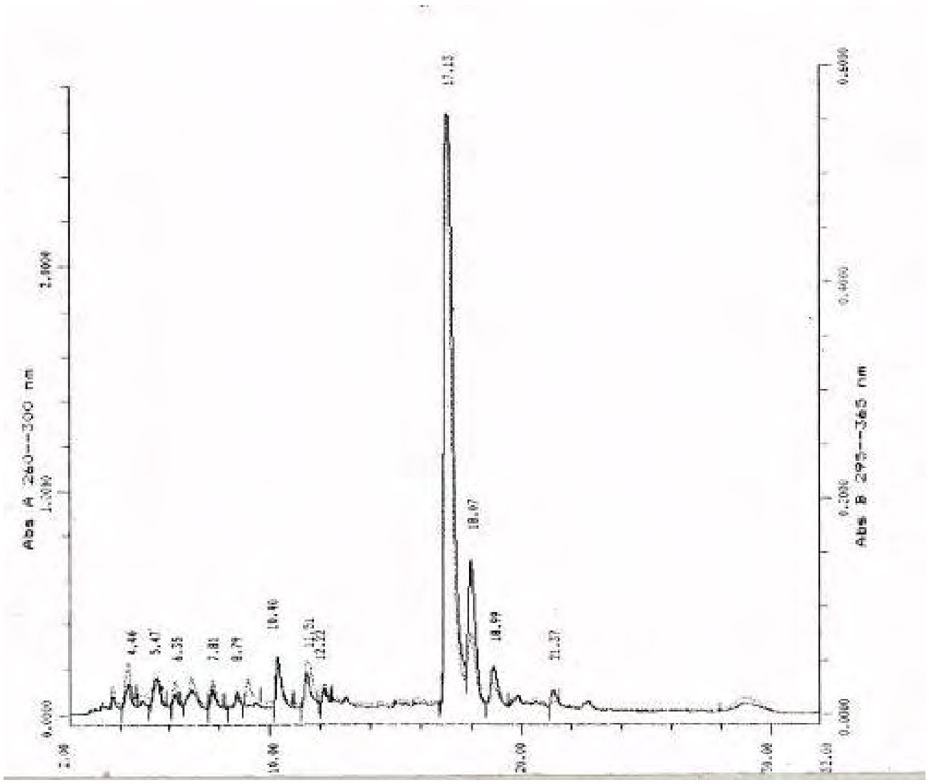

Figure 8.3.—HPLC profiles for three populations of *H. hemerocallidea* (samples 2, 3, 5) showing similarity.

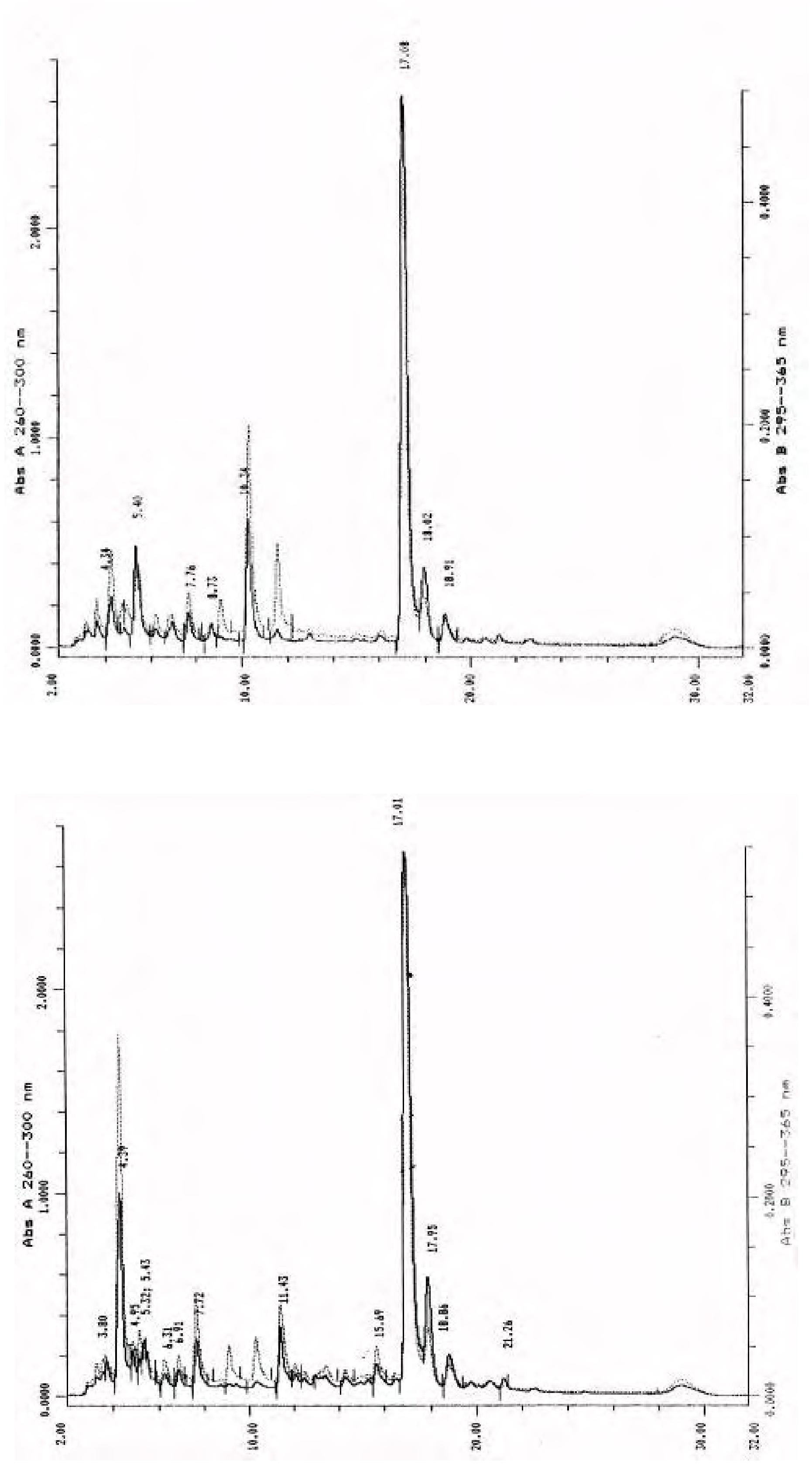

Figure 8.3 cont.—HPLC profiles for three populations of *H. hemerocallidea* (samples 2, 3, 5) showing similarity.

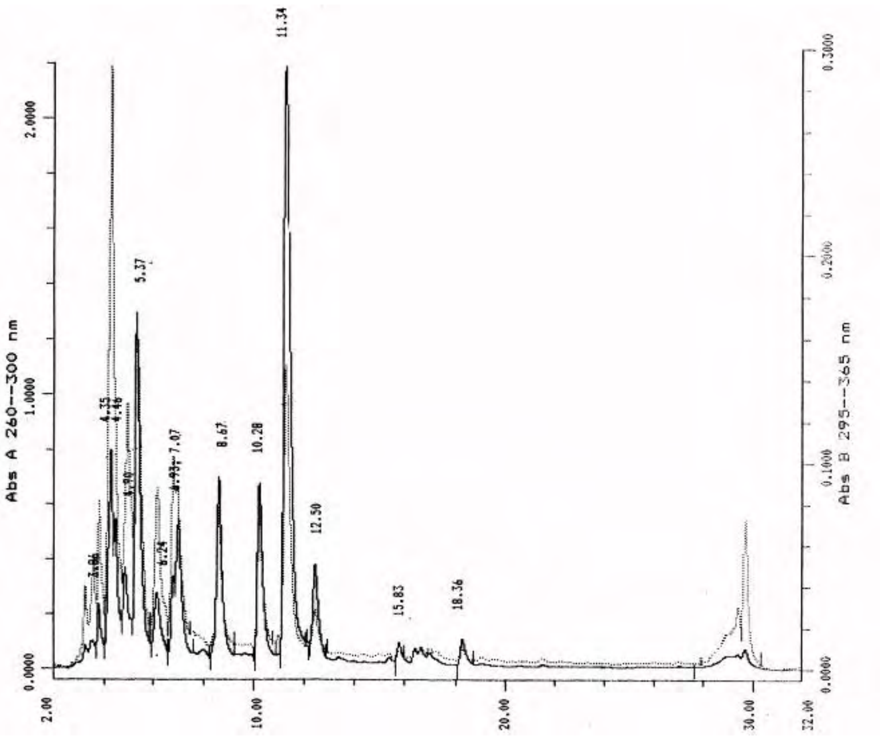

Figure 8.4.—HPLC profile of *H. angustifolia* showing a pattern different to that of the delicate, white rhizomes shown in Figure 8.2.

8.4 Discussion

Earlier phytochemical analyses in the Hypoxidaceae dealt with isolating and identifying active compounds in particular species (Table 2.1). Seven compounds were isolated from members of *Hypoxis* (Table 8.2), mostly from the rhizomes. These studies showed that hypoxoside occurs in *H. hemerocallidea*, the most commercially utilised species, as well as its closest relative, *H. obtusa*. This study confirms that hypoxoside is a major constituent of the rhizomes of many *Hypoxis* species with robust rhizomes that are yellow to orange within. Hypoxoside is a glycoside which on hydrolysis gives an aglycone with the trivial name rooperol (Figure 8.5) [Drewes 1984, Drewes & Khan 2004].

Due to the high degree of uniformity in floral characters, infrageneric classification in *Hypoxis* depends largely on vegetative characters. In Chapter 7, it was reported that the identification of species in the group is best achieved by combining leaf characters with inflorescence types. Rhizome size and internal colour are also useful in classifying species into two broad groups. Stigma shape is either pyramidal or spherical in the genus and is useful in separating the species with membranous leaves. However, both stigma types, more commonly pyramidal stigmas are found in *H. angustifolia*, a species found to have a unique combination of chemical compounds. Among the species included in this study, *H. angustifolia*, *H. argentea*, *H. filiformis*,

Table 8.2.—Selected compounds isolated in *Hypoxis*

Authors	**Year**	**Compound**	**Species**	**Organ**
Marini-Bettolo *et al.*	1982	hypoxoside	*H. obtusa*	rhizome
Drewes *et al.*	1984	hypoxoside	*H. hemerocallidea* (*H. rooperi*)	rhizome
Marini-Bettolo *et al.*	1985	hypoxoside nyasoside	*H. nyasica*	rhizome
Galeffi *et al.*	1987	nyasicoside	*H. nyasica*	rhizome
Drewes *et al.*	1989	hypoxoside	*H. hemerocallidea* (*H. rooperi*)	Rhizome
Galeff *et al.*	1989	nyaside	*H. nyasica*	rhizome
Msonthi *et al.*	1990	acuminoside hypoxoside obtusaside nyasoside	*H. obtusa*	whole fresh plant
Sibanda *et al.*	1990	nyasol nyasoside nyaside mononyasine A and B	*H. angustifolia*	rhizome

H. membranacea and *H. parvula* are related in having delicate rhizomes that are white internally. Further, in these species the tepals are linear in shape and the inner and outer tepals appear about equal in width to the naked eye. In the remaining species, rhizomes are robust and are distinctly yellow or orange internally. In these species, the inner tepals are broadly ovate and about twice as broad as the outer tepals which are linear or linear-acuminate. The *hemerocallidea*-type chemical profile is present in all species with yellow or orange rhizomes except *H. sobolifera* var. *pannosa*. It

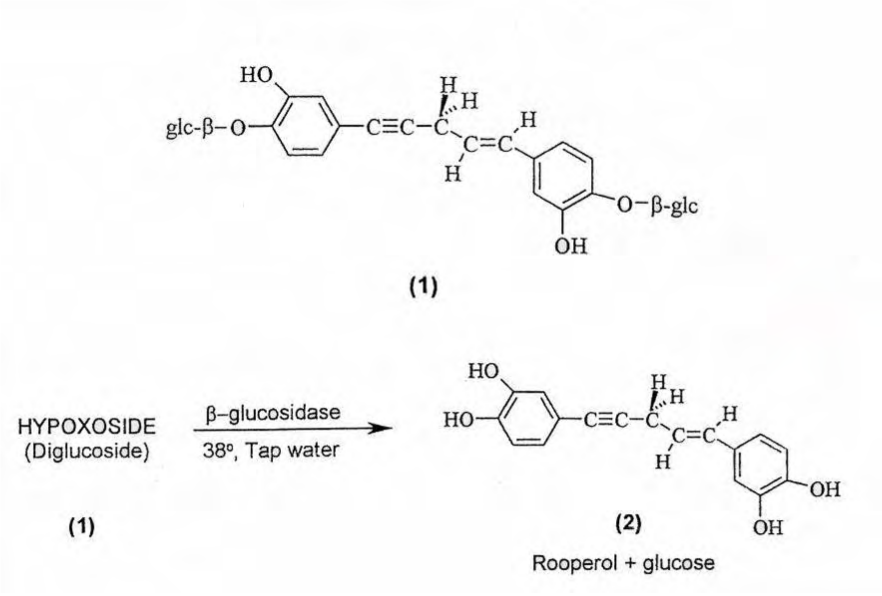

Figure 8.5.—Structure of hypoxoside and its aglycone, rooperol (from Drewes & Khan 2004).

is the dominant type in southern African members of *Hypoxis*. Species with soft, white rhizomes have *filiformis*- and *angustifolia*-type profiles with hypoxoside significantly reduced or absent in these species. *H. sobolifera* var. *pannosa* (Figure 8.1, track 11) has the *filiformis* type profile but the rhizomes of the species are white or yellow internally. The species is however related to the other species with this profile by the shape of its tepals. *H. angustifolia* (Figure 8.1, track 16; Figure 8.5) also has white rhizomes but the species has a unique combination of compounds. The distinctive red spot at R_f 0.4 and R_f 11.3 in *H. angustifolia*, is not visible in the *filiformis* type fingerprint. A flow diagram (Figure 8.6) was constructed to indicate relationships among the 14 species of *Hypoxis* used in the study. The grouping of species in the diagram is based on morphology and chemical data was superimposed onto the groups. As depicted in the diagram, chemical evidence from this study largely confirms the grouping of species based on morphology.

It is noteworthy that there is chemical congruence between morphologically similar species, e.g. *H. colchicifolia* and *H. galpinii*, and *H. hemerocallidea* and *H. obtusa*. *H. sobolifera* var. *pannosa* has the *filiformis*-type profile and this correlates with the flowers having inner and outer tepals about the same width but rhizomes in the species are white or pale yellow internally. The TLC plate (Figure 8.1) shows remarkable uniformity among different populations of *H. hemerocallidea* which is the main commercialised species. This uniformity is also seen in the HPLC profiles (Figure 8.4). Since the medicinal activity of *Hypoxis* is ascribed to the presence of phytosterols, the presence of these medicinally important antioxidants were investigated further using TLC (Figure 8.3). The presence of β-sistosterol and/or stigmasterol is shown in all the *H. hemerocallidea* samples and also in the remainder of the species studied.

8.5 Conclusions

This preliminary chemical evaluation showed that the *hemerocallidea* type profile is present in all species with hard rhizomes that are yellow or orange internally and with hypoxoside as a dominant constituent. Species with soft, white rootstocks have *filiformis*- or *angustifolia* type profiles and hypoxoside significantly absent or reduced in these types. The phenolic compounds show considerable promise as chemotaxonomic characters in the genus, and a detailed survey will be worthwhile in view of the ease at which the compounds can be studied in the genus.

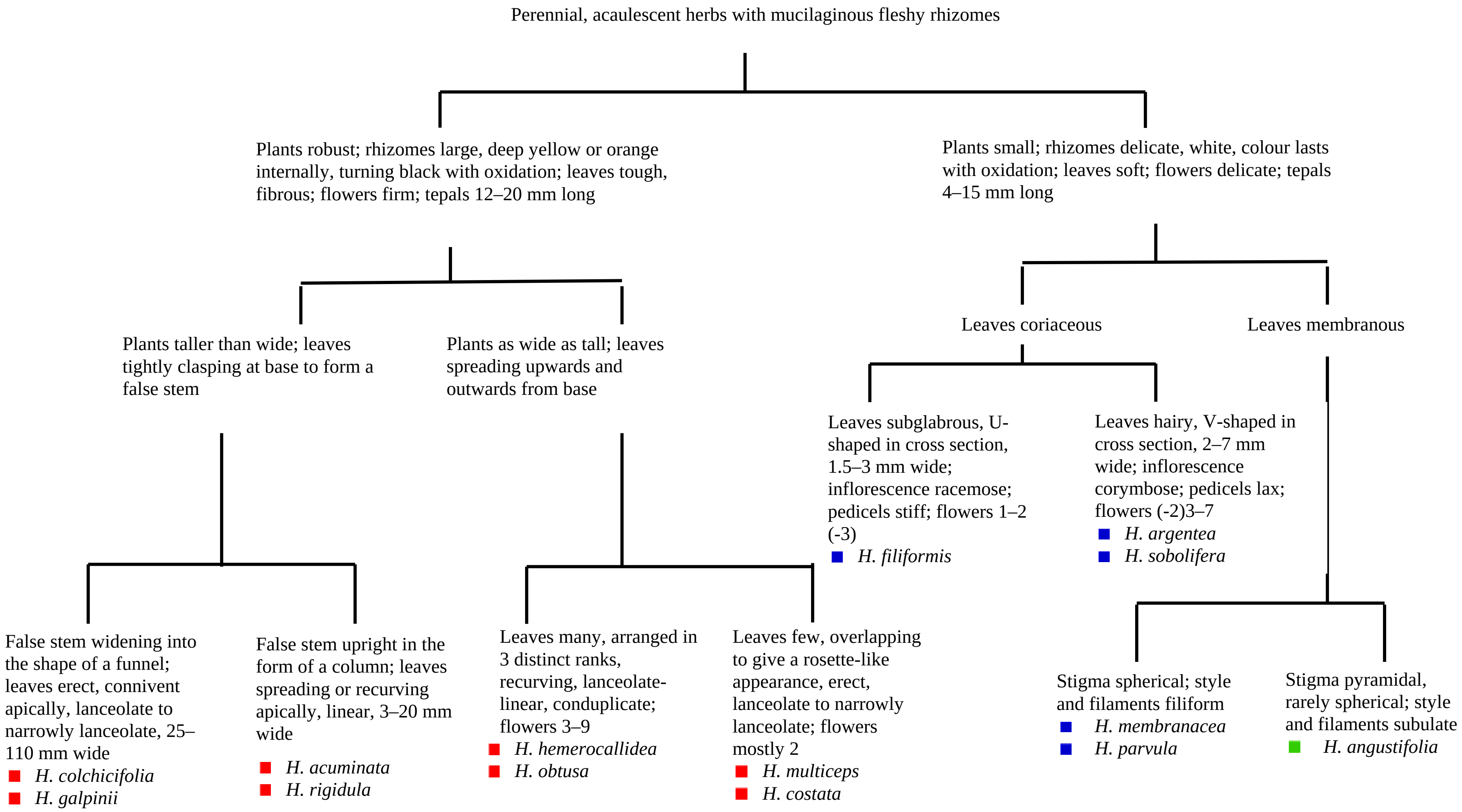

Figure 8.6.—Morphological grouping of *Hypoxis* species used in the study. The main phenolic profiles are superimposed on the diagram.

🟥 *hemerocallidea* type 🟦 *filiformis* type 🟩 *angustifolia* type

9

GEOGRAPHICAL DISTRIBUTION AND ECOLOGY

9.1 Introduction

The Hypoxidaceae is a predominantly African family with seven of the ten genera represented on the continent. The family is most diverse in southern Africa with six genera (*Empodium*, *Hypoxis*, *Pauridia*, *Rhodohypoxis*, *Saniella* and *Spiloxene*), comprising about 75 species, occurring in the area covered by the Flora of southern Africa [FSA] region (South Africa, Namibia, Botswana, Swaziland and Lesotho). Except *Hypoxis* and *Spiloxene*, all these genera are endemic to southern Africa. *Hypoxis* is widespread in Africa, mainly in the sub-Saharan region and also occurs in the New World, Australasia and some island archipelagoes, e.g. the Antilles and Galápagos. With about 30 species, of which 20 are endemic, southern Africa [FSA region] is the main centre of diversity and endemism for the genus. A secondary centre is located in tropical Africa in the Rift Valley where there are about 24 species, nine of which are endemic to the region. Smaller centres of diversity exist in the southeastern United States of America, Mexico (14 species) and Australia (six species), close to the coast. In Africa, *Hypoxis* is a typical floristic element of the afromontane phytochorion of White (1981, 1983). It occurs mainly in the Grassland Biome and extends into the associated Savanna, Albany Thicket, Indian Ocean Coastal Belt Biomes. Four taxa (the minority) are semi-shade dwellers, being restricted to open areas in forest, particularly cliff faces. This Chapter is a descriptive account of the geographical distribution patterns and habitat affinities of *Hypoxis* in Africa with emphasis on southern Africa. Its primary aim is to report on species richness and endemism for the genus in sub-Saharan Africa, and to correlate these to phytochoria and biome types. The distributions of species are discussed in terms of their ecological requirements. See Chapter 12 for the distribution of individual species in southern Africa. As biome preferences may influence pollination and seed dispersal strategies in the group, a short discussion on these aspects is also offered. The Chapter concludes with a discussion on the possible evolution of *Hypoxis* on the continent. As a member of the core monocots, the Hypoxidaceae probably has its origins in southern Gondwana (South America, Australasia and Antarctica) and diversified by the Early Tertiary (about 65.5–33.9 Ma) following break-up of the supercontinent and associated transitions in climate, geomorphology and vegetation patterns Bremer & Janssen (2006). It is proposed that orogenic events due to continental uplift in the mid-Tertiary (Oligocene-Miocene epochs, 33.9–5.332 Ma) gave rise to grasslands that fragmented the extensive forest vegetation in Africa (Scotese *et al*. 1988), and this change coupled with the ecological requirements of *Hypoxis* are the main causes of its speciation and high species richness and endemism on the continent. Speciation in the genus is also driven by evolutionary processes involving hybridisation, polyploidy and apomixis and these are discussed in Chapter 12.

9.2 Global distribution of *Hypoxis*

Hypoxis occurs in the warm parts of all continents except Europe (Figure 9.1). Of a total of approximately 85 species, some 50 species occur in sub-Saharan Africa, most of these being concentrated in South Africa where 28 species are recognised. A secondary centre of diversity with 24 species is located in tropical Africa. In the latter region, *Hypoxis* is often associated with mountainous regions, especially the Eastern Arc Mountains in Tanzania (mainly) and Kenya, as well as the Katanga Highlands in the Democratic Republic of Congo (DRC). The two centres of high diversity for the genus in Africa correspond to the South Africa and Rift Valley Centres of Diversity (Figure 9.2) recognised by White (1978). A fuller discussion on the physiognomy of these centres is covered below under Centres of Diversity.

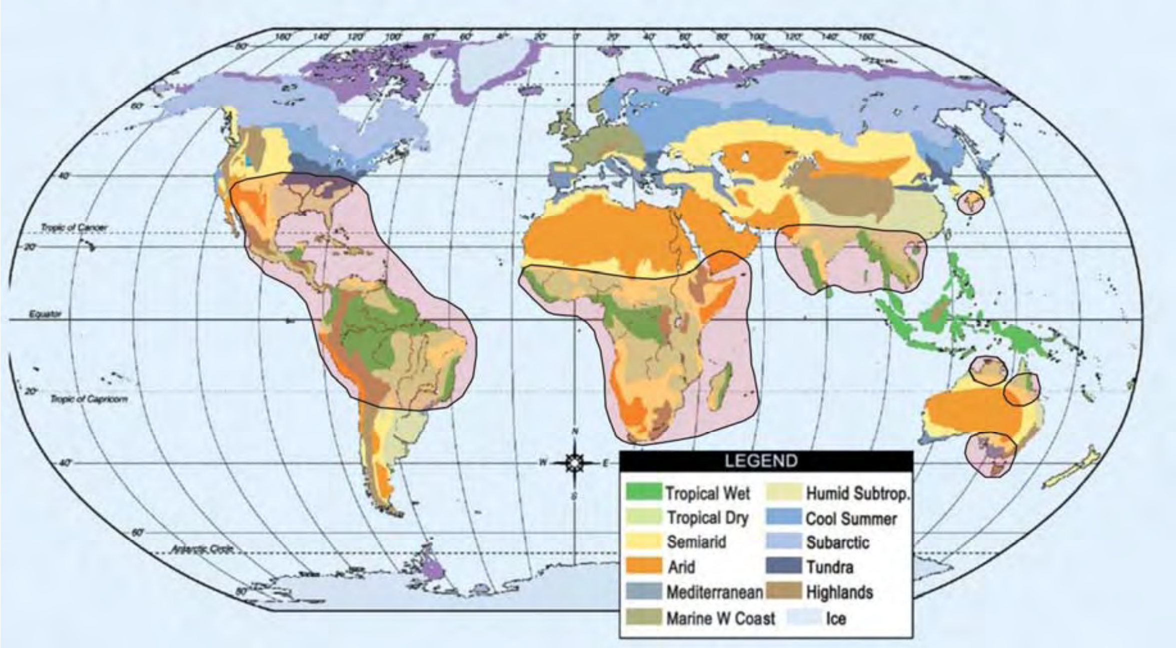

Figure 9.1.—Approximate global distribution of *Hypoxis* showing its occurrence in the warmer parts of the world. Base map from www.theodora/maps.

In the New World, 14 species occur from the southern provinces in Canada through the United States of America (USA), Meso- and Central America to South America with a southernmost occurrence at Buenos Aires (Argentina). In Mexico alone, there are nine species of which four are endemic to the country. Among the group of Mexican species, a few have a wide range. *H. hirsuta* (L.) Coville is widespread in the USA and is the only species that extends into the southern provinces of Canada, while *H. mexicana* Schultes & Schultes f. ranges into Arizona (USA) and *H. wrightii* (Baker) Brackett also occurs in the USA, Cuba and the Bahamas. South America has three species, *H. breviscapa* Kunth, *H. decumbens* L. and *H. humilus* Tharp. *H. brevicarpa* is known from Bolivia, Argentina and Cojedes, Venezuela. *H. humilus* ranges across Mesoamerica, from Mexico in the north through eastern Brazil to the northern part of Argentina. *H. decumbens* has a similar distribution range but is also present in the Carribean, the Galápagos and possibly in Tonga. The species is variable in fruit length and Nesom (1993) recognised the form with long fruits as a distinctive variety which he described as *H. decumbens* var. *dolichocarpa* G.L. Nesom.

Hypoxis decumbens was noted by Hilliard & Burtt (1979) as being introduced in the Lion's River District in the midlands of KwaZulu-Natal in South Africa. The species can be confused with *H. angustifolia* on vegetative morphology but differs in having long, slender ovaries and lanceolate capsules that are mostly indehiscent, the persistent tepals are about ⅓ to ½ the length of the capsules (*Wood 179*, *s.n.* in NU, *Moll 2860* in PRE). In *H. angustifolia*, the capsules are broadly ovate, dehiscent and the persistent tepals are equal to or longer than the length of the capsule. Seeds in Wood's specimens are black, either shiny or dull. Similar capsules were observed in *Chevalier 9485* (BR) collected in Baguirmi, Chad, which is also the ex type of *Curculigo baguirmiensis* A. Chev. Seeds in this specimen are distinctly brown. See paragraph in next section for a discussion on seed colouration in *H. angustifolia*. During this study, localities of *H. decumbens* were not specifically traced as the focus was on resolving the status of indigenous taxa. Therefore, field work is required to assess the extent of the KwaZulu-Natal populations of *H. decumbens* and to determine whether they have any reproductive influence on indigenous species in the area. *H. domingensis* Urb. appears to be restricted to the West Indies and is not known from the South American mainland.

In Australia, there are six species of *Hypoxis* are found mostly in southern Queensland and New South Wales and northern Western Australia, as well as in Tasmania. A few specimens are known from the northern part of Queensland. In Asia, the single species, *H. aurea* Lour. has a wide distribution. It ranges from western India across the Himalayas into south China through to the southeast Asian islands of Hong Kong and Taiwan, and into Japan. The species is superficially similar to *H. angustifolia* and *H. decumbens* in its soft leaves and inflorescences but is closer to the latter taxon in its fruit morphology, the crown of persistent tepals being shorter in length than the capsule.

Despite the fewer numbers of species, the taxonomy of the American or Australian members is by no means less notorious than in Africa. Controversial views are seen in the demarcation of species in these different centres. Based on seed characters, the American *H. potosina*, *H. fibrata* and *H. rugosperma* were recognised as separate species by Brackett (1923), whereas recently McVaugh (1989) and Serna & López-Ferrari (1996) considered them to represent a single species. Variation patterns noted in *H. decumbens* is analogous to the African *H. angustifolia*; both species pose problems for determining character and taxon limits. A comparable challenge is likely once specimens of *H. aurea* across its entire range in Asia are studied. Among the Australian species, the difficulties in dealing with morphological variation are evident in the varieties created for 50% of the species (Henderson 1987).

9.3 Distribution of *Hypoxis* in Africa

9.3.1 Continental distribution

As modern revisions for the various floras in Africa emerge, they help resolve the basic taxonomy of *Hypoxis* and provide a more accurate account of the numbers and distribution of species. In Africa, *Hypoxis* ranges from the Western Cape, South Africa, through central Africa into western Africa, and into the horn of the continent. Clearly, eastern southern Africa is the most species-rich region and the number of species decreases northwards in tropical Africa up to the 10^0S latitude (Figure 9.2). Species numbers increase again in Central and East Africa along the Rift Valley, approximately between the 10^0S and 5^0N latitudes. The high number of species in the Rift Valley is associated with the Eastern Arc Mountains of Tanzania and Kenya and the Katanga Highlands in the DRC, and this constitutes a secondary centre of diversity for the genus. A few species in the Rift Valley are endemic to the Katanga Highlands, mainly the Kendulungu Mountains (Table 9.1). Seven species were described by Wiland-Szymańska (2001) as new and are found to be restricted to this range. In south-central Africa (mainly Angola, Zambia, Zimbabwe and Mozambique) there are about 17 species of *Hypoxis*, five common with southern Africa (Table 9.1), nine found in Eastern and Central Tropical Africa (Table 9.2) and five species are widely distributed in Africa. The region has no endemic species. Beyond the 5^0N latitude, a single taxon, *H. angustifolia* var. *luzuloides*, occurs in most countries, or it is occasionally found with one or two other species.

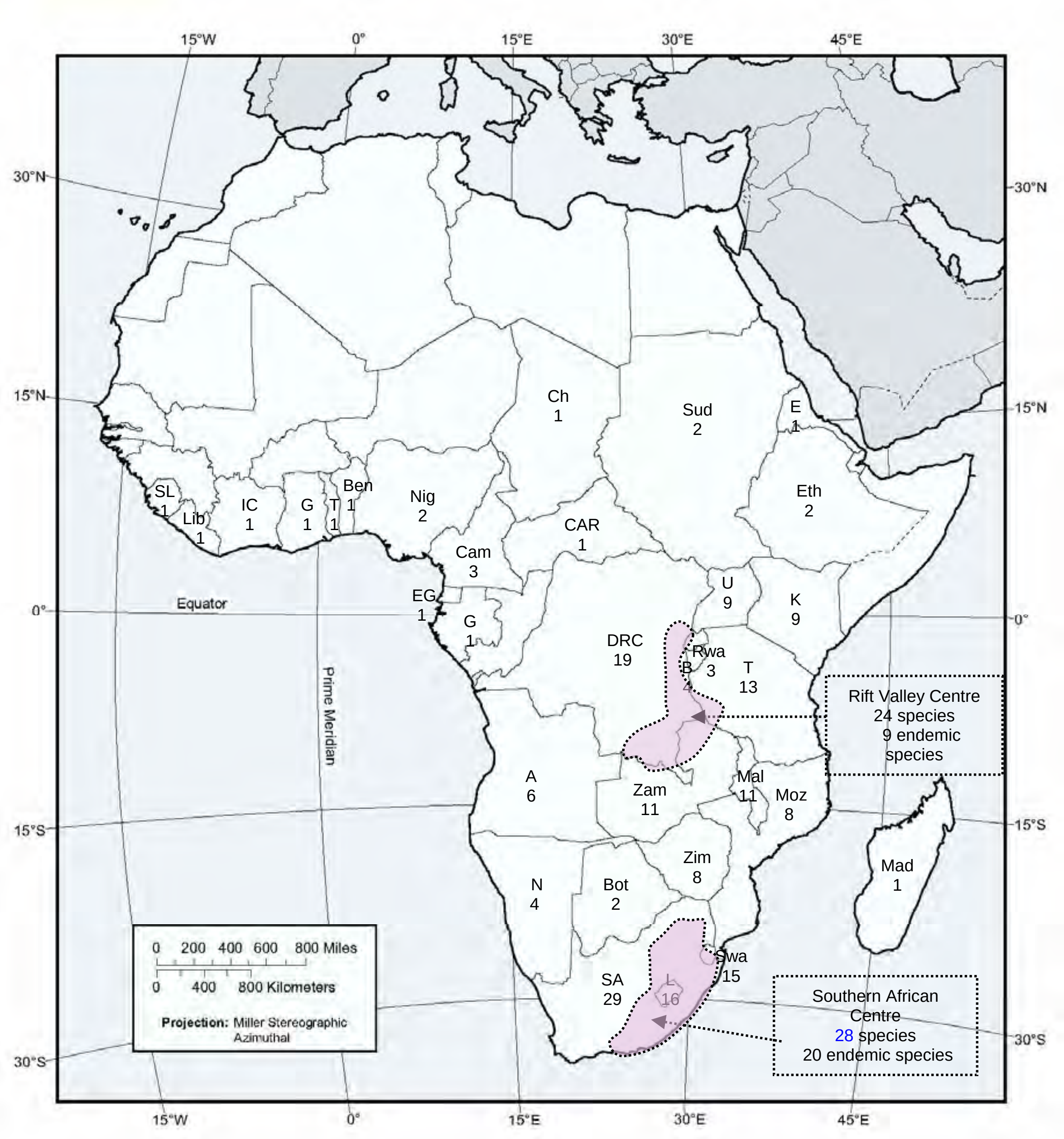

Figure 9.2.—Estimated number of species and endemics per country and the two Centres of high diversity and endemism (pink shade) in Africa. (Base map reproduced with permission from T. Dorschied, Arizona State University©).

Table 9.1.—Occurrence of southern African species of *Hypoxis* and their presence in countries in tropical Africa

Data for extra South African countires extracted from Hutchinson & Dalziel (1931), Hepper (1968), Nordal & Zimudzi (2001), Wiland-Szymańska & Adamski (2002), Wiland-Szymańska & Nordal (2006).

Countries classified into flora regions and are abbreviated alphabetically as: A = Angola; B = Burundi; Bot = Botswana; Cam = Cameroon; CAR = Central African Republic; Ch = Chad; DRC = Democratic Republic of Congo; E = Eritrea; Eth = Ethiopia; G = Gabon; Gu = Guinea; IC = Ivory Coast; K = Kenya; L = Lesotho; Lib = Liberia; Mad = Madagascar; Mal = Malawi; Mau = Mauritius; Moz = Mozambique; N = Namibia; Nig = Nigeria; Rè = Rèunion; Rwa = Rwanda; SL = Sierra León; SA = South Africa; Swa = Swaziland; Sud = Sudan; T = Tanzania; U = Uganda; Zam = Zambia; Zim = Zimbabwe. Note countries making up the West Africa Flora region that do not have *Hypoxis* are not included. ▨ = presence of a species ○ = possible presence of taxon ● = endemic taxon

	Southern Africa					South-central Africa					Central Africa			Tropical East Africa			Ehiopia and Eritrea		Tropical West Africa										West Indian Ocean Islands		
SPECIES OR INFRASPECIFIC TAXON	**SA**	**L**	**Swa**	**N**	**Bot**	**Moz**	**Mal**	**Zam**	**Zim**	**A**	**Rwa**	**DRC**	**B**	**U**	**K**	**T**	**E**	**Eth**	**G**	**Gu**	**LIb**	**IC**	**Sud**	**Nig**	**Cam**	**Ch**	**SL**	**CAR**	**Mad**	**Mau**	**Rè**
acuminata	▨	▨	▨																												
angustifolia																															
var. *angustifolia*	▨		▨			▨																								▨	▨
var. *buchananii*	▨	▨	▨																												
var. *madagascariensis*	○																												●		
var. *luzuloides*	○					▨	▨	▨	▨	○	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	○	▨	▨	▨	▨	▨	▨	▨		
argentea																															
var. *argentea*	▨	▨	▨																												
var. *sericea*	▨	▨		▨		▨		▨				▨																			
colchicifolia	●																														
costata	▨	▨	▨																												
filiformis	▨	▨	▨			▨	▨	▨	▨	▨		▨	▨	▨		▨															
flanaganii	●																														
floccosa	●																														
galpinii	▨	▨	▨						▨							▨															
gerarrdii									▨							▨															
hemerocallidea									▨					○	○	▨															
interjecta	●								▨							▨															

Table 9.1.—cont.

	Southern Africa					Zambesiaca					Central Africa			Tropical East Africa			Ehiopia and Eritrea		Tropical West Africa										West Indian Ocean Islands		
SPECIES	**SA**	**L**	**Swa**	**N**	**Bot**	**Moz**	**Mal**	**Zam**	**Zim**	**A**	**Rwa**	**DRC**	**B**	**U**	**K**	**T**	**E**	**Eth**	**G**	**Gu**	**LIb**	**IC**	**Sud**	**Nig**	**Cam**	**CH**	**SL**	**CAR**	**Mad**	**Mau**	**Rè**
kraussiana		▨				▨																									
longifolia	▨	▨				▨																									
ludwigii	▨	▨		▨																											
membranacea	▨		▨																												
multiceps	▨	▨	▨																												
nivea	●																														
obliqua	▨	▨																													
obtusa	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨		▨	▨	▨															
parvifolia	▨		▨				▨		▨																						
parvula																															
var. *albiflora*	●																														
var. *parvula*	▨	▨	▨																												
rigidula																															
var. *pilosissima*	▨	▨	▨																												
var. *rigidula*	▨	▨	▨	▨		▨			▨	▨					▨	▨															
sobolifera																															
var. *pannosa*	●																														
var. *sobolifera*	●																														
stellipilis	●																														
tetramera	▨	▨																													
villosa	●																														
zeyheri	●																														

Table 9.2.—Occurrence of Tropical African species of *Hypoxis*
Data for extra South African countires extracted from Hutchinson & Dalziel (1931), Hepper (1968), Nordal & Zimudzi (2001), Wiland-Szymańska & Nordal (2006). Country abbreviations as in Table 9.1.

▨ = presence of a species ○ = possible presence of taxon ● = endemic taxon

	Southern Africa					**Zambesiaca**					**Central Africa**			**Tropical East Africa**			**Ehiopia and Eritrea**		**Tropical West Africa**										**West Indian Ocean Islands**		
SPECIES	**SA**	**L**	**Swa**	**N**	**Bot**	**Moz**	**Mal**	**Zam**	**Zim**	**A**	**Rwa**	**DRC**	**B**	**U**	**K**	**T**	**E**	**Eth**	**G**	**Gu**	**LIb**	**IC**	**Sud**	**Nig**	**Cam**	**CH**	**SL**	**CAR**	**Mad**	**Mau**	**Rè**
angustifolia						▨	▨	▨	▨	○	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	○	▨	▨	▨	▨	▨	▨			
bampsiana							▨	▨				▨				▨															
canaliculata							▨	▨	▨	▨		▨																			
fischeri																															
var. *fischeri*														▨	▨	▨									▨						
var. *colliculata*												▨				▨															
var. *katangensis*								▨				▨				▨															
var. *hockii*												▨		▨		▨															
var. *zernyi*						▨	▨	▨								▨															
goetzei							▨	▨	▨			▨			▨	▨															
gregoriana														▨	▨	▨															
kilimanjarica																															
subsp. kilimanjarica											▨	▨	▨	○	▨	▨															
subsp. prostrata															▨	▨															
lejolyana								▨				▨																			
lusalensis												●																			
malaissei												▨				▨															
monanthos							▨			▨		▨	▨																		
muhilensis																															
subsp. muhilensis												●																			
subsp. kansimbensis												●																			
nyasica						▨	▨	▨	▨							▨															
polystachya							▨			▨		▨				▨															
robusta												●																			
schimperi								▨	▨						▨	▨		▨													
suffructicosa																								▨	▨						
symoensiana												●																			
upembensis												●																			
urceolata											▨	▨		▨	▨	▨															

Hypoxis angustifolia is the most widespread species in Africa, ranging from southern Africa far north into Ethiopia and Eritrea and westwards into Cameroon, Nigeria, Guinea and Sierra Leone. The species also occurs in Madagascar, Mauritius and the Rèunion. Recently, Wiland-Szymańska & Nordal (2006) recorded its presence in Yemen in southern Arabia. *H. angustifolia* is also the most variable species and in dealing with the variation, Baker (1878b) created two varieties, namely var. *angustifolia* and var. *buchananii.* Subsequently Wiland-Szymańska & Adamski (2002) added a further two varieties, var. *luzuloides* (Robyns & Tournay) Wiland and var. *madagascariensis* Wiland. The variety of *H. angustifolia* that is widespread in topical Africa, namely var. *luzuloides*, is considered absent or extremely rare in southern Africa while var. *buchananii* Baker is restricted to South Africa, Lesotho and Swaziland (Table 9.2). The separation of *H. angustifolia* var. *luzuloides* is on its brown seeds and Wiland-Szymańska & Adamski (2002) cite two specimens from South Africa (*Schlieben 7345* in BR; *Acocks 10832* in BR, PRE) as examples of the variety in the region. Unfortunately, the specimen of *Schlieben* at BR could not be studied and the duplicate specimen of *Acocks* collected in Weenen in KwaZulu-Natal housed at PRE is a poor specimen; it lacks flowers and fruit. Brown seeds in specimens were observed to be distinct under a stereomicroscope and these are seen in specimens from Mozambique (*Schlechter 11659* in GRA), Zambia (*Mulligan s.n.* in GRA), Chad (*Chevalier 9485* in BR) and Uganda (*Dummer 2437a* in SAM), and the ‘brown’ is associated with the discoloration of the ‘white’ cuticular folds on the seed surfaces, in these specimens. *H. angustifolia* in the Flora Zambesiaca region (Zambia, Zimbabwe, Malawi, Mozambique and Botswana) is reported as having dark brown seeds (Nordal & Zimudzi 2001). Also, according to current opinion (Wiland-Szymańska & Adamski 2002), the typical variety is restricted to Mauritius and Rèunion. However, plants in southern Africa closely resemble var. *angustifolia* in morphology and have variable seed types including that recorded in the typical variety (Singh & Van Wyk, Appendix 1.5), all with a black testa. In the present study, both varieties recognised by Baker (1896) for South Africa are upheld and the typical variety is considered to be present in southern Africa as well.

A few other southern African species extend into Tropical Africa (Tables 9.2 & 9.3). *H. hemerocallidea* and *H. parvifolia* range into the Flora Zambesiaca region, while the distribution range for *H. filiformis*, *H. galpinii*, *H. obtusa* and *H. rigidula* var. *rigidula* extends further north into tropical East Africa, being present in Tanzania and/or Kenya and Uganda (Table 9.1). It is suspected that *H. argentea* var. *sericea* (including *H. dinteri*) also occurs in Zambia and the DRC. This needs to be confirmed by comparison of material from these regions. *H. longifolia* also extends from southern Africa northwards into Mozambique.

9.3.2 Distribution of species in southern Africa

Within southern Africa, four taxa, *H. argentea* var. *sericea* (including *H. dinteri*), *H. ludwigii*, *H. obtusa* and *H. rigidula* var. *rigidula* occur in Namibia and two species (*H. hemerocallidea* and *H. obtusa*) occur in Botswana. The rest of the species are concentrated in South Africa, Swaziland and Lesotho (Table 9.4, Figure 9.3), most being associated with the grassland biome. Eight species are restricted to the latter three countries, while a further eight species occur in South Africa and either Lesotho or Swaziland. All southern African species occur in South Africa (Table 9.4), 13 being endemic to the country. In South Africa, *Hypoxis* is most prevalent in summer rainfall grasslands, especially those along the eastern seaboard (Figure 9.3). About 26 species occur in KwaZulu-Natal and Eastern Cape, 22 being common to these two provinces. Mpumalanga, Free State, Gauteng and Limpopo Provinces have between 13 and 17 species and similar numbers are noted for Lesotho and Swaziland. Fewer species are present in the Northern Cape, Namibia and Botswana, here mainly associated with arid Kalahari Basin Savanna and Nama-Karoo vegetation. The dynamics of the Nama-Karoo Biome namely the varying rainfall pattern, low winter temperatures and dry summers combined with the lime-rich, weakly developed soil over rock and insufficient fires do not favour *Hypoxis*. In fact, Mucina *et al.* (2006) point out that by comparison, the Nama-Karoo is not species rich, and that the dominance of asteraceous shrubs might indicate a young biome, but this statement is debatable.

Numbers of *Hypoxis* species also diminish in the Fynbos Biome of the Cape Floristic Region. The biome has a Mediterranean-type climate in part, experiencing winter rainfall and is dominated by fynbos, renosterveld and strandveld vegetation (Rebelo *et al.* 2006). Eight taxa, *H. argentea* var. *sericea*, *H. flanaganii*, *H. floccosa*, *H. longifolia*, *H. sobolifera* var. *sobolifera*, *H. stellipilis*, *H. villosa* and *H. zeyheri* occur in fynbos vegetation. *H. floccosa* and *H. villosa* are known from more sites in the Fynbos Biome than from the adjacent Albany Thicket and Grassland Biomes of the Eastern Cape; the other species being more common in the latter biomes.

In Chapter 12, the distribution of individual species of *Hypoxis* in southern African biomes as proposed by Rutherford *et al*. (2006), is presented. These maps indicate that although most members of *Hypoxis* are common in grassland in southern Africa, they are by no means endemic to this particular biome. They also occur in four other biomes namely the Indian Ocean Coastal Belt, Savanna, Albany Thicket and Fynbos, being more frequent in the former two types. After grassland, the higher frequency of *Hypoxis* in Indian Ocean Coastal Belt and Savanna is supported by the presence, at the local scale, of enclaves of grassland in these biomes. The Indian Ocean Coastal Belt is a mosaic of forest and grassland (Figure 9.4A) and most savanna has an herbaceous

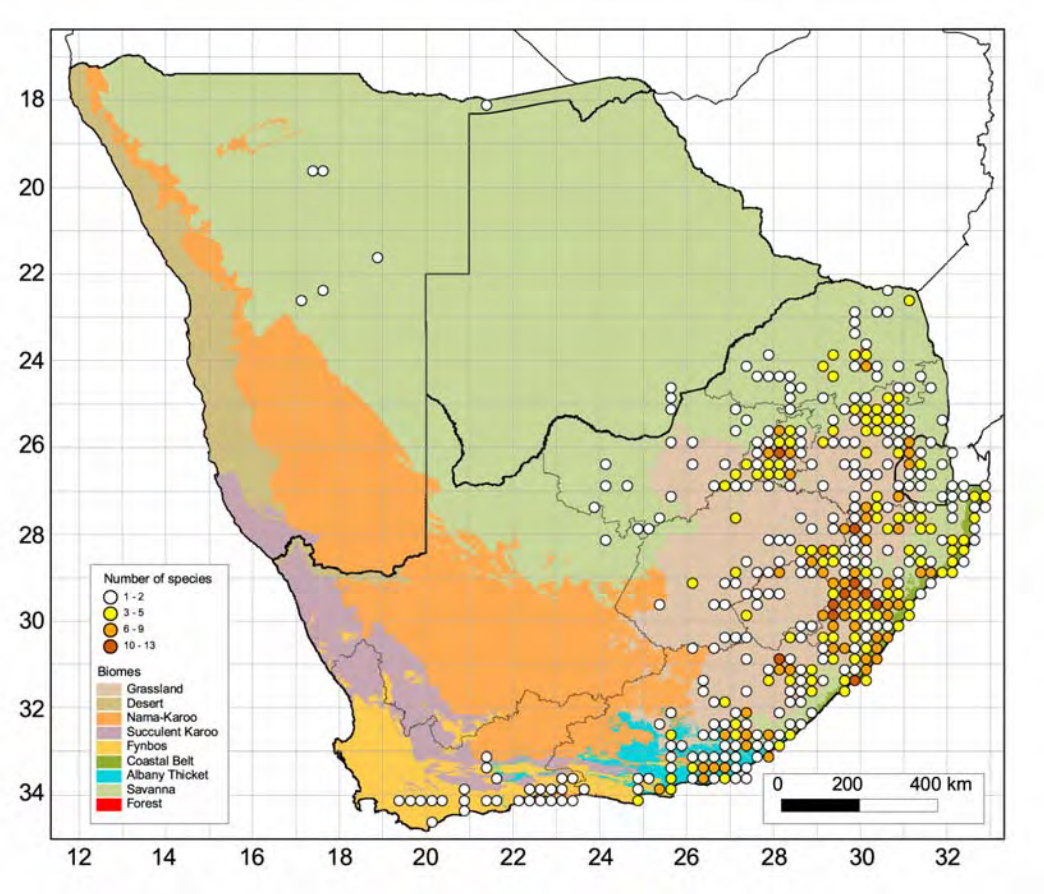

Figure 9.3.—Distribution of *Hypoxis* in southern Africa (South Africa, Lesotho, Botswana and Namibia) plotted against the biomes of the region.

layer dominated by grasses and an open tree layer (Rutherford *et al*. 2006). Mucina *et al*. (2006) explained that the Coastal Belt's tropical character makes it different from the Savanna Biome. It is dominated by trees, lianas and epiphytes and lacks an absolute rain-free period. Savannas, on the other hand, have strong seasonal rainfall and within the biome, trees and shrubs or grasses will dominate depending on the levels of rainfall (Rutherford *et al*. 2006). These authors describe savanna (Figure 9.4C) as being widespread in Africa from South Africa to Somalia and Ethiopia in East Africa and into West Africa reaching Senegal. They also mention its presence on other continents, coinciding mostly with the warmer areas and these contain many of the dominant grass genera that occur in southern African savannas.

The highest concentration of *Hypoxis* species occurs in the Grassland Biome followed by the Indian Ocean Coastal Belt and Savanna Biomes (Figure 9.3). Within the coastal belt, species prefer the grassland to forest. Two species with membranous leaves, *H. membranacea* and *H. nivea*, are restricted to open forests which form a typical component of the Coastal Belt along the eastern seaboard of South Africa. These species grow on forest cliff faces, in partial shade and have white

Figure 9.4.—Three of five biomes in southern Africa containing *Hypoxis* species, A, B, Indian Ocean Coastal Belt; C, Savanna; D, Albany Thicket.

Table 9.3.—Distribution of *Hypoxis* in southern Africa, including provinces in South Africa

Provinces in South Africa are abbreviated alphabetically as EC = Eastern Cape; FS = Free State; G = Gauteng; KZN = KwaZulu-Natal; LIM = Limpopo; M = Mpumalanga; NW = North West; NC = Northern Cape and WC = Western Cape. Countries outside South Africa are listed alphabetically as B = Botswana = L = Lesotho; N = Namibia and Swa = Swaziland. Light grey shade in column 1 indicates species with membranous leaves.

■ = presence of a species.

Species or infraspecific taxon	**KZN**	**EC**	**M**	**FS**	**G**	**LIM**	**NW**	**WC**	**NC**	**L**	**Swa**	**N**	**Bot**
obtusa	■	■	■	■	■	■	■		■	■	■	■	■
hemerocallidea	■	■	■	■	■	■	■			■	■		■
rigidula var. *pilosissima*	■	■	■		■	■	■			■	■		
rigidula var. *rigidula*	■	■	■	■	■	■	■			■	■	■	
longifolia	■	■	■	■	■	■		■		■			
acuminata	■	■	■	■	■	■				■	■		
multiceps	■	■	■	■	■	■				■	■		
filiformis	■	■	■	■	■	■				■	■		
galpinii	■	■	■		■	■					■		
costata	■	■	■	■	■					■			
interjecta	■	■	■		■								
parvifolia	■		■			■					■		
ludwigii	■	■										■	
obliqua	■	■		■									
colchicifolia	■	■		■									
kraussiana	■		■		■	■							
argentea var. *argentea*	■	■	■	■	■		■	■		■	■		
argentea var. *sericea*	■	■	■	■	■	■	■	■		■	■	■	
gerarrdii	■	■									■		
tetramera	■	■								■			
sobolifera var. *pannosa*	■	■											
sobolifera var. *sobolifera*	■	■						■					
flanaganii	■	■											
villosa	■	■						■					
stellipilis		■						■					
floccosa		■						■					
uniflorata				■									
zeyheri		■						■					
angustifolia var. *angustifolia*	■	■		■	■	■	■			■	■		
angustifolia var. *buchananii*	■	■	■								■		
parvula var. *parvula*	■	■	■	■						■			
parvula var. *albiflora*	■	■	■										
membranacea	■	■	■								■		
nivea	■	■											

flowers. Seeing that this habitat preference is unusual for *Hypoxis*, Singh *et al*. (2007) [Appendix 1.4] discussed in detail the ecology of one of the forest species, *H. nivea*. According to Mucina & Geldenhuys (2006), the forest realm represents an archipelago of forest islands present in Fynbos, Albany Thicket, Grassland and Savanna, and its patchy occurrence is indicative of its relict-like character. This suggests that the forest species of *Hypoxis* may be relictual and were possibly widely distributed when forest cover was more extensive in the past. It is possible that species have adapted to grassland conditions and diversified following the shrinkage of the forests. Further discussion on this is provided under 'origin and radiation of *Hypoxis* in Africa'.

In South Africa, the Grassland Biome covers mainly the high central plateau (Highveld), the inland areas of the eastern seaboard, the mountainous areas of KwaZulu-Natal and central parts of the Eastern Cape (Mucina *et al*. 2006), and the core distribution and diversity of *Hypoxis* correspond with these areas. According to Mucina *et al*. (2006), the grassland may represent a modern biome together with the Nama-Karoo and Fynbos. They also indicate that development of the Grassland Biome is possibly through global cooling and continental uplift in the Late Tertiary and the uplift moved a considerable area to high altitudes which are colder and more suitable for grassland than savanna vegetation. The diversity and taxonomic patterns in *Hypoxis* indicate that species with coriaceous leaves have either a thick waxy cuticle or an indumentum as possible adaptation to the grassland habitat. These exclude species with membranous leaves (*H. membranacea* and *H. nivea*) and those with slender leaves (3–4 mm wide) (*H. filiformis*, *H. flanaganii* and *H. tetramera*). *H. parvula* and *H. angustifolia* occur in forest and grassland and when in grassland, the species is associated with seasonally marshy patches and crannies among boulders.

The majority of the species prefer damp grassy patches or rock crannies where they often form stands. Many of the robust species, *H. acuminata*, *H. costata*, *H. galpinii*, *H. hemerocallidea*, *H. longifolia*, *H. multiceps*, *H. obtusa* and *H. rigidula*, defined by their coriaceous, firm leaves and racemose inflorescences, have a wide distribution in the eastern region of South Africa, extending in range from Savanna in Limpopo and Mpumalanga across Grassland/Coastal Belt region and reaching the Albany Thicket in the Eastern Cape. Smaller species (*H. argentea*, *H. flanaganii*, *H. sobolifera*, *H. stellipilis*, *H. villosa* and *H. zeyheri*) characterised by soft textured leaves and corymbose inflorescences, occur in Grassland, Savanna and the Albany Thicket. The Albany Thicket (Figure 9.4C) is floristically heterogeneous, having succulent elements from the Nama-Karoo as well as woody members from the subtropical vegetation, and have rainfall at any time of the year (Hoare *et al*. 2006). *H. stellipilis*, a morphologically distinct species (see Appendix 1.5 for discussion on morphology of the species) is markedly an Albany Thicket element that enters into the adjacent Fynbos. In this species, hairs form a tomentose cover on the lower surface of the leaves, suggesting an ecological adaptation towards water retention under relatively arid conditions.

9.4 Centres of diversity

Hypoxis species richness for tropical Africa was calculated from distribution data in Wiland-Szymańska (2001), Nordal & Zimudzi (2001), Wiland-Szymańska & Nordal (2006) and Hepper (1968) at a quarter degree square resolution. For southern African species, distribution data from the PRECIS database were used and built on by adding missing grids from collections obtained on loan-from various herbaria. Grid references per species were entered into a matrix and from this the number of species per degree was calculated. Species frequencies per degree confirmed that *Hypoxis* has its core area of diversity in the eastern region of South Africa (Figure 9.5), that corresponds with the Afromontane Archipelago-like regional centre of endemism recognised in White (1993). Species frequencies also suggest a secondary centre located in the Zambesian Centre of endemism and Guinea-Congolia/Zambezia regional transition zone demarcated by White (1993). The highest number of species in Africa, between 10 and 12 are found in 6 grids, all in southern Africa and between 5 and 9 species occur in about 30 grids in southern African and the Sudano-Zambesian region. Most grids have between 1 and 4 species. In southern Africa, *H. argentea*, *H. hemerocallidea*, *H. obtusa* and *H. rigidula* are known from the largest number of quarter degree grids, between 40 and 50. Seven taxa are known from less than 10 grids in the region (Table 9.4). It should be noted that the distribution presented in Figure 9.5 is an estimate based on specimens cited in literature and is likely to change when the grid data are worked of specimens.

Table 9.4.—Taxa known from less than 10 quarter degree square grids

Taxon	**Number of grids**	**Grids**
H. nivea	9	2930BD, 2930DD, 3030CC, 3030CD, 3128DC, 3129BD, 3130AA, 3228AD, 3228BC
H. interjecta	9	2528CA, 2528CC, 2529BB, 2529CB, 2627BB, 2628AA, 2729DD, 2929BA, 2929BC
H. sobolifera var. *pannosa*	7	3129BC, 3225DA, 3227CD, 3325CA, 3325DA, 3326AD, 3326BC
H. stellipilis	7	3323CA, 3324DD, 3325CD, 3325DA, 3325DC, 3326BA, 3326CB
H. kraussiana	6	2730CB, 2730CC, 2731CB, 2829DD, 2930CB, 2930DD
H. floccosa	5	3227CB, 3419AB, 3419BA, 3420AB, 3420CA, 3421AB
H. tetramera	5	2730AC, 2730AD, 2929CB, 2929CC, 2929CD

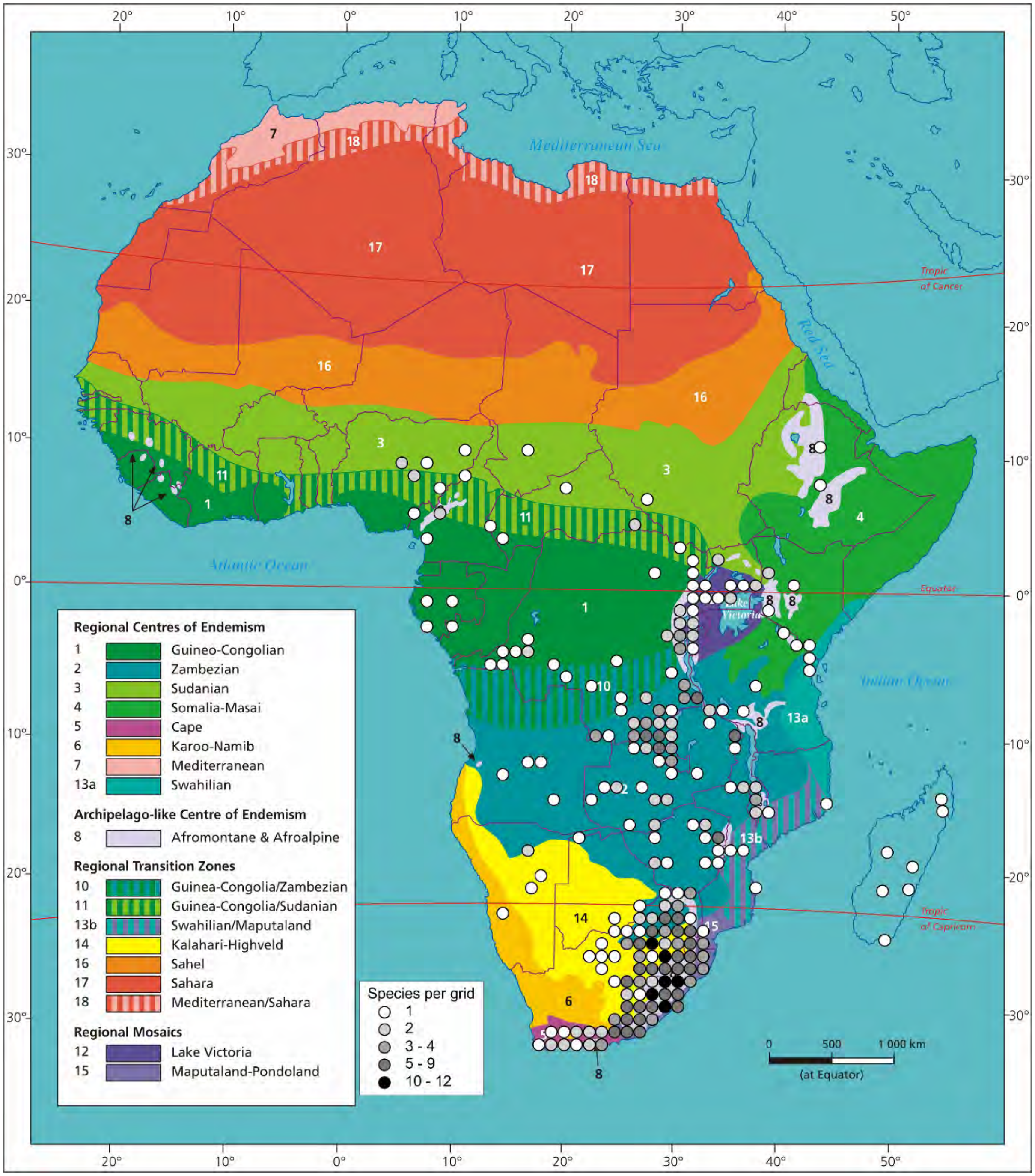

Figure 9.5.—*Hypoxis* diversity in sub-saharan Africa. Grid size is 1 by 1 degree. (Base map reproduced with permission from Van Wyk & Smith© 2001). Although *Hypoxis* occurs in Sierra Lorne, Liberia, Ivory Coast, Ghana, Tunisia, Benin and Ethiopia (see Figure 5.2), localities to trace grid references were not available for these countries. Further, for tropical Africa, grid data is based on records cited in literature and this distribution is likely to change when grids are added from specimen data.

In writing about *H. sobolifera* as an example of a widespread grassland species and *H. nivea* as a narrow forest endemic in southern Africa, Singh *et al*. (2007) [Appendices 7 & 8] indicated that *Hypoxis* is of special biogeographical significance as it is a predominantly grassland element with a few species restricted to forest habitats. These authors surmised that the range for the genus reflects a temperate rather than tropical affinity for the genus in Africa, its occurrence shows a strong Afromontane affinity and that its core diversity coincides with two Hotspots on the continent– the Eastern Afromontane (Brooks *et al.* 2004) and Maputaland-Pondoland-Albany (Steenkamp *et al.* 2004). See Singh *et al*. (2007a) [Appendix 1.3] for a general discussion on the biogeography of *Hypoxis* in Africa. This varies from the distribution and centre of diversity in Tropical Africa presented in Figure 9.5. However, the high numbers of endemic species of *Hypoxis* in Tropical Africa, occur in Centraland Tropical East Africa, located in the Eastern Afromontane Hotspot.

In the Eastern Afromontane Hotspot, *Hypoxis* is associated with the Uluguru and Usambara Mountains of the Eastern Arc (Wiland-Szymańska & Nordal 2006) and the High Katanga (Wiland 1997a, 2001) of the DRC. The Eastern Arc is a series of mountain blocks ranging in southern Kenya and Tanzania that peak to altitudes of 2000 to 2500 m. Concerning the origin of the Eastern Arc Mountains in East Africa, Griffiths (1993) explains that ‘the individual mountain blocks have been uplifted along ancient faults dating back to the breakup of Gondwana (more than 180 million years ago), with some uplift events occurring at least since the Miocene (about 30 million years ago), and especially over the last seven million years, associated with the development of the Rift Valley system’. The mountains receive an annual rainfall of mostly above 1500 mm, and as high as 3000 mm is recorded for the Ulugurus (Burgess *et al.* 2004).

Like the Coastal Belt in southern Africa, the Eastern Arc is a forest-grassland mosaic of Afromontane affinity. The mountain slopes are covered in tropical forests that grade into grassland and heathland plant communities with temperate affinities on the plateau (Lovett, 1990). This vegetation is nourished by moisture-laden winds from the Indian Ocean (Burgess *et al.* 2004), and Lovett & Wasser (1993) claim that the climatic regime of the region is maintained by the Indian Ocean climate that is believed to have been stable over millions of years.

The topography of the High Katanga (Central Africa) and the Zambesian region is mainly Savanna (=miombo woodlands). The mountainous margins of Lake Malawi (Nyasa) and the Mulanje Massif in southern Malawi form part of the Southern Rift, which is not under the stable Indian Ocean climatic regime and is biologically poorer (Burgess *et al.* 2004) in comparison to the Eastern Rift.

Outside of Africa, smaller centres of diversity are recorded in the USA-Mexico region, with high endemism of species recorded in the Mesoamerican Mountains. Australia represents the smallest centre of diversity. In general, *Hypoxis* on all continents is associated with the grasslands and savanna woodlands, and rarely open forests.

9.5 Ecology

Hypoxis species-richness in southern Africa is clearly centred in Grassland with predominantly summer rainfall. The genus, in general, prefers direct sunlight. The majority of species grow in open grassland and may continue into adjoining dune and savanna vegetation provided sites offer sufficient light. Species with membranous leaves, *H. angustifolia*, *H. parvula*, *H. membranacea*, and *H. nivea* grow in Coastal Belt Forest, on cliff ledges in partial shade and the latter two species are restricted to this habitat.

Most species of *Hypoxis* in southern Africa are either widespread and have a range from coast to the interior, reaching high altitudes of 2400 m above sea level (Snijman & Singh 2003) [Figure 9.6]. Species may be restricted either to the coast or to high altitudes in the interior, particularly the Drakensberg Mountains. Five species, *H. flanaganii*, *H. floccosa*, *H. nivea*, *H. stellipilis* and *H. villosa* have a coastal distribution. *H. sobolifera* occurs mainly along the coast and forms prolific masses along the rocky coastline (Figure 9.7) in the salt spray zone from Swellendam in the Western Cape to Port Edward in KwaZulu-Natal, but there are also rare inland collections of the taxon from the foothills of the Drakensberg Mountains in KwaZulu-Natal. A few species are endemic to the Drakensberg Mountains, the range of which forms part of the Great Escarpment and extends from the Eastern Cape through KwaZulu-Natal, Lesotho, Free State and reclines in Gauteng and Limpopo. Grasslands of the Drakensberg receive rainfall mainly in the form of thunderstorms, about 1000–2000 mm per annum, but orographic mist is also an important contributor to precipitation of the area. *H. tetramera* is restricted to high altitudes (1800–2400 m) and is an element of the Drakensberg Alpine Centre [DAC]. The DAC is recognised as a distinct local centre of floristic endemism by Van Wyk & Smith (2001). It has a temperate climate with summer rainfall, and mist is common throughout the year. However, these DAC endemic species do not reach the alpine belt, the region above 2800 m that endures severe changes in weather with cold to freezing winter temperatures (Van Wyk & Smith 2001). *H. parvifolia* occurs at a lower

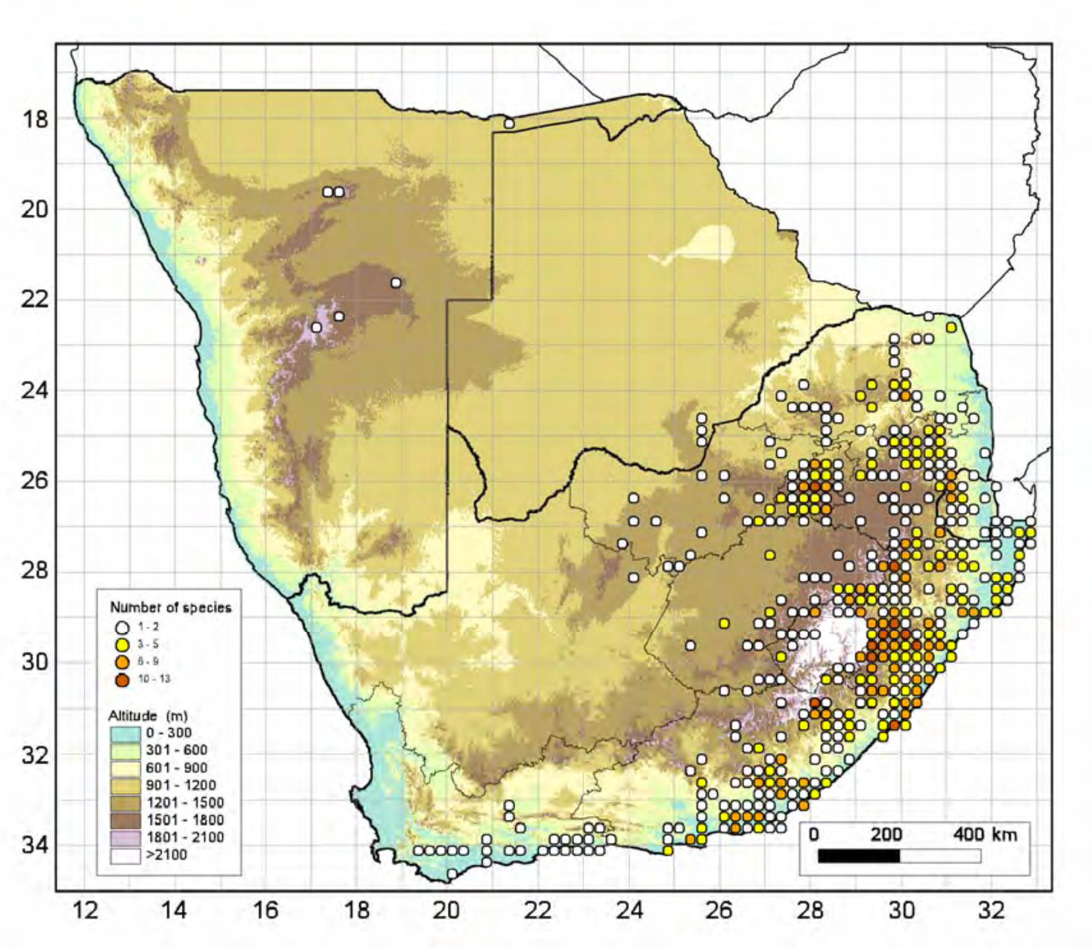

Figure 9.6.—Distribution of *Hypoxis* in southern Africa plotted against altitude.

Figure 9.7.—Mass of *H. sobolifera* along coast in East London, Eastern Cape.

altitude of 1200 m. *H. parvula* shows a disjunct distribution across biomes and altitudes. In the Coastal Belt, *H. parvula* occurs in forest but when in grassland, the species is restricted to high altitudes (1200–2400 m), reaching the DAC. In the DAC, it is often found growing with *Rhodohypoxis* (also Hypoxidaceae) among short grass. Hilliard & Burtt (1988) report on an association of flower colour with altitude and exposure in *H. parvula* in the Drakensberg Mountain and its outliers. They found that the white-flowered plants (var. *albiflora*) occur at lower altitudes (c. 1500–1850 m) and usually on thinner drier grassland of the northwestern slope. Plants with yellow flowers (var. *parvula*) on the other hand, usually grow at slightly higher altitudes (c. 1900–2200 m) in damp grass of the southeasterly slopes. *H. angustifolia* is widespread in forest and grassland from close to sea level and reaches an altitude of 1800 m in the Drakensberg.

Shade and moist habitats presumably facilitate water retention in species with membranous leaves (*H. angustifolia*, *H. membranacea*, *H. nivea* and *H. parvula*) and those with slender leaves, between 3–4 mm wide (*H. filiformis*, *H. flanaganii* and *H. tetramera*). In grassland, these species are largely confined to damp grassy slopes, seasonally marshy depressions and seepage or shade spots among boulders. Other species grow mostly in drier conditions and show structural adaptation presumably to reduce transpiration in having coriaceous (non-membranous) leaves either with a thick, waxy cuticle or a dense indumentum. Species with glabrous laminae (hairs completely absent or restricted to margins and veins), *H. colchicifolia*, *H. longifolia*, *H. obtusa*, *H. kraussiana*, *H. ludwigii*, *H. obliqua* and *H. rigidula* var. *rigidula* have a thick, waxy cuticle that probably reduces transpiration. Leaves in the remaining species are covered in hairs, usually more densely on the lower surface. The presence of hairs in *Hypoxis* is interpreted as an adaptation to drier conditions. It is known that hairs lessen air movement at the leaf surface by forming a zone of still air through which water vapour diffuses from the leaf interior to the relatively dry air surrounding the atmosphere (Woolley 1964). Hairs may also indirectly influence the water economy of plants by lowering leaf temperature (Fahn & Cutler 1992). The layer of hairs increases leaf reflectance substantially for all wavelengths of solar radiation between 400 and 3000 nm and reduces radiation absorption which results in reduced heat load, reducing transpiration (Ehleringer 1984). Similarly, cuticular waxes also reflect light and have been shown to regulate leaf temperature and reduce transpiration. Fahn & Cutler (1992) indicate that it is possible to find members of a family or even a genus, with dense indumentum on both or one surface growing in the same habitat. Varying densities of leaf hairs were observed in *H. argentea*, *H. acuminata*, *H. rigidula*, *H. sobolifera*, *H. villosa*, *H. flanaganii*, *H. floccosa* and *H. gerrardii*, often among plants in the same population.

Shade and moisture are also responsible for a fair amount of phenotypic plasticity in members of the genus. Leaves in species growing in partial shade provided by trees or rocks are usually about twice as large as those in direct sunlight. Singh *et al*. (2007a & b) described the variation in leaves recorded in plants of *H. sobolifera* [Appendix 1.3] and the similar effect of deeper shade on plants of *H. nivea* [Appendix 1.4]. Plants of *H. angustifolia* and *H. parvula* in forest habitats are almost glabrous in comparison to plants from grassland, denoting the possible role of hairs to reduce transpiration in warmer open habitats.

In southern Africa, flowering of *Hypoxis* is often associated with areas burned in winter/early spring and spring rains. The genus is noticeable in burnt fields (Figure 9.8A) due to their prolific flowering in the absence of above-ground growth and leaf litter. Their presence in unburnt fields is not only obscured by tall grasses (Figure 9.9), but flowering is also less prolific (Figure 9.8B). Figure 9.10 shows *Hypoxis* plants in unburnt grassland during the dormant season. Flowering in *Hypoxis* is clearly stimulated by periodic burning, but fire is not essential for this purpose (Figure 9.8B) and the plants cannot be regarded as obligate pyrophytes. The genus survives fires by a perennial rhizome, an adaptation possibly established during the Tertiary (Burgoyne *et al*. 2005). Burgoyne *et al*. (2005) emphasised that fire is an integral natural factor of the climate in Africa and that grassland and savanna biomes are fire-dependent for the maintenance of their structure and biodiversity as well as their proper functioning. Herndon (1988) studied the effect of fire on the reproductive activity of *H. sessilis* and *H. wrightii* in southern Florida. He concluded that fire acts as a strong flowering stimulus and flowering in these species peaks in the first three months after a burn. Flowering peaks occur in a similar time frame in southern African *Hypoxis*. In the summer-rainfall region, peak flowering in the grassland species coincides with burning during the dormant season (mainly May–July) and with the onset of the spring rains in September or later. Burning probably stimulates flowering in petaloid monocots by reducing competition from woody members (Goldblatt 1991), but this probably only applies to the Fynbos Biome. In the Grassland and Savanna Biomes, associated woody plants are usually dormant during flowering of *Hypoxis*. Herndon (1988) explains the effect of fire and rain on the herbaceous layer. Firstly, fire removes the litter layer and reduces the hardwood leaf area giving the herb layer access to increased light levels, and this stimulates reproductive activity. Secondly, there is a brief increase in soil fertility as nutrients mineralised by fire from the leaf litter enter the soil with the first rains and thirdly, more soil water and nutrient reserves become available to the herbs that re-sprout at a faster rate

Figure 9.8.—Impact of burning on *Hypoxis* growth. A, *Hypoxis obtusa* in burnt grassland in KwaZulu-Natal, Estcourt; B, *H. hemerocallidea* not noticeable in unbrunt grassland, KwaZulu-Natal, Durban.

Figure 9.9.—Winter dormant, summer rainfall grassland, Gauteng, Suikerbosrand (May-July).

Figure 9.10.—*Hypoxis* plants during winter dormancy. A, *Hypoxis rigidula*, past season’s leaves (arrow); B, *H. obtusa*, past season’s leaves (arrows).

than woody members, after a fire. Moreover, smoke from veld fires is known to stimulate seed germination (Brown & Van Staden 1997). Indications are that smoke may similarly stimulate flowering in some Grassland and Savanna Biomes species, but this requires further experimental study.

The nutrient rich soil, rainy season and absence of dominant vegetation also provide a favourable habitat for seed germination. Several species of *Hypoxis* belong to a unique group of perennial resprouters known as pre-rain flowers and is defined by Van Wyk (2004) as a group that flower and set seed before the first spring rains after the dormant season and especially following a fire. Production of flowers early in the season, in the absence of competitive vegetation is believed to promote pollination and seed set in the genus. Herndon's (1988) studies showed that by growing and reproducing quickly after a fire, *Hypoxis* species are able to disperse their seed in a habitat that supports germination. The temporary absence of a complete ground cover may be important for seedling establishment, as suggested for the Iridaceae by Goldblatt (1991). Recent studies (Brown *et al*. 2003 and Van Staden *et al*. 2004) showed that smoke from burning plant material contains a chemical compound that triggers seed germination. The compound presumably enters the soil with the nutrients and seeds of *Hypoxis* may depend on it as a germination trigger. Seeds of *Hypoxis* should be sown immediately after harvesting and seedlings develop between four to six weeks later as reported for *H. hemerocallidea* by Gillmer & Symmonds (1999). Poor germination rates were recorded for seeds of the same species stored for two to eight months (Hammerton & Van Staden 1988). Due to lack of competition (and probably more frequent watering), cultivated plants of *H. hemerocallidea*, *H. sobolifera* and certain forms of *H. angustifolia* remain evergreen for most of the year. Cutting back the browning leaves of the earlier season in these plants, stimulates new growth and flowering.

9.6 Pollination and seed dispersal

Except for white flowers in *H. membranacea*, *H. nivea* and *H. parvula* var. *albiflora*, flowers in *Hypoxis* are yellow. The anthers and pollen in the white flowers are yellow (Figure 7.7) and the stigma although white is dry and papillate like the rest of the members in the genus. In these white-flowered species, the stigma is oblong to spherical and is held on a filiform style. Yellow-flowered species of *Hypoxis*, on the other hand, have pyramidal stigmas on subulate styles, except in *H. parvula* that has a spherical stigma and filiform style, and *H. angustifolia* in which the shape of the stigma varies between pyramidal and spherical and the ratio of style to stigma length varies (Nordal *et al*. 1985; Wiland-Szymańska & Adamski 2002). The functional significance of flower colour and stigma types is most probably associated with different pollination strategies. Yellow-flowered species are pollinated by bees, mainly the common honeybee (*Apis mellifera scutellata*) [Figure 7.9] and solitary bees. Open flowers, free tepals, and lack of nectar and scent imply bee pollination for the genus. No pollinators were observed in populations of the white-flowered taxa during daylight hours. This has lead Singh *et al*. (2007b) to suggest primitive pollen-eating moths as potential pollinators for the white-flowered *H. nivea*. Flowers in *Hypoxis* open for a few hours only. On sunny days they open after sunrise, between 6:30 and 7:00 and close around midday, following pollination. On cloudy and rainy days when bee activity is low, flower opening and closing is delayed till late afternoon. Usually, only one to three flowers per inflorescence open each day, the lower ones on the inflorescence opening first. In *H. acuminata*, *H. hemerocallidea*, *H. obtusa*, *H. galpinii*, *H. ludwigii* and *H. sobolifera* flowers on many inflorescences open at the same time and the flowers in these species are large and of a thicker texture, revealing their floriferous status. Rogers (2006) points out that duration of the flower is species specific and carefully tailored to its ecological requirements. She suggests three reasons for flowers closing after pollination: firstly the flower is a substantial sink on the plant's resources, and it is energetically expensive to maintain beyond its useful life, secondly, it prevents pathogens that exploit the stigma as a point of entry and thirdly, it removes them from the population and reduces competition for pollinators. These reasons may also, singly or in combination, hold for *Hypoxis*, but the duration of flowers in the genus corresponds with the time of day when bee activity is highest. Further, closing of flowers after pollination must trigger the physiology for seed set, as there is an ecological need in the genus for seeds to be set swiftly.

From a study on seed surfaces in *Hypoxis* in southern Africa (Singh & Van Wyk, Appendix 1.5), it is estimated that close to 85% of the species have papillate seeds. In this contribution, the authors indicate that the ecological significance of papillations or its absence in *Hypoxis* seeds is unclear, but may relate to uptake of water. Of further interest is the water droplet that collects over dehisced capsules of *H. parvula* var. *parvula* (Figure 7.11). This suggests a possible dependence on water for seed dispersal, at least in the delicate species with lax, drooping inflorescences.

9.6 Origin and radiation of *Hypoxis* in Africa

Naturally, the origins and radiation of any group should be dealt with at family level to fully understand specialisation of members and radiation patterns. In this section, data from literature on historical biogeography and age of monocot groups were synthesised to propose a generalised view on the possible origin of Hypoxidaceae (Asparagales) in Africa, and the possible radiation of *Hypoxis* on the continent, a genus present on all Gondwana fragments, and North America. However, in the absence of a robust phylogenetic hypothesis for *Hypoxis*, evolution at generic and species level must be seen as highly speculative at the moment. Moreover, the conventional view that Afromontane grassland is a relatively young vegetation type in Africa (compared to Afromontane forest) rests also on questionable assumptions. For example, the high levels of local plant endemism in Afromontane grassland compared to the low plant endemism of the associated Afromontane forest suggest a considerable age for these temperate grasslands (Van Wyk & Smith 2001).

From a combined biogeographical and geological history analysis, Bremer & Janssen (2006) inferred a South Gondwana (South America, Antartica and Australasia) origin for commelinids, and core monocots Asparagales and Liliales. According to these authors, Africa and North America were presumably not parts of the ancestral area for these plant groups. They suggest that the Asparagales, with its many small families, has a Southern Hemisphere distribution, especially in Australasia, thus suggesting an originally Australasian distribution for the order. From Janssen & Bremer's (2004) age estimates for families and orders of monocots, all orders are older than 100 Mya (except the Zingiberales) and Hypoxidaceae has a crown node age of 78 Mya while that for the Asparagales is 119 Mya. These authors indicate that most monocot families diverged between 100 and 65 Mya and this timing coincides with the Late Cretaceous (97.5–65 Mya). By this period Africa had separated from South America (in the Mid-Cretaceous, around 100 Mya according to Scotese *et al*. 1988) but South America remained connected to Australia via Antartica until the Eocene epoch (55.8–33.9 Mya) of the Tertiary (Bremer & Janssen 2006). Raven and Alexrod (1972) mention that although gymnosperms seemed to have reached Africa overland from the south, distribution patterns of angiosperms agree with a Tertiary origin for most genera.

Patterns of distribution indicate a conglomeration of genera (six of ten) in the Hypoxidaceae in southern Africa. *Curculigo*, *Hypoxidia*, *Heliacme* and *Molineria* are absent from southern Africa, but occur in areas that were also part of Gondwana. *Curculigo* occurs in Tropical Africa and Asia, *Molineria* is found in Asia and *Hypoxidia* is restricted to the Seychelles. The breakup of Gondwana caused vicariant division of its ancestral biota that is reflected in the biogeography of the Southern Hemisphere (Raven & Axelrod 1972). Likewise, the Hypoxidaceae probably has an austral affinity described by Raven & Axelrod (1972) as the time when Africa was joined with Antartica, and its disjunct distribution may be due to vicariance. However, long distance dispersal cannot be dismissed as a cause of disjunction in the Hypoxidaceae, as Sanmartín & Ronquist (2004) maintain that land link and recent dispersal is a likely explanation for the biogeographical relationships in the southeastern tropics. The southeastern tropics include Africa, Madagascar, India, Southeast

Asia/Southwest Pacific, northern Australia and New Guinea. In the absence of fossil pollen for the Hypoxidaceae, distribution by vicariance remains speculative.

The genus *Hypoxis* is best developed in Africa at two centres, South Africa and the Rift Valley. Its ancestors were most likely similar to the extant fragile, almost glabrous species found in forests. These fragile members have small delicate rhizomes, membranous leaves, few, lax corymbose inflorescences with not many flowers (1–3, less often 5). Species with these characters are fewer in number and are found in Africa, South America, Australia and Asia. On the continent of Africa, the diversification of geophytic monocots has been linked to uplift events in southern and East Africa. These events are believed to have caused the extensive forest cover in Africa to fragment in the Tertiary. Fragmentation created open areas which with climate change gave rise to Afromontane grassland that further supported the development of an extensive herbaceous flora (Goldblatt 1991). Although the ancestors of Hypoxidaceae are considered to be ancient (80–90 Mya or earlier), diversification of the family on the continent is hypothesized to be recent, as species are found mainly in grassland, that are recognised as a modern biome by some authors. Burgoyne *et al*. (2005) mentioned findings by Rayner *et al*. (1991) that suggest the climate of Botswana in the Mid-Cretaceous was temperate, seasonal and wet and the surrounding area was forested. This presumably implies that forest-dwellers, if they existed at the time, were widespread in southern Africa. It may also mean that species of both forest and grassland habitats were also widely distributed in forests, but with uplift events in Africa in the Miocene (23.03–5.332 Ma) and consequential fragmenting of forests, forest species descendents, such as *H. parvula*, have become restricted to forests and cooler alpine grasslands, while grassland-forest species, such as the extant *H. angustifolia*, retained a wide range, but migrated to wetter areas in open grasslands. *H. angustifolia* is very variable in morphology and probably represents the image of those ancestral species with transitional adaptation from forest to grassland habitats in Africa, especially in also having both stigma types.

All other species of *Hypoxis* show adaptation to grassland in having acquired a coriaceous leaf texture or a strong indumentum or both. Increase in grassland areas in Africa, meant that plants were subjected to regular burning and the development of a robust underground storage in *Hypoxis* can be interpreted as a modification to survive fires. Another possible adaptation to fire is the change from corymbose, few-flowered inflorescences and small, thin-textured flowers in fragile species to racemose, many flowered inflorescences and larger, firm-textured flowers in grassland species of robust stature. The increase in number of flowers possibly indicates enhanced reproductive vigour as a result of the extra resources available in the enlarged rhizomes.

9.7 Conclusions

There is a clear assemblage of genera of the Hypoxidaceae in southern Africa. Data presented in this Chapter confirmed that the genus *Hypoxis* is also centred in the region and that a secondary centre of diversity is located in Tropical Africa. Members of the genus are dominant in Afromontane grassland that is considered by some authors to be of modern origin. Essentially, the development of grasslands due to climate changes on the continent is recognised as one of the main reasons for speciation of *Hypoxis*, as for the herbaceous flora in general. Speciation in the group may also have been driven by evolutionary events involving polyploidy, hybridisation and apomixis (discussed on Chapter 12) and these factors contribute towards the group’s complex taxonomy.

10

GENERAL DISCUSSION

10.1 Introduction

Hypoxis, like many other lilioid groups provides a challenge for taxonomists. The fairly uniform flower structure in the genus means that greater emphasis is placed on vegetative characters, mainly the leaves, and often these characters overlap between closely related species and thus hamper identification. In a few species, the changing appearance of leaves during the growing season leads to a fair amount of variation not always accounted for in available descriptions. More importantly, the difficulty in providing a practical key to species is due to the high level of polymorphism in the genus. Earlier works on the cytology and reproduction in *Hypoxis* point out that variability in chromosome numbers is caused through polyploidy and apomixis. Since hybridization is known to promote apomixis (Stebbins 1950), it is plausible to consider it as a further mechanism of genetic variability in the genus. Hybridization, polyploidy and apomixis in combination seems to drive speciation in *Hypoxis*. In short, the hybrid and apomictic forms derived through these phenomena end up with characters that no longer align with the original parent species. The derived character sets of these polymorphs start to obscure species limits.

The main purpose of this study was to recognise diagnostic character states for species in the richest *Hypoxis* region of the world, and in so doing provide accurate names that will form the basis for cytological, DNA and other studies within the genus and family. This Chapter presents a synopsis of the outcomes of this study in accordance with the objectives outlined in Chapter 1; the main result being a formal taxonomic treatment for southern African *Hypoxis*. A summary of the diagnostic morphological characters and a schematic representation of the infrageneric groupings described by Singh (2004) for the genus are included. As part of the discussion, relationships inferred from leaf anatomy, rhizome chemistry and seed micromorphology are compared with the infrageneric groupings. Putative hybrids involving three species of *Hypoxis* and an intergeneric hybrid with *Rhodohypoxis* in nature are discussed. This Chapter based mainly on earlier publications describes how hybridization, polyploidy and apomixis bring about chromosome variation in the genus which is in turn responsible for a fair amount phenotypic variation. Evidently, the phylogeny of such an intricately variable group cannot be resolved with certainty on external morphology alone. Cytotaxonomic and molecular studies, for instance are necessary to establish polyploid taxa and confirm reticulate evolution in the genus. At the end of the Chapter, facets for follow up study in *Hypoxis* are suggested.

10.2 Synopsis of outcomes

10.2.1 Revision of *Hypoxis* in southern Africa

Based on the morphological species concept, 28 species of *Hypoxis* are recognised in the Flora of southern Africa region. The study succeeded in recognising macromorphological characters of diagnostic value in circumscribing species in *Hypoxis*. The most significant characters for separating species were found to include habit, arrangement of leaves from point of emergence (false stem forming or not); leaf shape, length and width, texture, number of veins raised on the upper surface of the leaf, distribution, density and types of leaf hairs; inflorescence type, diameter of open flowers, texture of tepals and stigma type. As character ranges overlap between closely related species, the characters selected for separating species work most effectively when applied in combination. Morphological characters were selected from the discussion on vegetative, and flower and fruit characters provided in Chapters 5 and 7, and presented for use in future phenetic analyses. Table 10.1 provides a list of potential diagnostic characters and their states for the southern African species of *Hypoxis*. The reason the analyses were not run in this study is that only 28 of a total of about 85 *Hypoxis* species world-wide were surveyed. The data are provided so that they can be incorporated in a monographic treatment for the group in future.

Due to the extensive field work undertaken in South Africa for the present study, variation in several common species was studied. Six species namely *H. flanaganii*, *H. floccosa*, *H. kraussiana*, *H. ludwigii* and *H. uniflorata* are known from very few herbarium specimens and although the general morphology of the species is understood, they have not been fully studied in the wild. Phenotypic variation within species in relation to dimensions of vegetative parts was considered to have little value for infraspecific classification. Only in *H. angustifolia*, two varieties are recognised with emphasis on leaf width, but it is also noted that the status of varieties in this species needs to be revisited. Species limits were expanded in some cases to incorporate slight variation in ranges of macromorphological characters like rhizome and leaf dimensions. This resulted in species like *H. cordata* Nel being considered to represent the extreme end of the range in leaf width for *H. rigidula* (Singh 2007) [Appendix 1.2]. *H. cordata* was described by Nel (1914) as a new species based on its broad leaves in comparison to the typical leaves of *H. rigidula*. Unlike leaf dimensions, density of leaf hairs was found to be extremely useful for infraspecific

Table 10.1.—Diagnostic characters and character states of *Hypoxis* in southern Africa

1	Rhizome large, yellow or orange within (0); small, white within (1)
2	Leaves clasped together forming a false stem (0); spreading upwards and outwards from base (false stem absent (1)
3	Leaves broadly lanceolate (0); linear-lanceolate (1); narrowly linear (2)
4	Leaves rigid (0); firm (1); soft (2); membranous (3)
5	Leaf indumentum absent (0); present (1)
6	Indumentum evenly spread over lamina, midrib and margins (0); dense along midrib and margins only (1)
7	Hair bifurcate (0); stellate (1); mixture of bifurcate and stellate (2)
8	Veins on upper surface almost evenly thickened (0); unevenly thickened, 1–3 veins close to margins raised on upper surface (1)
9	Leaf hairs white (0); golden yellow (1); red-brown (2)
10	Inflorescence racemose (0); corymbose (1); single-flowered (2)
11	Tepal colour yellow (0); white (1)
12	Diameter of open flowers 20 mm or more (0); 12 mm or less (1)
13	Tepal length 12–20 mm long (0); 4–15 mm long (1)
14	Stigma pyramidal (0); spherical (1)
15	Filaments and style subulate (0); filiform (1)
16	Capsule dehiscing by circumscissile split only (0); by circumscissile split and longitudinal split (1)
16	Seed smooth (0); papillate (1)
17	Papillate seeds lack secondary papillae (0); with secondary papillae (1)

classification. In *H. argentea*, *H. rigidula* and *H. sobolifera*, two varieties are distinguished on intensity of hairs. The approach of creating complexes for validly published species that are hardly distinguishable from closely related species was avoided; one such example being *H. ludwigii* which is very similar to *H. obtusa*. Such species were retained as valid and it was noted that decisions on their status should be taken following thorough population sampling combined with cytological studies.

10.2.2 Infrageneric groupings for southern African *Hypoxis*

Singh (2004) [Appendix 2.3] classified 35 species of *Hypoxis* into eight informal groups and two subgroups based on habit, leaf, inflorescence and flower characters. Representatives of each group are illustrated in Figure 10.1. For descriptions of the groups refer to Singh (2004). The allocation of species to groups remains similar to that proposed in this publication, except for a few changes based on taxonomic decisions and data from seed micromorphology. The taxonomic changes include a new species *H. nivea* added to Group 7, and the reduction of a few species (*H. cordata* = *H. rigidula*, *H. dinteri* = *H. argentea*, *H. oblonga* = *H. rigidula*, *H. obconica* = *H. hemerocallidea*, *H. limicola* = *H. parvula*, *H. patula* = *H. hemerocallidea*) to synonymy in Singh (2007) [Appendix 1.2] and in the treatment presented in Chapter 12. Seed surface characters suggest the placement of *H. kraussiana* and *H. parvifolia* in Group 2 and *H. argentea* into Group 5a. The reasons for repositioning the species are discussed in 10.2.3.

10.2.3 Data from leaf anatomy, rhizome chemistry and seed micromorphology

Leaf anatomy, rhizome chemistry and seed micromorphology in *Hypoxis* provided key characters that broadly support the groups and confirm relationships of species. From the study on internal leaf anatomy, two characters were found to be useful for grouping species, namely the thickness of mesophyll cell layers and the sclerenchyma in the inner bundle sheath. Species with membranous leaves have few (2–4) cell layers in the mesophyll, while coriaceous leaves have many more mesophyll layers, confirming differences in leaf texture. The arrangement of sclerenchyma varies depending on the species and it is useful in separating species with rigid or firm leaves from those with soft leaves. However, it is impossible to apply this character to the morphological groupings in Singh (2004).

From the chemical analysis of rhizome extracts of 14 species, three fingerprint types were recognised for *Hypoxis*: the *hemerocallidea*-type found in *H. colchicifolia*, *H. galpinii*, *H. rigidula*, *H. acuminata*, *H. hemerocallidea*, *H. obtusa*, *H. costata* and *H. multiceps* has hypoxoside as the main compound; the *filiformis*-type is present in *H. argentea*, *H. filiformis*, *H. membranacea* and *H. parvula* and has a characteristic unknown compound; and the *angustifolia*-type which has a unique combination of compounds. Species showing *hemerocallidea*-type chemical profile have robust rhizomes that are distinctly yellow or orange internally. Further, these species are related in tepal size and shape. The tepals in these species are 12–20 mm long and the inner tepals are broadly ovate and about twice as wide as the outer tepals which are linear or linear-acuminate. In contrast, species showing *filiformis*- and *angustifolia*-type profiles have delicate rhizomes that are white internally. They are further related by their tepals being 4–15 mm long, linear shaped with inner and outer tepals of almost equal width. *H. sobolifera* var. *pannosa* has *filiformis*-type profile but the rhizomes of the species are white or yellow internally. This species is however more closely related to those of the *filiformi*s-type by the size and shape of its tepals. Chemical profiles confirmed the close relationship between species with robust rhizomes and large leaves of a coriaceous, firm texture (*hemerocallidea*-type) and correlates with Groups 1 to 4 in Singh (2004); those with delicate rhizomes and small coriaceous or soft leaves (*filiformis*- and *angustifolia*-type) associate well with Groups 5 to 8 (Singh 2004). In the grouping of species on morphology, *H. angustifolia* is placed with *H. membranacea* and

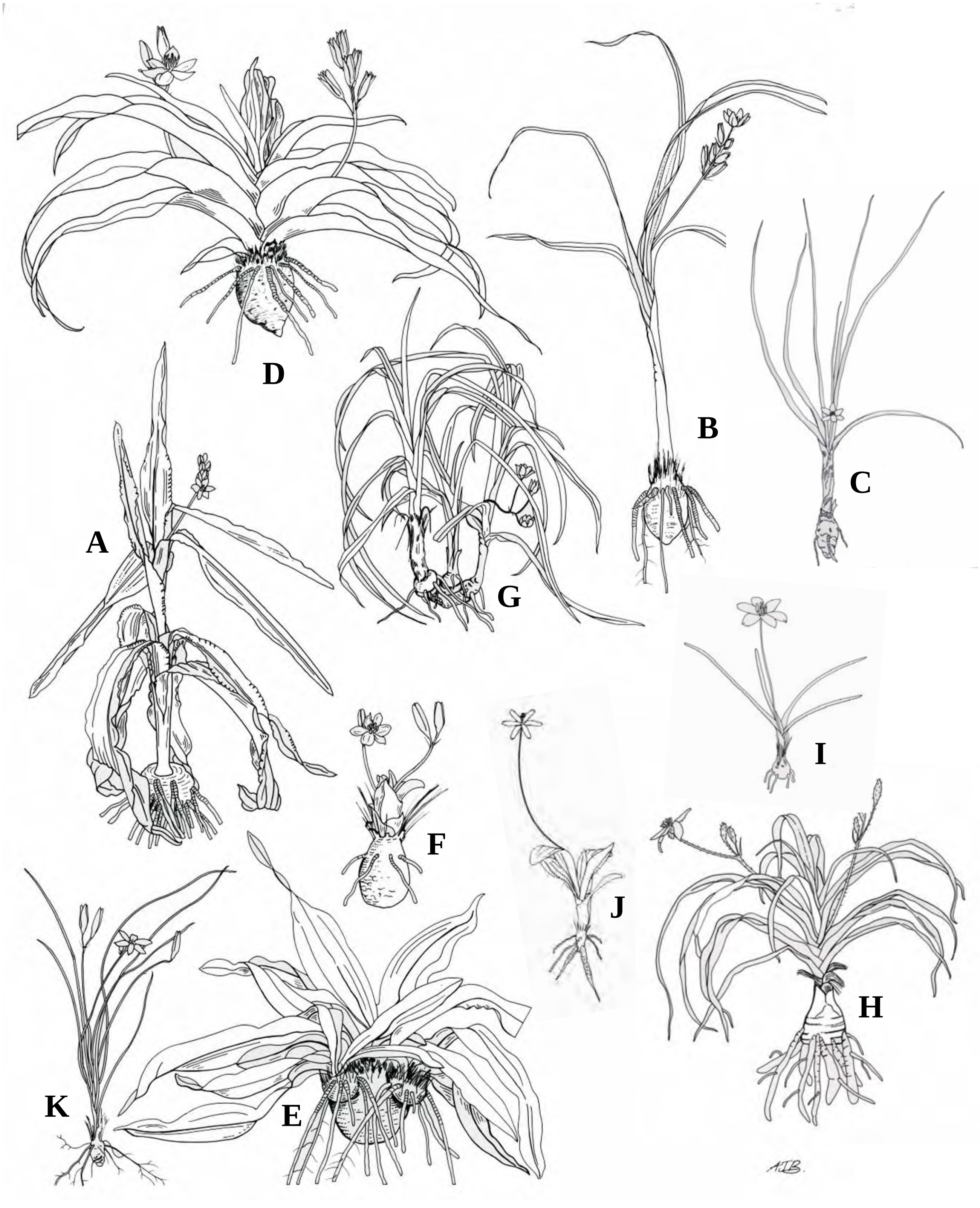

Figure 10.1—Species representing eight groups recognised for southern African *Hypoxis*. A, Group 1a, *H. colchicifolia*; B, Group 1b, *H. rigidula*; C, Group 2 *H. acuminata*; D, Group 3, *H. hemerocallidea*; E, F, Group 4, *H. multiceps*, mature and young; G, Group 5a, *H. sobolifera*; H, Group 5b, *H. stellipilis*; I, Group 6, *H. flanaganii*; J, Group 7, *H. parvula*; K, Group 8, *H. filiformis*.

H. parvula (Singh 2004), but the chemical profile suggests that it is unique in the group. However, wider chemical sampling of members of Hypoxidaceae is needed to determine the phylogenetic relationships of the different varieties of *H. angustifolia* within Group 7 and with related genera *Spiloxene* and *Empodium*, with which it shares the character of soft-textured leaves.

Seed micromorphology contributed characters useful in separating species [see Singh & Van Wyk [Appendix 1.5]. It broadly supported the phylogenetic relationships of species surmised from macromorphology (Singh 2004) but suggested the repositioning of *H. argentea*, *H. kraussiana* and *H. parvifolia*. These species were considered to be morphologically similar to members of Group 6 on the basis of their narrow leaves (usually less than 6 mm). Seed characters indicate that *H. argentea* is closer to species in Group 5a in having cuticular wings as secondary sculpturing and that *H. parvifolia* and *H. kraussiana* are related to members in Group 2 in their lack of secondary sculpturing. On revisiting the morphological characters, leaf hair and inflorescence type were found to support a closer relationship of these species with taxa in Group 5 and Group 2 respectively. *H. argentea* shares with *H. villosa* (Group 5a) the characters of long, silky hairs on leaves and corymbose inflorescences. Leaf hairs in *H. kraussiana* are similar to those of *H. longifolia* (Group 2); hairs in both species are stellate with 4–6 arms. *H. parvifolia* shares with *H. acuminata* (Group 2) the two-flowered inflorescences (sometimes 3 or 4) with flowers held on short pedicels. *H. argentea* is better placed in Group 5a and *H. kraussiana* and *H. parvifolia* in Group 2.

10.2.4 *Hypoxis* species of uncertain taxonomic status

The taxonomic status of nine species, namely *H. beyrichii* Nel, *H. exaltata* Nel, *H. jacquinii* Baker, *H. longipes* Baker, *H. mollis* Baker, *H. nigricans* Baker, *H. sagittata* Nel, *H. setosa* Baker and *H. uniflorata* Markötter remains unresolved. The problems associated with resolving these taxa are mentioned at the end of the taxonomic treatment in Chapter 12.

10.3 Evidence of hybridization, polyploidy and apomixis

During field work in South Africa, stands of vigorous plants were found among populations of *H. angustifolia* var. *buchananii*, *H. hemerocallidea*, *H. rigidula* var. *rigidula* and *H. sobolifera*. These plants were two to three times larger than the regular form in the area. The larger plants were considered to represent variation in morphology, and the ranges for these species were therefore expanded to incorporate the deviations. Although the larger forms are suspected of being polyploids, in the absence of cytological data for these populations it is not possible to link this variation to polyploidization.

10.3.1 Putative ybrids in the wild in southern Africa

In southern Africa, *Hypoxis* shows mainly sympatric patterns of distribution. In a number of single sites on farms or Nature Reserves throughout South Africa, three to five species were recorded to grow sympatrically. The sympatric species common in grasslands throughout the region are those with a wide distribution and include *H. angustifolia*, *H. argentea*, *H. filiformis*, *H. hemerocallidea*, *H. obtusa*, *H. longifolia H. multiceps* and *H. rigidula*. Though not widely distributed, *H. colchicifolia*, *H. galpinii* and *H. obliqua* may also occur sympatrically with the widespread species. During this study, possible hybrids were observed at a few sites in South Africa. Putative hybridisation was noted to be most common between *H. obtusa* and *H. rigidula* (*Singh & Govender 440*, *Singh 569, Singh & Wiland 662*, *773*, *Singh 605,* all in NH). Hybrids of *H. colchicifolia* and *H. rigidula* (*Singh & Govender 560* in NH) were recorded only at one site, the QwaQwa National Park in the Free State. At this site, large populations of both species overlap with each other and a number of plants were observed to display characters of both species. In Vryheid, populations of *H. colchicifolia*, *H. rigidula* var. *rigidula* and *H. argentea* were observed to grow sympatrically with no obvious hybrids between taxa. However, at the edge of the *H. rigidula* var. *rigidula* population, a group of plants typical of the species (*Singh 435* in NH) was found to have broader leaves, close to 20 mm wide. This entity was described by Nel (1914) as a distinct species, *H. cordata*, which was subsequently sunk (Singh 2007). Such examples of morphological variation may be due to hybridization between distinct species (in this case *H. colchicifolia* and *H. rigidula*) or polyploidy in the genus (see 10.3.2).

Intergeneric hybridization occurs between *Hypoxis* and *Rhodohypoxis*, although it is rare in the wild. Cultivated hybrids between the genera are being referred to as *Rhodoxis hybrida* which does not appear to be validly published and has the common name ‘Hebron Farm Pink’. Hilliard & Burtt (1978) recorded hybrids between *Hypoxis parvula* and *Rhodohypoxis baurii* (Baker) Nel and *R. milloides* (Baker) Hilliard & Burtt, and reported that crossing with the latter species is rare. Hybridization between the two genera was observed during this study at a site on the Ukhlahamba-Drakensberg Mountains at Sentinel Peak, Free State, where populations overlap (Figure 10.2A). Only one plant (*Singh 555* in NH) [Figure 10.2B] being a likely cross between *Hypoxis parvula* (*Singh 556* in NH) (Figure 10.2C) and *Rhodohypoxis baurii* (*Singh 554* in NH) [Figure 10.2D] was found. The hybrid plant (Figure 10.2B) resembles the larger plants of *Rhodohypoxis* more closely in its leaf texture and, pink and white colouration of tepals, but the tepals are free to the base as in *Hypoxis*. In the field, it was noticed that the older inflorescences on the plant did not produce fruit but were drying out without setting seed. In contrast, dehisced capsules were common among plants of the putative parents, *Hypoxis parvula* and *Rhodohypoxis baurii*.

10.3.2 High polymorphism in *Hypoxis* due to polyploidy

During the sexual cycle, organisms double their number of homologous chromosomes (ploidy) after fertilization and reduce their ploidy by half at meiosis. Polyploidy refers to the process of chromosome duplication that gives rise to multiple sets of chromosomes in an organism. The process can occur naturally in a number of ways but the two main modes for polyploidy are somatic doubling in mitosis and non-reduction in meiosis. Modes of polyploid formation have been discussed extensively by many different general works for example Grant (1971), Ramsey & Schemske (1998) and Wendel & Doyle (2005).

Polyploidy is common in mosses, ferns and angiosperms and less prevalent in liverworts and gymnosperms (Stebbins 1950; Grant 1971). In providing frequency values of polyploidy in higher plants, Grant (1971) classified species with 14 or more chromosome pairs as polyploids and those with fewer than 14 pairs as mainly diploids. For the monocot families, Goldblatt (1980) suggested a lower number; species with 11 or more chromosome pairs are polyploids and those with 9 or 10 chromosome pairs are aneuploid (having one or more extra or less chromosomes and the set is not an exact multiple of the haploid number) derivatives of ancestors with higher diploid numbers. He concluded that although needing confirmation, a relatively high percent (62%) of the 13 species surveyed for the family Hypoxidaceae, mainly belonging to *Hypoxis* had a count of 13 chromosome pairs or more, implying high polyploidy in the family. It is accepted that there is a high frequency of polyploidy in *Hypoxis* following the cytological reports by Wilsenach & Papenfuss (1967), Nordal *et al*. (1985) and Zimudzi (1994). From the chromosome records available for *Hypoxis* (Table 10.2), all species except *H. filiformis* and *H. stellipilis* are polyploids.

The development of knowledge in *Hypoxis* cytology over the years indicates high ploidy levels for species and diverse levels for some taxa, and makes a correlation between polyploidy and robustness of species. Significant reporting on chromosome numbers in the genus took place between 1955 and 1975 and counts for 11 species were published (Table 10.2), mainly through the work of Wilsenach and co-workers (1967). Counts for a further six species emerged in later years (Table 10.1). In a series of cytological papers, Wilsenach and co-workers (1967) presented data to

Figure 10.2.—Putative hybrid between *Hypoxis* and *Rhodohypoxis*. A, Plants of *Hypoxis parvula* var. *parvula* and *Rhodohypoxis baurii* growing sympatrically; B, x *Rhodoxis hybrida*; C, *Hypoxis parvula* var. *parvula*; D, *Rhodohypoxis baurii.*

support that polyploidy drives speciation in *Hypoxis* and strongly suggested the occurrence of apomixis in the genus. The first article by Wilsenach (1967) proposed a basic chromosome number of 7 or 8 for the genus and deduced that counts of 2n = 16, 32, 36, 72, and 96 represented polyploids. He concluded that it was difficult to establish a basic number for the genus and although x = 8 suited four of the species studied, it could not explain 2n = 36 for *H. multiceps*. In the follow up article, Wilsenach & Papenfus (1967) reported low chromosome numbers and normal meiosis in species of *Hypoxis* with smaller growth forms and higher chromosome numbers and abnormal meiosis in those with larger growth forms, and mention that this is consistent with the hypothesis of sexual reproduction in the smaller forms and apomixis in the larger forms. They also confirmed that there are numerous abnormalities during meiosis in the polyploid species.

Among the first 11 species listed in Table 10.2, Naranjo (1975) noted that *H. filiformis* and *H. stellipilis* were diploid in having n = 7 and 2n = 16 respectively, and the remaining species were polyploids. Based on W.D. Jackson’s unpublished count for the Australian *H. pusilla*, Darlington & Wylie (1955) proposed x = 11 for *Hypoxis*. Naranjo (1975) argued that the chromosome numbers recorded for the genus do not support 11 as the basic chromosome number. He postulated that for a wide group like *Hypoxis*, four basic numbers are likely to exist namely 7, 8, 9 and 19, the last mentioned being suggested earlier by Fernándes & Neves (1962) following their counts for *H. hemerocallidea* (*H. rooperi*).

The association of higher ploidy levels and robust habit was confirmed by Nordal *et al*. (1985). These authors described in detail the chromosome kinetics for various stages of meiosis and reported on irregular chromosome separation in populations of their *H. obtusa*-complex in which they incorporated 21 species. In this article, the authors reported a correlation between extensive morphological variation and cytological variability in the *H. obtusa*-complex, which was resolved by Wiland-Symańska & Nordal (2006) to incorporate six valid species, listed in Table 10.2. Now that there is agreement that the species in the *H. obtusa*-complex are morphologically distinct (Wiland-Symańska & Nordal 2006), the chromosome counts produced by Nordal *et al*. (1985) can now be compared to determine relationships. However, the voucher specimens cited in the publication on chromosome counts (Nordal *et al*. 1985) are not recorded in the treatment for the Flora of Tropical East Africa (Wiland-Symańska & Nordal 2006). This poses a challenge to match the species with a chromosome number without studying the vouchers.

Table 10.2.—Summary of chromosome counts for species of *Hypoxis* from the literature

Species	n	2n	Authors
H. hemerocallidea (*H. rooperi*)		38, 76	Fernándes & Neves (1962)
H. pusilla		22 28	Darlington & Wylie (1955) Beuzenberg & Hair (1963)
H. stellipilis		16	Wilsenach (1967)
H. cf. *zeyheri*		32	Wilsenach (1967)
H. multiceps		36	Wilsenach (1967)
H. longifolia		72	Wilsenach (1967)
H. hemerocallidea (*H. rooperi*)	± 43-58	96	Wilsenach (1967)
H. obtusa (*H. nitida*)		48, 80	Wilsenach (1967)
H. filiformis	7		Wilsenach & Papenfus (1967)
H. acuminata	18, 20		Wilsenach & Papenfus (1967)
H. aurea		54	Mehra & Sachdeva (1971)
H. decumbens		22, 44 42	Stenar (1925) Naranjo (1975)
H. angustifolia		14, 28	Nordal *et al.* (1985)
H. goetzei		62	Nordal *et al.* (1985)
H. filiformis (*H. malosana*)		14	Nordal *et al.* (1985)
H. obtusa pro parte, *H. fischeri* pro parte, *H. gregoriana* pro parte, *H. nyasica* pro parte, *H. urceolata* pro parte, *H. rigidula* pro parte. [*H. obtusa*-complex sensu Nordal *et al.* (1985)]		40-50, 75, 92, 98, 108, 130–135, 160–200	Nordal *et al.* (1985)
H. angustifolia		28	Zimudzi (1994)
H. filiformis		14	Zimudzi (1994)
H. cuanzensis (= *H. schimperi*)		53	Zimudzi (1994)
H. galpinii		54, 55	Zimudzi (1994)
H. multiceps (= *H. bampsiana*)		70	Zimudzi (1994)
H. rigidula		56, 67, 80, 81, 87, 76	Zimudzi (1994)
H. *villosa*-complex sensu Zimudzi (1997) (= *H. obtusa* pro parte, *H. nyasica* pro parte)		41, 42, 55, 56, 70, 76, 78, 80, 85, 89, 92, 94, 96, 98, 102, 105	Zimudzi (1994)

Zimudzi (1994) provided counts for seven species of *Hypoxis* and found *H. filiformis* to be the only diploid species. He points out that the diploid form of *H. angustifolia* common to East Africa does not occur in Zimbabwe, but that the tetraploid form noted from south-western Tanzania by Nordal *et al*. (1985) is also present in Zimbabwe. He speculated that *H. angustifolia* originated in the tropical parts of Africa and developed tetraploid forms on its migration south, and that its vigour and viability as a polyploid allows it to colonize new habitats compared to the diploid form. From his work, *H. rigidula* and *H. obtusa* were shown to have diverse chromosome numbers (Table 10.2) and their counts represent three ploidy levels namely octoploid, decaploid and dodecaploid. Zimudzi (1997) reported 16 varying counts for his *H. villosa* complex which Wiland-Symańska & Nordal (2006) recognised as *H. obtusa* and *H. nyasica*. This implies that *H. obtusa* shows high ploidy levels, similar to *H. hemerocallidea*, an allied species, and this correlates well with the extensive morphological variation recorded for the species.

Since species of *Hypoxis* with robust habit were shown to have high chromosome numbers, mostly over hexaploid levels, it suggests that diploids like *H. filiformis* and *H. stellipilis*, and those with lower ploidy levels for example *H. angustifolia* may represent species with chromosomes closest to the ancestral basic number. However, in the absence of chromosome counts for the majority of the validly recognised species, it is futile to speculate on the chromosome complements as indicators of primitive or advanced states.

10.3.3. Role of apomixis in polymorphism

Wilsenach & Papenfus (1967) concluded that high ploidy levels, irregular meiosis and morphological variation within a species points to the occurrence of apoximis (formation of seeds without fertilization in the genus). Using data from Wilsenach (1967) and Wilsenach & Papenfus (1967), Wilsenach & Warren (1967) surmised that *H. hemerocallidea* (*H. rooperi*) had the most convincing apomictic attributes, namely a high somatic chromosome number (96), abnormalities during meiosis, pollen grains are formed which contain a variable number of chromosomes (43 to 58) and populations show morphological variation. In contrast, they considered *H. filiformis* with a low chromosome number n = 7 in the group, and constant counts as representing a species with normal sexual reproduction. Following on the probability of *Hypoxis* populations being apomictic, these authors studied embryo sac development in *H. hemerocallidea* (*H. rooperi*) and *H. filiformis*. They found that in both species there is degeneration of the megaspore mother cells and the embryo sac is produced from nucellular cells which strongly suggest apomixis, even in the diploid, *H. filiformis*.

Nordal *et al.* (1985) reported on reproduction trials in two specimens each of *H. angustifolia* and their *H. obtusa*-complex. They found that all plants were autogamous, being able to produce seeds after self-pollination. These authors subjected the same plants to apomixis by emasculation and isolation and found that all, except one belonging to the *H. obtusa*-complex, did not produce seeds without pollen. They deduced that apoximis was proved in one case at least, but the process cannot be excluded from the other tests as pollen may be required for endosperm production (pseudogamy).

Zimudzi (1994) undertook trials to test apomixis, autogamy and cross fertilization for about seven species of *Hypoxis* in Zimbabwe. His results indicated that the majority of the plants tested for apomixis produced seeds in the absence of pollen. However, the percentage seed set was lower than in plants with pollen and this led him to suggest that the plants may be pseudogamous or facultative apomicts. Plants tested by Zimudzi (1994) for autogamy and cross fertilization also produced seeds, with higher seed sets recorded for the autogamous plants. Zimudzi's trials confirmed that members of *Hypoxis* produce seed by crossing, selfing or apomixis.

Studies on embryo sac development (Wilsenach & Papenfus 1967) and reproductive traits (Nordal *et al*. 1985, Zimudzi 1994) confirm the occurrence of apomixis in a few species of *Hypoxis*.

The reason for the occurrence of apomixis in *Hypoxis* is unknown. It cannot be ascribed to pollen viability as it is recorded as being high in the genus (Nordal *et al*. 1985). However, its association with hybridization and polyploidy in bringing about speciation in *Hypoxis* is complex. Stebbins (1950) provided an in depth review on apomixis in relation to variation and evolution. He explains that polymorphism is caused in apomicts by first, hybridization between the original sexual ancestors of the apomicts; second, hybridization between facultative apomicts, or between apomicts and sexual species, and third, chromosomal and gene changes within the apomictic clones themselves. Other points from the review that help to interpret how hybridization and polyploidy may effect apomixis in *Hypoxis* include:

- Hybridization promotes apomixis by firstly the combination of genes that initiate an apomictic cycle is probably put together most easily by hybridization, either between two species or between different forms of the same species, and secondly, the hybrid genotypes have greater vigour and tolerance for a wide range of ecological conditions in comparison to the parents.
- Although apomixis can be induced in diploids by gene mutation, the action of the apomixis-inducing gene is stronger at the polyploid level.
- The tendency towards pseudogamy may be induced by increasing chromosome number.
- An obvious feature of many apomictic plants is the abnormalities in the meiotic division of both ovules and anthers.

Complexity in *Hypoxis* taxonomy relates to polymorphism most likely caused by genetic abnormalities arising from hybridization, polyploidization and apomixis. Polymorphism in the genus makes the treatment of species taxonomically unstable and decisions on whether and when to treat clones as separate species remain a vexing problem. Nordal & Kativu (1999) highlighted this as the most difficult taxonomic problem within the Hypoxidaceae. Suggestions on how some of the taxonomic complexities may be resolved are outlined in the next section.

10.4 Further research in *Hypoxis*

Wilsenach & Warren (1967) cautioned that a revision of *Hypoxis* should not be attempted until apomixis is confirmed through cytological and breeding studies, and they refer to general works on handling agamic complexes. It is tempting to agree with such a statement for a group like *Hypoxis* that displays reticulate variation in morphology, but it should be noted that such studies require critical selection of populations for testing. Critical selection of material is only possible once there is clarity on species even if the boundaries that define them are arbitrary. The greatest investment of species-level taxonomies like the present one is the collection of morphological data from extensive field and herbarium work, and the recording of variation among and between populations and clones. It is this underlying knowledge that guides sampling for research in breeding, population genetics and molecular studies of the genus. The lack of a good taxonomy for *Hypoxis* impedes research in other disciplines. The argument for a revision first is clearly one-sided for a genus where hybridization, polyploidy and apoximis are responsible for variation and drives speciation.

More research is certainly necessary to resolve the taxonomy of *Hypoxis*. For the African members, the starting point will be a cytotaxonomic study of the heterogenous and widespread species like *H. angustifolia*, *H. argentea*, *H. hemerocallidea*, *H. obtusa* and *H. rigidula*, to fully understand the mechanisms of variation. A study using heritable polymorphism and genetic markers is necessary to assess genetic variation in populations (clones) and this should be undertaken for a single species, for example *H. obtusa* initially. These studies when combined with reproductive trials will clarify whether a gene for a particular character is dominant or recessive in offspring arising from hybridization and apomixis and their subsequent generations, and its role on variation. A considerable number of studies linked with flora regions in Africa have been completed for the genus and a monograph of *Hypoxis* through a collaborative effort is inevitable. A major motivation for a monograph is to attain agreement on handling polyploid and agamic clones in the genus. The monograph will also provide a phylogeny for the largest genus of the Hypoxidaceae and should identify cryptic agamic complexes for cytological and DNA analyses.

11

CONCLUSIONS

The results of this study lead to the following principal conclusions for southern African *Hypoxis*:

- Twenty eight species of *Hypoxis* (close to 70% of the genus) occur in the Flora of southern Africa [FSA] region, undoubtedly making it the most pronounced centre of diversity and endemism for the genus world-wide.

- The most significant characters for demarcating species include habit, arrangement of leaves from point of emergence (false stem forming or not); leaf shape, length and width, number of prominent veins, distribution, density and types of leaf hairs and it is necessary to use these in combination with reproductive features like inflorescence type, diameter of open flowers, texture of tepals and stigma type for accurate identifications.

- Other characters that aid species delimitation are the unusual white colour of flowers in *H. membranacea*, *H. parvula* var. *albiflora* and *H. nivea*, rhizome size and anther tips being either entire or split.

- Geographical distribution is valuable in identifying species with restricted ranges, e.g. *H. stellipilis* is restricted to Albany Thicket along the Eastern-Western Cape boundary and *H. kraussiana* is found only in KwaZulu-Natal.

- Species can be separated broadly into two groups: robust characterised by a large habit, tough leaves and a hardy racemose inflorescence (seldom a strong corymb), and delicate species defined by small stature, flaccid leaves and fragile corymbose inflorescence (seldom an abbreviated raceme). Leaves in *Hypoxis* are coriaceous, except in *H. membranacea*, *H. parvula*, *H. angustifolia* and *H. nivea*, in which leaves are soft tending towards membranous.

- Using morphology, species can be placed in eight informal groups. Data from leaf anatomy, rhizome chemistry and seed morphology support the broad grouping of species.

- The most widely distributed species, *H. angustifolia* occurs in Africa, the west Indian

Ocean Islands and Yemen. It is extremely variable and four varieties are recognised on morphology. The species is unique in its rhizome chemistry.

- Spatial distribution and biogeographic knowledge provided in this study contributes to decisions on conservation and sustainable use of species.

12

TAXONOMIC TREATMENT

New taxa, synonyms and insufficiently known species

Rcently published species

H. nivea Y. Singh

Species put into synonymy in the present study

H. arnottii Baker = **H. rigidula** Baker **var. pilosissima**

H. cordata Nel = **H. rigidula** Baker var. **rigidula**

H. distachya Nel = **H. colchicifolia** Baker

H. dinteri Nel = **H. argentea** Harv. ex Baker var. **sericea** Baker

H. ecklonii Baker = **H. floccosa** Baker

H. gilgiana Nel = **H. colchicifolia** Baker

H. iridifolia Baker = **H. obtusa** Burch. ex Ker Gawl.

H. junodii Baker = **H. gerrardii** Baker

H. lata Nel **= H. angustifolia** Lam. var. **angustifolia**

H. limicola B.L. Burtt **= H. parvula** Baker var. **parvula**

H. neliana Schinz = **H. kraussiana** Buchinger

H. obtusa Burch. ex Ker Gawl. var. *chrysotricha* Nel = **H. obtusa** Burch. ex Ker Gawl.

H. pretoriensis (manuscript name) **= H. interjecta** Nel

H. rigidula Baker var. *hemerocallidea* Fisch., C.A. Mey. & Avé-Lall. = **H. rigidula** Baker var. **rigidula**

H. rooperi T. Moore var. *forbesii* Baker **= H. hemerocallidea** Fisch., C.A. Mey. & Avé-Lall.

H. villosa L.f. var. *obliqua* Jacq. **= H. obliqua** Jacq.

H. woodii Baker = **H. angustifolia** Lam. var. **buchananii**

H. zuluensis S.E. Wood quoad specim. *Gerstner 4936*, nom. illeg. = **H. longifolia** Baker ex Hook.f.

H. zululandensis S.E. Wood non. nud. = ***H. longifolia*** Baker ex Hook.f.

Species insufficiently known

H. beyrichii Nel

H. exaltata Nel

H. jacquinii Baker
H. longipes Baker
H. mollis Baker
H. nigricans Conrath ex Baker
H. setosa Baker
H. sagittata Nel
H. uniflorata Markötter

Hypoxis *L.*, Systema Naturae: 986 (1759); Baker: 98 (1878b); Salisbury: 712 (1883); Pax: 121 (1889); Baker in Thiselton-Dyer: 174 (1896); Baker: 377 (1898); Nel: 259 (1914); Hepper: 172 (1968); Geerinck: 72 (1969) & : 4 (1971); Nordal *et al*.: 15 (1985); Nordal & Iversen: 46 (1986); Nordal & Iversen: 34 (1987); Champluvier: 81 (1987); Nordal in Kubitzki: 292 (1998); Nordal & Zimudzi: 1 (2001); Wiland: 305 (2001); Wiland-Syzmańska & Nordal (2006). Type: *H. hirsuta* (L.) Colville (syn.: *H. erecta* L.)

Herbs, small to robust, 50–700 mm high, near-glabrous to densely hairy, growing solitary or in tufts; underground stem a perennial rhizome, vertical, sometimes producing short horizontal stolons ending in rhizome-like structures, each bearing a shoot. *Rhizome* globose, oblong or turbinate, older basal portion slowly withering away over time, crowned by leaves and a tunic formed by the remains of old leaf bases, tunic either a ring of fibrous bristles (brush-like) or a papery sheath in delicate species, white, yellow to deep orange inside; roots few to many, short, thick, contractile. *Leaves* winter (spring in SW Cape species) deciduous, 5–20, outer few reduced to cataphylls, spreading outwards from base, generally in three ranks or bases clasping to form a funnel- or column-like false stem (pseudostem), base lighter in colour approaching white, hyaline in delicate species, occasionally purple or red; coriaceous or membranous, sickle-shape (falcate) or erect, linear, lanceolate or filiform, folded together along the length (conduplicate) towards the base, rarely subterete; V-shaped or flat in cross section, gradually or rapidly tapering to a narrow point (acuminate); veins of even or uneven thickness, flush with or raised on upper surface; pilose, floccose, tomentose, sericeous or ciliate, hairs appearing more dense in young leaves, bifurcate (2 arms), stellate (3–8 arms), rarely simple (one-arm) or a combination, filiform or needle-shaped, ascending in a V- or U-shape, or appressed, white, yellow or brown. *Inflorescence* 1–8 per plant, axillary, produced with emergence of leaves, only at start of, or sequentially in growing season, racemose or corymbose, rarely spicate, near-glabrous or sparsely to densely hairy; indumentum white, yellow, or red-brown; scapes overtopping, as tall as or slightly shorter than leaves, flattened in cross section (ancipitous), rarely terete, covered in hairs apically. *Bract* one per flower, unless flower aborted then two, subulate, setaceous, hairy abaxially.

Flowers 2–17, rarely solitary, short-lived, bisexual, actinomorphic, star-like, yellow, rarely white; pedicels shorter or longer than flowers, sometimes reduced, green, sometimes red, slightly longer in fruit. *Tepals* 3+3, rarely 4 in two whorls of 2, free, persistent; outer tepals, elliptic, green-yellow (or green-white) and hairy abaxially; inner tepals elliptic or ovate-elliptic, yellow (or white), green and sparsely hairy along midrib abaxially, midrib~~s~~ occasionally red. *Stamens* 3+3, rarely 4 in two whorls, exserted, filaments inserted at base of tepals, subulate or filiform, outer whorl slightly longer (by ± 0.5 mm) than the inner whorl; anthers sagittate, thecae 2, versatile, opening by longitudinal slits, latrorse; pollen grains yellow, ellipsoid, monosulcate. *Ovary* inferior, turbinate or subglobose, 3-locular; style subulate or filiform, sometimes reduced or absent; stigma 3-lobed, spherical or pyramidal, with 3 concave faces, ovules numerous, biseriate in each locule, placentation axile. *Fruit* a capsule, turbinate or oblong, opening by a circular split around the middle (circumscissile dehiscence), in a few species followed by splitting into 3-segments (longitudinal dehiscence). *Seeds* few to many, globose to ovoid, black rarely brown, glossy or dull; testa smooth or papillate. *Chromosome number*: 2n = 14.

Species ± 85, in the warmer parts of all continents, except Europe, mostly in sub-Saharan Africa, 28 in the Flora of southern Africa region (South Africa, Namibia, Botswana, Swaziland and Lesotho), with 70% endemic to the region and three taxa having white flowers, deviating from the usual yellow for the genus. The range of seven taxa, *H. angustifolia* var. *angustifolia*, *H. argentea* var. *argentea*, *H. filiformis*, *H. galpinii*, *H. hemerocallidea*, *H. longifolia*, *H. obtusa*, *H. parvifolia*, *H. rigidula* var. *rigidula*, extends from southern Africa to tropical Africa. *H. angustifolia* is the most widespread species in Africa with a distribution also in West Africa. With the start of the growing season (September), plants of *Hypoxis* develop new shoots, usually stimulated by fire and are more noticeable when the grass is short. Plants show variation in leaf length over growing season; specimens collected later in the season, January to May have elongated leaves in comparison to those collected early, in October to December. *Hypoxis* has potential use in medicine. Rhizomes of the larger species are a rich source of hypoxoside (Drewes *et al.* 1984; Bayley & Van Staden 1990) which in its active form, rooperol has been shown to inhibit the growth of cancer cells (Drewes & Khan 2004). Such species are also used in traditional and alternative medicines in South Africa where their popularity is driving unsustainable harvesting of rhizomes in the wild. Exploitation of target and related species of the genus has expedited the need for correct species identification and more data on the morphology, ecology and distribution of species.

KEY TO SPECIES

Note— Plant height excludes inflorescence length, and leaf width is measured midway between base and apex. Vein and hair characters are described from a stereomicroscope at 10–40 x magnifications. To avoid ambiguity, descriptive terms are used with botanical equivalents in brackets.

In species with a robust habit and many flowers per inflorescence, the first few inflorescences in young plants may bear only 2 flowers, the flowers being opposite and this causes difficulty on classifying it as racemose or corymbose. For such specimens, a combination of habit, leaf dimensions, leaf hair distribution, length of pedicel and, type and length of tepal should be applied.

1a Plants medium to large in size, more than 150 mm tall (if shorter, then leaves lanceolate and more than 12 mm wide); flowers firm, yellow, large, tepals of lowermost flowers 12–20 mm long:

2a Plants taller than wide; leaves tightly clasping at base to form a false stem:

3a False stem widening into the shape of a funnel; leaves erect, converging apically (connivent), lanceolate, 25–110 mm wide:

4a Leaves broadly lanceolate, 3–6 times longer than wide; veins of uniform thickness, raised on upper surface (ribbed); leaf blade glabrous or with a few hairs scattered near the base and on margins; inflorescence near-glabrous with few scattered hairs; specimens drying straw-coloured or light brown . . . . 1. *H. colchicifolia*

4b Leaves narrowly lanceolate, 8–20 times longer than wide; veins of uneven thickness, 2(–4) near each margin raised on upper surface; leaf blade sparsely hairy, margins and midrib fringed with hairs (ciliate); inflorescence densely hairy; specimens drying red-brown or dark brown . . . . 2. *H. galpinii*

3b False stem upright in the form of a column; leaves spreading or recurving apically, linear or filiform, 3–20 mm wide:

5a Leaves firm but not rigid, erect, spirally twisting towards apex, with an even distribution of long, weak hairs (pilose) on both surfaces, margin and midrib on lower surface; hairs bifurcate; flowers 2 (occasionally 4–6) . . . . 4. *H. acuminata*

5b Leaves rigid, erect or recurving above the middle, ± straight towards apex, near-glabrous or sparsely to densely hairy on one or both surfaces, margins and midrib on lower surface fringed with hairs (ciliate); hairs bifurcate or stellate; flowers 4–11 (2 or 3 in first few inflorescences):

6a Leaves ribbed near margins only; veins of uneven thickness with 3–5 near each margin raised on upper surface; leaf blade sparsely to densely hairy . . . . 3. *H. rigidula*

6b Leaves strongly ribbed; veins of uniform thickness, raised on upper surface; leaf blade near-glabrous, margins and midrib on lower surface outlined in white by a thickened band of squat hairs

7a Leaves filiform, 3–4 mm wide, subterete, rarely flat; veins 4–6 . . . . 5. *H. longifolia*

7b Leaves strap-like, 10–15 mm wide, V-shaped or flat; veins 10–16. . . . 6. *H. ludwigii*

2b Plants as wide as tall; leaves spreading upwards and outwards from base (false stem absent):

8a Plants in flower small, 50–120 mm tall; leaves few (usually less than 7), overlapping in helical arrangement to give a rosette-like appearance, flat, broadly ovate; inflorescences produced at start of growing season; flowers 2 (occasionally 3–5):

9a Leaves glabrous, margin rarely with a few scattered hairs; inflorescence with 2 flowers . . . . 10. *H. interjecta*

9b Leaves hairy (pilose or scabrous), inflorescence with 2–5 flowers:

10a Leaves covered with long, weak hairs (pilose) mostly along margins and midrib . . . . 11. *H. costata*

10b Leaves covered with short stiff hairs (scabrous) throughout . . . . 12. *H. multiceps*

8b Plants in flower large, 150–300 mm tall; leaves many (usually more than 7), arranged one above the other in three ranks, folded together along the length (conduplicate), sickle-shape (falcate); inflorescences produced sequentially throughout growing season; flowers 4–12 (2 in first few inflorescences):

11a Leaves near-glabrous or with even distribution of bifurcate hairs; pedicels firm, erect, lowermost 5–25 mm long:

12a Leaves firm but not rigid, remaining straight with age, non waxy; veins flush with upper surface, with an even distribution of long, weak hairs (pilose); hairs bifurcate . . . . 7. *H. hemerocallidea*

12b Leaves rigid, spirally twisting towards apex with age, waxy (glaucous); veins raised on upper surface (ribbed), near-glabrous, margin and midrib outlined in white by a thickened band of squat hairs (ciliate); hairs stellate (3–6 arms) . . . . 8. *H. obtusa*

11b Leaves with white-velvety hair layer on lower surface or with an even distribution of stellate hairs in tufts; pedicels soft, flexible, lowermost 20–35 mm long:

13a Leaves dark green, glabrous on upper surface, lower surface with a distinct white-velvety layer formed by dense appressed interwoven hairs (tomentose); restricted to area between Uniondale (Western Cape) and Grahamstown (Eastern Cape) . . . . 9. *H. stellipilis*

13b Leaves dull green, sparsely or densely covered with an even distribution of white or brown, ascending hairs in tufts (floccose); widespread along the coasts of Western Cape (from Mossel Bay) and Eastern Cape and reaching KwaZulu-Natal . . . . . 13. *H. sobolifera*

1b Plants small in size, less than 150 mm high (if taller then leaves linear, less than 12 mm wide); flowers delicate, yellow or white, small, tepals of lowermost flowers 4–10 mm long:

14a Leaves membranous in texture, drying papery (if leaves are thicker then inflorescence with one flower only),sparsely covered with long, weak hairs (pilose):

15a Leaves linear-triangular (subulate), arranged loosely in three ranks, V-shaped in cross section (fresh material):

16a Flowers white, stigma spherical . . . . 25. *H. nivea*

16b Flowers yellow; stigma pyramidal (rarely approaching spherical) . . . . . . 26. *H. angustifolia*

15b Leaves lanceolate, radiating irregularly from rhizome, flat in cross section:

17a Leaves 80–150 x 8–25 mm, upper surface of leaf with pustules appearing as dots; inflorescence usually with 2 or 3 flowers, (if single-flowered, then other scapes on plant with 2 or 3 flowers); flowers white .... 27. *H. membranacea*

17b Leaves 15–70(–90) x 5–10 mm, upper surface without pustules; inflorescence usually with a single flower, rarely 2; flowers yellow or white .... 28. *H. parvula*

14b Leaves thick (not membranous) in texture, sparsely or densely covered with hairs of different types:

18a Leaves lanceolate, 7–25 mm wide:

19a Leaves 7–10 mm wide, usually erect, with an even distribution of bifurcate hairs .... 17. *H. gerrardii*

19b Leaves 10–25 mm wide, obliquely twisting or recurving, near-glabrous or sparsely to densely covered with stellate hairs:

20a Leaves near-glabrous, margins sparsely to densely hairy; hairs short, stiff, appressed:

21a Leaves erect, obliquely twisting towards apex; margins fringed with squat hairs (ciliate); persistent; pedicels firm, lowermost 5–20 mm long when flowers open .... 15. *H. obliqua*

21b Leaves falcate, ± straight towards apex; margins with sparse hairs; falling off (caducous); pedicels flexible, lowermost 25–50 mm long when flowers open .... 16. *H. zeyheri*

20b Leaves covered with hairs throughout, dense on margins; hairs long, weak, appressed or ascending (villose or floccose):

22a Leaves 75–150 mm long, margins undulate; hairs silky white, as strands stacked one above the other in two rows opposite each other and parallel along the length of the leaf, not clearly separated, appressed (villose) .... 14. *H. villosa*

22b Leaves 100–300 mm long, margins straight, hairs white or brown (not silky), in tufts, separated, ascending (floccose) .... 13. *H. sobolifera*

18b Leaves linear (if linear-lanceolate, then plants up to 60 mm tall), 2–10 mm wide:

23a Leaves strongly ribbed, with veins close to each other, uniformly thickened and raised on upper surface; scapes wiry, subterete (round in cross-section):

24a Leaves sparse to densely hairy; hairs bifurcate, stellate (4–6 arms) on margins, squat, patent, U-shaped and curling into rings; filaments subulate .... 22. *H. kraussiana*

24b Leaves sparsely hairy; hairs bifurcate, long, weak (thread-like), ascending, V-shaped and straight; filaments filiform:

25a Flowers 6-merous, very rarely 4-merous; scape erect in fruit, widespread in southern Africa from Eastern Cape to Limpopo .... 23. *H. filiformis*

25b Flowers 4-merous; scape decumbent in fruit, restricted to the Drakensberg range in KwaZulu-Natal .... 24. *H. tetramera*

23b Leaves not ribbed, with veins of uneven thickness, one to two near each margin thickened and raised on upper surface; scapes weak, ancipitous (flattened in cross section):

26a Plants 70–120 mm tall; scapes as tall as or shorter than leaves; flowers 2–5(–7):

27a Plants dark-green; leaves rigid, 4–10 mm wide; hairs bifurcate, ascending in V- or

U-shape, white or brown; inflorescence furry, brown . . . . 17. *H. gerrardii*

27b Plants silvery; leaves firm but not rigid, 2–5 mm wide; hairs bifurcate or stellate, appressed as strands parallel to length of leaf (sericeous), silky-white; inflorescence silky-white . . . . 18. *H. argentea*

26b Plants 30–60 mm tall; scapes overtopping leaves; flowers 1 or 2:

28a Leaves 4–8 mm wide, covered in bifurcate, stiffly U-shaped hairs; inflorescences firm, pedicels 5–15 mm long; found in the interior of southern Africa (Swaziland, Mpumalanga, Limpopo and Free State . . . . 19. *H. parvifolia*

28b Leaves 2–4 mm wide; covered in bifurcate hairs, lying parallel to length of leaf or with stellate hairs in tufts; inflorescences lax, pedicels 12–25 mm long, found along the coasts of Western Cape and Eastern Cape:

29a Leaf hairs mostly bifurcate, appearing in a V shape, ascending, white . . . . 20. *H. flanaganii*

29b Leaf hairs stellate, in tufts, ascending (floccose), red-brown (rufous) . . . . 21. *H. floccosa*

Key to varieties of *Hypoxis rigidula*

1a Plants glaucous green, usually drying dark brown; leaf blade hairs sparse, confined mostly to channels between veins, bifurcate or stellate, long, weak and ascending or needle-shaped and appressed . . . . var. *rigidula*

1b Plants grey-white, retaining colour on drying; leaf blade hairs dense giving leaves a furry texture (floccose), evenly spread throughout; stellate, tufted, long, weak and ascending . . . . var. *pilosissima*

Key to varieties of *Hypoxis sobolifera*

1a Hairs sparsely scattered throughout leaf, in distinct tufts, drying white or light brown . . . . var. *sobolifera*

1b Hairs dense, giving leaves a soft furry texture, tufts obscured, drying red-brown (rufous) . . . . var. *pannosa*

Key to varieties of *Hypoxis angustifolia*

1a Plants solitary, usually less than 120 mm tall; leaves 3–4 mm wide; 2 veins near each margin raised on upper surface . . . . var. *angustifolia*

1b Plants in tufts, usually more than 120 mm tall; leaves 8–18 mm wide; 4 veins near each margin prominent on upper surface . . . . var. *buchananii*

Key to varieties of *Hypoxis parvula*

1a Flowers yellow . . . . var. *parvula*

1b Flowers white . . . . var. *albiflora*

Key to varieties of *Hypoxis argentea*

1a Hairs mostly stellate, dense in channels between veins, forming a silky-white layer on lower surface . . . . var. *argentea*

1b Hairs mostly bifurcate, scattered in channels between veins, with an even distribution on both surfaces . . . . var. *sericea*

1. **Hypoxis colchicifolia** *Baker*, Journal of Botany: 3 (1889); Baker in Thiselton-Dyer: 186 (1896); Burtt: 201 (1986); Singh: 362 (2007). Type: South Africa, Cape, without precise locality, hort. *Bull s.n.* Nov. 1884 (K, holo!).

H. latifolia Hook.: t.4817 (1854) nom. illegit.; Baker: 115 (1878b); Baker in Thiselton-Dyer: 185 (1896)—non *H. latifolia* Wight (1853). Type: South Africa, KwaZulu-Natal, *Adlam s.n.* June 1857 (K, holo!).

H. oligotricha Baker: 3 (1889); Baker in Thiselton-Dyer: 187 (1896); Nel: 321 (1914). Type: South Africa, KwaZulu-Natal, Clairmont, *Wood 1170* (K, holo!, BM!, NH!).

H. distachya Nel: 322 (1914). Type: South Africa, KwaZulu-Natal, Pinetown, *Thode s.n.* August 1893 (B, holo!).

H. gilgiana Nel: 322 (1914). Type: South Africa, without precise locality, *Ecklon? 4529* (B, holo!).

Tall, robust herb, 250–500 mm high, growing singly, near-glabrous. *Rhizome* globose or oblong, 40–70 mm in diameter or 1.5 times longer than wide, with many contractile roots, crowned by leaves and a dense mass of fibrous bristles from remains of old leaves, light yellow to orange inside, with faint incense-like smell. *False stem* cylindrical, thick, 50–75 x 15–30 mm. *Leaves* few, 4–8, clasping at base to form a false stem, opening into funnel above, converging apically (connivent), broadly lanceolate, (100–)200–600 x 30–85(–110) mm, erect, flat, coriaceous; veins ± 18–40, evenly spaced, almost all thickened and raised on upper surface (ribbed), approaching white at base, sometimes purple or red, usually glabrous; hairs if present, scattered on margins, veins and channels in between veins, bifurcate, needle-shaped, appressed. *Inflorescence* 1–4 per plant, appearing with leaves and produced sequentially, racemose, with few scant white hairs; scapes shorter than leaves, 150–300 mm x 2–3 mm, flattened in cross section (ancipitous). *Bract* subulate, basal two stronger, 16–30 x 1.5–2 mm. *Flowers* (5–)8–17, basal two opposite, 1 to 3 upper tiers with 3 flowers each; pedicels varying slightly in length from base to apex of raceme, 7–15 mm long when flowers open. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 13–19 x 3–5 mm, pale green with short stiff hairs abaxially; inner tepals ovate-elliptic, 11–15 x 4–5 mm, yellow, green and sparsely hairy along midrib abaxially.

Stamens 3+3, with filaments subulate, 3–4 mm long; anthers 4–6 mm long, sagittate, apex entire or slightly split. *Ovary* 4–6 mm long, style ± 1 mm long, stigma 2–5 mm long, pyramidal with 3 concave faces. *Capsule* turbinate or subglobose, 6–8 mm x 4–7 mm, opening by a circular slit. *Seeds* ovoid, 1.5–2 x 1–1.8 mm, black, glossy or dull; testa papillate. *Flowering time*: September–February. Figure 12.6.

Diagnostic characters and relationships: *H. colchicifolia* is the taxon with the most robust habit among the southern African species. It is easily distinguished by its large, broadly lanceolate leaves that clasp at the base to form a thick false stem (pseudostem) which widens upwards in the shape of a funnel. Further, the leaves are glabrous and ribbed on the upper surface. The species is likely to be confused with *H. galpinii* in having lanceolate leaves and racemose inflorescences, but it lacks hairy leaf margins and densely hairy inflorescences, which is characteristic of *H. galpinii*.

Two specimens, *Burtt-Davy 13457* (in PRE) and *Reid 53* (in PRE), both collected in Northern KwaZulu-Natal deviate from the typical glabrous leaves in the species. These specimens have bifurcate hairs on leaves similar to those in *H. galpinii* and *H. rigidula* var. *rigidula*. Although rare, this state is recognised as the extreme limit for hairiness in the species, seeing that in habit, leaf shape and ribbing, the specimens closely match *H. colchicifolia*.

Distribution and ecology: *H. colchicifolia* is a South African endemic with a coastal and inland distribution. It occurs in the Eastern Cape, KwaZulu-Natal and Free State, from Mkambati in the south and is concentrated towards the uplands in KwaZulu-Natal (Figure 12.34F). The species forms strong stands in protected grasslands. *H. colchicifolia* grows sympatrically with *H. obtusa* and *H. rigidula* and like these species, prefers full sun and well-drained soil. It is recorded at altitudes from 30 to 2100 m above sea level. Although large populations of plants are encountered in the field, the species is not frequently collected for herbarium records. There is a record of a specimen (*Moss 13679* in J) collected outside the range for the species. It was noted as collected in Milner Park, Johannesburg, Gauteng in November 1926. In December of the same year, Moss collected *H. galpinii* at the same locality (*Moss 14026* in J). Heideman (1979) was unsuccessful in finding the plant on the Witwatersrand. As suggested by Burtt (1986), there may have been a mistake in the labelling of the specimen. This outlier record has not been included in mapping of the distribution of the species in this study.

Conservation status: Lower risk-Near Threatened (LRnt).

Etymology: the name *colchicifolia* describes the species as having leaves like those of the European genus, *Colchicum*.

Common names: broad-leaved hypoxis, igudu, ilabatheka, ingcobo, inkomfe (Zulu).

Uses: *H. colchicifolia* is used in traditional medicine to treat various ailments including bad dreams, barrenness, impotence and hysterical fits (Watt & Breyer-Brandwijk 1962). In her inventory of Zulu medicinal plants, Hutchings (1996) discussed the several uses of the species in Zulu healing practices, and as such the species is in great demand. It is, for example, available at the Warwick Avenue Muthi Market in Durban, KwaZulu-Natal as ilabatheka (Zulu), together with the more popular medicinal species, *H. hemerocallidea*, which is sold as inkomfe (Zulu).

Notes: Wight (1851) published an illustration of a new species that he called *Hypoxis latifolia*, unfortunately without a description. In 1854, the name was used by Hooker for a South African plant and with a proper description. Wight's plant turned out to be *Curculigo finlaysoniana* Wall. from India and this makes *H. latifolia* Hook. a later homonym. *H. colchicifolia* was described by Baker in 1889 and since there are no difficulties with the species, its name is in use as suggested by Burtt (1986). *H. oligotricha* was recognised by Baker (1889) as being different to *H. colchicifolia* in having longer leaves, more flowers, shorter pedicels and a less hairy inflorescence. This study, however, confirms that the claimed differences fall within the range of *H. colchicifolia*.

Vouchers: *Abbott 6383* (NH); *Burtt-Davy 13457* (PRE); *Herbst s.n.* NBG18441 (NBG); *Nicholson 797* (PRE); *Singh 802* (NH).

2. **Hypoxis galpinii** *Baker*, in Thiselton-Dyer, Flora Capensis: 188 (1896) as 'galpini'; Nel: 320 (1914); Compton: 130 (1976); Zimudzi: 16 (1996); Nordal & Zimudzi: 11 (2001). Type: South Africa, Mpumalanga, Barberton, Saddleback Range, Umlomati Valley, *Galpin, 1098* (K, holo!; PRE!; NBG!).

H. stricta Nel: 320 (1914). Type: South Africa, Pondoland, *Buchanan 338* (B, holo!).

Tall, robust herb, 250–400 mm high, growing singly, occasionally in tufts of 2 to 10 plants. *Rhizome* globose or oblong, 20–60 mm in diameter or ± 1½ times longer than wide, with many contractile roots, crowned by leaves and a dense mass of fibrous bristles from remains of old leaves, sometimes proliferating by means of short stolons, light yellow to orange inside. *False stem* cylindrical, 50–120 x 12–20 mm. *Leaves* few, 4–7, clasping at base to form a false stem, opening into funnel, converging apically (connivent) lanceolate to narrowly-lanceolate, 150–470 x 13–40 mm, erect, flat, coriaceous; veins 20–40, flush with surface, 2–4 near each margin thickened and raised on upper surface, approaching white at base; hairs sparse, mainly on lower surface, along margins and midrib, predominantly stellate (5–8 arms) with bifurcate hairs intermingled, bifurcate hairs 1–1.5 mm long, stellate hairs with 1 or 2 arms more strongly developed, shorter arms needle-shaped, ± 0.3 mm long, longer arms 3–3.5 mm long, appressed, white or brown. *Inflorescence* 2–7 per plant, appearing with leaves and produced sequentially, racemose, covered in white hairs; scape as tall as leaves or taller than leaves, 120–280 mm x 2–3 mm, flattened in cross section (ancipitous). *Bract* subulate, basal two stronger, 12–25 x 1–3 mm. *Flowers* (5–)8–11 per inflorescence, basal two opposite, 1 to 3 upper tiers with 3 flowers each; pedicels varying slightly in length from base to apex of raceme, 2–12 mm long when flowers open. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 10–16 x 3–5 mm, green and hairy abaxially; inner tepals ovate-elliptic, 10–16 x 5–7 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2–3 mm long; anthers 4–5 mm long, sagittate, apex entire or slightly split. *Ovary* 3–4 mm long; style 2–3 mm long; stigma pyramidal with 3 concave faces, 2–3 mm long. *Capsule* turbinate, 6–10 mm x 4–6 mm, opening by a circular slit. *Seeds* ovoid, 1.2–1.8 x 1–1.6 mm, black, glossy; testa papillate. *Flowering time*: September–December. Figure 12.11.

Diagnostic characters and relationships: *H. galpinii* is recognised by its long, lanceolate leaves that clasp at the base to form a false stem, widening above into the shape of a funnel and its near-glabrous leaves, similar to the arrangement in *H. colchicifolia*. It differs from *H. colchicifolia* in having veins flush with the leaf surface, with only two to four near each margin thickened and raised on the upper surface, and densely hairy inflorescences. In *H. colchicifolia*, the upper surface of the leaf is ribbed due to almost all veins being thickened and raised, and the inflorescences are sparsely hairy. *H. galpinii* could also be confused with plants of *H. rigidula* var. *rigidula* when leaves of the latter species are still developing or are wider, approaching linear-lanceolate. In *H. galpinii*, leaves are broader and folded into a thick (more than 13 mm wide), short false stem while in *H. rigidula*, leaves are strap-like and wrap in a narrow (usually about 10 mm wide), slender false stem.

Distribution and ecology: *H. galpinii* occurs in the eastern region of southern Africa with an inland distribution. It occurs in the Eastern Cape, KwaZulu-Natal, Mpumalanga, Lesotho and Swaziland (Figure 12.34K). The species extends into tropical Africa, occurring in Zimbabwe and Tanzania. *H. galpinii* grows in open rocky grasslands, in full sun and at altitudes of 900 to 2300 m above sea level. It is found growing sympatrically with many species, including *H. argentea*, *H. costata*, *H. multiceps*, *H. gerrardii* and *H. obtusa*.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named after Ernest Galpin [1858–1941], a banker, who started out as an amateur botanist and developed in taxonomy through leisure learning and encouragement from influential persons like George Elliot, William Tyson and N.E. Brown (Gunn & Codd 1981).

Uses: no known uses recorded in literature. As the species is similar to *H. colchicifolia* and the latter is frequently used in Zulu traditional medicine, it is very likely that *H. galpinii* is also collected in the wild as ilabetheka (Zulu). It could become a target species for use in herbal remedies should populations of the more popular species, *H. hemerocallidea* and *H. colchicifolia* start to decline.

Vouchers: *Compton 30881* (NBG, NH, PRE); *Gibbs-Russel 3482* (GRA); *Gilliland* s.n. J26911(J, PRE); *Ngwenya 1504* (NH); *Thode 2544* (NH).

3. **Hypoxis rigidula** *Baker*, Journal of the Linnean Society, Botany 17: 116 (1878b) & in Thiselton-Dyer: 186 (1896); Nel: 331 (1914); Eyles: 328 (1916) pro parte quoad saltem specm. *Eyles 455*; Norlindh & Weimarck: 166 (1937); Compton: 130 (1976); Zimudzi: 16 (1996) pro parte; Retief & Herman: 69 (1997); Nordal & Zimudzi: 12 (2001); Singh: 364 (2007). Type: South Africa, Free State, *Cooper 883* (K, lecto!).

Tall slender herb, mostly 600–700 mm high, growing singly, occasionally in tufts forming clumps. *Rhizome* oblong-globose, 40–90 x 30–50 mm or 1.25–2 times longer than wide, with many contractile roots, crowned by leaves and a mass of fibrous bristles from remains of old leaves, sometimes proliferating by means of short stolons, light yellow to orange inside. *False stem* cylindrical, slender, (65–)400–700 x (6–)8–13 mm. *Leaves* few to many, 4–12, clasping at base to form false stem, usually recurving apically, rigid, whip- or strap-like, linear, 320–800 x (4–)7–20 mm, tapering gradually from base to apex; veins flush with surface, two to five near each margin thickened and raised on upper surface; hairs sparse to dense, mainly along margins and midrib (ciliate) or forming a furry covering, bifurcate or stellate (3–8 arms, tufted), one arm more strongly developed, ascending or appressed, shorter arms needle-shaped, white. *Inflorescence* 2–5 per plant, appearing with leaves and produced sequentially, racemose or spicate, covered in white hairs; scapes as tall as or shorter than leaves, 150–300 mm x 2–3 mm, flattened in cross section (ancipitous). *Bract* subulate, 7–20 x 1–2 mm. *Flowers* 3–9 (2 in the first produced inflorescences of the new season’s growth); pedicels subsessile or short, 8–16 x 1–1.5 mm when flowers open. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 10–20 x 3–4 mm, green and hairy abaxially; inner tepals ovate-elliptic, 8–16 x 4–6 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 1.5–2 mm long; anthers 4–7.5 mm long, sagittate, apex entire. *Ovary* 4–5 mm long, style 1–1.5 mm long; stigma pyramidal with 3 concave faces, 2.5–3.5 mm long. *Capsule* turbinate or ellipsoidal, 5–8 x 3–5 mm, opening by a circular slit. *Seeds* globose to ovoid, 1.3–2 x 1.2–1.8 mm, black, glossy; testa papillate. *Flowering time*: September–March.

3a. var. **rigidula**

H. cordata Nel: 331 (1914). Type: South Africa, Limpopo, Bergwiesen, Shiluvane, *Junod 1445* (Z!).

H. elliptica Nel: 332 (1914). Syntypes: South Africa, Eastern Cape Province, Alexandra, *Rudatis 688* (K!); South Africa, KwaZulu-Natal, Pietermaritzburg, *Schlechter 3303* (B!); South Africa, KwaZulu-Natal, between Pietermaritzburg and Greytown, *Wilms 2317* (K!); South Africa, KwaZulu-Natal, Fields Hill near Pinetown, *Wood 734* (B!).

H. longifolia Baker: 176 (1904). Type: South Africa, Limpopo, Berglehnen um Shiluvane, *Junod 1445* (Z!).

H. oblonga Nel: 332 (1914). Type: South Africa, KwaZulu-Natal, Weenen District, *Wood 4372* (K!, B!, NH!).

H. volkmanniae Dinter: 257 (1931). Type: Namibia, Hereroland, *Dinter 5601* (PRE!).

H. rigidula var. *hemerocallidea* (Fisch. & C.A. Meyer) Heideman: 892 (1983), nom. nud. Type: South Africa, Kalahari Region, Basutoland *Cooper 3242* (K!).

Diagnostic characters and relationships: *H. rigidula* is a distinct species, plants being the tallest in the genus, with a rigid, elongated column-like false stem and strap-like leaves, recurving above the middle. *H. rigidula* var. *rigidula* is variable in leaf length, width and hairiness. The newly formed leaves are erect and densely hairy in comparison to mature leaves. Its closest allied species is *H. acuminata*. In the growing season, newly formed leaves of *H. rigidula* var. *rigidula* closely resemble those of *H. acuminata* and are likely to be confused with this species. However, the softer appearance of leaves and ascending long, bifurcate leaf hairs and usually two- flowered inflorescences in *H. acuminata* separates it from *H. rigidula*. In *H. rigidula* var. *rigidula*, leaves are rigid, erect and needle-shaped when young and inflorescences mostly more than four-flowered. Specimens of *H. rigidula* var. *rigidula* with broader leaves approach the range of *H. galpinii* but differ in their elongate, narrow false stem and leaves recurving above the middle, while those in *H. galpinii* form a thick false stem and converge apically. Figure 12.27.

Distribution and ecology: *H. rigidula* var. *rigidula* is found in Namibia, South Africa, Swaziland and Lesotho. It is widespread in South Africa, occurring in all provinces except the Western Cape and Northern Cape (Figure 12.34AA). It is concentrated in the eastern region of the country with a coastal and inland distribution. The species also extends into tropical Africa, occurring in Zimbabwe, Mozambique, Kenya and Tanzania. *H. rigidula* is frequent in open grasslands and easily spotted because of its tall, lanky habit and 'strap-like' leaves. The species grows in open, well-drained areas, rocky slopes and on the edges of shrubland, wetlands and stream banks. The typical variety is more abundant forming pure populations although it grows sympatrically with many other taxa including *H. colchicifolia*, *H. galpinii*, *H. hemerocallidea*, *H. obtusa*, *H. multiceps*, *H. acuminata* and *H. rigidula* var. *pilosissima*.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named from the Latin *rigidulus* (somewhat rigid) referring to its stiff leaves.

Common names: Kaffertulp, silver-leaved star-flower, moli-teane (Sesotho); inkomfe (Zulu).
Uses: the rigid leaves of the species are suitable for rope making and are used with *H. obtusa* in rural areas in the midlands of KwaZulu-Natal to make twine for cross threading thatch roofing of huts.

Vouchers: *Compton 32393* (NBG, PRE); *Dold 1365* (GRA); *Dieterlen 223* (NBG, PRE); *Dinter 5601* (PRE, SAM); *Singh 460*, *463* (NH).

3b. var. **pilosissima** *Baker*, Journal of the Linnean Society, Botany: 117 (1878b); Baker: 186 (1896); Nel: 331 (1914); Singh 364 (2007): Type: South Africa, Gauteng, Magalies Berg [Magliesberg], *Burke 156* (K, lecto!).

H. arnottii Baker: 552 (1877); Baker: 112 (1878b); Baker in Thiselton-Dyer: 132 (1896). Type: South Africa, Eastern Cape, Colesberg, *Arnott s.n.* (not yet traced, seemingly not at K), June 1870, Hort. Kew.

Diagnosis: *H. rigidula* var. *pilosissima* is distinct in its slender, tall, soft, grey-white appearance and is not likely to be confused with any other species in the genus. It is distinguished from the typical variety by density and type of leaf hairs. Hairs in the typical variety are sparse, scattered mainly on the lower surface in channels between veins, bifurcate, long and ascending or stellate, short and appressed. In *H. rigidula* var. *pilosissima*, hairs are dense on both surfaces, stellate, long and ascending giving leaves a soft, furry, grey-white appearance. Figure 12.26.

Distribution and ecology: *H. rigidula* var. *pilosissima* has a similar distribution to that of var. *rigidula*, being present in South Africa, Lesotho and Swaziland. It occurs in all provinces in South Africa, except the Western Cape, Northern Cape and Free State (Figure 12.34Z). The variety does not occur in tropical Africa. *H. rigidula* var. *pilosissima* is often found growing in the vicinity of *H. rigidula* var. *rigidula*, but its occurrence is less frequent in comparison to the typical variety. The difference in density of hairs on leaves between the two varieties is often not obvious to field collectors and both varieties are sometimes presented in the same gathering.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: Named from the Latin *pilosus* meaning hairy in reference to the felt-like hairs in this taxon.

Common names: Kaffertulp, silver-leaved star-flower, moli-teane (Sesotho); inkomfe (Zulu)

Vouchers: *Abbott 6121* (NH, PRU, Umtamvuna); *Compton 28102* (NH, NBG); *Singh 326* (NH); *Thode 2534* (PRE); *Van Wyk 1749* (PRE).

4. **Hypoxis acuminata** *Baker*, Journal of Botany: 3 (1889); Baker in Thiselton-Dyer: 186 (1896); Compton: 129 (1976). Type: South Africa, KwaZulu-Natal, Inanda, *Wood 1347* (NH, holo!; K!).

Tall, slender, sparsely hairy herb, ±200 mm high, growing singly or in tufts of 3–40 shoots forming large clumps. *Rhizome* subglobose or oblong, 15–25 mm in diameter, with many contractile roots arising above middle; crowned by leaves and a dense mass of fibrous bristles from remains of old leaves, sometimes proliferating by short stolons, white to pale yellow inside. *False stem* cylindrical, slender, 30–100 x 5–10 mm. *Leaves* few, 4–8, erect or semi-erect, spirally twisting, linear, 130–380 x 4–7 mm, V-shaped in cross section; veins 6–12, flush with surface, two to four near each margin thickened and raised on the upper surface; hairs predominantly bifurcate with few stellate intermingled, mainly on lower surface and along veins and margins, V- or U-shaped. *Inflorescence* 1–4 per plant, appearing with leaves and produced sequentially, racemose, covered sparsely in white, long hairs; scape shorter than leaves, 200–300 mm x 1.5–2 mm, flattened in cross section (ancipitous). *Flowers* 2(–5), basal two opposite, upper tier with 1–3 flowers; pedicels 4–12 mm long when flowers open. *Bract* subulate, 10–20 x 1–2 mm. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 11–20 x 3–7 mm, green and hairy abaxially; inner tepals ovate-elliptic, 9–15 x 2–5 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments linear, 1–1.5 mm long; anthers 2–6 mm long, sagittate, apex split. *Ovary* 3–4 mm long; style 1–2 mm long; stigma pyramidal with 3 concave faces, 2–3 mm long. *Capsule* turbinate, 5–8 x 4–6 mm, opening by a circular slit. *Seeds* globose to ovoid, 1.8–2.1 x 1.6–1.8 mm, black, glossy; testa papillate. *Flowering time*: September–December. Figure 12.1.

Diagnostic characters and relationships: *H. acuminata* is recognised by its grass-green, slender habit, few leaves arising from a narrow short false stem and acuminate apices. Its racemes are mostly two-flowered. The species is most closely related to *H. rigidula* var. *rigidula*, but differs in having shorter, firm but not rigid leaves, fewer flowers per raceme and sparsely hairy inflorescences. Further, its even distribution of bifurcate, weak, long V- or U-shaped, ascending hairs on leaves can be separated from the predominantly stellate, short, needle-shaped, appressed hairs in *H. rigidula* var. *rigidula*.

Distribution and ecology: *H. acuminata* occurs in South Africa, Lesotho and Swaziland and displays a coastal and inland distribution. It occurs in all provinces of South Africa, except the Western Cape, Northern Cape and North West (Figure 12.34A). It is possibly more abundant in the Eastern Cape, Free State and Lesotho, but these areas lack herbarium records. The species grows in open grasslands in damp areas, sometimes associated with forest margins, stream banks and roadside depressions, in full sun or partial shade. It is concentrated away from the coast, at higher altitudes of 500 to 2000 m above sea level. *H. acuminata* grows sympatrically with *H. argentea*, *H. filiformis*, *H. galpinii* and *H. rigidula*. The typical form of *H. acuminata* is a slender plant with a false stem, but a form lacking a false stem and with shorter leaves was recorded. The latter form is less common and associated with dry ground, usually just after a burn and before the spring rains. Except for the false stem, both forms are similar in leaf shape, hairs and inflorescences, and display the characteristic oblique twisting of leaves.

Conservation status: Lower Risk Least Concern (LRlc).

Etymology: named from the Latin *acuminatus* meaning tapering to a narrow point, referring to the shape of the leaf apices.

Common names: Moli-motsanyane, thotolinyenyane (Sesotho).

Vouchers: *Compton 27182* (NBG); *Dieterlen 290* (PRE); *Dold 678* (GRA); *Moss 13888* (J); *Singh 655* (NH).

5. **Hypoxis longifolia** *Baker ex Hook.f.*, Curtis Botanical Magazine 26: t. 6035 (1873), non Baker (1904); Baker: 115 (1878b); Baker in Thiselton-Dyer: 185 (1896); Singh: 363 (2007). Type: South Africa, Free State, Vet River, *Burke s.n.* (K, lecto!).

H. longifolia var. *thunbergii* Baker: 116 (1878b). Type: South Africa, Cape, *Thunberg s.n.* (UPS, image no. 8269!) as *H. villosa* var. δ.

H. zululandensis S.E. Wood (MS), MSc. Dissertation, unpublished, pg. 65. Type: South Africa, KwaZulu-Natal, Ubombo, Manzengwenya, *Moll 4740* (NBG, holo!).

Tall, slender, glabrous herb, 200–350 mm high, growing singly. *Rhizome* turbinate, 40–52 x 35–50 mm, with many contractile roots arising above middle, crowned by leaves and a dense mass of fibrous bristles from remains of old leaves, yellow inside. *False stem* slender, 40–70 x 6–10 mm. *Leaves* few, 4–6(–8), erect or semi-erect, clasping at base to form a narrow false stem, filiform, 150–500 x 2–4 mm, subterete rarely flat, ribbed; veins 4–6, close to each other, uniformly thickened and raised on upper surface, straw-colour, blade near-glabrous or with few hairs, margins and midrib on lower surface outlined in white by a thickened band of squat hairs; hairs stellate (4–5 arms) with one to two arms three times longer than the rest, short arms ± 0.3 mm, long arms ± 1 mm, appressed, white. *Inflorescence* 2–4 per plant, appearing with leaves and produced sequentially, racemose, covered in white, patent hairs; scapes as tall as or shorter than leaves, 150–400 x 1–2 mm, flattened in cross section (ancipitous). *Flowers* 4–5(–7); pedicels 11–30 x 0.5–1.0 mm when flowers open. *Bract* subulate, 5–19 x 1–2 mm. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 12–14 x 4–5 mm, green and hairy abaxially; inner tepals ovate-elliptic, 10–12 x 5–6 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments linear, 2–3 mm long; anthers 4–5mm long, sagittate, apex split. *Ovary* 4–5 mm long; style cylindrical, ± 3 mm long; stigma pyramidal with 3 concave faces, 1–3 mm long. *Capsule* turbinate, 4–7 x 3–5 mm, opening by a circular slit. *Seeds* ovoid, 1.8–2 x 1.4–1.5 mm, black, glossy; testa papillate. *Flowering time*: August–May, mostly in November–January. Figure 12.16.

Diagnostic characters and relationships: *H. longifolia* is a slender herb with a narrow, short false stem and characteristic linear, subterete leaves with few veins close to each other, thickened and

raised on the upper surface making the leaves appear ribbed. The blade is usually glabrous while the margins and midrib on lower surface are ciliate, being lined with squat white stellate hairs.
H. longifolia closely resembles *H. kraussiana* in leaf width, venation and hair characters. However, the longer leaves, more than 120 mm long, and inflorescences with usually more than two flowers in *H. longifolia* separates it from *H. kraussiana*. In *H. kraussiana*, leaves are shorter and inflorescences consistently two-flowered. The slender, subterete, ribbed leaves of *H. longifolia* are also similar to those in *H. filiformis*. However, the rhizome in *H. longifolia* is also much larger with a strong crown of bristles in comparison to *H. filiformis*, and leaves in the latter species are sparsely covered with long, weak mostly bifurcate hairs (pilose).

Distribution and ecology: *H. longifolia* occurs in South Africa, Lesotho and Swaziland. It is found in all provinces of South Africa, except the Northern Cape and has a coastal and inland distribution. It extends along the coast from Knysna (Western Cape) to Ubombo in KwaZulu-Natal and westwards across Free State and Lesotho and into North West (Figure 12.34P). The species also extends into tropical Africa, occurring in southern Mozambique. A specimen, *Govender 79* (NH), collected west of Zitundo in Mozambique during a SABONET southern Mozambique Expedition 2001, was found to closely match the type specimen. It has not been previously recorded in Mozambique. Plants of *H. longifolia* occur in grasslands, in well-drained or moist soil and full sun. The species grows at altitudes of 10 to 700 m above sea level. It appears not to be frequently collected, possibly being missed among tall grass due to the very slender habit.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: derived from the Latin *longi* and *folia* describing the long, narrow leaves of the species.

Vouchers: *Gerstner 4936* (PRE); *Hugo 2088* (PRE); *MacOwan 2123* (NBG); *Moll 4740* (NBG, NH); *Ngwenya 1738* (NH).

6. **Hypoxis ludwigii** *Bake*r in Journal of Botany 14: 181 (1876), 116 (1878b), in Thiselton-Dyer: 185 (1896). Type: South Africa, Eastern Cape, Baziya, *Baur 301*, cult. in Baron Ludwig's garden in Cape Town (K, image!; B!).

Tall, slender herb, 250–350 mm high, sparsely hairy, usually growing in tufts forming large stands. *Rhizome* oblong, 25–40 x 15–20 mm, with contractile roots, crowned by leaves and a mass of dense bristles from remains of old leaf bases, yellow or orange inside. *False stem* cylindrical, slender, 40–50 x 20-30 mm. *Leaves* 8–10, clasping at base to form false stem, coriaceous, erect, linear, 300–450 x (8–)10–20 mm; veins 16–40, almost all thickened and raised on upper surface (ribbed), sparsely hairy; hairs scattered on blade, bifurcate, V-shaped, ascending, dense on margin and midrib below forming a white band (ciliate), stellate (3–6 arms); arms of unequal length, needle-shaped, 1–2 mm long. *Inflorescence* 1–4 per plant, produced sequentially in the growing season, racemose, covered in white, ascending hairs; scapes as tall as or shorter than leaves, 150–200 x 2–3 mm, ancipitous. *Flowers* 2–5, lower two opposite each other, upper tier with 2–3 flowers; pedicels 16–25 x 1–2 mm when flowers open. *Bract* linear-subulate, 5–12 mm long, hairy below. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 10–12 x 3–3.5 mm, green and densely hairy abaxially; inner tepals ovate-elliptic, 8–10 x 3–4 mm, with a green band and hairy along midrib abaxially. *Stamens* with filaments subulate, 2–3 mm long; anthers 2.5–3 mm long, sagittate, apex entire. *Ovary* 4–5 mm long; style 1–2 mm long; stigma pyramidal with 3 concave faces, 1–3 mm long. *Capsule* turbinate, 4–7 mm x 3–4 mm, opening by a circular slit. *Seeds* ovoid, 1.5–2 x 1–1.5 mm, black, glossy; testa smooth. *Flowering time*: August–February. Figure 12.17.

Diagnostic characters and relationships: *H. ludwigii* is a slender herb with a narrow false stem and linear leaves with many veins close to each other, thickened and almost all raised on the upper surface making the leaves appear ribbed. The blade is glabrous or lightly covered with bifurcate long hairs, while the margins and midrib on lower surface are ciliate, being lined with squat white stellate hairs. *H. ludwigii* is closely related to *H. longifolia* having strongly ribbed ciliate leaves.~~ and corymbose inflorescences~~. It is separated from *H. longifolia*, in its leaves being wider and inflorescences usually with more than two flowers. In *H. longifolia* leaves are subterete and inflorescences usually two-flowered. *H. ludwigii* may be confused with *H. rigidula* var. *rigidula* in its rigid, hairy leaves but differs in its shorter false stems, shorter and broader ribbed leaves, and ~~corymbose~~ fewer (usually 2–4) flowers per inflorescence. In *H. rigidula* var. *rigidula*, false stems are long and narrow, leaves strap-like, ribbed near each margin and inflorescences with usually more than five flowers ~~racemose~~. Further, specimens of *H. ludwigii* dry light green while those of *H. rigidula* var. *rigidula* dry dark brown.

Distribution and ecology: *H. ludwigii* occurs in South Africa and possibly Lesotho, and is known from a single specimen in Namibia. In South Africa, it is found in the Eastern Cape, KwaZulu-Natal and Free State, and is associated with the Drakensberg Mountains. It extends from Stutterheim in the south to Warden in the north and is concentrated in the Drakensberg mountain range close to the KwaZulu-Natal-Lesotho border (Figure 12.34Q). *H. ludiwgii* grows in grasslands, in well-drained or moist soil and full sun. The species grows at high altitudes of 1300 to 2400 m above sea level.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: Named in honour of Baron Carl Ludwig (1784–1847), who established a noteworthy botanic garden known as the Ludwig-burg Garden in the Cape around 1830.

Vouchers: *Hilliard & Burtt 187692* (NU); *Hilliard & Burtt 18751* (NU); *Singh 522*, (NH); *Singh & Baijnath* 314 (NH).

7. **Hypoxis hemerocallidea** *Fisch., C.A. Mey. & Avé-Lall.*, Index Seminum quae Hortus Botanicus Imperialis Petropolitanus 8: 64 (1842); Baker: 119 (1878b); Baker in Thiselton-Dyer: 188 (1896); Nel 51: 316 (1914); Compton: 130 (1976); Burtt: 202 (1986); Singh: 362 (2007). Type: South Africa, Cape of Good Hope, cult. in Hort. Bot. Petrop. (LE, image!).

H. elata Hook.f. (non Schultes & Schultes): t. 5690 (1868). Type: From specimen grown in Reigate, 1862.

H. obconica Nel: 330 (1914). Syntypes: South Africa, KwaZulu-Natal, Pinetown, South Africa, KwaZulu-Natal, Verulam, *Schlechter 2898* (B!, BR, GRA!, PRE!, ZT!); *Thode* July 1893 (B!); South Africa, KwaZulu-Natal, Inanda, *Wood 184* (K, image!).

H. patula Nel: 333 (1914); Retief & Herman: 69 (1997). Type: South Africa, Mpumalanga, Barberton, Saddleback Range, *Galpin 1100* (K, holo., image!; PRE, isolecto!).

H. rooperi T. Moore: 65 cum icone (1852); Lemaire: t. 303 (1853); Baker: 118 (1878b) excl. specim. Forbes (1822); Baker in Thiselton-Dyer: 188 (1896); Wood: 132 (1907); Nel: 337 (1914); Phillips t.172 (1925); Burtt: 202 (1986). Type: cult. by Rev. T. Rooper of Wick Hill, Brighton in October 1850, from a plant collected by Captain E. *Rooper* in the Eastern Cape at the Buffalo River mouth in July 1837 (K, image!). Syntype: South Africa, Eastern Cape, Albany Division, near Bushmans River, *Drège 8529* (K!).

H. rooperi var. *forbesii* Baker: 118 (1878b); Baker in Thiselton-Dyer: 189 (1996). Type: Mozambique, Delagoa Bay, *Forbes s.n.*K1999/1186 (1822) (K, holo., image!).

Robust sparsely hairy herb, 100–600 mm high, growing singly. *Rhizome* globose, turbinate or oblong, 25–100 x 25–60 mm, with many contractile roots arising above middle; crowned by leaves and a dense mass of fibrous bristles from remains of old leaves; yellow to orange inside. *Leaves* many, (6–)8–12, noticeably arranged one above the other in three ranks with roughly 120^0 between the ranks, lanceolate, seldom linear-lanceolate, (10–)200–500(–900) x 18–25(–45) mm, sickle-shaped (falcate), recurving, folded together along the length (conduplicate) towards the base, V- or inverted

W-shaped in cross section; veins flush with surface, two near each margin thickened and raised on upper surface; with an even distribution of hairs, mainly on lower surface and in young leaves, less hairy with age; hairs on blade bifurcate, V- or U-shaped, on margins scattered, stellate (3–6 arms) with 1or 2 arms more strongly developed, ascending, white. *Inflorescence* 3–8 per plant, produced sequentially throughout the growing season with leaves, racemose, covered in long, ascending, white hairs; scapes as tall as or shorter than leaves, 150–350 x 15–50 mm, flattened in cross section (ancipitous). *Flowers* (2–)4–12 in tiers, basal tier with 2 flowers, opposite, upper tiers with 2 or 3 flowers; pedicels 10–30 x 1.5–4.0 mm when flowers open. *Bract* subulate, ½ to 1½ the length of pedicel, 5–38 x 3–4 mm. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 12–20 x 4–7 mm, green and hairy abaxially; inner tepals ovate-elliptic, 10–18 x 7–8 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2–4 mm long; anthers 4–7 mm long, sagittate, apex entire or split. *Ovary* 3–4 mm; style 1–2.5 mm long; stigma pyramidal with 3 concave faces, 2–5 mm long. *Capsule* ellipsoidal or turbinate, 7–10 x 5–7 mm, opening by a circular slit. *Seeds* ovoid, 1.5–2 x 1–1.8 mm, black, glossy; testa smooth. *Flowering time*: August–May, mostly September–March. Figure 12.13.

Diagnostic characters and relationships: In southern Africa, *H. hemerocallidea* is the best known species in the genus. Plants of the species are diagnostic in their appearance and easy to identify, particularly in the field. The leaves are arranged one above the other in three ranks with roughly 120^0 between the ranks. Leaves are sickle-shape (falcate), recurving with an even distribution of soft, ascending hairs. The species is most similar to *H. obtusa* in the size of rhizomes, habit and inflorescence. However, the soft, pilose leaves of *H. hemerocallidea* are distinct from the rigid, ribbed near-glabrous leaves with ciliate margins in *H. obtusa*. *H. hemerocallidea* is one of the most variable species in the genus with regards to plant height, leaf dimensions, hairiness, number of flowers depending on the age of plants and part of season. The new season’s leaves are always densely hairy and as the leaves mature, hair density is reduced by the enlargement of the leaf surface area. In young plants, less than three years that develop from seed, leaves are short and narrow approaching linear, densely hairy and have fewer flowers in comparison to older plants. The smaller form has been confused as representing a new entity. Also, at the start of the growing season, like in *H. rigidula*, the first few inflorescences in *H. hemerocallidea* bear two flowers, opposite each other; deviating from the usually many-flowered racemes in the species.

Distribution and ecology: *H. hemerocallidea* is found in Botswana, South Africa, Swaziland and Lesotho. It occurs in all provinces in South Africa, except the Western Cape and Northern Cape. It is concentrated in the eastern region of the country with a coastal and inland distribution (Figure

12.34M). Its distribution extends into tropical Africa, where it occurs in Zimbabwe and Mozambique but is scarce in these countries in comparison to southern Africa. Possibly, also in Kenya and Uganda (see notes). In southern Africa, plants of *H. hemerocallidea* occupy a wide range of habitats. Plants form extensive pure stands in open grasslands. To a lesser degree, they extend into sandy dune slopes and damp areas around streams. The species is adaptable enough to grow in semi-shade conditions for example in thicket and forest margins. It also occurs in disturbed areas like road verges and pine plantations. *H. hemerocallidea* occurs from just above sea level at 5 m to high altitudes up to 1800 m.

Conservation status: Lower risk-Near Threatened (LRnt) due to its exploitation for the medicinal trade especially in the Eastern Cape Province and KwaZulu-Natal.

Etymology: *hemerocallidea* is used in reference to the species resembling the leaves of *Hemerocallis*, the day lily.

Common names: African potato (coined recently by the media following its popularization in South Africa as a potential immune booster for patients with immune-related diseases like cancer and HIV/AIDS, star-flower, gifbol, sterblom, kaffertulp (Afrikaans), moli-kharatsa (Sesotho), inkomfe (Zulu).

Uses: *H. hemerocallidea* is the species most used by humans among the hypoxids in southern Africa. Rhizomes of the species were used for centuries to treat various ailments including headaches and mental disorders by the Zulu (Hutchings, 1996). White farmers in South Africa used the rhizomes as a herbal remedy to treat prostate cancer (Van Staden 1981). The species has potential in Western medicine as it contains the diglucoside, hypoxoside, which in its active form rooperol is known to inhibit cancer cells (Drewes & Khan 2004). Plants of the species are still being harvested from the wild for the medicinal plant (muthi) trade and this is of concern to conservationists, as populations diminish in the wild, especially in the Eastern Cape Province (Dold & Cocks 2002) and KwaZulu-Natal. *H. hemerocallidea* is an excellent species for the garden and when massed in a bed, its large bright yellow flowers provide a resplendent display.

Notes: *Hypoxis hemerocallidea* is not considered to occur in the Flora of Tropical East Africa region and is possibly considered within the concept of *H. urceolata* or *H. obtusa* (Nordal *et al.* 1995; Wiland-Szymańska & Nordal 2006). Specimens *Verdcourt & Fraser Darling 2281*, *Glover, Gwynne & Samuel 809*, *Hansen 756*, *Horeau 73*, *Iveas 871*, *Kerfoot 2640*, *Sheldrick 11559* and *Verdcourt 3828C*, collected in Kenya, *Gillett & Kariuki 18825* and *Lye & Rwaburindore 4517* and *Harker 445* from Uganda, all in EA (and on loan to NH, except *Verdcourt 3828C* and *Harker 445*) are identified as *H. hemerocallidea* in the present study. Considering the number of collections, there appears to be a marked decline in the occurrence of *H. hemerocallidea* in tropical Africa.

Baker (1878b) separated *H. rooperi* T. Moore from *H. hemerocallidea* on its corymbose-like inflorescence. Based on the smallness in stature of the plant, Baker (1878b) proposed the variety *forbesii* citing *Forbes s.n.* (in K) collected in Mozambique. Burtt (1986) clarified the concept of *H. hemerocallidea* and reduced *H. rooperi* as a synonym of *H. hemerocallidea*. Burtt (1986) also discusses the problems around Heideman's (1983) concept of *H. rigidula* and *H. hemerocallidea*. Heideman (1979, 1983) considered two varieties in *H. rooperi* namely var. *rooperi* and var. *forbesii*. She recognised var. *forbesii* as a smaller plant and included with these, plants with new leaves in the growing season e.g. *Leisgang 46* (NU). During fieldwork in South Africa, plants of *H. hemerocallidea* were found to have a varying degree of leaf dimensions, number of flowers and dimensions of pedicels. It is extremely difficult to define limits for leaf dimensions in order to create varieties within *H. hemerocallidea*. As in other robust species, younger plants of *H. hemerocallidea* appear different from the older plants in a population and if collected independently, can be mistaken for a new entity. Therefore, the approach in this study has been to extend the limits of variability to accommodate the small and large facies of a species over its growing season. Variety *H. rooperi* var. *forbesii* is considered within the limits of *H. hemerocallidea*.

Vouchers: *Barker 4367* (NBG); *Cloete & Bosa 3219* (NH); *Galpin 1190* (PRE); *Nicholas & Perks 1502* (PRE); *Singh 649* (NH).

8. **Hypoxis obtusa** *Ker Gawl*., Botanical Register 2: t. 159 (1816); Baker: 114 (1878b) & in Thiselton-Dyer: 184 (1896); Burtt: 205 (1986); Nordal & Zimudzi: 13 (2001); Singh: 363 (2007). Type: Bot. Reg. t. 159, icono!.

H. iridifolia Baker: 117 (1878b); Burtt: 204 (1986); Retief & Herman: 69 (1997); Nordal & Zimudzi: 13 (2001). Type: "Tropical South Africa", *Baines s.n*. October 1872, (K, holo!.).

H. nitida I. Verd. 27: t. 1058 (1949). Type: South Africa, Gauteng, Pretoria, *Robertson 2* (holo., PRE!).

H. obtusa var. *chrysotricha* Nel: 334 (1914). Type: South Africa, KwaZulu-Natal, Newmarket, *Krook 405* (W)-type lost in World War II.

Robust herb, 200–450 mm high, growing singly. *Rhizome* subglobose, oblong or turbinate, 4–12 x 4–8 mm, with many contractile roots arising above middle, crowned by leaves and a dense mass of fibrous bristles from remains of old leaves, yellow or orange inside. *Leaves* many, (6–)8–15, coriaceous, erect or recurving, arranged one above the other in three ranks with about 120^0 between the ranks, folded together along the length (conduplicate) at least at base, spirally twisting upwards with age, lanceolate, sometimes linear-lanceolate, 100–700 x 6–30 mm, gradually tapering to a narrow acute apex; veins 30–70, close to each other, uniformly thickened and raised on upper surface (ribbed), bases sometimes red or purple, near-glabrous or hairy towards base, margin and midrib outlined in white by a thickened band of squat hairs (ciliate); hairs stellate (3–6 arms) with 1 or 2 arms more strongly developed, needle-shaped, appressed. *Inflorescence* 2–5 per plant, produced sequentially throughout growing season with leaves, racemose, covered in short bristle-like, patent, white hairs; scapes as tall as or shorter than leaves, 250–350 x 25–70 mm, flattened in cross section (ancipitous). *Flowers* (2–)5–12 in tiers, basal tier with 2 flowers, opposite, upper tiers with 2 or 3 flowers, two to four opening at a time; pedicels unequal in length, lowermost longer, 5–20 x 1–2 mm when flowers open. *Bract* subulate, 7–35 mm x 3–4 mm. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, (10–)12–20 x 4–8 mm, green and hairy abaxially; inner tepals ovate-elliptic, 10–18 x 6–10 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2–5 mm long; anthers 5–8 mm long, sagittate, apex entire. *Ovary* 3–4 mm; style 1–2.5 mm long; stigma pyramidal with 3 concave faces, 2–4 mm long. *Capsule* turbinate, 6–7 x 5–7 mm, opening by a circular slit. *Seeds* ovoid, 1.5–2 x 1–1.5 mm, black, glossy; testa smooth. *Flowering time*: August–February. Figure 12.22.

Diagnostic characters and relationships: *H. obtusa* is easy to identify from its leaf characters. Its leaves are stiff and ribbed due to the many veins close to each other, thickened and raised on upper surface. The leaf blade is glabrous except at bases. Leaf hairs form a conspicuous white band along margins and midrib on lower surface. The species is also floriferous, with 5–11 flowers per raceme. *H. obtusa* is most similar to *H. hemerocallidea* in its habit and inflorescences, but leaves in the latter species are moderately firm (not rigid and ribbed) and have an even distribution of long, weak hairs. *H. obtusa* is also related to *H. longifolia* and *H. obliqua* in its ciliate leaf margins and midrib on lower surface but can be separated from these species on habit, leaf width, inflorescence type and tepal size. *H. longifolia* has linear leaves wrapped in false stem at the base and four to five flowers in a corymbose inflorescence while *H. obtusa* lacks a false stem, its leaves are lanceolate and usually more than five flowers held in a racemose inflorescence. *H. obliqua* is a short plant, less than 150 mm high and tepals up to 12 mm long in comparison to *H. obtusa* which is usually more than 200 mm high and tepals are more than 12 mm long.

Distribution and ecology: *H. obtusa* occurs in Namibia, Botswana, South Africa, Lesotho and Swaziland. In South Africa it occurs in all provinces except the Western Cape . The species is common in South Africa with a more inland distribution. It is known from a few localities in Botswana and Namibia and is the only species that extends marginally into the Northern Cape at the North West border (Figure 12.34V). *H. obtusa* also extends into tropical Africa and occurs in Zimbabwe, Uganda, Kenya and Tanzania. The species prefers open grasslands, especially sandy areas and full sun. It grows at altitudes of 300 to 2100 m above sea level. In southern Africa, *H. obtusa* forms pure stands or grows sympatrically with *H. rigidula* and *H. colchicifolia*. Although hybridization among these species is suspected, it is not obvious from field observations as suspected hybrids tend to strongly resemble one parent and can be placed into the range for one species. It is therefore not possible to provide a conclusive remark on occurrence of hybridisation between these species in the absence of extensive field observations and breeding studies that include apomixis and hybridization.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: Named from the Latin *obtusus*, referring to the blunt tips of the tepals.

Common names: Mr Burchell’s hypoxis, Moli-boea (Sesotho); inkomfe (Zulu).

Uses: *H. obtusa* has a few varied uses in southern Africa. Hypoxoside, the di-glucoside targeted mainly from *H. hemerocallidea* and *H. colchicifolia* for its anti-tumor activity for treating cancer patients, was first isolated from *H. obtusa* (Marini-Bettolo *et al.* 1982). *H. obtusa*, like the two former species would therefore also be a good source of hypoxoside. Together with *H. rigidula* var. *rigidula*, *H. obtusa* is used to make twine for cross threading thatch roofing of huts in the midlands of KwaZulu-Natal. The species is also reported to be used in the making of floor polish for huts in rural KwaZulu-Natal (Singh 1999). Like *H. hemerocallidea*, *H. obtusa* offers a brilliant display of large yellow flowers in gardens in the spring and summer months.

Vouchers: *Bester 1333* (NH, PRU); *Dinter 617* (NBG); *Cross PRE38186* (PRE); *Jenkins TM7124* (PRE); *Singh & Wiland 689* (NH).

9. **Hypoxis stellipilis** *Ker Gawl*., Botanical Register t. 663 (1822); Fisch. & C.A. Meyer (1845); Baker: 118 (1878b). Type**:** t. 663 (1822) icono. Epitype selected here: South Africa, Eastern Cape, Uitenhage, Zwartkops River, *Zeyher 4140* (K!, NBG!).

H. lanata Eckl. in herb. ex Baker: 118 (1878b). Exsic.

Medium-sized, soft herb, 100–200 mm high, growing singly. *Rhizome* oblong, slightly longer than wide, 40–60 x 30–50 mm, with many contractile roots arising above middle, crowned by leaves and a mass of bristles from remains of old leaves, yellow inside. *Leaves* many, 10–18, arranged one above the other in three ranks, lanceolate, 150–300(–400) x 12–25 mm, sickle-shaped (falcate), recurving, folded together along the length (conduplicate) at least at base, upper surface dark green and glabrous, lower surface white tomentose; veins 8–14, slender, flush with surface, one to two near each margin thickened and raised on upper surface, obscured on lower surface by hairy layer; hairs stellate (6–14 arms), star-shaped; arms needle-shaped, short, one or two more strongly developed, 1–3 mm long, appressed, in different heights over each other, interwoven to form thick, silvery-white layer. *Inflorescence* 2–4 per plant, produced sequentially in growing season, corymbose, covered in dense, long, soft hairs (furry); scapes as tall as or shorter than leaves, 75–130(–200) mm long, flattened in cross section (ancipitous). *Flowers* 3 or 4(–7); pedicels unequal in length bringing flowers to same height; two lowermost 10–20 mm long; upper 2–5 mm long. *Bract* subulate-linear, 10–25 mm long, hairy below. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, (12–)15–19 x 4–5 mm, green and hairy abaxially; inner tepals ovate-elliptic 14–18 x 5–6 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments linear, 2–3 mm long; anthers 3–5 mm long, sagittate, apex split. *Ovary* 6 mm long; style ± 4 mm long; stigma pyramidal with 3 concave faces, ± 4 mm long. *Capsule* turbinate, 6–8 x 4–5 mm, opening by a circular slit. *Seeds* ovoid, 1–2 x 0.8–1.0 mm, black, glossy; testa papillate. *Flowering time*: August–April. Figure 12.30.

Diagnostic characters and relationships: *H. stellipilis* is the most distinct species in the genus. The entire lower surface of leaves is silvery-white and tomentose due to the stellate, appressed, interwoven, thick hairs. The upper surface of leaves is near-glabrous and dark green. The type and distribution of hairs makes the species unique. *H. stellipilis* is most closely allied with *H. hemerocallidea* and *H. obtusa* in leaves arranged one above the other in three ranks and large flowers, more than 20 mm in diameter. It differs from these species in its unique hair type and distribution, and corymbose inflorescences. In *H. hemerocallidea* hairs are bifurcate and evenly distributed throughout leaves while in *H. obtusa* leaves are near-glabrous and ciliate on margins, being lined with stellate hairs.

Distribution and ecology: *H. stellipilis* is a South African endemic with a very narrow distribution range. It occurs from Uniondale (Western Cape) in the south, along the coast to Port Elizabeth (Eastern Cape) in the north, making it the only *Hypoxis* species near-endemic to the Cape Floristic Region (Figure 12.34AD). The species is known mainly from the Albany Thicket Biome, where it grows in grassy patches on drier hill slopes, in full sun or partial shade. *H. stellipilis* prefers lower altitudes of 160 to 560 m above sea level. Plants of this species are very scarce in its distribution range, never forming strong populations.

Conservation status: Lower risk-Near Threatened (LRnt) due to few and small size of populations.

Etymology: named from the Latin *stellipilis* (star-shaped), referring to the mass of stellate hairs forming a silvery-white layer on lower surface of leaves.

Common names: Starry-furred hypoxis.

Vouchers: *Acocks 16117* (PRE); *Drege 9018* (PRE); *Ecklon & Zeyher 1063* (BOL, GRA, NBG); *Phillips & Van Rensberg 2113* (J); *Singh 621* (NH).

10. **Hypoxis interjecta** *Nel*, Engler Botanische Jahrbücher 51: 321 (1914). Type: South Africa, Mpumalanga, near Lydenburg *Wilms 1454* (B, holo!).

H. pretoriensis Goossens (MS). Type: South Africa, Gauteng, near Pretoria, Muckleneuk, *Goossens 91* (K, holo., image!).

Stout, tough, glabrous herb, 100–120 mm high, glabrous, growing singly. *Rhizome* oblong to subglobose, 20–60 mm x 15–30 mm, with few contractile roots arising above middle; crowned by leaves and a dense mass of fibrous bristles from remains of old leaves; yellow or orange inside. *Leaves* few, 4–7, erect or semi-erect, bases overlapping in a rosette, lanceolate to broadly oblong-lanceolate, 40–60 x 8–20 mm, elongating to 250–400 mm in post-flowering, forming false petioles when shaded by dense grass, flat, tapering rapidly to subacute apices; veins 12–18, close to each other, flush with surface, two near each margin slightly thickened and raised on upper surface, glabrous; hairs if present then on margins and midrib of younger leaves, caducous in mature leaves, stellate (3 or 4 arms), white or yellow. *Inflorescence* 2–4 per plant, appearing before or with emergence of leaves, corymbose noticeable when flowers more than 2, densely covered with coarse, short, white or yellow hairs (hispid); scapes as tall as to twice as tall as leaves, 50–80 mm long, flattened in cross section (ancipitous). *Flowers* usually 2, opposite, seldom 4 in 2 tiers of 2 flowers each; pedicels short, 6–15 x 1.5 mm, densely covered in short, yellow hairs. *Bract* subulate, 5–6 mm long, densely covered in short hairs. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 14–15 x 6–8 mm, green and densely hairy abaxially; inner tepals ovate-elliptic, 13–14 x 8–10 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 3–4 mm long; anthers 4–5 mm long, sagittate, apex entire; *Ovary* 2–3 mm long. style 0.5–2 mm long, stigma pyramidal with 3 concave faces, 1.5–2 mm long. *Capsule* turbinate, 5–6 x 4–5 mm opening by a circular slit. *Seeds* few, 3–5, ovoid, large, 2–3 x 1–1.8 mm, black, glossy; testa smooth. *Flowering time*: August–October. Figure 12.14.

Diagnostic characters and relationships: *H. interjecta* can be identified by its short leaves, less than 100 mm long when flowers open, completely glabrous when mature, and usually two-flowered, strong inflorescences. The species is closely related to *H. multiceps* and *H. costata* in having few, short, broadly oblong leaves overlapping in a rosette-like arrangement and stout inflorescences, produced at the start of the growing season and reaching fruiting by the time leaves develop fully. *H. interjecta* differs from *H. multiceps* and *H. costata* in having glabrous leaves. In *H. multiceps*, leaves are scabrous while in *H. costata*, veins, margins and midrib on lower surface are ciliated with long soft hairs, noticeable to the naked eye. Glabrous leaves in *H. interjecta* are similar to those in *H. colchicifolia* but cannot be confused with *H. colchicifolia* as the latter is a robust plant with large, ribbed leaves and racemose inflorescences. A few specimens of *H. interjecta* (*Behr 607* in NBG, *West 387* in PRE), *Thode 161* (in PRU) were found to have stellate hairs sparsely distributed on margins and midrib on the lower surface of young leaves and may be confused with *H. obliqua*. However, in *H. interjecta*, hairs are scattered, ascending, falling off with age while in *H. obliqua*, margins and midrib on the lower surface are ciliate, with stellate, appressed hairs that persist.

Distribution and ecology: *H. interjecta* is a South African endemic with an inland distribution. It occurs in KwaZulu-Natal, Mpumalanga and Gauteng; most collections being from around Pretoria, (Gauteng) [Figure 12.34N]. The species occurs on hill and mountain slopes, in full sun and at high altitudes, between 1400 and 1800 m above sea level. As the species does not continue to produce inflorescences sequentially into the growing season, they are possibly overlooked in the field, and this may explain the scant number of herbarium specimens. Like *H. multiceps* and *H. costata*, *H. interjecta* shows pronounced environmentally induced variation (phenotypic plasticity) in post-flowering. Leaves are two to four times longer, appearing different from the start of the growing season. Elongation of leaves is possibly due to ecological change from full sun to partial shade created by tall grass. Although not recorded for the species from the few number of specimens collected, bases of leaves possibly narrow to form petioles as in the allied species, *H. multiceps* and *H. costata*.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named from the Latin *interjectus* (placed in between, intermediate between) presumably in reference to it being intermediate between the tall near-glabrous *H. colchicifolia* and the stout scabrous species like *H. multiceps* with very hairy inflorescences.

Vouchers: *Behr 607* (NBG); *Codd 2215* (PRE); *Reddy, Reddy & Reddy 520* (J, NH); *Singh 613* (NH); *Venter & Vorster* 5 (PRE).

11. **Hypoxis costata** *Baker*, Journal of the Linnean Society, Botany 17: 119 (1878b); Baker in Thiselton-Dyer: 188 (1896); Burtt: 202 (1986); Retief & Herman: 69 (1997). Type: South Africa, Free State, Nelson's Kop, *Cooper 879* (K, holo!).

Stout, tough, sparsely hairy herb, 100–150 mm high when in flower, growing singly or in tufts. *Rhizome* oblong to subglobose, 10–40 mm in diameter or 1.5 times longer than wide, with many contractile roots arising above middle, crowned by leaves and a mass of fibrous bristles formed from remains of old leaves; yellow or orange inside. *Leaves* few, 4–6(–8), bases overlapping in a rosette, erect or semi-erect, oblong-lanceolate, 100–200 x 30–50 mm, elongating in post flowering, flat, tapering rapidly to a subacute apex, stiff, strongly ribbed; veins 30–50, close to each other, uniformly thickened (one or two veins near each margin more strongly thickened) and raised on upper surface (ribbed), ciliate; hairs mainly along veins, margins and midrib on lower surface, bifurcate with a few stellate intermingled, long, weak, white or yellow; arms varying in length, shorter arms 1–1.5 mm long, longer arms 2.3–2.7 mm long. *Inflorescence* 1–5 per plant, corymbose, more noticeable when flowers more than 2, covered in long, soft (villous), white or yellow stellate hairs; scapes overtopping emerging leaves, 80–200 mm x 2–3 mm, flattened in cross section (ancipitous). *Flowers* mostly 2, occasionally 3–5 in 2 tiers, upper tier with 2 or 3 flowers; pedicels 4–12 mm long, villous. *Bract* subulate, 13–20 mm long, hairy below. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, pale green and hairy abaxially, 12–17 x 3–4 mm; inner tepals ovate-elliptic, 11–16 x 4–5 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2.5–3 mm long; anthers 4–6 mm long, sagittate, apex entire. *Ovary* 4–5 mm, style 0.5–2 mm long; stigma subsessile, pyramidal with 3 concave faces, 2–4 mm long. *Capsule* turbinate or subglobose, 5–6 mm in diameter, opening by a circular slit. *Seeds* large, ovoid, 2–3 x 1.5–1.8 mm, black, glossy; testa smooth. *Flowering time*: September–December. Figure 12.7.

Diagnostic characters and relationships: *H. costata* is recognised by its stiff, broadly oblong-lanceolate leaves, ribbed and ciliate along margins and midrib on lower surface. The species resembles *H. multiceps* in its habit and leaf characters at the start of the growing season, but *H. costata* differs in having strongly ribbed leaves with ciliate margins and midrib on lower surface. *H. multiceps* has a scabrous texture from the dense short hairs. The size and shape of leaves in the species are variable; one extreme of the range includes plants with broad stout oblong-lanceolate leaves, while the other extreme includes plants with long, narrow leaves. The form with long, narrow leaves is associated with tall grass that creates a shaded environment later in the season. As in most members of *Hypoxis*, density of leaf hairs was found to be variable in the species; blades being densely hairy when young and on maturing, blades appear near-glabrous or sparsely hairy.

Distribution and ecology: *H. costata* occurs in South Africa, Swaziland and Lesotho. In South Africa, it occurs in Eastern Cape, KwaZulu-Natal, Free State, Gauteng, Mpumalanga and Limpopo, with an inland distribution (Figure 12.34G). The species grows on grassy hill tops and mountain slopes, in patches where the grass is scant, in well-drained sandy or loam soil. *H. costata* occurs at high altitudes of 1300 to 2500 m above sea level. It prefers full sun and when shaded by tall grasses, plants show environmentally induced variation (phenotypic plasticity) as noted in *H. interjecta* and *H. multiceps*. Leaves are two to three times larger in the post-flowering period which coincides with the grass becoming taller. Further, in plants overshadowed by grass, as leaves age they narrow at base to form false petioles. Elongation and widening of leaves, and petiole formation are possibly due to ecological change from full sun to partial shade created by tall grass.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named from the Latin *costatus* meaning ribbed, in reference to the strongly veined leaves in the species.

Common names: Kharatsa (Sesotho).

Vouchers: *Abbott 5453* (NH); *Flanagan 1836* (PRE); *Gibbs Russell 3456* (GRA); *Onderstall 1287* (PRE); *Singh 300, 309* (NH).

12. **Hypoxis multiceps** *Buchinger ex Krauss*, Flora 28: 311 (1845); Baker: 118 (1878b); Baker in Thiselton-Dyer: 187 (1896); Nel: 319 (1914); Compton: 130 (1976). Type: South Africa, KwaZulu-Natal, Pietermaritzburg, *Krauss 248* (K, holo!, BM!).

Stout, tough, scabrous herb, 100–200 mm high, growing singly or in tufts forming large clumps. *Rhizome* oblong to subglobose, 30–50 mm x 15–35 mm, with few contractile roots arising above middle, crowned by leaves and a mass of fibrous bristles from remains of old leaves, occasionally proliferating by means of short stolons giving rise to new rhizomes, yellow or orange inside. *Leaves* few, 4–6(–8), bases overlapping in a rosette, erect or semi-erect, oblong-lanceolate, (30–)80–120 x 12–45(–60) mm, elongating to 250–300 mm in post-flowering, sometimes forming false petioles of 40–200 mm length, flat, tapering rapidly to subacute apex, twisting obliquely with age; veins 25–40, slender, of uniform thickness, flush with surface, two to four near each margin slightly raised, scabrous; hairs stellate (4 or 5 arms), yellow or brown; arms needle-shaped, short, of equal length, 0.5–1 mm long, patent (hirsute). *Inflorescence* 2–6 per plant, appearing before or with emergence of leaves, corymbose, more noticeable when flowers more than 2, densely covered with coarse, short, yellow hairs (hispid); scapes usually overtopping emerging leaves, (20–)40–60(–120) x 1–2.5 mm, flattened in cross section (ancipitous), covered in long, stiff, ascending hairs apically. *Flowers* 2, opposite, occasionally 3–5 in 2 tiers; pedicels short, 4–15 x 1 mm, with long, stiff, ascending hairs. *Bract* subulate, 4–10 mm long, densely hairy below. *Tepals* 3+3, yellow adaxially; outer tepals broadly elliptic, 11–15 x 5–7 mm, pale green and densely hairy below; inner tepals ovate-elliptic, 10–14 x 6–8 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2.5–3 mm long; anthers 4–6 mm long, sagittate, apex entire. *Ovary* 3–4 mm, style 0.5–1 mm long, stigma subsessile, pyramidal with 3 concave faces, 2–3 mm long. *Capsule* turbinate, 5–8 x 4–6 mm, opening by a circular slit. *Seeds* few, 3–5, large, ovoid, 2–2.5 x 1.5–1.8 mm, black, glossy; testa smooth. *Flowering time*: August–November. Figure 12.19.

Diagnostic characters and relationships: *H. multiceps* is distinct in having broadly oblong-lanceolate, scabrous leaves. The species is closely related to *H. costata* in its habit and leaves but in *H. costata* leaves are strongly ribbed and ciliate (not scabrous). *H. multiceps* and *H. interjecta* are initially hysteranthous and the inflorescences of these species can be confused with each other in the absence of leaves. In *H. multiceps*, inflorescences are distinctly scabrous, but the species are best separated on leaf characters, being glabrous in *H. interjecta*.

Distribution and ecology: *H. multiceps* is widespread in South Africa, Swaziland and Lesotho. In South Africa, the species occurs in Eastern Cape, KwaZulu-Natal, Free State, Gauteng, Mpumalanga and Limpopo (Figure 12.34S). Like *H. costata*, it has an inland distribution, growing on grassy hills and mountain slopes, in sandy, well-drained soil. The species occurs from close to sea level to high altitudes, between 20 and 2100 m. In slightly moist depressions, *H. multiceps* proliferates by short stolons giving rise to daughter rhizomes and forming large tufts. The species prefers full sun and when shaded by tall grasses, plants show environmentally induced variation (phenotypic plasticity) as in *H. interjecta* and *H. multiceps*. Leaves appear longer and broader and tend to narrow at the base to form pseudopetioles, suggesting modifications due to ecological change from full sun to partial shade created by tall grass.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: derived from the Latin *multi* (many) and from the Greek *cephalus* (headed) in reference to many shoots from a single crown either in allusion to the habit of the plant or to the stellate hairs on the leaves.

Common names: Winter star-flower, moli-kharatsa, moli-motsane, morethetho (Sesotho), inkomfe (Zulu).

Uses: In Lesotho, a mixture of *H. multiceps* and *Ipomoea oblongata* is prepared and smeared on pegs that are placed around a kraal for protection against lightning (Watt & Breyer-Brandwijk 1962).

Vouchers: *Bester 1594* (NH); *Flanagan 1173* (NBG); *Galpin 1603* (PRE); *Singh 642* (NH); *Thode 2539* (NH).

13. **Hypoxis sobolifera** *Jacq*. Collectaneorum supplementum: 53 (1796), with illustrations in Icones plantarum rariorum: t. 372 (1788); Ker Gawler: t. 711 (1804); Schultes & Schultes: 764 (1830); Fischer & Meyer: 51 (1846); Nel: 309 (1914). Type: t. 372, icono! Epitype: *Thunberg*, cultivated in Hort. Kew.

Soft hairy herb, 100–200(–250) mm high, growing singly or in tufts forming large clumps. *Rhizome* subglobose or turbinate, 40–60(–100) × 20–50 mm, with few stout contractile roots, crowned by leaves and a mass of fibrous bristles from remains of old leaves, proliferating by means of short stolons, giving rise to new rhizomes, white or light yellow inside. *Leaves* usually many, (4–)8–12, arranged one above the other in three ranks, lanceolate-linear, 100–300 × 10–25 mm, sickle-shaped (falcate), folded together along the length (conduplicate), twisting towards apex; veins ± 20, slender, flush with surface, two to four near each margin thickened, raised on upper surface; sparse to densely hairy mainly on lower surface; hairs bifurcate or stellate (6–10 arms); arms radiating, ascending, usually in distinct tufts (floccose), except when very dense then appearing appressed in dried pressed specimens, of varying lengths, short arms 0.5–0.6 mm, medium arms 1.0–1.5 mm and long arms 1.7–2.5 mm long, white, turning light to red-brown (rufous) in young leaves on drying, grey-white in old leaves on drying, falling off in leaves of previous season, resulting in blade becoming glabrous with age. *Inflorescence* 2–6 per plant, appearing with leaves and produced sequentially, corymbose, more noticeable when more than 2-flowered, densely hairy in upper part; hairs white, turning red-brown on drying; scapes as tall as or shorter than leaves, 80–300 × 1–2 mm, flattened in cross section (ancipitous). *Bract* subulate, 10–25 mm long, hairy below. *Flowers* 2–7, basal two opposite, 1 or 2 upper tiers with 2 or 3 flowers each; pedicels unequal in length, 20–70 × 1.0–1.5 mm, hairy, lowermost 2–6 times longer than uppermost, bringing flowers to about the same height. *Tepals* 3+3, yellow adaxially; outer tepals elliptic, 8–15 × 3.0–6.5 mm, pale green and densely hairy abaxially; inner tepals ovate-elliptic, 8–14 × 3.5–7.5 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 3–4 mm long; anthers 2–5 mm long, sagittate, apex clearly split. *Ovary* 2–4 mm long; style 1.5–2.5 mm long; stigma 2–3 mm long, pyramidal with 3 concave faces. *Capsule* oblong or turbinate, 6–12 × 4–5 mm, opening by a circular slit then splitting longitudinally into 3 lobes. *Seeds* ovoid or subglobose, 1.3–1.5 × 1.0–1.2 mm, black, glossy; testa papillate with brown micropapillae. *Flowering time*: August–March.

13a. var. **sobolifera**

H. canescens Fisch.: 50 (1845). Type: *Thunberg*, without further details.

H. krebsii Fisch.: 72 (1846). Type: South Africa, Cape of Good Hope, *Krebs*, cultivated.

H. villosa L.f. var. *canescens* (Fisch.) Baker: 114 (1878b); Baker in Thiselton-Dyer: 184 (1896). Syntypes: *Thunberg*, without further details; South Africa, Eastern Cape, *Burchell 3380-2, 3542* (K!); South Africa, Eastern Cape, Somerset East, *MacOwan 1899* (NBG!).

H. villosa L.f. var. *sobolifera* (Jacq.) Baker: 114 (1878b). Type: *Thunberg*, cultivated in Hort. Kew.

H. sobolifera Jacq. var. *accedens* Nel: 310 (1914). Syntypes: South Africa, Cape, Lions Creek, *Schlechter 12215* (B!); South Africa, Eastern Cape, Kentani District, without closer locality, *Pegler 108* (K!, BOL!, PRE!); *Burchell 6401* (K, image!).

Diagnostic characters and relationships: *H. sobolifera* is recognised by its grey-white leaves arranged in three-ranks, corymbose inflorescences and tufted ascending hairs, usually light brown in colour. It is most closely related to *H. villosa* which also has leaves in three ranks and corymbose inflorescences, but differs from *H. villosa* in the distribution and type of hairs. In *H. villosa*, hairs are dense on the lower surface, forming a thin, white layer and unlike *H. sobolifera*, they are appressed, with arms arranged in rows parallel to the length of leaf. The tufted, stellate hairs of *H. sobolifera* are similar to those in *H. floccosa*, but the latter species is distinctly smaller, less than 100 mm tall and has tiny flowers in comparison to *H. sobolifera*. Figure 12.29.

Distribution and ecology: *H. sobolifera* is a South African endemic with a coastal and inland distribution. *H. sobolifera* var. *sobolifera* occurs in the Western Cape, Eastern Cape and KwaZulu-Natal from Stellenbosch in the south to Zululand in the north. It has a mainly coastal distribution but a few populations are noted from the foothills of the Drakensberg in KwaZulu-Natal (Figure 12.34AC). *H. sobolifera* var. *sobolifera* shows pronounced environmentally induced variation (phenotypic plasticity). Leaves of plants growing in the shade of trees or among tall grass are two to three times longer and broader than those growing in open grassland. The leaves of the larger plants are more sparsely hairy than those of smaller plants, implying that hair density is reduced by enlargement of leaf surface which may be due to ecological change from full sun to partial shade. In the Eastern Cape, var. *sobolifera* occurs among short, dense coastal scrub. Along the beach in West Bank, East London, the variety forms mats in between rocks where it is sheltered from the salt spray.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: derived from the Latin *sobolifera* which means with an underground creeping stem in reference to dividing rhizomes.

Common names: Creeping hypoxis.

Vouchers**:** *Chering s.n.* PRE38062 (PRE); *Hall 206* (NBG); *MacOwan 1899* (GRA, NBG); *Singh 578, 622* (NH); *Starke 100/27* (BOL).

13b. **var**. **pannosa** (*Baker*) *Nel*, Botanische Jahrbücher 51: 309 (1914). Type: South Africa, Cape, without precise locality, from the Royal Horticultural Society, cultivated at Kew and flowered in 1874. Specimen prepared in 1875 (K!).

H. pannosa Baker: 130 (1874). Type: South Africa, Cape, without precise locality, from the Royal Horticultural Society, cultivated at Kew and flowered in 1874. Specimen prepared in 1875 (K!).

H. villosa L.f. var. *pannosa* (Baker) Baker: 114 (1878b); Baker in Thiselton-Dyer: 184 (1896). Type: South Africa, Cape, without precise locality, from the Royal Horticultural Society, cultivated at Kew and flowered in 1874. Specimen prepared in 1875 (K!).

Diagnostic characters: Variety *pannosa* differs from var. *sobolifera* in having felt-like leaves and predominantly red-brown hairs. Figure 12.28.

Distribution and ecology: *H. sobolifera* var. *pannosa* occurs in the Eastern Cape and possibly KwaZulu-Natal. It extends along the Eastern Cape coast, from Humansdorp in the south to Kentani in the North (Figure 12.34AB). Only a single collection, *Wood 3434* (in K, NH), collected in 1886 is known from the slopes of the Drakensberg Mountains in KwaZulu-Natal, without precise locality and is therefore not reflected on the map. To date, no other specimens of the variety have been collected so far inland.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: derived from Latin *pannosus* meaning felt-like in reference to the hair covering on leaves.

Vouchers**:** *Cloete & Calvo-Ugarteburu 3889* (NH); *MacOwan 1899* (NBG); *Theron 1692* (PRE); *Scharf 1074* (PRE); *Singh 828* (NH).

14. **Hypoxis villosa** *L.f.*, Supplementum Plantarum: 198 (1781); Thunberg: 60 (1794), Schultes & Schultes: 765 (1830); Baker: 113 (1878b); Baker: 113 (1978) Baker in Thiselton-Dyer: 184 (1896); Baker in Thiselton-Dyer: 379 (1898). Type: South Africa, Cape, without closer locality, *Thunberg* (UPS image no. 8267, 8268!).

H. microsperma Ave-Lall. in Fischer & C.A. Meyer: 50 (1845). Type: South Africa, Cape of Good Hope, without further information.

H. scabra Lodd. t. 970 (1824). Type: South Africa, Cape of Good Hope, *Bowie*, cultivated from specimens received in 1823.

H. tomentosa Lam.: 182 (1789). Cap de Bonne-Esperance, without further details.

H. villosa L.f. var. *fimbriata* Nel: 310 (1914). Type: Eastern Cape, Riversdale, *Schlechter 1788* (BOL!, Z!).

H. villosa L.f. var. *scabra* (Lodd.) Baker: 114 (1878b); Baker: 184 (1896). Type: South Africa, Mossel Bay, *Burchell 6307* (K).

Small, soft, silky-white herb, 60–150 mm high, growing singly. *Rhizome* oblong to globose, 30–55 x 20–40 mm, with a few contractile roots, arising above middle, crowned by leaves and a mass of bristles from remains of old leaves, white inside. *Leaves* few, 4–7, tightly arranged one above the other in three ranks, moderately firm in texture, lanceolate, sometimes linear-lanceolate, 150–175(–200) x (6–)10–20 mm, sickle-shape (falcate), recurving, folded together along the length (conduplicate) towards base, obliquely twisting towards apex; veins 18–20, flush with the surface, one to two near each margin slightly thickened and raised on upper surface, sparse to densely on margins; hairs forming thin layer on lower surface, soft, silky-white, stellate (4–6 arms); arms unequal in length, shorter arms 0.7–1 mm long, longer arms 2–2.5 mm long, usually stacked one above the other in two rows opposite each other and parallel along the length of the leaf, appressed, occasionally ascending, then shaggy. *Inflorescence* 3–6 per plant, appearing with leaves and produced sequentially, corymbose, covered in long, soft brown (on drying) hairs in upper part; scapes slender, 70–120 x 1.5–2 mm, flattened in cross section (ancipitous). *Flowers* 2–6(–10), basal two opposite, 1 or 2 upper tiers with 2 or 3 flowers each; *pedicels* unequal in length bringing flowers to about the same height, 12–25 x 0.75–1 mm. *Bract* subulate, 6–20 mm long, hairy below. *Tepals* 3+3, yellow adaxially; outer tepals elliptic, 8–10(–13) x 3–4 mm, pale green and densely hairy abaxially; inner tepals ovate-elliptic, 8–12(–14) x 4–5 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2–3.5 mm long; anthers 2.5–4 mm long, sagittate, apex split. *Ovary* 2–3 mm long; style 1.5–3 mm long; stigma pyramidal with 3 concave faces, 1.5–2 mm long. *Capsule* turbinate, 5–8 x 3–4 mm, opening by a circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid, 1.2–1.5 x 1–1.2 mm, black, dull; testa papillate. *Flowering time*: October–April. Figure 12.32.

Diagnostic characters and relationships: *H. villosa* is recognised by its leaves arranged in three ranks, corymbose inflorescences and hairs forming a silky-white layer on lower surface of leaves. The species is most similar to *H. sobolifera* in its leaf arrangement and inflorescences. It differs from *H. sobolifera* in hairs with arms in rows lying parallel to the length of the leaf, appressed and remaining white on drying. In *H. sobolifera*, hairs are in distinct tufts, ascending, drying light- or red-brown. *H. villosa* can also be confused with *H. argentea* which has similar leaf hairs but the species can be separated on their leaf shape and width; being linear and less than 6 mm wide in *H. argentea*, and lanceolate and more than 6 mm wide in *H. villosa*.

Distribution and ecology: *H. villosa* is a South African endemic, restricted to the Western Cape and Eastern Cape from Swellendam in the south to Mkambati in the north (Figure 12.34AF). It has a coastal distribution and occurs at low altitudes of 5–250 m above sea level. The species grows in open grasslands in the east and fynbos in the west, in well-drained soil and full sun. It is known from very few specimens.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named from the Latin *villosus* meaning shaggy with long, soft ascending hairs probably referring to those covering inflorescences in the species.

Common names: Golden winter star, sterretjie; inkbol (rhizomes were used by colonists as a source of ink, hence the vernacular name).

Uses: Watt & Breyer-Brandwijk (1962) recorded that the rhizomes of *H. villosa* were used by the Sotho as a charm against thunder.

Notes: *H. villosa* has been confused with *H. sobolifera* (Baker 1878b) and *H. obtusa* (Zimudzi 1996; Nordal 1997).

Vouchers: *Muir 1326* (PRE); *Thode A2766* (NH); *Ecklon & Zeyher 270* (NBG); *Zeyher 4138* (BOL, K).

15. **Hypoxis obliqua** *Jacq*., Collectaneorum Supplementum: 54 (1796), with illustrations in Icones Plantarum Rariorum Ic. t. 371 (1786–1793); Schultes & Schultes: 766 (1830); Nel: 309 (1914). Type: t. 317, icono! Epitype: South Africa, Somerset East, *MacOwan 1594a* (K!, NBG!).

H. villosa var. *obliqua* (Jacq.) Baker: 114 (1878b). Type: South Africa, Somerset East, *MacOwan 1594a* (K!).

Stout, tough, near-glabrous herb, 50–120 mm high, growing singly. *Rhizome* small, oblong, 40–50 x 25–40 mm, with a few stout contractile roots, crowned by leaves and a dense mass of bristles from remains of old leaves. *Leaves* few, 5–8, lanceolate, 80–150 x (6–)10–25 mm, erect, twisting obliquely towards apex; veins 9–10, slender, flush with surface, one to two near each margin thickened and raised on upper surface, near-glabrous, margins and midrib on lower surface fringed with hairs (ciliate) forming white band; hairs stellate (4–8 arms), white; arms needle-shaped, appressed, one to two more strongly developed, short arms 0.5–1.2 mm long, longer arms 3–3.5 mm long, breaking off with age. *Inflorescence* 3–6 per plant, appearing with emergence of leaves, overtopping leaves, racemose, more noticeable when flowers more than 2, covered with coarse, rigid (hispid) white hairs in upper part; scape stiff, 80–150 x 1–2 mm, flattened in cross section (ancipitous). *Flowers* 2–7, close to each other; pedicels short, stiff, 8–18(–35) x 0.7–1 mm, covered with coarse hairs (hispid). *Bract* subulate, 4–10 mm long, hairy below. *Tepals* yellow adaxially; outer tepals elliptic, 9–10(–12) x 2–3 mm, pale green and densely hairy abaxially; inner tepals ovate-elliptic, 8–10 x 2–4 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 1–2 mm long; anthers ± 3 mm long, sagittate, apex slightly split. *Ovary* 6–7 mm; style 1–2 mm long, stigma pyramidal with 3 concave faces, 3 mm long. *Capsule* oblong or turbinate, 7–10 x 4–6 mm, opening by a circular slit. *Seeds* ovoid to subglobose, 1.5–1.8 x 1.1–1.5 mm, black, dull; testa papillate. *Flowering time*: September–December. Figure 12.21.

Diagnostic characters and relationships: *H. obliqua* is a distinct species, recognised by its stiff leaves, twisting towards apex, ciliate margins and coarsely hairy inflorescences. The species is most similar to *H. interjecta* in having broadly lanceolate glabrous leaves and coarsely hairy inflorescences but differs from *H. interjecta* in its leaf margins and midrib on lower surface outlined in white by dense short hairs, racemose inflorescences and small flowers (tepals less than 12 mm). In *H. interjecta*, leaves are completely glabrous, inflorescences corymbose and flowers large with tepals more than 12 mm long.

Distribution and ecology: *H. obliqua* occurs in South Africa and Lesotho. In South Africa, it occurs in the Eastern Cape and KwaZulu-Natal with a coastal to inland distribution. It extends from Port Elizabeth in the south to Zululand in the north (Figure 12.34U). *H. obliqua* grows in open rocky grasslands, in well-drained soil and full sun. The species is found from altitudes of 500 to 1800 m above sea level.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: Named from the Latin *obliquus* referring to oblique twist of leaves towards the apex.

Common names: Oblique-leaved hypoxis, ixalanxa (Xhosa).

Uses: Water boiled in hollowed out rhizomes of *H. obliqua* was used to dress septic wounds (Wright 1963). *H. obliqua* is an excellent species to propagate, as it produces up to seven small flowers which provide a bright display, and like most members of *Hypoxis*, it is hardy, requiring little care in the summer rainfall region of southern Africa.

Vouchers: *Bester 1343* (PRU); *Goossens 190*, 193 (PRE); *Hilliard & Burtt 19051* (NU); *MacOwan 1594a* (NBG); *Singh 512* (NH).

16. **Hypoxis zeyheri** *Baker*, Journal of the Linnean Society, Botany 17: 112 (1878b); Baker: 181 (1896). Type: South Africa, Cape Colony, *Ecklon & Zeyher 7* (TCD, holo, image!, P!).

Small, glabrous herb, 50–100 mm high, growing singly. *Rhizome* small, oblong, 20–40 x 10–20 mm, with a few stout contractile roots, crowned by leaves and a mass of fibrous bristles from remains of old leaves. *Leaves* few, 5–8, stacked loosely one above the other in three ranks, erect or recurving, lanceolate or linear-lanceolate, 80–120 x 5–25 mm, sickle-shaped (falcate), folded together along the length (conduplicate) towards the base, tapering to a narrow point (acuminate); veins 10–20, slender, flush with surface, one to three near each margin thickened and raised on upper surface, near-glabrous; hairs indistinct, ± evenly spaced along margins and midrib on lower surface, predominantly stellate (4 or 5 arms) with few bifurcate, white or lightly brown, one or more arms more strongly developed, shorter arms 0.5–0.8 mm long, longer arm 1–1.5 mm long, loosely ascending, caducous. *Inflorescence* 2–7 per plant, appearing with leaves and produced sequentially in growing season, corymbose, covered with sparse long, soft, white (brown on drying) hairs; scape slender, 80–120 x 0.5–1.0 mm, flattened in cross section (ancipitous), hairy in upper part. *Flowers* 2–5, lower tier with 2 flowers, opposite, upper tier with 1–3 flowers; pedicels slender, 15–50 x 0.5–0.75 mm. *Bract* subulate, 7–15 mm long, hairy below. *Tepals* yellow adaxially; outer tepals elliptic, 6–10 x 3–4 mm, pale green and sparsely hairy adaxially; inner tepals ovate-elliptic, 5–10 x 4–5 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 1.2–2 mm long; anthers 1.8–2.5 mm long, sagittate, apex entire or split. *Ovary* 3–4 mm long; style 0.5–0.6 mm long; stigma pyramidal with 3 concave faces, 1.6–2 mm long. *Capsule* turbinate-oblong, 4–8 x 3–4 mm, opening by a circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid, 1.1–1.5 x 0.6–0.8 mm black, glossy or dull; testa papillate. *Flowering time*: October–April. Figure 12.33.

Diagnostic characters and relationships: *H. zeyheri* is distinct in having glabrous, lanceolate, leaves and corymbose inflorescences with slender, flexible pedicels. The species is most closely related to *H. angustifolia* var. *buchananii* in its leaves and inflorescences but differs in distribution and type of leaf hairs. In *H. angustifolia* var. *buchananii*, leaves are sparsely hairy throughout (pilose) and hairs mostly bifurcate while in *H. zeyheri*, hairs are restricted to leaf margins and midrib on lower surface, and are stellate, breaking off with age. *H. zeyheri* may also be confused with *H. obliqua* in having smooth, glabrous leaf blades. However, in *H. obliqua*, leaf margins and midrib on lower surface are fringed with short hairs and inflorescences are racemose with short, stiff pedicels which is distinctive in the species in comparison to the corymbose inflorescences with long, flexible pedicels in *H. zeyheri*.

Distribution and ecology: *H. zeyheri* is a South African endemic, occurring in the Eastern Cape, from Grahamstown in the south to Maclear in the north (Figure 12.34AG). It has a coastal and inland distribution. The species grows in well-drained or marshy soil and at altitudes of 15 to 1400 m. It appears to be rare.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named in honour of Carl Zeyher (1799–1858), botanical collector who travelled widely collecting specimens in South Africa.

Common names: Small yellow star, sterretjies.

Vouchers: *Ecklon 4134* (BOL); *Gibbs Russell 3420* (PRE); *MacOwan 1898* (NBG); *Germishuizen 1185* (PRE); *Singh 526* (NH).

17. **Hypoxis gerrardii** *Baker*, Journal of the Linnean Society, Botany 17: 110 (1878b); Baker: 181 (1896); Nel: 306 (1914); Burtt: 188 (1988). Type: South Africa, KwaZulu-Natal, Zululand, *Gerrard & McKen 1827* (NH, holo!, BM!, K!, P!).

H. junodii Baker: 859 (1901) as *junoidi*. Type: South Africa, Pinetown, *Junod 157* (Z!).

Slender, hairy, dark green herb, 80–200 mm high, growing singly. *Rhizome* deep seated, small, oblong, 10–25 x 8–15 mm, with a few contractile roots, crowned by leaves and a mass of fine bristles, white inside. *Leaves* few, 6–7(–10), loosely arranged in three ranks, sometimes clasping in short, slender false stem when leaves elongate, linear (40–)80–150(–300) x 3–8(–11) mm, rigid in texture, flat or subterete; veins 6–8, one or two near each margin strongly thickened and raised on upper surface, straw-coloured, sparse or densely covered in long, weak hairs, compact on margins; hairs bifurcate, white or brown; arms needle-shaped of unequal length, shorter arms 0.5–0.6 mm long, longer arm 0.8–1 mm long, ascending in the shape of V or U, appressed on margins, lying parallel along the length of the leaf in the direction of apices, occasionally ascending, then appearing shaggy. *Inflorescence* 2–5 per plant, appearing with leaves and produced sequentially throughout growing season, corymbose, densely covered in long, weak, needle-shaped, white or brown hairs in upper part, often furry brown; scape slender, 8–20 x 1–1.5 mm, flattened in cross section (ancipitous). *Flowers* 2–5(–7); pedicels slender, (12–)20–30 mm long, hairy. *Bract* subulate, 4–12 mm long, hairy below. *Tepals* yellow adaxially; outer tepals narrowly elliptic, 7–9 x 3–4 mm, pale green and densely hairy adaxially; inner tepal elliptic, 7–8 x 2.5–3.5 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 1–2 mm long; anthers ± 3 mm long, sagittate, apex split. *Ovary* 4 mm long; style 1–2 mm long, stigma pyramidal with 3 concave faces, 3 mm long. *Capsule* turbinate, 3–8 x 2–4 mm, opening by a circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid to globose, 1 x 0.8–1 mm, black, dull, testa papillate with brown micropapillae. *Flowering time***:** September–March. Figure 12.12.

Diagnostic characters and relationships: *H. gerrardii* is recognised by its slender habit, narrow, rigid leaves with an even distribution of bifurcate hairs and corymbose, brown usually furry inflorescences. The species is most closely related to *H. argentea* in habit, leaves and inflorescences and is often confused with *H. argentea* var. *sericea* in having bifurcate hairs. However, in *H. gerrardii*, hairs are short, stiff, needle-shaped, ascending to form a V or U. *H. argentea* var. *sericea* differs in having long, weak hairs, with arms mostly appressed, lying opposite each other, more noticeable on the margins and midrib below. Like in most *Hypoxis* species, variation in leaf dimensions was noted in *H. gerrardii*. Tall, slender habit and linear leaves are typical in the species, but in some populations (*Singh & Baijnath 271* in NH; *Wood 74* in J, NU), shorter plants, with linear-lanceolate leaves were recorded and the variation may relate to start of the growing season. These plants display hair and inflorescence characters typical of the species.

Distribution and ecology: *H. gerrardii* occurs in South Africa, Lesotho and Swaziland. In South Africa, it has been recorded in the Eastern Cape and KwaZulu-Natal, with a concentration in the midlands and uplands of KwaZulu-Natal (Figure 12.34L). The species grows in open grasslands, usually on rocky slopes, in full sun and at altitudes of 500 to 2300 m. It grows sympatrically with *H. argentea*, *H. costata*, *H. filiformis* and *H. galpinii* and *H. multiceps*.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named in honour of William Gerrard (?–ca.1866), naturalist and traveller, collected along the coast and inland in KwaZulu-Natal.

Common names: Small yellow star, inkomfe (Zulu).

Uses: The Zulu prepares a decoction from the rhizomes to treat stomach aches like gripe and dysentery (Hulme 1954).

Notes: Nel (1914) reduced *H. junodii* under *H. dregei* Baker. *H. dregei* is synonymous with *H. argentea* var. *sericea*. This study confirms the observation by Burtt (1988) that *H. junodii* is conspecific with *H. gerrardii*.

Vouchers**:** *Bayliss 2547* (NBG); *Wood 74* (NH); *Gordon-Gray 107* (NU); *Rudatis 1748* (PRE); *Singh & Baijnath 419* (NH).

18. **Hypoxis argentea** *Harv. ex Baker*, Journal of the Linnean Society, Botany 17: 110 (1878b); Baker in Thiselton-Dyer: 181 (1896); Nel: 305 (1914). South Africa, Eastern Cape, Grahamstown, *MacOwan 50* (K, lecto., selected here, SAM, GRA, isolecto!).

Slender, silvery-white herb, 70–100 mm high, growing singly. *Rhizome* small, deep seated, oblong, two to three times as long as wide, 20–30 mm x 10–15 mm, with few contractile roots, crowned by leaves and a sparse to dense mass of fine bristles, white inside, *Leaves* few 4–7(–10), clasping at base to form a slender false stem wrapped in a membranous brown tunic, arranged loosely in three ranks, linear, (–35)50–200 x 3–6 mm, slightly broader and folded together along the length (conduplicate) towards base, erect or recurving; veins 8–10, flush with surface, one to two near each margin strongly thickened and raised on upper surface, straw-coloured, drying grey-white, sparse to densely hairy, mainly on lower surface and margins; hairs bifurcate or stellate (3–6 arms), long, soft, weak, silky, closely pressed (sericeous), white or yellow-brown; arms ± 1.5 mm long, appressed, usually stacked one above the other in two rows opposite each other and parallel along the length of the leaf, appressed, occasionally ascending, then appearing shaggy. *Inflorescence* 1–6 per plant, produced sequentially throughout growing season, corymbose, covered with soft, long, white hairs in upper part; scape slender, 30–200 x 1 mm, flattened in cross section (ancipitous). *Flowers* 1–5; pedicels slender, 10–30(–40) x 0.5 mm when flowers open. *Bract* subulate, 0.5–1.2 mm long, hairy below.

Tepals 3+3, yellow adaxially; outer tepals narrowly elliptic, 6–10 x 2–3 mm, green and hairy abaxially; inner tepals ovate-elliptic, 5–9 x 2.5–3 mm, yellow, green and sparsely hairy along midrib abaxially, sometimes midrib red striped. *Stamens* 3+3, with filaments subulate, 1–2 mm long; anthers 2–3 mm long, saggitate, apex split. *Ovary* 3–4 mm, long style 1–1.5 mm long; stigma pyramidal with 3 concave faces, 0.5–2.5 mm long. *Capsule* turbinate, 3–5 x 2.5–3 mm, opening by circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid, 1–1.2 x 0.8–1 mm, black, glossy, testa papillate.
Flowering time: August–March.

18a. var. **argentea**

Diagnostic characters and relationships: *H. argentea* can be recognised by its slender habit, narrow, silvery-white leaves and corymbose inflorescences. The species is similar to *H. gerrardii* in a number of characters but is separated on leaf hairs. See discussion under *H. gerrardii* on how to separate the species. *H. argentea* may also be confused with *H. filiformis* in their slender, subterete leaves but in *H. argentea*, hairs are long, weak and appressed lying parallel to leaf length, and inflorescences are corymbose with usually more than three flowers. In *H. filiformis*, leaf hairs are scattered along margins, ascending and inflorescences are racemose and mostly two-flowered. As in *H. sobolifera* and *H. rigidula*, two varieties are recognised in *H. argentea*, based on hair density. Variety *sericea* differs from the typical variety in being less hairy, especially on leaf margins and the lower surface while in var. *argentea*, hairs are compact on margins and lower surface. Figure 12.4.

Distribution and ecology: *H. argentea* var. *argentea* occurs in South Africa, Lesotho and Swaziland. It is found in the Western Cape, Eastern Cape, KwaZulu-Natal, Free State, Mpumalanga and Gauteng, with a coastal and inland distribution (Figure 12.34D). The species grows in open grasslands on well-drained hill slopes and full sun. It occurs at altitudes of 20 to 1000 m above sea level and is common across its range, growing sympatrically with most species of *Hypoxis*.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: named from the Latin *argenteus* meaning silvery, referring to the silvery shine caused by the soft shiny hairs on the leaves.

Common names: Small yellow star-flower, star of Bethlehem, leihlo-khomo le leholo, lesikitlane (Sesotho), ixalanxa (Xhosa), inongwe (Xhosa, Zulu), isinana (Zulu), kaffertulp (Afrikaans).

Uses: Noted as having a few uses among African people (Watt & Breyer-Brandwijk 1962). Rhizomes used by Xhosa as famine food and to make an oil to anoint chafes on horses. The Sotho prepare an ointment from the rhizome to treat cracks on teats of cows. It is also used in African medicine in Democratic Republic of Congo.

Vouchers: *Bayliss 2135* (NBG); *Brynard 297* (PRE); *Cloete 691* (KEI, NH); *Germishuizen 1460* (PRE); *Singh 490*, *650* (NH).

18b. var. **sericea** (*Baker*) *Baker* in Thiselton-Dyer, Flora Capensis 6: 182 (1896); Retief & Herman: 69 (1997); Singh: 361 (2007). Type: South Africa, Eastern Uitenhage, *Zeyher 950* (K, lecto., image!, BM!).

H. sericea Baker: 111 (1878b). Type: South Africa, Uitenhage, *Zeyher 950* (K! BM!, BOL!, NBG!).

H. sericea Baker var. *dregei* Baker: 112 (1878b), in part based on Drège *8525*; Singh: 361 (2007). Type: South Africa, Eastern Cape, Stockenstrom, *Drège 8525* (K, lecto!; BM, isolecto!).

H. sericea Baker var. *flaccida* Baker: 112 (1878b). Type: South Africa, Albany, South Africa, Free State, ‘Seven Fountains’, *Burke s.n.* (K!).

H. dinteri Nel: 302 (1914). Type: Namibia, Otavital, *Dinter 634* (B, holo!, NBG!).

Diagnostic characters and relationships: *H. argentea* var. *sericea* differs from var. *argentea* in having hairs scattered in channels between veins on leaves, unlike in var. *argentea* where the leaf hairs are closely pressed forming a layer on the lower surface. *H. argentea* var. *sericea* may also be confused with *H. gerrardii*, both having sparsely hairy leaves but in *H. gerrardii*, hairs are short, stiff, needle-shaped and ascending in a V- or U-shape while in *H. argentea* var. *sericea*, hairs are long, weak and appressed, more noticeable on the margins and midrib below. *H. argentea* also lacks the brown, furry inflorescences common in *H. gerrardii*. Figure 12.5.

Distribution and ecology: *H. argentea* var. *sericea* occurs in South Africa, Lesotho, Swaziland and is known from a single specimen in Namibia. It is found in all provinces of South Africa, except the Northern Cape (Figure 12.34E). It is likely that it extends into tropical Africa, in Tanzania (see notes for details). Like *H. argentea var. argentea*, the taxon grows in open grasslands, in well-drained soil and full sun, at altitudes 40 to 1000 m above sea level. It is often found growing with *H. argentea var. argentea* and a number of other species of *Hypoxis*.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: Named from the Latin *sericeus* meaning silky with long, straight closely pressed glossy hairs in reference to the leaves in the taxon.

A study of specimens from EA indicates that specimens *Guebson 947* collected in Nachingwea and *Robertson 374A* from the Nguru Mountains, both in Tanzania, are similar to *H. argentea* var. *sericea*. Wiland-Szymańska (2001), recorded for the first time that *H. dinteri* also occurs in the Democratic Republic of Congo and Zambia. Unfortunately, the specimens cited by Wiland-Szymańska from BR and MO were not examined and it was therefore not possible to confirm if these may be classified as *H. argentea* var. *sericea*.

Vouchers: *Tyson 1095* (GRA, NBG); *Acocks 12960* (NH); *Acocks 17902* (PRE); *Reid 130* (PRE); *Singh 570, 648* (NH).

19. **Hypoxis parvifolia** *Baker*, in Thiselton-Dyer, Flora Capensis 6: 183 (1896); Nel: 307 (1914), as "parviflora"; Compton: 131 (1976); Retief & Herman: 70 (1997). Type: South Africa, Mpumalanga, Barbeton, Saddleback Range, *Galpin 1059* (K, holo!; BOL!, NBG!, NH!).

Small soft, hairy herb, 50–60 mm high, growing singly. *Rhizome* small, oblong, 10–30 x 5–15 mm, with a few stout contractile roots, crowned by leaves and a few fine bristles from remains of old leaves. *Leaves* few, 4–8, bases wrapped in membranous, brown tunic, linear, sometimes linear-lanceolate, 40–100 x 5–6 mm, folded together along the length (conduplicate) towards the base, tapering to a narrow apex, yellow on drying; veins 4–6, flush with surface, one to two near each margin thickened and raised on upper surface, sparsely to densely hairy on both surfaces; hairs predominately bifurcate, stellate (4 or 5 arms) on margins, U-shaped, almost at 90^0 to surface (patent), needle-shaped, white; arms short, 0.3–0.5 mm long, one or two more strongly developed, ±0.7 mm long. *Inflorescence* 1(2) per plant, appearing before or with leaves, corymbose, covered in white or yellow long hairs; scape taller than leaves, 60–130 x 0.75–1.2 mm, flattened in cross section (ancipitous). *Flowers* 1 or 2(3); pedicels short, 5–15 x 1–1.5 mm. *Bract* subulate, 4–10 mm long, hairy below. *Tepals* 3+3, yellow adaxially, outer tepals narrowly elliptic, 8–10 x 3–5 mm, pale green and densely hairy abaxially; inner tepals ovate-elliptic, 9–10(–13) x 5–7 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2–3 mm long; anthers 3–4 mm long, sagittate, apex entire or slightly split. *Ovary* 2–3 mm long; style 1.5–2 mm long; stigma pyramidal with 3 concave faces, 0.5 mm long. *Capsule* turbinate, 3–5 x 2–3 mm, opening by a circular slit. *Seeds* globose, 1–1.5 mm in diameter, black, glossy; testa papillate. *Flowering time*: August-December (occasionally in March-May). Figure 12.23.

Diagnostic characters and relationships: *H. parvifolia* is distinct in having few, dwarf leaves with striking patent U-shaped hairs and usually single weak inflorescence with mostly two flowers. *H. parvifolia* is closely related to *H. kraussiana* in its hairs but is separated from *H. kraussiana* by its dwarf, flat leaves with indistinct veins. In *H. kraussiana*, leaves are tall, subterete and strongly ribbed. The species may also be confused with smaller plants of *H. costata* in its linear-lanceolate leaves, bifurcate hairs and two flowered inflorescences. It differs in lacking the strongly ribbed leaf characteristic of *H. costata*.

Distribution and ecology: *H. parvifolia* occurs in South Africa and Swaziland. In South Africa, the species occurs in Limpopo, Mpumalanga and Free State (Figure 12.34W). It extends into tropical Africa, where it occurs in Zimbabwe and Malawi. *H. parvifolia* associated with high mountain areas at altitudes of 1300 to 2500 m above sea level. The species grows in open grasslands, on slopes and rock crevices, in full sun and well-drained soil or muddy ground. The species may be more plentiful in southern Africa, but like *H. flanaganii* and *H. floccosa* is possibly overlooked in the field due to its small size.

Conservation status: Lower risk-Least Concern (LRlc).

Etymology: Named from the Latin *parvitas* (smallness) and *folia* (leaf) indicating a species with small leaves.

Vouchers: *Compton 26991* (NBG, PRE); *Compton 32165* (PRE); *Jacobs 2982* (PRE); *Kerfoot K8360* (J); *Moss 15426* (J).

20. **Hypoxis flanaganii** *Baker*, in Thiselton-Dyer in Flora Capensis 6: 179 (1896); Nel: 301 (1914). Type: South Africa, Eastern Cape, Komga, *Flanagan 314* (K, holo!, NBG!, PRE!).

Diminutive, sparsely hairy herb, 30–50 mm high, growing singly. *Rhizome* oblong to subglobose, 10–20 x 7–10 mm, with a few contractile roots; crowned by leaves, devoid of bristles, white inside. *Leaves* few, 4–7, bases wrapped in membranous, brown tunic, linear, 40–70 x 2–3 mm, erect or semi-erect, V-shaped, sometimes red at base; veins 8–10, flush with surface, one near each margin slightly thickened and raised on upper surface, sparsely hairy on both surface, mainly on margins and midrib on lower surface; hairs bifurcate intermingled with few stellate (3–8 arms) on margins, white or light brown, ascending; arms 0.5–1 mm long, one or two more strongly developed, up to 1.8 mm long. *Inflorescence* 1(–3) per plant, corymbose, hairy in upper part; scapes as tall as leaves, 10–25 mm long, subterete. *Flowers* 1 or 2; pedicels slender, 15–25 mm long. *Bracts* 2, even when flowers solitary indicating reduction in a flower, subulate, 4–8 mm long. *Tepals* 3+3, small, inner and outer narrowly elliptic, about equal in size, 4–6 x 1.5–2 mm, yellow adaxially; outer tepals pale green and hairy adaxially; inner tepals yellow, green and sparsely hairy along midrib abaxially, sometimes midrib red striped. *Stamens* 3+3, with filaments subulate, 1–2 mm long; anthers 1.2–1.5 mm long, sagittate, apex split. *Ovary* ± 2 mm long; style ± 2 mm long, stigma pyramidal with 3 concave faces, ± 1.4 mm long. *Capsule* oblong or subglobose, 2–3 x 2 mm, opening by a circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid to globose, 1–1.2 x 0.8–1 mm, black, glossy; testa papillate. *Flowering time*: September–December. Figure 12.9.

Diagnostic characters and relationships: *H. flanaganii* is the smallest member in *Hypoxis*. It has few short, very narrow sparsely hairy leaves and inflorescences usually solitary with one or two tiny flowers. In habit, *H. flanaganii* is close to *H. floccosa*, but differs in its leaves being less hairy with hairs bifurcate and white. In *H. floccosa* leaves and inflorescences are densely hairy with the hairs stellate and red-brown.

Distribution and ecology: *H. flanaganii* is endemic to South Africa, being restricted to the Western Cape, Eastern Cape and KwaZulu-Natal. It occurs along the coast from Bredasdorp in the Western Cape and just reaches KwaZulu-Natal, where it is known only from a single specimen, collected in the Umtamvuna Nature Reserve (*Nicholson 1693*, PRE) [Figure 12.34I]. Populations of *H. flanaganii* are found in rocky outcrops in fynbos, thicket and grasslands where the vegetation is sparse or low-growing. By growing among rocks, the tiny plants are offered protection from wind. The species grows at altitudes of 15–500 m. Plants are abundant at sites where they have been collected. However, there are very few collections of the species and it is therefore difficult to assess its full range of distribution and variation. Like *H. floccosa*, due to its small stature and tiny flowers, the species is easily overlooked during fieldwork.

Conservation status: Data Deficient (DD). Probably more abundant than reflected by in collections.

Etymology: named in honour of Henry Flanagan (1861–1919) who actively collected plants from Komga and Kei River Mouth in the Eastern Cape Province.

Vouchers**:** *Fourcade 895* (BOL, PRE); *Nicholson 1693* (PRE); *Schlechter 7731* (GRA, NH); *Schönberg 2795* (GRA, PRE); *Singh 807* (NH).

21. **Hypoxis floccosa** *Baker*, Kew Bulletin: 357 (1894); Baker in Thiselton-Dyer: 181 (1896); Nel: 303 (1914); Singh: 362 (2007). Type: South Africa, Western Cape, Swellendam, *Bolus 7469* (BOL, holo!; K!).

H. ecklonii Baker: 859 (1901) [as eckloni]; Nel: 307 (1914). Type: South Africa, Western Cape, Zwarteberg, *Ecklon & Zeyher 4136* (K, image! B!, Z!).

Diminutive, densely hairy herb, 50–70 mm high, growing singly. *Rhizome* oblong to subglobose, 20–25 x 10–15 mm in diameter, with a few contractile roots, crowned by leaves, devoid of bristles, white inside. *Leaves* few, 6–7, bases wrapped in membranous, brown tunic, linear, 50–100 x 2–4 mm, erect or semi-erect, subterete or flat; veins 8–10, slender, flush with surface, one near each margin slightly thickened and raised on upper surface, margins and lower surface covered densely in long, soft hairs (floccose); hairs stellate (4–8 arms) intermingled with few bifurcate, white turning red-brown on drying; arms of unequal length, short 0.5–1.2 mm long, one or two more strongly developed, 2–3 mm long. *Inflorescence* 2(–4) per plant, corymbose; scapes as tall as or shorter than leaves, 40–80 mm long. *Flowers* 2, sometimes 1; pedicels long, slender, 15–25 mm long. *Bract* subulate, 4–10 mm long, hairy below. *Tepals* 3+3, small, inner and outer narrowly elliptic, about equal in size, 6–7 x 2.5–3.0 mm yellow adaxially; outer tepals pale green and densely hairy abaxially, inner tepals yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 1.5–2.0 mm long; anthers 1.5–2 mm long, sagittate, apex split. *Ovary* 2–3 mm long; style 0.5–0.6 mm long, stigma pyramidal with 3 concave faces, 1.5–2 mm long. *Capsule* turbinate or subglobose, 2–4 x 1.5–2 mm, opening by a circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid to globose, 1–1.2 x ±1 mm, black, glossy; testa papillate. *Flowering time*: November–May. Figure 12.10.

Diagnostic characters and relationships: *H. floccosa* is recognised by its small stature, leaves covered in dense, soft, red-brown hairs, and weak scapes with slender pedicels bearing one or two tiny flowers. Leaf hairs in *H. floccosa* are predominantly stellate. In leaf and inflorescences characters, *H. floccosa* is closely related to *H. flanaganii*, but is separated from *H. flanaganii* by its stellate hairs, radiating loosely from the centre in a tuft and turning red-brown on drying, giving plants a dirty brown furry appearance. In *H. flanaganii*, hairs are predominantly bifurcate. The tufted red-brown hairs in *H. floccosa* is similar to those in *H. sobolifera* but the leaves in *H. floccosa* are small and linear while *H. sobolifera* has large, lanceolate leaves.

Distribution and ecology: *H. floccosa* is a South African endemic, restricted to the Western Cape and Eastern Cape from Swellendam to Stutterheim (Figure 12.34J). It grows in open areas in fynbos and grassland, in well-drained soil, full sun and at altitudes of 50 to 600 m above sea level. Known from very few collections, none from recent years.

Conservation status: Data Deficient (DD). Probably more abundant than reflected by collections.

Etymology: named from the Latin *floccosus* (with tufts of soft hairs) relating to the appearance of woolly hairs on leaves.

Common names: sterretjie (Afrikaans).

Vouchers**:** *Bolus 7469* (BOL); *Ecklon & Zeyher 4136* (BOL); *Lewis 3009* (NBG); *Sim 665* (NU); *Gillet 885* (PRE).

22. **Hypoxis kraussiana** *Buchinger ex Baker*, Journal of the Linnean Society, Botany 17: 109 (1878b); Baker in Thiselton-Dyer: 180 (1896); Wood: 132 (1907); Nel: 306 (1914). Type: South Africa, KwaZulu-Natal, hills near Pietermaritzburg, *Krauss 104* (BM holo!, BOL!, PRE!).

Hypoxis neliana Schinz: 136 (1926). Type: South Africa, KwaZulu-Natal, mountains near Estcourt, *Schlechter 3348* (BOL!, K!, GRA!, PRE!).

Slender, erect hairy herb, 70–100 mm high, growing singly. *Rhizome* small, oblong, 10–20 x 7–15 mm, crowned by leaves and a dense mass of bristles from remains of old leaves, white inside. *Leaves* few, 4–6, linear, 50–250 x 2–4 mm, subterete; veins 8–12, close to each other, uniformly thickened and raised on upper surface (ribbed) sparse to densely hairy; hairs with an even distribution on blade, dense on margins and midrib on lower surface, bifurcate or stellate (4–6 arms), U-shaped, curling into rings, sharply pointed (needle-shaped), ascending, yellow; arms 0.3–0.6 mm long, one or two more strongly developed, 1.2–2.5 mm long, breaking off with age. *Inflorescence* 1 or 2 per plant; racemose, covered with short, yellow hairs in upper part; scape wiry, 60–150 x 1 mm. *Bract* subulate, 4–10 mm long, hairy below. *Flowers* 2(3), pedicels short, 5–10 mm long. *Tepals* 3+3, yellow adaxially; outer tepals, elliptic, 8–9 x 2–3 mm, pale green and densely hairy adaxially; inner tepals ovate-elliptic, 7–8 x 3–4 mm, yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2–3 mm long; anthers 3–5 mm long, sagittate, apex slightly split. *Ovary* 3–4 mm long; style

0.5–1 mm long; stigma pyramidal with 3 concave faces; 1.2–2.5 mm long. *Capsule* turbinate, 3 x 2.5 mm, opening by a circular slit. *Seeds* ovoid ± 1.2 x 0.7 mm; black, glossy; testa papillate. *Flowering time*: October–December. Figure 12.15.

Diagnostic characters and relationships: *H. kraussiana* is recognised by its narrow, strongly ribbed, leaves and short, yellow, U-shaped hairs curling into rings. It is closely related to *H. filiformis* in its slender leaves and wiry two-flowered scapes, but differs in having squat stellate hairs on margins and midrib on lower surface. *In H. filiformis*, leaves are lightly covered in long, weak hairs throughout (pilose) and hairs are white. Further, in *H. kraussiana* inflorescences are densely hairy appearing yellow from the colour of hairs, while in *H. filiformis*, inflorescences are sparsely hairy.

Distribution and ecology: *H. kraussiana* is a South African endemic, with a coast to inland distribution. It occurs in KwaZulu-Natal, Free State, Mpumalanga, Gauteng and Limpopo (Figure 12.34O). The species grows in open rocky grasslands, on mountain slopes in well-drained soil and full sun. Like *H. parvifolia*, it grows at high altitudes of 1200 to 2000 m above sea level.

Conservation status: Lower risk-Least Concern (LRlc). *Wood 130* (in NU) recorded a large population along the Himeville Road. Such populations are threatened by rapidly expanding development and agriculture in the province.

Etymology: named in honour of Christian Krauss (1799–1858), scientist, traveller and collector who collected from the Western Cape, through the Eastern Cape into KwaZulu-Natal.

Vouchers**:** *Allsopp 911* (NH, NU); *Ngwenya 1607* (NH); *Robertson 12* (NU); *Saltmarshe 984* (NBG); *Singh 636* (NH).

23. **Hypoxis filiformis** *Baker*, Journal of the Linnean Society, Botany 17: 109 (1878b); Baker in Thiselton-Dyer: 180 (1896); Nel: 305 (1914); Compton: 130 (1976); Zimudzi: 15 (1996); Nordal & Zimudzi: 10–11. Type: South Africa, Eastern Cape Province, Queenstown, *Cooper 462* (K, holo!, B!, BM!)

H. caespitosa Baker: 858 (1901). Type: South Africa, Gauteng, Pretoria, *Fehr s.n.* (Z!).

H. dregei (Baker) Nel: 306 (1914); Burtt: 188 (1988). Type: South Africa, Eastern Cape, Kaffraria, *Cooper 1811* (K, lecto!).

Slender, wiry, lightly hairy herb, 50–150 mm high, growing singly. *Rhizome* oblong or globose, 10–20 mm in diameter or 1½ times longer than wide, crowned by leaves and a mass of strong bristles from remains of old leaves, white inside. *Leaves* few, 4–7, bases wrapped in membranous, brown tunic, erect, rigid, subterete, 80–200 (300) x 2–3 mm, wiry, U-shaped in cross section; veins 4–11, close to each other, uniformly thickened and raised on upper surface (ribbed), sparsely covered in long, weak hairs (pilose); hairs mainly along margins and midrib on lower surface, predominantly bifurcate with a few stellate (3 arms) intermingled, white; arms filiform, unequal in length, shorter arms 0.8–1 mm; longer arms 1.5–2 mm, ascending, occasionally appressed on margins. *Inflorescence* 1–5 per plant, produced with leaves and sequentially in the growing season, racemose, covered with long, weak white hairs; scapes shorter than or as tall as leaves, wiry, 40–300 x 1 mm, stiff, with thickened venation as in leaves, subterete. *Flowers* 2(–4), one above the other, pedicels short, 5–15 x 1 mm when flowers open. *Bract* subulate, 4–10 mm long, hairy below. *Tepals* 3+3, occasionally 2+2, outer and inner elliptic, about the same size, 4.5–9 x 1.8–4 mm, yellow adaxially, outer tepals green and pilose adaxially, inner tepals yellow, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments filiform; 2–2.5 mm long; anthers 1.8–2.3 mm long, sagittate, apex split. *Ovary* 2.0–2.5 mm long; style 0.5–1.5 mm long; stigma pyramidal with 3 concave faces, 0.5–1.8 mm long. *Capsule* turbinate or globose, 4–5 x 2–3 mm, opening by a circular slit, splitting longitudinally into three lobes. *Seeds* ovoid or globose, 1.5 x 1.2–1.4 mm, black, dull or shiny, testa papillate. *Flowering time*: mostly from September to February, less frequently from March to May. Figure 12.8.

Diagnostic characters and relationships: *H. filiformis* is recognised by its erect, subterete, strongly ribbed leaves and wiry inflorescences, mostly two-flowered and on very short pedicels. *H. filiformis* is most closely related to *H. kraussiana* in its habit and leaves. It differs from *H. kraussiana* in having long, weak, filiform hairs while in *H. kraussiana*, hairs are squat, stiff and needle-shape, curling into rings. *H. filiformis* is also similar to *H. longifolia* in habit and two-flowered inflorescences. It differs from *H. longifolia* in that it is a much smaller plant, with pilose leaves and tiny flowers (tepals less than 10 mm long). In *H. longifolia*, leaves are near-glabrous, margins fringed with squat, stellate hairs and flowers large (tepals more than 10 mm long).

Distribution and ecology: *H. filiformis* occurs in South Africa, Lesotho and Swaziland. In South Africa, it is found in all provinces, except the Western and Northern Cape, with a coastal and inland distribution (Figure 12.34H). The species extends into tropical Africa, occurring in Zambia, Zimbabwe, Malawi, Mozambique, Angola, Democratic Republic of Congo, Burundi, Uganda and Tanzania. In southern Africa, *H. filiformis* grows in open grasslands, on drier hill slopes but are more plentiful in damp areas. Hilliard & Burtt (1988) recorded collections of *H. filiformis* from the almost bare floor of a partially dried up pond. The species occurs across a wide altitude range from sea level to 2500 m, and grows sympatrically with most grassland species of *Hypoxis*.

Conservation status: Lower Risk Least Concern (LRlc).

Etymology: named from the Latin *filiformis* (thread-like), describing the leaves.

Common names: Grass star-flower, moli-letsana (Sesotho), izinongwe (Zulu).

Vouchers: *Compton 26129* (NBG, NH); *Devenish 769* (PRE); *Flanagan 1811* (NBG); *Mauve 4506* (PRE *Singh 443* 823 (NH)).

24. **Hypoxis tetramera** *Hilliard & Burtt*, Notes from the Royal Botanic Garden Edinburgh 41: 299 (1983). Type: KwaZulu-Natal, Underberg District, *Hilliard & Burtt 13524* (E, holo; NU, iso!).

Short, wiry, sparsely hairy herb, 50–120 mm high, growing singly, flowers minute. *Rhizome* tiny, oblong-globose, 6–8 x 4–7 mm, with very few contractile roots, crowned by leaves and few fine bristles from remains of old leaves, white inside. *Leaves* few, 4–8, bases wrapped in membranous, brown tunic, linear, 60–150 x 1–1.2 mm, subterete, sparsely covered; veins 10–12, flush with surface or thickened and raised on upper surface, sparsely hairy; hairs bifurcate and stellate (3 or 4 arms), filiform, 3–4 mm long, ascending, white. *Inflorescence* 1 or 2 per plant, covered with long, weak, white hairs; scapes shorter than leaves, 25–60 x 0.5 mm, subterete, sometimes decumbent in fruiting. *Flowers* 1(2), racemose; pedicels 4–6 mm long when flowers open. *Bract* subulate, 0.6–10 mm long, hairy below. *Tepals* 2+2, rarely 3+3, minute, outer and inner elliptic, about equal in size, 4.5–5 x 1.5–2 mm, yellow adaxially; outer tepals green and pilose abaxially; inner tepals yellow, green and sparsely hairy along midrib abaxially green and sparsely hairy along midrib abaxially. *Stamens* 2+2, rarely 3+3, with filaments filiform, 1.5–2 mm long; anthers 1 mm long, sagittate, apex minutely split. *Ovary* 2 mm long; style 1 mm long; stigma pyramidal with 3 concave faces, 1 mm long. *Capsule* globose or oblong, 4–6 x 2 mm. *Seeds* ovoid or globose, 0.5–1.0 x 0.5–0.1 mm, black, testa papillate, *Flowering time*: November to January. Figure 12.31.

Diagnostic characters and relationships: *H. tetramera* is recognised by its subterete, lightly hairy leaves and wiry inflorescences. Flowers in this species are diagnostic in that they are solitary, minute and have only four tepals and stamens, instead of the usual six parts found in the genus. On the label of specimen *Hoener 1623* (in PRE), it is noted that the ‘number of perianth parts were variable 4, 5 or

6 and number of stamens were variable 4, 5 or 6'. Most other sheets indicate four tepals. The species is most closely related to *H. filiformis* in its habit and subterete leaves. It differs from *H. filiformis* in the usually solitary flowers with four tepals. In *H. filiformis*, inflorescences bear 2 or 3 flowers with six tepals, seldom four.

Distribution and ecology: *H. tetramera* is a South African endemic and occurs in KwaZulu-Natal and Lesotho (Figure 12.34AE). It occurs on the Drakensberg Mountains and is associated with mud pans that become submerged during periods of high water. The species occurs in grasslands, mainly on the margin of mud pans, in full sun. *H. tetramera* is known from high altitudes 2000 to 2500 m.

Notes: *Abbott 1660* (PRU, Umtamvuna Nature Reserve) has fine, thread-like leaves and could be considered as the end of the range for width of leaves in *H. tetramera*. It could also represent *H. sagittata*, a species excluded from this study.

Conservation status: Lower Risk Least Concern (LRlc).

Etymology: named from the Latin *tetra* (four) and Greek *merus* (parts or their number) in reference to most flowers having four instead of six tepals, the latter being the prevailing state in *Hypoxis*.

Vouchers**:** *Devenish 1336* (PRE); *Guillarmod, Getliffe* & *Mzamane 274* (GRA); *Hilliard & Burtt 16798* (NU); *Killick 3868* (PRE); *Manning, Hilliard & Burtt 16011* (PRE).

25. **H. nivea** *Y. Singh*, Flowering Plants of Africa 60: 28 (2007) TYPE.—South Africa, KwaZulu-Natal, Kranzkloof Nature Reserve, *Singh 874* (NH, holo; K, PRE, PRU).

Slender, delicate herb, 70–120 mm high, lightly hairy, growing singly. *Rhizome* small, oblong, 8–10 mm in diameter or 1.5 times longer than wide, with few contractile roots; crowned with leaves and few fine bristles from remains of old leaves; white inside. *Leaves* few, 4–7, bases wrapped in membranous, white or brown tunic, linear, 70–150 × 4–12(–18) mm when flattened, pale green, paler approaching white at base, forming an inverted W from above, semi-erect, flaccid, thin and semitransparent against the light, apex browning in older leaves; veins 7–14, two near each margin slightly thickened and raised on upper surface, sparsely hairy; hairs a mixture of simple and bifurcate hairs, mostly along margins and midrib, filiform, soft, white. *Inflorescence* 1–5 per plant, corymbose, covered with soft, white hairs; scapes as tall as or shorter than leaves, 50–80 × 1 mm. *Flowers* 2–4; pedicels slender, 15–30 mm long. *Bract* subulate, 4–15 mm long. *Tepals* 3+3, white; outer tepals narrowly elliptic, 3–6 × 1.5–2.5 mm, green and hairy abaxially; inner tepals elliptic, 3.0–6.5 × 1.25–2.00 mm, white, green and sparsely hairy along midrib abaxially. *Stamens* 3+3, with filaments filiform, 1.5–3 mm long, white; anthers 1.0–2.5 mm long, yellow. *Ovary* subglobose, ± 1 mm in diameter; style filiform, 2–4 mm long; stigma minute, spherical, 0.4–0.5 mm in diameter, minutely lobed, white. *Capsule* turbinate, 2.0–2.5 × 2.5–3.0 mm, opening by a circular slit, splitting longitudinally into 3 lobes. Seeds ovoid or globose, ± 1 mm in diameter, black, papillate. *Flowering time* (September) October–November. Figure 12.20.

Diagnostic characters and relationships: *H. nivea* is easy to recognise by its membranous leaves and by its small, white flowers. It is most closely related to *H. angustifolia*, from which it differs in its smaller flowers, white flowers, thin-textured tepals, filiform filaments and style, and oblong to spherical stigmas. In these characters, *H. nivea* is similar to *H. membranacea* and *H. parvula* var. *albiflora*. In *H. angustifolia*, the flowers are yellow, tepals thicker, style subulate approaching filiform and stigma pyramidal approaching spherical. *H. nivea* differs from *H. membranacea* in its narrow, linear, smooth leaves. In *H. membranacea*, the leaves are lanceolate and the upper surface bears translucent pustules that appear as dots to the naked eye. *H. nivea* can be separated from *H. parvula* var. *albiflora* by its long, slender leaves lightly covered in hairs and by the scapes equal to or slightly shorter than leaves, with two or three flowers per inflorescences. *H. parvula* is distinguished by its short leaves, more dense leaves and flowers that are held singly on slender scapes, overtopping the leaves.

Distribution and ecology: *H. nivea* is endemic to South Africa and occurs in the Eastern Cape and KwaZulu-Natal. It extends from Kentani in the south to just north of Durban and displays a coastal distribution (Figure 12.34T). Populations of *H. nivea* are found in shade in forest, growing on rocky edges and ledges in shallow, well-drained soil. Leaves of plants in deeper shade are one and a half times longer and wider than leaves of those in light shade. It is known from altitudes of 30 to 250 m above sea level.

Conservation status: Lower risk-Near Threatened (LRnt) as it appears to be localised and rare.

Etymology: named from the Latin *niveus* (pure white) in reference to white flowers.

Common name: White star-flower.

Uses: Like *H. angustifolia*, *H. nivea* has potential as a garden or pot plant; its dainty form and white flowers are quite attractive.

Vouchers: *Cloete 1251* (NH); *Jordaan 952*, *1118* (NH, PRE); *Nicholas & Smook 2412* (K, KEI, NH, PRE); *Van Rooyen 2005* (PRE); *Wood 771* (BOL, NH, K).

26. **Hypoxis angustifolia** *Lam*. Encyclopedia Méthodique Botany 3: 182 (1789); Schult.: 767 (1819); Fischer & C.A. Meyer: 49 (1845); Baker: 369 (1877); Baker: 111 (1878b); Baker in Thiselton-Dyer: 180 (1896); Baker in Thiselton-Dyer: 378 (1898); Rendle in Hiern.: 31 (1899); Nel: 303 (1914) pro parte; Perrier de la Bathie: 10 (1950); Geerinck: 5, fig. pro parte (1971); Nordal *et al*.: 24 (1985); Zimudzi: 15 (1996); Nordal: 87 (1997); Retief & Herman: 69 (1997); Nordal & Zimudzi: 6–7 (2001); Wiland-Szymańska & Adamski: 145–147 (2002); Wiland-Szymańska & Nordal: 5 (2006); Singh: 361 (2007). Type: Mauritius, *Commerson s.n.* (P-LA, holo, image!).

H. biflora Baker: 181 (1876). Type: South Africa, Eastern Cape, Transkei, *Baur 347* (K!).

Soft almost glabrous herb, 50–150 mm high, growing singly or in tufts forming large clumps. *Rhizome* deep seated, small, oblong, up to 60 mm long, 1½ to 5 times longer than wide, with few contractile roots, crowned with leaves and few fine bristles, proliferating by means of short stolons giving rise to new rhizomes each bearing a shoot, white inside. *Leaves* few, 6–10, bases wrapped in a membranous white or brown tunic, linear, 50–300 x 3–18 mm, arranged in three ranks in smaller plants, hanging laxly in taller plants, erect or semi-erect, V- or inverted W-shaped in cross section, grass-green, flaccid, membranous; veins 7–11, flush with surface, 2–4 near each margin slightly thickened and raised on upper surface, sparsely covered in long, weak hairs (pilose) mainly scattered along veins and margins; hairs simple, bifurcate or stellate (3 or 4 arms), filiform, 0.3–0.4 mm, one arm more strongly developed 1½ to 2 times longer than rest, ascending, white. *Inflorescence* 1–4 per plant, corymbose, lightly pilose; scapes as tall as or shorter than leaves, 5–20 x 0.5–1 mm, slender, weak, flattened in cross section (ancipitous). *Flowers* 2–4(–6); pedicels slender, lax, unequal in length bringing flowers to about same height, 4.5–6.0 mm long when flowers open. *Bract* subulate, 6–12 mm long, pilose below. *Tepals* 3+3 (rarely 4 or 8 in two whorls); yellow adaxially, outer tepals elliptic or narrowly elliptic, 3.5–9 x 1.5–3.5 mm; inner tepals elliptic or ovate-elliptic, 4–10 x 2–4 mm, yellow, green and sparsely hairy along midrib abaxially, sometimes midrib red striped. *Stamens* 3+3, with filaments subulate, 1–3 mm long; anthers 1–3 mm long, sagittate, apex split. *Ovary* 2–4 mm long; style 0.5–3 mm long, variable in shape, subulate or filiform; stigma pyramidal with 3 concave faces, variable in shape, 0.5–2.5 mm long. *Capsule* turbinate, 4–10 x 2–5 mm, opening by a circular slit, then splitting longitudinally into 3 lobes. *Seeds* ovoid, 1–1.2 x 0.5–1.0 mm, black, glossy, testa papillate. *Flowering time*: mostly November–January, less often March to October.

26a. var. **angustifolia**

H. lata Nel: 324 (1914). Syntypes: South Africa, KwaZulu-Natal, Van Reenen, *Wood, 9646* (B!, NBG!); South Africa, KwaZulu-Natal, Van Reenen, *Wood, 6254* (B!, BM!, K!, NH!).

Diagnostic characters and relationships: *H. angustifolia* is recognised by its soft appearance, leaves grass green, membranous in texture and corymbose, lax inflorescences. *H. angustifolia* var. *angustifolia* is separated from variety *buchananii* in growing as solitary plants, usually less than 120 mm tall, narrow leaves, 3–4 mm wide and two veins near each margin raised on the upper surface of leaves. Variety *buchananii* includes plants growing in tufts, usually more than 120 mm tall, with broad leaves, 8–18 mm wide and four veins near each margin prominent on upper surface. *H. angustifolia* var. *angustifolia* is most similar to *H. nivea* in habit, leaf and inflorescence characters but differs from *H. nivea* in its yellow flowers. Although variable in its ratio of filaments:anthers and style:stigma and approaching the limits of *H. nivea*, filaments and style are predominantly subulate and stigmas mostly pyramidal in southern African material of *H. angustifolia*, a character typical for the genus. In *H. nivea*, flowers are white, filaments and style filiform and stigma oblong or spherical. Further, *H. angustifolia* var. *angustifolia* is more widespread in southern Africa and occurs in grassland, savanna and forest margins, while *H. nivea* is restricted to riverine forest habitats, in the Eastern Cape and KwaZulu-Natal in South Africa. Figure 12.2.

Distribution and ecology: *H. angustifolia var. angustifolia* occurs in South Africa, Lesotho and Swaziland. In South Africa it is found in the Eastern Cape, KwaZulu-Natal, Free State, Mpumalanga and Limpopo (Figure 12.34B). The variety has a coastal to inland distribution and occurs in grassland, dune banks, shrubland and forest margins. It grows in full sun or partial shade in well-drained sandy soil or marshy ground, forming strong populations in marshy depressions. The variety occurs at altitudes of 15 to 1700 m above sea level. *H. angustifolia* var. *angustifolia* is also found in disturbed areas like mowed patches, grazed fields and roadside banks where it becomes plentiful. With elongation of leaves later in the season, plants appear much taller than at the start of the season.

Etymology: Named from the Latin *angusti* (narrow) and *folia* (leaf) in reference to its slender leaves.

Common names: Molinyana (Sesotho).

Conservation status: Lower Risk Least Concern (LRlc).

Notes: *H. angustifolia* is the most widespread species in Africa. It extends from the Eastern Cape Province in South Africa to Ethiopia in the north. Varieties *angustifolia* and *buchananii* are known only from southern Africa, while *H. angustifolia* var. *luzuloides* is known from Tropical Africa. The fourth variety, *H. madagascriensis* is restricted to Madagascar. See Wiland-Szymańska & Adamski (2002) for delimitation of varieties. These authors record *H. angustifolia* var. *luzuloides* (Robyns & Tournay) Wiland as the most widespread species that occurs in intertropical and southern Africa, Madagascar and the Mascarenes. During this study, specimens *Moll 251* (in NBG), Chipinga, Zimbabwe, *Mulligan s.n.* Jan. 1953 (GRA), Zambia and *Groenedijk, Koning & Dungo 1063* (LMU), Nampula, in the northern part of Mozambique were found to match the seeds described for var. *luzuloides*. Other specimens *Faden et al.* 96/24, *Vesey-FitzGerald 6152* and *Renvoize & Ardallah 1531*, all from Tanzanzia and in EA, also match var. *luzuloides*. However, no specimen of *H. angustifolia* with a seed sculpture of var. *luzuloides* was found among the southern African material. Therefore, the two varieties described by Baker (1878b) are upheld for southern Africa. It is possible to separate the plants with leaves 3–4 mm wide as var. *angustifolia* and those with leaves more than 8 mm as var. *buchananii*.

Of note is a specimen *Ash 2016* (EA) collected in Sire in Ethiopia that matches *H. angustifolia* var. *buchananii* in habit and seed morphology. Such specimens were previously determined as *H. villosa* which brought about the use of the name in tropical Africa. *H. villosa* is endemic to South Africa. Such specimens require further study.

Uses: Rhizomes eaten by children in times of famine and used as toys in Kenya (Burkill 1994).

Vouchers: *MacDevette 284* (NH); *Nicholas 666* (PRE); *Reid 525* (PRE); *Singh 163* (NH); *Snijman 1617* (NBG).

26b. var. **buchananii** *Baker*, Journal of the Linnean Society 17: 111 (1878b); Baker in Thiselton-Dyer: 180 (1896); Retief & Herman: 69 (1997). Type: South Africa, without locality, *Buchanan s.n.* (K, holo!).

H. woodii Baker: 3 (1889); Baker in Thiselton-Dyer: 183 (1896); Wood: 132 (1907). Type: KwaZulu-Natal, Inanda, *Wood, 426a* (K, image!; NBG!).

H. obliqua Jacq. var. *woodii* (Baker) Nel: 309 (1914). Type: KwaZulu-Natal, *Wood 426a* (K, image!; NBG!).

Diagnostic characters: *H. angustifolia* var. *buchananii* is recognised from var. *angustifolia* by its larger, flaccid habit, broader leaves, 8–18 mm wide and usually four veins slightly raised on the upper surface. It also proliferates by short stolons to form tufts and like *H. nivea* and *H. membrancea* is associated it with forest localities. Two forms are recorded in the variety based on leaf dimensions. A short form with leaves arranged distinctly in distinct ranks [*Bole s.n.*, *Wood 426*, *Haygarth 79*, *Singh, 647*], all in NH. This form was described as *H. woodii* by Baker (1889). As in var. *angustifolia* later in the season, leaves elongate and plants have a lanky appearance, losing the the three-ranked arrangement of leaves [*Pegler 690* (PRE), *Strey 5974* (PRE), *Thode 2549* (PRE). The short form of *H. angustifolia* var. *buchananii* is most closely related to and often confused with *H. zeyheri* in leaf shape and corymbose inflorescences but differs in texture and distribution and type of leaf hairs. In *H. angustifolia* var. *buchananii*, leaves are membranous, sparsely hairy throughout (pilose) and hairs mostly bifurcate. In *H. zeyheri*, leaves are thick (not membranous), glabrous, hairs restricted to leaf margins and midrib on lower surface and stellate, breaking off with age. Figure 12.3.

Distribution and ecology: *H. angustifolia* var. *buchananii* occurs in South Africa and Swaziland. In South Africa, it occurs in the Eastern Cape, KwaZulu-Natal, Free State and Mpumalanga. The variety is concentrated in the Eastern Cape and KwaZulu-Natal with a coastal and inland distribution (Figure 12.34C). It grows in partial shade in forest margins or cliff faces in sandy or loamy soil, and at altitudes from 15 to 1800 m above sea level. *H. angustifolia* var. *buchananii* grows sympatrically with the other soft species, *H. membranacea* on cliff faces.

Conservation status: Lower Risk Least Concern (LRlc).

Etymology: Named in honour of Reverend John Buchanan, clergyman who collected mainly in the KwaZulu-Natal Province.

Uses: *H. angustifolia* var. *buchananii* is suitable for garden beds as they proliferate easily by short stolons to produce new rhizomes, each bearing a shoot, and over a short period form masses with plentiful flowers.

Vouchers: *Baker TM14171* (PRE); *Jordaan 317* (NH); *Singh, 647* (NH.); *Strey 5974* (PRE); *Thode 2549* (NH).

27. **Hypoxis membranacea** *Baker*, Journal of the Linnean Society, Botany 17: 106 (1878b); Baker in Thiselton-Dyer: 182 (1896); Retief & Herman: 70 (1997). Type: South Africa, KwaZulu-Natal, Tugela, *Gerrard 1835* (K, holo!, P!).

Small, delicate, lightly hairy herb, up to 100 mm high, growing in tufts. *Rhizome* oblong, 10–12 x 5–6 mm or 2 times longer than wide, with few contractile roots, crowned by leaves and a few fine bristles, white inside. *Leaves* few, 6–8, wrapped at base in a membranous, brown tunic, lanceolate or ovate, 80–150 x 8–25 mm, flat, tapering rapidly to a narrow apex, scattered with pustules, translucent and visible against the light; veins 13–14, all flush with surface, covered in long, weak hairs; hairs stellate (3–5 arms), white; arms unequal in length, 0.5–0.6 mm long, more developed arms 1.8–2 mm long, ascending, white. *Inflorescence* 1 or 2 per plant, corymbose, covered in long, weak, white hairs; scapes shorter than or as tall as leaves, delicate, 40–90 mm long, flattened in cross section (ancipitous). *Bract* subulate, 3–6 mm long, lightly hairy below. *Flowers* (1)2 or 3; pedicels weak, lax, 12–40 x 0.5 mm when flowers open. *Tepals* 3+3, white adaxially; outer tepals narrowly elliptic, 4.5–7 x 1.5–2 mm, green abaxially; inner tepals ovate-elliptic, 5–8 x 2–2.5 mm, white, green and sparsely hairy abaxially. *Stamens* 3+3, with filaments subulate, 1.5–2 mm long; anthers 1.2–1.5 mm long, sagittate, apex split. *Ovary* 1–1.5 mm long; style filiform, 2.0–2.5 mm long; stigma minute, spherical, ±0.5 mm in diameter. *Capsule* turbinate, 2–3 x 1.5–3 mm, opening by a circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid, 1–1.2 x 0.7–0.8 mm, black, dull; testa papillate. *Flowering time*: mostly during November to February, less frequently until April. Figure 12.18.

Diagnostic characters and relationships: *H. membranacea* is easily distinguished from all other species by its broad, membranous leaves covered in long, weak hairs, white flowers and minute, spherical stigmas. The species is most closely related to *H. parvula* in leaf texture, shape and stigma shape, and similar to *H. parvula* var. *albiflora* in its white flowers. It differs from *H. parvula* var. *albiflora* in its larger leaves and usually two to three flowers per inflorescence. In *H. parvula* var. *albiflora*, inflorescences usually bear a single flower, very rarely are there two flowers. *H. membranacea* is also similar to *H. angustifolia* var. *buchananii* in its soft leaves and lax inflorescences, but differs in having white flowers. In *H. angustifolia* var. *buchananii*, flowers are yellow.

Distribution and ecology: *H. membranacea* is a South African endemic, restricted to KwaZulu-Natal and the Eastern Cape, with a coastal to inland (Figure 12.34R). The species is plentiful in coastal forest where it often occurs with *H. angustifolia* var. *buchananii*. It grows on forest floor or cliff faces in rock crevices. *H. membranacea* also occurs in grasslands of mountains and outliers of the Drakensberg range among boulders at the side of rivers and streams. It is associated with damp rock and partial-shade habitats, and grows at altitudes of 20 to 900 m above sea level.

Etymology: named from the Latin *membranaceus* which translates to membranous in reference to the thin leaf texture in the species.

Common names: Small white hypoxis.

Vouchers**:** *Flanagan 1172* (BOL, PRE); *Ngwenya 489* (NH); *Oliver 6732* (PRE); *Pegler 109A,B* (PRE); *Singh 826* (NH).

28. **Hypoxis parvula** *Baker*, Journal of Linnean Society, Botany 17: 113 (1878b); Burtt: 190 (1988). Type: South Africa, KwaZulu-Natal, *Sanderson s.n.* anno 1854 (K!, holo!).

H. brevifolia Baker: 183 (1896). Type: South Africa, KwaZulu-Natal, Liddesdale, *Wood 3940* (K; NH!).

Small, delicate, sparsely hairy herb, up to 80 mm high, growing singly. *Rhizome* mostly oblong, sometimes globose, 50–100 mm in diameter or 1.5–2 times longer than wide, with a few contractile roots, crowned by leaves and few fine bristles, white inside. *Leaves* few, 3–5, wrapped at base in a membranous, white or brown tunic, lanceolate, 15–70(–90) x 5–10 mm; veins 14–18, all flush with surface; sparsely hairy throughout, mainly on lower surface; hairs a mixture of simple (one arm), bifurcate or stellate (3–5 arms); arms of unequal length, 0.5–5.0 mm long, weak, ascending, white. *Inflorescence* 1(–3) per plant, corymbose; scapes as tall as or taller than leaves, weak, lax, 30–50 mm long, covered with soft, white hairs. *Flowers* 1(2); pedicels, long, weak, 30–40 x 0.5 mm when flower open. *Bract* subulate, 2–2.5 mm long, lightly hairy below. *Tepals* 3+3, yellow or white (occasionally pink) adaxially; outer tepals narrowly elliptic, 2.0–6.5 x 1–2 mm, green and hairy adaxially; inner tepals ovate-elliptic, 2.5–7 x 1.5–2.5 mm, yellow or white, green and lightly hairy along midrib abaxially. *Stamens* 3+3, with filaments subulate, 2–3 mm long; anthers 1–1.5 mm long, apex split. *Ovary* minute, ± 1 mm long; style filiform, 3.5 mm long; stigma minute, spherical, ±0.5 mm in diameter. *Capsule* turbinate or globose, 3–4 x 2–3 mm, opening by a circular slit, splitting longitudinally into 3 lobes. *Seeds* ovoid, 0.9–1.1 x 0.8 mm, black, testa papillate. *Flowering time*: November–April.

28a. var. **parvula**

H. limicola Hilliard & Burtt: 188 (1988) syn. nov. Type: South Africa, Mpumalanga, Mac Mac Pools, *Hilliard & Burtt 18455* (NU, iso!).

Diagnostic characters and relationships: *H. parvula* var. *parvula* is distinguished by its short, thin-textured leaves, covered in long, weak white hairs, inflorescences usually overtopping the leaves, mostly with a solitary flower, and spherical stigmas. The variety is most closely related to *H. membranacea* in its habit; thin leaves; long, slender inflorescences, delicate flowers and spherical stigmas. It differs from *H. membranacea* in producing mostly a single flower per inflorescence and yellow flowers. In *H. membranacea*, inflorescences usually bear two to three white flowers. Figure 12.25.

Distribution and ecology: *H. parvula* var. *parvula* occurs in South Africa and Lesotho. In South Africa, it is found in Eastern Cape, KwaZulu-Natal, Free State, Mpumalanga and Limpopo (Figure 12.34Y). It is widespread in the Drakensberg mountains, where it grows in masses on the summit and slopes of the mountains, usually with *Rhodohypoxis*. *H. parvula* var. *parvula* is found in rock crevices or moist areas among short grass in full sun. It also occurs in coastal forest, along cliff faces, in partial shade. The variety prefers high altitude areas of 1200 to 2800 m above sea level.

Etymology: Named from the Latin *parvutus* (very small) alluding to the small stature of plants in the species.

Vouchers**:** *Haygarth 12077* (NH); *Hilliard & Burtt 13687* (NU); *Jacobsz 1662* (PRE); *Killick 1539* (PRE); *Singh 556* (NH).

28b. var. **albiflora** *B.L.Burtt*, Notes from the Royal Botanic Garden Edinburgh 45: 190 (1988).

Type: South Africa, KwaZulu-Natal Richmond District, escarpment above Byrne Valley, *Hilliard 5589* (E, holo, NU!).

Diagnostic characters: *H. parvula* var. *albiflora* is separated from variety *parvula* by its white (not yellow) flowers. Figure 12.24.

Distribution and ecology: *H. parvula* var. *albiflora* is a south African endemic and occurs in the Eastern Cape, KwaZulu-Natal and Mpumalanga (Figure 12.34X). It appears to be plentiful in the midlands and uplands of KwaZulu-Natal. Burtt (1988) recorded that the species is widespread in southern and western KwaZulu-Natal along foothills of the Drakensberg Mountains from Kokstad through to the Karkloof range. The variety forms large colonies in damp areas on mountain ridge grasslands of high altitudes, between 1500 to 2200 m. above sea level. When growing with *H. parvula* var. *parvula*, it is usually found at slightly lower (about 20 m) altitudes and they seldom overlap.

Etymology: Named from the Latin *albi* (white) and *floralis* (flower) in reference to its white flowers, unusual for the genus of yellow-flowered plants.

Vouchers**:** *Abbott 4764* (NH, PRU, UMTAMVUNA); *Galpin 10245* (PRE); *Greene 426, 886* (NH); *Hilliard & Burtt 7377, 7931* (NU); *Wood 4979* (PRE).

SPECIES INSUFFICIENTLY KNOWN

Hypoxis beyrichii Nel in Engler, Botanische Jahrbücher 51: 318 (1914). Type: South Africa, *Beyrich 326* (B!).
Named in honour of Conrad Beyrich, engineer and traveller, who joined Frans Bachman on a collecting trip to Pondoland in 1888. Insufficient material to decide on status.

Hypoxis exaltata Nel in Botanische Jahrbücher 51: (1914). Type: South Africa, without closer locality, *Poppe s.n.* B412000-19 (B, image!).
Named from the Latin *exaltata* (raised high), referring to the tall leaves of the species. Known only from type specimen. Most likely a synonym of *H. argentea* var. *argentea*.

Hypoxis jacquinii Baker in Gardener's Chronicle VIII: 552; Baker: 112 (1878b); Baker: 182 (1896). Type South Africa, [Northern Cape], Colesberg sent to Kew in 1855, flowered in June 1870.
Named after Baron Nikolaus von Jacquin (1727-1817), a Dutch scientist According to descriptions by Baker (1878b, 1896), the rhizome is oblong with a long neck and brown membranous tunic and the leaves are thin in texture. Most likely a synonym of *H. obtusa* or *H. villosa*.

Hypoxis longipes Baker in Vierteljahrsschrift der Naturforschenden Gesellschaft: 176 (1904). Type: Northern Transvaal [Limpopo] (Spelonken), Shiluvane *Junod 1446*. Named from the Latin *longus* (long) and *pes* (foot) in reference to the long leaves in the species. Listed by Nel under Species non visae: 337 (1914). Specimen seemingly not at K and Z.

Hypoxis mollis Baker in Vierteljahrsschrift der Naturforschenden Gesellschaft: 177 (1904). Type: South Africa, Northern Transvaal [Gauteng], Modderfontein, *Conrath s.n.*
Named from the Latin *mollis* meaning soft, pliant in reference to the leaves.Listed by Nel under Species non visae: 338 (1914). Specimen seemingly not at K and Z.

Hypoxis nigricans Conrath ex Baker in Herb Univ. Turic; Baker in Vierteljahrsschrift der Naturforschenden Gesellschaft: 177 (1904). Type: North Transvaal [Gauteng], Modderfontein, *Conrath s.n.*
Named from the Latin *niger* (black) probably referring to its dirty brown leaves. Presumably examined by Nel (1914) as not listed under Species non visae: 337. Specimen seemingly not at K.

Hypoxis sagittata Nel in Engler, Botanische Jahrbücher 51: 323 (1914). Type: South Africa, [Eastern Cape] Kat und Klipplaatrivier *Ecklon 3515* (B!).
Described by Nel from a single specimen. Second collection made by *Hilliard & Burtt 13264* (NU) at top of Katberg Pass. Similar to *H. filiformis* and *H. tetramera*. Hilliard & Burtt suggest that it is closer to *H. tetramera* as it has entire anther tips as opposed to split anther tips as in *H. filiformis*. Field knowledge insufficient and specimens lacking to decide on status of *H. sagittata*.

Hypoxis setosa Baker: 113 (1878b). South Africa, Eastern Cape, Grahamstown, *MacOwan 72* (TCD, holo, image!; GRA!).
Named from *setosus* meaning bristly, referring to the dense mass of fibrous bristles from remains of old leaves. The type specimen resembles *H. zeyheri* closely but requires further field studies to confirm status.

Hypoxis uniflorata Markötter in Annals of the University of Stellenbosch 8: 15 (1930). Type: South Africa, Free State, Koolhoek, *Thode 2548* (PRE, holo!).
Named from the Latin *uni* (one) and *florus* (flower) referring to the plant bearing a single-flowered inflorescences. Known only from the type specimen. Most likely synonym of *H. parvula* var. *parvula*. Requires field studies to confirm status.

Specimens examined

The numbers in brackets signify the identity of specimens: (1) *H. colchicifolia*; (2) *H. galpinii*; (3a) *H. rigidula* var. *rigidula*; (3b) *H. rigidula* var. *pilosissima*; (4) *H. acuminata*; (5) *H. longifolia*; (6) *H. ludwigii*; (7) *H. hemerocallidea*; (8) *H. obtusa*; (9) *H. stellipilis*; (10) *H. interjecta*; (11) *H. costata*; (12) *H. multiceps*; (13a) *H. sobolifera* var. *sobolifera*; (13b) *H. sobolifera* var. *pannosa*; (14) *H. villosa*; (15) *H. obliqua*; (16) *H. zeyheri*; (17) *H. gerrardii*; (18a) *H. argentea* var. *argentea*; (18b) *H. argentea* var. *sericea*; (19) *H. parvifolia*; (20) *H. flanaganii*; (21) *H. floccosa*; (22) *H. kraussiana*; (23) *H. filiformis*; (24) *H. tetramera*; (25) *H. nivea*; (26a) *H. angustifolia* var. *angustifolia*; (26b) *H. angustifolia* var. *buchananii*; (27) *H. membranacea*; (28a) *H. pavula* var. *parvula*; (28b) *H. parvula* var. *albiflora*.

Abbott 308a (1) UMTAMVUNA; *Allsopp 909* (1) NH; *Arkell & Abbott 164* (1) NH; *Cawe 407* (1) KEI; *Compton 26341* (1) NH; *Cunningham 2718* (1) NH; *Eckhardt 661* (1) PRU; *Feldman s.n* - 1958 (1) NU; *Frankish 251* (1) NU; *Gillett 3284* (1) BOL; *Green 474* (1) NH; *Green 727* (1) NH; *Johnson 658* (1) KEI; *MacDevette 1453* (1) NH; *Miller 150* (1) NH; *Miller 202* (1) NH; *Ngwenya 2572* (1) NH; *Reid 53* (1) PRE; *Rudatis 1791* (1) NH; *Singh & Govender 564* (1) NH; *Singh & Willand 756* (1) NH; *Singh 138* (1) NH; *Singh 294* (1) NH; *Singh 433* (1) NH; *Singh 575* (1) NH; *Singh 825* (1) NH; *Staples 18583* (1) NH; *Stielau 199* (1) NH; *Strey 4521* (1) NH; *Strey 5949* (1) NH; *Thode 2542* (1) NH; *Thode 4662* (1) NH; *Ward 12844* (1) NH; *Ward 12844* (1) NH; *Wiley* NH 27973 (1) NH; *Williams & Menne 1235* (1) NH; *Wood 541* (1) BOL, NBG; *Wood 5193* (1) NH; *Wylie s.n* - 1936 (1) PRE.

Bester 1331 (2) NH, PRU; *Bredenkamp 926* (2) PRU; *Burgoyne 388* (2) PRU; *Codd 4723* (2) PRE; *Compton 26341* (2) NBG; *Demp s.n* J035104 (2) J; *Devenish 85* (2) PRE; *Dreyer 312* (2) PRE; *Edwards 2027* (2) NH; *Ellery & Ellery 92/158* (2) J; *Flint s.n* J088207 (2) J; *Germishuizen 5881* (2) PRE; *Goossens 384* (2) PRE; *Hartely 1443* (2) J; *Hilliard & Burtt 18505* (2) NU; *Hilliard & Burtt 18566* (2) NU; *Hilliard & Burtt 18574* (2) NU; *Hilliard & Burtt 18598* (2) NU; *Hilliard & Burtt 18603* (2) NU; *Hilliard & Burtt 8382* (2) NU; *Hodson 7* (2) NU; *Hull 34* (2) J; *Jordaan 861* (2) NH; *Kerfoot, Forrester & Gooyer 319* (2) J; *Kunhardt 128* (2) NH; *Matthews 717* (2) PRU; *McCallum 172* (2) PRE; *Mogg 17401* (2) PRE; *Moss 14026* (2) J; *Moss 15882* (2) J; *Moss 16141* (2) J; *Moss 17720* (2) J; *Muller 2035* (2) PRE; *Nicholas 1663* (2) NH; *Noel 9056* (2) GRA; *Peacock SBP048* (2) NH; *Pott-Leendertz s.n.* TM 15137 (2) PRE; *Robbeson 294* (2) PRU; *Rogers 11659* (2) BOL; *Rogers 27505* (2) NH; *Rogers 28267* (2) NH; *Rycroft 2585* (2) NBG; *Singh & Baijnath 320* (2) NH; *Singh & Baijnath 336* (2) NH; *Singh & Wiland 657* (2) NH; *Singh & Wiland 717* (2) NH; *Singh 307* (2) NH; *Singh 464b* (2) NH; *Singh 468* (2) NH; *Singh 640* (2) NH; *Smit 881* (2) PRU; *Thode 2538a* (2) NH; *Tuko 12* (2) NH; *Van der Zeyde s.n* - Nov 1969 (2) NBG; *Van Vuuren 1314* (2) UNIN; *Venter 11136* 2) UNIN; *Venter 12384* (2) UNIN; *Wood 372* (2) NH; *Wood, S. E 104* (2) NU.

Abbott 3249 (3a) NH, UMTAMVUNA; *Abbott 4757* (3a) NH, PRU; UMTAMVUNA; *Abbott 4961* (3a) NH, PRU, UMTAMVUNA; *Abbott 5361* (3a) KEI, NH, PRU, UMTAMVUNA; *Abbott 5432* (3a) NH; *Abbott 5548* (3a) UMTAMVUNA; *Abbott 5553* (3a) NH, PRU, UMTAMVUNA *Abbott 6174* (3a) NH; *Abbott 6175* (3a)

NH, PRU; *Abbott 6547* (3a) NH; *Abbott 6608* (3a) NH; *Acocks 10604* (3a) NH; *Acocks 10641* (3a) NH; *Acocks 10833* (3a) NH; *Allsopp 920* (3a) NH; *Archibald 5002* (3a) GRA; *Arkell 331* (3a) NH; *Arkell 396* (3a) NH; *Arkell 397* (3a) NH; *Arnold 548* (3a) NH; *Balkwill & Balkwill 4552* (3a) J; *Balkwill & Balkwill 4962* (3a) J; *Balkwill & Balkwill 9374* (3a) J; *Balkwill & Cadman 3636* (3a) J; *Balkwill 9424* (3a) J; *Balkwill and Reddy 7214* (3a) J; *Balkwill, Hartley and Reddy 6945* (3a) J; *Balkwill, Hartley and Reddy 7028* (3a) J; *Balkwill, Hartley and Reddy 8350* (3a) J; *Barnad & Mogg 915* (3a) PRE; *Bayer & McClean 237* (3a) NU; *Bester 273* (3a) PRU; *Bester 1046* (3a) PRU; *Bester 1188* (3a) NH; *Blom 48* (3a) (3a) PRE; *Bolus 10318* (3a) BOL; *Bredenkamp 106* (3a) PRU; *Britten 4598* (3a) GRA; *Britten 4598* (3a) PRE; *Brusse* J48582 (3a) J; *Buitendag 890* (3a) NBG; *Burgoyne 623* (3a) PRU; *Catta 99* (3a) PRU; *Cloete 653* (3a) KEI, NH; *Codd 2155* (3a) PRE; *Cohen s.n.* - Sept. 1936 (3a) J; *Coleman 803* (3a) NH; *Compton 26342* (3a) NBG; *Compton 27095* (3a) PRE; *Compton 28129* (3a) NH; *Cooper 3631* (3a) BOL; *Cotterrell 90* (3a) GRA; *Crooke 5* (3a) NH; *Cunningham 2114* (3a) NH; *Dold & Booi 473* (3a) GRA; *Downing BD31* (3a) NH, PRE; *Drews 1* (3a) PRE; *Du Plessis 648a* (3a) PRU; *Du Preez 1076* (3a) PRE; *Edwards 322* (3a) NU; *Ekokonsult 30-56* (3a) PRE; *Fairall 220* (3a) NBG; *Flanagan 2842* (3a) SAM; *Forssman s.n* - Oct. 1939 (3a) PRE; *Galpin 1604* (3a) GRA; *Garnett s.n* - Oct. 1931 (3a) J; *Gerstner 279* (3a) PRE; *Gerstner NH28986* (3a) NH; *Getliffe, Hearne & Kerfoot 14*(3a) J; *Glass 738* (3a) NBG; *Goosens 7* (3a) PRE; *Gordon-Gray 117* (3a) NU; *Gordon-Gray s.n.* (3a) NU; *Green 420* (3a) NH; *Green 471* (3a) NH; *Greene 397* (3a) NH; *Greene 820* (3a) NH; *Greene 864* (3a) NH; *Grice NH122580* (3a) NH; *Heideman 99* (3a) J; *Heideman 101* (3a) J; *Heideman 103*(3a) J; *Hill 6180* (3a) GRA; *Hilliard & Burt 8383* (3a) NU; *Hilliard & Burt 13681* (3a) NU; *Hilliard & Burt 18588* (3a) NU; *Hilliard & Burt 18607* (3a) NU; *Hofmeyer 69* (3a) PRE; *House 25*(3a) J; *Hudson s.n* - Oct. 1930 (3a) J; *Hull 79* (3a) J; *Hull 171* (3a) J; *Hull 394* (3a) J; *Jacobs 752* (3a) PRE; *Jenkins 7133* (3a) PRE; *Knep s.n* - Oct 1959 (3a) J; *Kok 23* (3a) PRU; *Lambert s.n* - Oct 1950 (3a) J; *Lang s.n.* - Dec. 1932 (3a) PRE; *Lawson 1222* (3a) NH; *Lubke & Botany3 class 2078* (3a) GRA; *MacDevette 1545* (3a) NH; *Macnae 1202* (3a) J; *Macnae 1339* (3a) J; *MacOwan 1649* (3a) SAM; *Mathews 981* (3a) PRU; *Mattison 8* (3a) NU; *Mc.Murtry c.3* (3a) NBG; *McGillivray s.n* - Sept. 1928 (3a) J; *Mildrea 2* (3a) NBG; *Moffat 39* (3a) PRE; *Mogg 34441* (3a) J; *Mogg 35460* (3a) J; *Mogg et al.* 26687 (3a) J; *Moll 1255* (3a) NH, PRE; *Moll 4740* (3a) NH; *Moss 3327* (3a) PRE; *Moss 6200* (3a) J; *Moss 13679* (3a) J; *Moss 15425* (3a) J; *Moss 15883* (3a) J; *Mull 1040* (3a) NU; *Murray s.n* - Jan 1938 (3a) J; *Ndungane s.n* - Mar. 1974 (3a) GRA; *Ngwenya 1500* (3a) NH; *Ngwenya 1576* (3a) NH; *Ngwenya 1739* (3a) NH; *Ngwenya 1932* (3a) NH; *Obermeyer 37* (3a) NH; *Oliver 604* (3a) NH; *Palmer 2962* (3a) GRA; *Peackock 65759* (3a) NBG; *Peacock* SAM65759 (3a) SAM; *Pegel Jhb1* (3a) NH; *Pegler 1286* (3a) BOL; *Phillips 1474* (3a) J, PRU; *Piek 89* (3a) NH; *Pott 13305* (3a) PRE; *Raal 60* (3a) J; *Reid 125* (3a) J; *Reynolds 9677* NBG; *Roberts 2480* (3a) PRE; *Robbertse 651* (3a) PRU; *Robertson s.n.* - Oct 1945 (3a) GRA; *Rogers 12150* (3a) BOL; *Rogers 13271* (3a) PRE; *Rogers 23539* (3a) J; *Rogers 27786* (3a) NH; *Rogers 28511* (3a) NH; *Ross 4* (3a) NH; *Rossouw 76* (3a) BLFU; *Rudatis 472* (3a) NH; *Ruddock 42* (3a) NU; *Rycroft* 2585 (3a) NBG; *SAGP/SAAB 2/73* (3a) PRU; *SAGP/SAAB 1/29* (3a) PRU; *SAGP/SAAB 3/40* (3a) PRU; *Scheepers 737* (3a) PRE; *Schonland 4142* (3a) GRA; *Shackleton 531* (3a) J; *Shirley 76* (3a) NU; *Sim 670* (3a) NU; *Singh 306* (3a) NH; *Singh 310* (3a) NH; *Singh 394* (3a) NH; *Singh 400* (3a) NH; *Singh 511* (3a) NH; *Singh 519* (3a) NH; *Singh 523* (3a) NH; *Singh 549* (3a) NH; *Singh 550* (3a) NH; *Singh 607* (3a) NH; *Singh 608* (3a) NH; *Singh 629* (3a) NH; *Singh 653* (3a) NH; *Singh 654* (3a) NH; *Singh & Baijnath 312* (3a) NH; *Singh & Baijnath 313* (3a) NH; *Singh & Baijnath 319* (3a) NH; *Singh*

& Baijnath 333 (3a) NH; *Singh & Govender 414* (3a) NH; *Singh & Govender 414* (3a) NH; *Singh & Govender 436* (3a) NH; *Singh & Govender 561* (3a) NH; *Singh & Wiland 680* (3a) NH; *Singh & Wiland 688* (3a) NH; *Singh & Wiland 692* (3a) NH; *Singh & Wiland 720* (3a) NH; *Singh & Wiland 732* (3a) NH; *Singh & Wiland 748* (3a) NH; *Singh & Wiland 766* (3a) NH; *Smit 168* (3a) PRU; *Stephansen s.n.* (3a) PRE; *Stirton 1045* (3a) NU; *Stirton 1219* (3a) NU; *Strey 9100* (3a) PRE; *Tarr & Heilgendorf NH115903* (3a) NH, PRE; *Taylor 57* (3a) J; *Thackwary 3* (3a) PRU; *Theron 162* (3a) PRU; *Theron 711* (3a) PRU; *Theron 2025* (3a) PRU; *Theron 2115* (3a) NH, PRE; *Thode 2534a* (3a) NH; *Thode 2546* (3a) NH; *Tyson 1124* (3a) BOL, PRE; *Tyson 1211* (3a) BOL, SAM; *Van der Merwe 49* (3a) UNIN; *Van der Schiff 5891* (3a) PRU; *Van der Schiff 6379* (3a) PRU; *Van der Zeyde 264* (3a) NBG; *Van Huyssteen 2966* (3a) PRU; *Van Rooyen 2413* (3a) PRU; *Van Wyk 437* (3a) PRE; *Van Wyk 1749* (3a) PRE; *Van Wyk 6667* (3a) PRU; *Venter s.n.* - Nov. 1967 (3a) UNIN; *Venter s.n.* - Nov. 1985 (3a) UNIN ; *Walker s.n* - Oct. 1952 (3a) J; *Westfall 863* (3a) PRE; *Wight 2276* (3a) NU; *Wiley NH21681* (3a) NH; *Wiley NH23357* (3a) NH; *Wiley NH28016* (3a) NH; *Williams 313* (3a) NH; *Williams 433* (3a) NH; *Williams 550b* (3a) NH; *Williamson 9901* (3a) NH; *Wood 754* (3a) NBG; *Wood 2435* (3a) NH; *Wood 2627* (3a) NH; *Wood 3456* (3a) NH; *Wood 3870* (3a) NH; *Wood, S.E 92* (3a) NU; *Wood, S.E 107* (3a) NU; *Wood, S.E 124* (3a) NU; *Wood, S.E 128* (3a) NU; *Wood, S.E 152* (3a) NU; *Wood, S.E 164* (3a) NU; *Wood, S.E 175* (3a) NU; *Wood, S.E 210* (3a) NU; *Young* 1297 (3a) J; *Young A239* (3a) PRE; *Younghusband 72* (3a) NH; *Zeyde 33* (3a) PRE.

Abbott 6121b (3b) PRU, UMTAMVUNA; *Anonymous s.n.* - Sept. 1957 (3b) J; *Balkwill, Hartley & Reddy 8349* (3b) J; *Behr 52* (3b) NBG; *Buitendag 158* (3b) NBG; *Burrows 4336* (3b) J; *Burtt-Davy 682* (3b) NH; *Burtt-Davy 2218* (3b) BOL, PRE; *Compton 26342A* (3b) NH; *Compton 26924* (3b) NBG, PRE; *Davidson 570* (3b) J; *Duplessis 648* (3b) PRU; *Ellery & Ellery 92/217* (3b) J; *Flanagan 1170* (3b) BOL, NBG; *Germishuizen 7045* (3b) PRE; *Gerrard & McKen 1826* (3b) NH; *Gerstner 1965* (3b) PRE; *Gerstner 3855* (3b) NH; *Gilliland s.n.* - Dec. 1952 (3b) J; *Halse 43* (3b) NH; *Harrison 245* (3b) NH, PRE; *Heydoorn 45* (3b) PRE; *Hilliard & Burtt 18823* (3b) NU; *Kerfoot 8148* (3b) J; *Kerfoot K 8149* (3b) J; *Leendertz s.n.*TM5620 (3b) PRE; *Lewis 6184* (3b) NBG; *Lucas 18* (3b) UNIN; *Mathews 645* (3b) PRU; *Mathews 716* (3b) PRU; *Mogg 34731* (3b) GRA; *Page s.n.* - Oct 1927 (3b) J; *Reddy, Reddy & Reddy 452* (3b) NH; *Rogers 237* (3b) GRA; *Sikhakhane 365* (3b) NH; *Singh & Baijnath 224* (3b) NH; *Singh & Baijnath 332* (3b) NH; *Singh & Wiland 659* (3b) NH; *Singh & Wiland 755* (3b) NH; *Singh 438* (3b) NH; *Singh, Baijnath & Govender 258A* (3b) NH; *Smith, C.A 3311* (3b) PRE; *Smith, R 906* (3b) PRU; *Smuts s.n.* - Sept. 1924 (3b) BOL; *Sutton 293* (3b) PRE; *Taylor 3338a* (3b) NBG; *Theron 1893* (3b) PRE, PRU; *Trauseld 865* (3b) NU, PRE; *Tucker s.n.* - Jan 1906 (3b) BOL; *Van der Westhuizen 820* (3b) PRE; *Van Rooyen 1919* (3b) PRU; *Van staden 153* (3b) PRU; *Van Wyk 295* (3b) NH; *Venter 11046* (3b) PRE; *Ward 1583* (3b) PRE; *Weberling 9155* (3b) PRE; *Westfall 1586* (3b) PRE; *Williams 1131* (3b) NH; *Williamson 323* (3b) J; *Wilsenach s.n.* - Dec. 1962 (3b) J; *Wood 2463* (3b) NH; *Zeyher 156* (3b) BOL.

Abbott 5374 (4) PRU; *Abbott 5426* (4) UMTAMVUNA; *Allsopp 682* (4) NH; *Arnold 839* (4) J; *Beetonzy l2486* (4) NBG; *Blenkiron s.n.* PRE27395 (4) PRE; *Bolus 12358* (4) BOL; *Bourquin 137* (4) NU; *Bruce & Codd s.n.* PRE33556 (4) PRE; *Codd & De Winter 3361* (4) PRE ; *Coetzee 14* (4) NH; *Compton 24551* (4) NBG; *Compton 26128* (4) NBG; *Compton 27182* (4) NBG; *Compton 28129* (4) NBG; *Compton 28379* (4) NH;

Compton 28289 (4) PRE ; *Crook 57* (4) NH; *Devenish 1208* (4) PRE; *Dieterlen 290* (4) NBG; *Dieterlen 290* (4) PRE; *Dieterlen 709* (4) NBG; *Dieterlen 918* (4) PRE; *Dieterlen 924* (4) PRE; *Dold 678* (4) GRA; *Drewes s.n.* - Nov. 1981 (4) NU; *Du Plessis 859* (4) PRU; *Du Tois s.n.* - Dec 1926 (4) PRU; *Du Toit s.n.* - Aug. 1957 (4) NU; *Forrester & Gooyer 94* (4) PRE; *Greene 550* (4) NH; *Gerstner 2382* (4) NH; *Gerstner 2588* (4) NH; *Gertenbach & Groenewald 9125* (4) PRE; *Gilliland s.n.* J027355 (4) J; *Hilliard & Burtt 18516* (4) NU; *Hilliard & Burtt 18601* (4) NU; *Hilliard & Burtt 18693* (4) NU; *Hilliard & Burtt 18739* (4) NU; *Hilliard & Burtt 18743* (4) NU; *Hilliard & Burtt 19007* (4) NU; *Jacobsz 2275* (4) NBG; *Jacobsz 2275* (4) PRE; *Jenkins 6241* (4) BOL; *Jordaan 837* PRE; *Kerfoot K7225* (4) J; *Kerfoot s.n.* J048136 (4) J; *Lang NH 27190* (4) NH; *Lawson 1221* (4) NH; *Leendertz 2847* (4) PRE; *Leendertz s.n.* TM 10375 (4) PRE; *Leipoldt s.n.* TM38078 (4) PRE; *Lloyd 21* (4) GRA; *McClean 905* (4) NH; *Mogg 2425* (4) PRE; *Mogg 4488* (4) PRE; *Moll 1253* (4) PRE; *Moss & Rogers 1101* (4) J; *Moss & Rogers 1189* (4) J; *Moss & Rogers 1240* (4) J; *Moss & Rogers 1888* (4) J; *Moss 13888* (4) J; *Moss 17069* (4) J; *Moss 17070* (4) J; *Moss 17713* (4) J; *Moss 5211* (4) J; *Moss 6030* (4) J; *Moss 6214* (4) J; *Muller 1274* (4) PRE; *Nicholas & Smook 2444* (4) KEI; *Ngwenya 1049* (4) NH; *Ngwenya 2370* (4) NH; *Ngwenya 2600* (4) NH; *Phillips* J32949 (4) J; *Pienaar 73* (4) NU; *Potgieter s.n.* - June 1955 (4) PRE; *Pott 5164* (4) BOL; *Potter 1695* (4) PRE; *Roberts 3101* (4) PRE; *Rogers 11561* (4) BOL; *Schrire 1600* (4) NH; *Scott 5* (4) NU; *Shirley s.n.* - Nov. 1964 (4) NU; *Singh 286* (4) NH; *Singh & Baijnath 272* (4) NH; *Singh & Baijnath 338* (4) NH; *Singh & Baijnath 846* (4) NH; *Singh & Govender 566* (4) NH; *Singh & Wiland 712* (4) NH; *Singh 155* (4) NH; *Singh 461* (4) NH; *Singh 645b* (4) NH; *Singh 655* (4) NH; *Stewart 3676* (4) NBG; *Symons 70* (4) NBG; *Taylor 5262* (4) NBG; *Theron 3973* (4) PRU; *Thode 2856* (4) PRE; *Tuko 8* (4) NH; *Turner 284* (4) PRE; *Venter 11046* (4) UNIN; *Victor 795a* (4) GRA; *Wall s.n.* - Oct. 1938 (4) BOL; *West 441* (4) GRA; *Williams 674* (4) NH; *Williams 8* (4) NH; *Wood 121* (4) NU; *Wood 6120* (4) BOL; *Wood S.E. 154* (4) J; *Wood, S.E 149* (4) NU; *Wood, S.E. 132* (4) NU; *Wood, S.E. 146* (4) NU; *Wood, S.E. 149* (4) J; *Wood, S.E. 72a* (4) J; *Wylie s.n.* TM 34326 (4) PRE; *Zietsman 3102* (4) PRE.

Acocks 12055 (5) PRE; *Archibald 4126* (5) GRA; *Bolus 9133* (5) BOL; *Breen S.P 63* (5) GRA; *Brown 27785* (5) NH; *Burrows 2895* (5) GRA; *Burrows 3151* (5) GRA; *Daly 591* (5) GRA; *Dieterlen 1370* (5) NBG; *Dold 1001* (5) GRA; *Dyer 2045* (5) GRA; *Dyer 4538* (5) PRE; *Ecklon & Zeyher 4137* (5) BOL; *Edwards 258* (5) NU; *Felton & Thornhill 337* (5) PRU; *Flanagan 1169* (5) BOL; *Flanagan 22253* (5) NBG; *Fourcade 1097* (5) GRA; *Galpin 7703* (5) PRE; *Galpin s.n.* - May 1831 (5) BOL; *Gerstner 4936* (5) PRE; *Gibbs Russell 3483* (5) GRA; *Gillett 1396* (5) BOL; *Hartley 1207* (5) J; *Henrici 4242* (5) PRE; *Howe s.n.* - Nov. 1978 (5) GRA; *Hugo 2088* (5) PRE; *Kerfoot, Gooyer & Eastman s.n.* - Jan 1977 (5) J; *Lubbe 285* (5) PRU; *Lubbe 57* (5) PRU; *Lubbe, Everan & Avis 2707* (5) GRA; *Lubke 52* (5) NH; *MacDevette 303* (5) NH; *MacOwan 2123* (5) NBG; *Matthews 1203* (5) PRU; *McDonald & Smith 96* (5) PRU; *Moll 4740* (5) NBG; *Moll 4740* (5) PRE; *Moraile 3515* (5) PRE; *Moss 17071* (5) J; *Nicholas & Perks 1503* (5) PRE; *Nicholas 670* (5) PRE; *Pooley 1903* (5) NU; *Potts 5116* (5) BLFU; *Robbertse 613* (5) PRU; *Shackleton 35* (5) PRE; *Sibaya Project 63* (5) GRA; *Sim 643* (5) NU; *Singh 500* (5); *Singh 598* (NH); *Singh 794* (5) NH); *Singh & Wiland 721* (5) NH; *Smook 636* (5) NU; *Stephen, Theron 675* (5) NH; *Theron 1191* (5) NH; *Van Graan & Schwabe 1175* (5) PRE; *Taylor 255* (5) NU; *Taylor 40* (5) GRA; *Thode A1051* (5) NH, PRE; *Tyson 2926* (5) NBG; *Van Wyk 269* (5) NH; *Venter 4885* (5) BLFU;

Ward M.C. 2093 (5) NH; Williams 1142 (5); *Williams 1122* (5) NH; *Wormarld 88* (5) GRA; *Zietsman 2528* (5) PRE.

Hilliard & Burtt 18822 (6) NU; *Hilliard & Burtt 18076* (6) NU; *Hilliard & Burtt 17652* (6) NU; *Trace 30* (6) (NU).

Abbott 344 (7) NH, PRU, UMTAMVUNA; *Abbott 5038* (7) NH, PRU, UMTAMVUNA; *Abbott 6264* (7) NH; *Abbott 6381* (7) NH; *Abbott 6496* (7) NH; *Archibald 5096* (7) GRA; *Arkell 338a* (7) NH; *Arnold 840* (7) J; *Baker s.n.* - Nov. 1909 (7) PRE; *Balkwill & Cron 191* (7) J; *Balkwill 10236* (7) J; *Balkwill, Hartley & Reddy 8351* (7) J; *Barbana 33* (7) NU; *Barker 3428* (7) NBG; *Barker 4367* (7) NBG; *Batten 6-Pl119* (7) NBG; *Baur 8726* (7) PRE; *Booke s.n.* - Oct 1932 (7) BOL; *Bourquin 458* (7) NU; *Brandmuller* 1506/28 (7) BOL; *Bredenkamp 98* (7) PRE, PRU; *Bredenkamp 383* (7) PRE; *Bredenkamp 1188* (7) UNIN; *Breyer s.n.* - Feb 1918 (7) PRE; *Bruecknee 620* (7) KMG; *Bullock 29* (7) NH; *Burrows 4417* (7) GRA; *Burtt-Davy 2171* (7) PRE; *Clark 1* (7) NU; *Clemitson 41* (7) GRA; *Cloete & Bosa 3219* (7) NH; *Codd & De Winter 3240* (7) PRE; *Codd 1822* (7) PRE; *Coleman 159* (7) NH; *Compton 27337* (7) NBG; *Compton 28104* (7) NH; *Compton 28843* (7) NBG, NH; *Compton 31790* (7) NBG; *Courtenay-Latimer s.n.* - Oct. 1945 (7) NBG; *Creed 4* (7) GRA; *Daly 78* (7) PRE; *Davey 21* (7) NU; *De Leur 11* (7) NH; *Dickinson 16* (7) GRA; *Dieterlen 229* (7) NBG; *Dieterlen 229a* (7) NBG, NH, PRE; *Dixon 6* (7) NU; *Dold & Booi 474* (7) GRA; *Dold & Booi 475* (7) GRA; *Du Plessis 164* (7) PRU; *Du Plessis 525* (7) PRU; *Du Plessis 561* (7) PRU; *Du Preez 1254* (7) GRA; *Earthy 325* (7) BOL; *Eckhardt 407* (7) PRU; *Edwards, D. 2407* (7) NU; *Edwards, T. 265* (7) NU; *Ellery 34* (7) NU; *Fairall 110* (7) NBG; *Felton & Thornhill 381* (7) NH, PRU; *Flanagan 1171* (7) BOL; *Flanagan 1810* (7) NBG; *Flanagan 1893* (7) BOL; *Forbes sn.* (7) NH; *Fourcade s.n* - Mar 1908 (7) BOL; *Franklin 9* (7) J; *Galpin 1190* (7) PRE; *Germishuizen 1667* (7) PRE; *Gerstner 3638* (7) NH; *Gilliland s.n.* - Dec 1935 (7) J; *Glass 376* (7) NBG; *Goosens 143* (7) PRE; *Goosens 779* (7) PRE; *Gordon-Gray 1438* (7) NU; *Green 239* (7) NH; *Groenewald 4* (7) NH; *Guy & Jarman 84* (7) NU; *Harrison 183* (7) NH; *Hart 29* (7) NU; *Haygarth 18* (7) NH; *Haygarth 78* (7) NH; *Heideman 104* (7) J; *Heidenman s.n.* - March 1978 (7) J; *Henderson, Brokensha & Collins 175* (7) J; *Hilliard & Burtt 8486* (7) NU; *Hilliard & Burtt 18258* (7) PRE; *Hilner 330* (7) GRA; *Hobson 438* (7) GRA; *Hoffe 1* (7) PRE; *Howe s.n.* - Oct. 1988 (7) GRA; *Huntley 247* (7) NH; *Hutchings & Johnson 1157* (7) KEI; *Hutchings 301* (7) KEI; *Hutchings 424* (7) KEI; *Hutchings 620* (7) KEI; *Hutchinson, Forbes & McClean 31* (7) NH; *Jacobsz 1813* (7) PRE; *JBG 4761* (7) PRE; *Jenkins s.n.* - Sept. 1909 (7) PRE; *Johnson, S.M. 768* (7) GRA; *Kluge 291* (7) PRE, PRU; *Kok 210* (7) PRU; *Kotze 502* (7) PRE; *Lachman 7* (7) NU; *Lambert 20* (7) NH; *Lang s.n.* - Nov. 1932 (7) PRE; *Lang s.n.* - Oct 1932 (7) PRE; *Lawn 335* (7) NH; *Lawn 446* (7) NH; *Lawn 1161* (7) NH; *Leighton 2620* (7) BOL; *Leisgang 46* (7) NU; *Lenwick 20* (7) NU; *Long 177* (7) GRA; *Lubbe 44* (7) NH, PRU; *Luddick s.n.* - Sept. 1969 (7) PRU; *MacDevette 1102* (7) NH; *Macnae 1252* (7) J; *McDonald 144* (7) NU; *McLea 5801* (7) BOL; *Mogg 33048* (7) J; *Mogg 36349* (7) J; *Moll & Strey 3807* (7) NH, PRE; *Moraille 3518* (7) BLFU; *Morris 365* (7) NU; *Moss & Rogers 1419* (7) J; *Moss 13901* (7) J; *Moss 17737* (7) J; *Moss s.n.* - 1924 (7) J; *Mthembu 10* (7) NH; *Murray s.n.* - Dec. 1937 (7) J; *Ngcobo 6* (7) NH; *Ngwenya 1230* (7) NH; *Ngwenya 1577* (7) NH; *Ngwenya 2024* (7) NH; *Nicholas & Perks 1502* (7) NH, PRE; *Nicholson 238* (7) NH; *Noel 1437* (7) GRA; *Nombekela 115* (7) NH; *Nombekela 116* (7) NH; *Ntombela 4* (7) NH; *Page 22370* (7)

BOL; *Palmer 2647* (7) GRA; *Pappenfus s.n.* - Dec. 1962 (7) J; *Paterson 29* (7) GRA; *Peacock SBP048* (7) NH; *Pegler 1142* (7) PRE; *Pegler 1143* (7) BOL, PRE; *Phelan 667* (7) NU; *Pienaar 7* (7) PRU; *Pienaar 74* (7) NU; *Pocock 3* (7) GRA; *Porter & Ward 230* (7) NH; *Potts 394* (7) GRA; *Rogers 3169* (7) BOL; *Rogers s.n.* - Feb 1908 (7) PRE; *Rogers 24612* (7) NH; *Ross 2157* (7) NH, PRE; *Rudatis 1736* (7) PRE; *Rump NH20300* (7) NH; *Russell 29* (7) NH; *Scheepers 32* (7) PRU, UNIN; *Scheepers 1329* (7) PRE; *Schonland 3925* (7) GRA; *Schonland 4201* (7) GRA; *Schrire & Peinaar 22* (7) NH; *Scully 117* (7) NBG; *Sebola 279* (7) J; *Shirley 241* (7) NU; *Sikhakhane 245* (7) NH; *Sim 1124* (7) NU; *Sim 1129* (7) NBG, NU; *Singh 139* (7) NH; *Singh 169* (7) NH; *Singh 276* (7) NH; *Singh 327* (7) NH; *Singh 399* (7) NH; *Singh 401* (7) NH; *Singh 410* (7) NH; *Singh 488* (7) NH; *Singh 489* (7) NH; *Singh 491* (7) NH; *Singh 497* (7) NH; *Singh 503* (7) NH; *Singh 504* (7) NH; *Singh 541* (7) NH; *Singh 579* (7) NH; *Singh 618* (7) NH; *Singh 630* (7) NH; *Singh 656* (7) NH; *Singh 801* (7) NH; *Singh 806* (7) NH; *Singh 820* (7) NH; *Singh & Baijnath 213* (7) NH; *Singh & Baijnath 225* (7) NH; *Singh & Baijnath 316* (7) NH; *Singh & Baijnath 321* (7) NH; *Singh & Govender 389* (7) NH; *Singh & Govender 411* (7) NH; *Singh & Govender 437* (7) NH; *Singh & Govender 568* (7) NH; *Singh & Govender 571* (7) NH; *Singh & Ngwenya 159* (7) NH; *Singh & Wiland 574* (7) NH; *Singh & Wiland 734* (7) NH; *Singh & Wiland 742* (7) NH; *Singh & Wiland 747* (7) NH; *Singh & Wiland 751* (7) NH; *Singh & Wiland 762* (7) NH; *Singh & Wiland 770* (7) NH; *Singh & Wiland 773* (7) NH; *Smit s.n* - Sept. 1957 (7) NU; *Smith 227* (7) PRE; *Sole 382* (7) GRA; *Stalmans 1099* (7) PRE; *Stalmans 2047* (7) J; *Stalmans 670* (7) PRE; *Stephen, Van Graan & Schwabe 1151* (7) PRE; *Stirton 105* (7) NU; *Stirton 12177* (7) PRU; *Strey 5163* (7) NH; *Strey 5942* (7) NH; *Strey 9256* (7) NH; *Strey 9962* (7) NH, PRE; *Taylor 4966* (7) NBG; *Taylor 5584* (7) NBG; *Theron 806* (7) PRU; *Theron 1147* (7) PRU; *Theron 1190* (7) NH, PRU; *Theron 1890* (7) PRU; *Theron 1997* (7) PRE, PRU; *Thode 2540* (7) NH; *Trace 40* (7) NU; *Tyson 1125* (7) BOL, NBG; *Tyson 1210* (7) NBG; *Van Dam s.n.* - Dec 1911 (7) PRE; *Van Dam s.n.* TM26292 (7) PRE; *Van Rooyen 1919* (7) PRU; *Van Rooyen 1919a* (7) PRU; *Van Vuuren 1568* (7) UNIN; *Van Wyk 2364* (7) PRU; *Vassilatos & Mantell* 555 (7) J; *Venter 1568* (7) BLFU; *Wahl 3* (7) PRU; *Ward 398* (7) NU; *Ward 1586* (7) NH; *Ward & Rajh 11654* (7) NH; *Ward, M.C. 448* (7) NH; *Ward, M.C. 531* (7) NH; *Ward, M.C. 1131* (7) NH; *Wells 2113* (7) NH; *Widdecombe 1254* (7) GRA; *Williams 550a* (7) NH; *Wood 6924* (7) NH; *Wood, S.E 13* (7) NU; *Wood, S.E. 72* (7) J; *Wood, S.E. 75* (7) J; *Wood, S.E. 76* (7) J, NU; *Wood, S.E. 79* (7) J, NU; *Wood, S.E. 82* (7) J; *Wood, S.E. 86* (7) J, NU; *Wood, S.E. 102* (7) J, NU; *Wood, S.E 106* (7) NU; *Wood, S.E. 118* (7) NU; *Wood, S.E. 145* (7) NU; *Wood, S.E. 167* (7) J; *Wood, S.E. 171* (7) NU; *Wood, S.E. 174* (7) NU; *Wulff s.n.* - Dec. 1974 (7) GRA; *Wylie s.n.* - Sept. 1933 (7) BOL; *Wylie NH22420* (7) NH; *Wylie NH23107* (7) NH; *Xaba 5* (7) NH; *Young A127* (7) PRE.

Anonymous s.n. - Sept 1980 (8) J; *Anonymous s.n.* - Sept. 1957 (8) J; *Arnold 842* (8) NU; *Auret sub Moss 18347* (8) J; *Balkwill 251* (8) J; *Balkwill 9402* (8) J; *Balkwill & Balkwill 4648* (8) PRE; *Balkwill & Reddy 7213* (8) J; *Barker* 1 (8) NBG; *Barker s.n.* - Jan. 1943 (8) NBG; *Baur 904* (8) NBG; *Bayliss 1707* (8) NBG; *Bester 1332* (8) BOL, PRE; *Bester 1333* (8) PRU; *Bester 2623* (8) PRU; *Bester 2642* (8) PRU; *Bilse 4206* (8) BOL; *Bolus 181* (8) BOL; *Bolus 6446* (8) BOL; *Bolus 10320* (8) BOL; *Braun 1258* (8) PRE; *Britten 4653* (8) GRA; *Bruce & Codd s.n.* - Nov 1947 (8) PRE; *Brueckner 508* (8) KMG; *Brusse s.n.* - Oct 1975 (8) J; *Brusse s.n.* - Oct 1976 (8) J; *Buitendag 619* (8) NBG; *Burgoyne 464* (8) PRU; *Burtt-Davy 5577* (8) PRE; *Burtt-Davy 10139* (8) PRE; *Cain* s.n. - *Sept. 1980* (8) J; *Bremekamp 836* (8) PRU; *Clarke 1442* (8) PRE; *Coetzee 209* (8) PRU;

Coetzee 71 (8) PRE; *Compton 9677* (8) PRE; *Cook 9/30* (8) BOL; *Cross s.n.* - Nov 1949 (8) PRE; *Cunningham 2114* (8) NH; *Cunningham 2129* (8) NH; *Dieterlen 223* (8) NH; *Dieterlen 310* (8) NBG; *Dieterlen 6972* (8) NBG; *Dinter 617* (8) NBG; *Dinter 617a* (8) NBG; *Dinter 5308* (8) NBG; *Dinter 5368* (8) BOL; *Du Preez 374* (8) BLFU; *Du Plessis 601* (8) PRU; *Du Preez 1086* (8) BLFU; *Ellery & Ellery 92/95* (8) J; *Flanagan 1642* (8) BOL, NBG; *Galpin 12497* (8) PRE; *Galpin 17336* (8) NBG; *Galpin M336* (8) PRE; *Galpin s.n.* - Oct. 1932 (8) BOL; *Geiss 14970* (8) PRE; *Giess 13665* (8) PRE; *Gillett s.n.* - Nov 1925 (8) BOL; *Grant 3079* (8) PRE; *Greene 821* (8) NH; *Grobbelar EB36M* (8) UNIN; *Gubb 10254* (8) KMG; *Hanekom 1621* (8) PRE; *Heatly sub Moss 2655* (8) J; *Heideman 108* (8) J; *Heideman s.n.* - Nov. 1978 (8) J; *Heideman s.n.* - Oct 1978 (8) J; *Hilliard & Burtt 14620* (8) NU; *Hilliard & Burtt 17853* (8) NU; *Hilliard & Burtt 18587* (8) PRE; *Hilliard & Burtt 18595* (8) PRE; *Hilliard & Burtt 18599* (8) NU; *Hilliard & Burtt 18615* (8) NU; *Hilliard & Burtt 18716* (8) NU; *Hilliard & Burtt 18821* (8) NU; *Hilliard & Burtt 18921* (8) NU; *Hofmeyr 50* (8) GRA; *Holland s.n.* - Feb 1932 (8) BOL; *J.H.I'ons* (8) NBG; *Jacobsen 766* (8) PRE; *Jacobsz 1812* (8) NBG, PRE; *Jacobsz 2273* (8) NBG; *Jenkins s.n.* - Dec 1908 (8) PRE; *Kinges 1904* (8) PRE; *Leendertz 918* (8) BOL; *Leendertz s.n.* - Dec 1909 (8) PRE; *Leighton s.n.* - Jan. 1947 (8) BOL; *Liebenberg 8423* (8) PRE; *MacOwan 1649* (8) SAM; *Maguire s.n.* - Oct 1945 (8) J; *Markötter 8851* (8) NH; *Marsden s.n.* - Nov 1941 (8) PRE; *Mathews 302* (8) NBG; *Meggitt 63* (8) GRA; *Mey 20* (8) PRU; *Mogg 3281* (8) PRE; *Mogg 32993* (8) J; *Mogg 34103* (8) J; *Mogg 35284* (8) J; *Moss 2556* (8) J; *Moss 10526* (8) J; *Moss 14027* (8) J; *Moss 16184* (8) J; *Moss 17756* (8) J; *Nation 287* (8) BOL; *Nicholas 502* (8) NU; *O'Connor 59* (8) PRE; *Obermeyer 56* (8) PRE; *Pearson 22366* (8) BOL; *Peeters, Gericke & Burelli 121* (8) J; *Pegel 1* (8) NH; *Pegel 3* (8) NH; *Pegel 4* (8) NH; *Pegel Jhb 2* (8) NH; *Pettifer 195* (8) PRE; *Phillips 986* (8) NBG; *Pole-Evans 13211H* (8) PRE; *Pont 183* (8) PRE; *Prinsloo 1* (8) PRU; *Prosser s.n.* - Oct 1948 (8) J; *Raal 61* (8) J; *Rogers 12151* (8) BOL; *Rogers 704* (8) J; *Roux 16* (8) PRU; *Rudatis 39* (8) PRE; *Schmitz 8565* (8) PRE; *Singh 547* (8) NH; *Singh 611* (8) NH; *Singh 619* (8) NH; *Singh & Baijnath 323* (8) NH; *Singh & Baijnath 340* (8) NH; *Singh & Govender 412* (8) NH; *Singh & Govender 413* (8) NH; *Singh & Govender 415* (8) NH; *Singh & Govender 440* (8) NH; *Singh & Govender 562* (8) NH; *Singh & Govender 565* (8) NH; *Singh & Wiland 663* (8) NH; *Singh & Wiland 689* (8) NH; *Singh & Wiland 693* (8) NH; *Singh & Wiland 746* (8) NH; *Smit 1404* (8) PRU; *Smit 167* (8) PRU; *Smit 455* (8) PRU; *Smit 700* (8) PRU; *Smith 1130* (8) PRE; *Smith 2130* (8) PRE; *Stalmans 2351* (8) J; *Strey 9101* (8) NH; *Stutterheim D35* (8) PRE; *Taylor 174* (8) NU; *Teague 505* (8) BOL; *Theron 2112* (8) PRU; *Theron 515* (8) PRE; *Thode A1782* (8) PRE; *Thode A249* (8) PRE; *Thorncroft* s.n. - March 1905 (8) BOL; *Trauseld 868* (8) NU; *Turner 1127A* (8) PRE; *Tyson 1476* (8) BOL; *Tyson 1478* (8) GRA; *Van Dam TM 23373* (8) PRE; *Van der Zeyde & Van der Laarse* s.n. -Nov 1974 (8) NBG; *Van der Zeyde* 23/69 (8) NBG; *Van der Zeyde* s.n. - Nov 1970 (8) NBG; *Van Jaarsveld 28* (8) NBG; *Van Rensburg 25556* (8) J; *Van Rooyen 2568* (8) PRU; *Van Staden 1336* (8) GRA; *Van Staden 152* (8) PRU; *Van Wyk, S. 434* (8) PRE; *Weeks 25* (8) J; *Von Fintel 97* (8) NH; *Weintraub 22367* (8) BOL; *Williams 315* (8) NH; *Wilman 3662* (8) BOL; *Wood.* - Mar 1974 (8) J; *Young 732* (8) J; *Young A253* (8) PRE; *Zuma 17* (8) NH.

Archibald 6093 (9) GRA; *Barnes 130* (9) GRA; *Brink & Guillarmod s.n.* - Nov 1984 (9) GRA; *Chan 27* (9) GRA; *Cowling 1165* (9) GRA; *Drege 3104* (9) GRA; *Drege 9018* (9) PRE; *Ecklon & Zeyher 1063* (9) BOL; *Ecklon & Zeyher 1063* (9) GRA; *Ecklon & Zeyher 22298* (9) NBG; *Fourcade 2769* (9) BOL; *Gledhill & Archibald 6093* (9) GRA; *Hoffman 1002* (9) GRA; *Olivier 2615* (9) GRA; *Paterson 87* (9) BOL; *Paterson 87*

(9) GRA; *Phillips & Van Rensberg 2113* (9) J; *Thode s.n.* NH17784 (9) NH; *Thode A704* (9) NH; *Zeyher 4140* (9) BOL.

Codd 2215 (10) PRE; *Du Plessis 679* (10) PRU; *Du Plessis 679a* (10) PRU;*Gilliland 26127* (10) PRE; *Gilliland s.n.* - March 1955 (10) J (cultivated); *Leeman s.n.* - Sept. 1928 (10) PRE; *Leendertz 312(4072)* (10) PRE; *Reddy, Reddy & Reddy 520* (10) NH; *Singh 613* (5) NH; *Smit 877* (10) PRU; *Strey 3956* (10) PRE; *Theron 161* (10) PRU; *Venter & Vorster 5* (10) PRE; *Verdoorn 525* (10) PRE; *West 387* (10) PRE; *Wright 1549* (10) NU; *Young A230* (10) PRE.

Abbott 4949 (11) NH, UMTAMVUNA; *Abbott 5453* (11) NH, UMTAMVUNA; *Bester 3220* (11) PRU; *Bolus 8169* (11) BOL; *Codd 5759* (11) PRE; *Coetzee 2243a* (11) PRU; *Compton 21311* (11) NBG; *Devenish 1759* (11) PRE; *Dieterlen 229b* (11) NBG, NH; *Dold 679* (11) GRA; *Everson 215* (11) PRE; *Flanagan 1836* (11) PRE; *Greene 986* (11) NH; *Gibbs Russel 3456* (11) GRA; *Hilliard & Burtt 11947* (11) NU; *Hilliard & Burtt 11947* (11) PRE; *Hilliard & Burtt 16117* (11) NU; *Hilliard & Burtt 16805* (11) NU; *Hilliard & Burtt 17966* (11) NU; *Hilliard & Burtt 18039* (11) NU; *Hilliard & Burtt 18258* (11) NU; *Hilliard & Burtt 18411* (11) NU; *Hilliard & Burtt 18552* (11) NU; *Hilliard & Burtt 18749* (11) NU; *Hilliard & Burtt 18750* (11) NU; *Hilliard, Burtt & Manning 16039* (11) NU; *Jacobsen 1568* (11) PRE; *Johnstone 528* (11) NU; *Kluge 2652* (11) PRE; *Kurzweil 1313* (11) NBG; *MacOwan 104* (11) NBG; *Onderstall 1287* (11) PRE; *Rennie 1860* (11) NU; *Schmitz 7007* (11) PRE; *Singh 309* (11) NH; *Smuts & Gillett 2465* (11) PRE; *Strever 1202a* (11) NH; *Thode 2543* (11) NH; *Williamson 194* (11) J; *Wood 158* (11) NU.

Acocks 10605 (12) NH, PRE; *Anonymous 350* (12) NU; *Balkwill, Williamson & Smith 9902* (12) NH; *Breyer s.n.* - Jan 1922 (12) PRE; *Bester 709* (12) NH; *Bester 1594* (12) NH; *Bester 2881* (12) PRU; *Bredenkamp 75* (12) PRU; *Codd 5912* (12) PRE; *Coetzee 279* (12) PRU; *Compton 27121* (12) NBG; *Compton 27121* (12) PRE; *Daly & Sole 512* (12) GRA; *Dieterlen 149* (12) NBG; *Eckhardt 319* (12) PRU; *Flanagan 1173* (12) BOL; *Flanagan 1173* (12) GRA; *Flanagan 1173* (12) NBG; *Flanagan 1173* (12) PRE; *Galpin 1603* (12) GRA; *Galpin 1603* (12) PRE; *Guillard 10100* (12) PRE; *Hartley 8353* (12) J; *Haygarth 77* (12) NH; *Heideman 116* (12) J; *Heideman 98* (12) J; *Hilliard & Burtt 17959* (12) NU; *Hilliard & Burtt 17959* (12) PRE; *Hilliard & Burtt 18272* (12) NU; *Hilliard & Burtt 8534* (12) NU; *Jacobsz 2274* (12) NBG; *Jacobsz 2274* (12) PRE; *Joubert 1182/30* (12) BOL; *Macnae 1169* (12) J; *Moll 1044* (12) PRE; *Moodley 2310* (12) J; *Moss 3337* (12) J; *Moss 10818* (12) J; *Moss 13585* (12) J; *Moss 17736* (12) J; *Ngwenya 2764* (12) NH; *Phillipson & Huctchings 91* (12) KEI; *Reid 584* (12) PRE; *Sim 1127 (666)* (12) NU; *Singh 539* (12) NH; *Singh 652* (12) NH; *Singh 805* (12) NH; *Singh & Wiland 726* (12) NH; *Singh & Wiland 687* (12) NH; *Singh & Wiland 725* (12) NH; *Singh & Wiland 741* (12) NH; *Smit 114* (12) PRU; *Smit 1423* (12) PRU; *Stalmans 611* (12) PRE; *Strey 10117* (12) NH; *Thode 2539* (12) NH; *Venter 10942* (12) UNIN; *Walker s.n.* PRE 38122 (12) PRE; *Willie 11673* (12) NH; *Wood 22296* (12) NBG; *Wood 91* (12) NU; *Wood. 97* (12) NU; *Wood 1011* (12) NH; *Young A126* (12) PRE; *Youthed 162* (5) NH.

Acocks 16126 (13a) PRE; *Allen s.n.* GRA10287 (13a) GRA; *Anonymous 1-PL30* (13a) NBG; *Anonymous s.n.* - Jan 1901 (13a) GRA; *Archibald 4101* (13a) PRE; *Bayer & MacClean 60* (13a) PRE; *Bolus 18782* (13a) BOL; *Bolus 22374* (13a) BOL; *Bradley 16* (13a) GRA; *Breyer s.n.* - Feb. 1921 (13a) PRE; *Chering s.n.* - Jan 1914 (13a) PRE; *Compton 17622* (13a) NBG; *Compton 23389* (13a) NBG; *Creed 3* (13a) GRA; *Dold 180* (13a) GRA; *Duthie 12* (13a) PRU; *Flanagan 813* (13a) BOL; *Flanagan 813* (13a) GRA; *Flanagan 813* (13a) NBG; *Fourcade 353* (13a) BOL; *Fourcade 353* (13a) GRA; *Fourcade 4189* (13a) BOL; *Fourcade 4196* (13a) BOL; *Fourcade 4548* (13a) BOL; *Fourcade 4548* (13a) PRE; *Fourcade 5364* (13a) BOL; *Fourcade 671* (13a) GRA; *Geel 23* (13a) GRA; *Guillarmod & Brink 64* (13a) GRA; *Guillarmod 10700* (13a) GRA; *Guillarmod 8238* (13a) GRA; *Hall 206* (13a) NBG; *Harries s.n.* - Feb 1930 (13a) BOL; *Hilner 185* (13a) GRA; *Hilner 185* (13a) PRE; *Hobson 1344* (13a) GRA; *Howe s.n. 1979* (13a) GRA; *Howe s.n. 1980* (13a) GRA; *Jessop 1010* (13a) GRA; *Johns s.n.* - April 1942 (13a) NBG; *JR & BR s.n.* - Oct 1931 (13a) BOL; *Lanham s.n.* - Jan 1980 (13a) GRA; *Lanham s.n.* - Jan. 1980 (13a) PRE; *Leighton 2619* (13a) BOL; *Lewis 3611* (13a) NBG; *Lombard s.n.* NBG727/35 (13a) NBG; *MacClean & Bayer 196* (13a) PRE; *MacOwan 1899* (13a) GRA; *MacOwan 1899* (13a) NBG; *Marloth 7490* (13a) PRE; *Moran 94* (13a) (KMG); *Muir 1827* (13a) BOL; *Nicholas & Smook 2444* (13a) PRE; *Paterson 1218* (13a) GRA; *Richardson 10* (13a) GRA; *Sim 1122* (13a) BOL; *Sim 1123* (13a) NBG; *Stanton 28* (13a) NU; *Starke 100/27* (13a) BOL; *Steyn 751* (13a) NBG; *Steytler s.n.* - Feb 1932 (13a) BOL; *Thode A1050* (13a) PRE; *Wirminghaus 224* (13a) GRA; *Wirminghaus s.n.* (13a) GRA.

Blenkinson sub Moss 16037 (13b) J; *Booi 95* (13b) GRA; *Galpin 3085* (13b) PRE; *Hoare 476* (13b) PRU; *Lubke 2040* (13b) GRA; *Rogers 25480* (13b) GRA; *Scharf 1074* (13b) PRE; *Seagrief 4070* (13b) GRA; *Sim 657* (13b) NU; *Stirton 777* (13b) NU; *Theron 1692* (13b) PRE; *Van Dam s.n.* - Sep. 1918 (13b) PRE; *Van Wyk & Matthews 7946* (13b) KEI.

Cloete 1104 (14) KEI; *Duthie 746* (14) BOL; *Ecklon & Zeyher 270* (14) NBG; *Gordon-Gray 666* (14) NU; *Johnson 9* (14) GRA; *Muir 1326* (14) PRE; *Muir 1827* (14) BOL; *Ofsowitz 9* (14) NBG; *Salisbury 76* (14) GRA; *Shackleton 412* (14) PRE; *Stokoe s.n.* - Mar. 1948 (14) NBG; *Thode A2398* (14) PRE; *Turner 70* (14) GRA; *Tyson 8514* (14) PRE; Tyson *s.n.* - May 1916 (14) PRE; *Whitehead 18* (14) GRA; *Williamson 97* (14) GRA.

Fourcade 4498 (15) BOL; *Daly 767* (15) GRA; *Flanagan 2138* (15) GRA; *MacOwan 1594* (15) NBG; *Granger 3600* (15) KEI; *Hilliard & Burtt 18712* (15) NU; *Hilliard & Burtt 19051* (15) NU; *Flanagan 2843* (15) PRE; *Goossens 190* (15) PRE; *Goossens 193* (15) PRE; *Long 526* (15) PRE; *Bester 1343* (15) PRU; *Dieterlen s.n.* - Nov. 1918 (15) PRE; *Galpin s.n.* - Aug 1932 (15) BOL.

Bester 2882 (16) PRU; *Bolus 8713* (16) BOL; *Cloete 1104* (16) GRA; *Daly 565* (16) GRA; *Emmerson 80* (16) GRA; *Fourcade 4134* (16) BOL; *Fourcade 535* (16) BOL; *Frankish 233* (16) NU; *GeoPotts 1688* (16) BOL; *Germishuizen 1185* (16) PRE; *Gibbs Russell 3420* (16) PRE; *Huckkloof* 1072 (16) GRA; *J & R Rennie 140* (16) BOL; *Leighton 2780* (16) BOL; *MacOwan 1898* (16) NBG; *Malan s.n.* - Nov 1945 (16) NBG; *Rennie 140* (16) BOL; *Singh 645a* (16) NH; *Schonberg 2796* (16) GRA; *Schonland 3785* (16) GRA; *Schonland 4468* (16) PRE; *Schönnberg 2796* (16) PRE; *White 1072* (16) GRA.

Abbott 4585 (17) NH, PRU, UMTAMVUNA; *Abbott 5423* (17) NH, UMTAMVUNA; *Abbott 5551* (17) NH, UMTAMVUNA; *Abbott 6124* (17) PRU; *Acocks 12946* (17) PRE; *Allsopp 728* (17) NH; *Allsopp 921* (17) NH; *Archibald 9* (17) GRA; *Archibald 42* (17) GRA; *Arkell 367* (17) NH; *Arkell 395* (17) NH; *Arkell & Abbott 169* (17) NH; *Balkwill & Balkwill 4554* (17) J; *Balkwill & Balkwill 4889* (17) J; *Bandert 24* (17) GRA; *Bayliss 2547* (17) NBG; *Bester 740* PRU; *Bester 1384* (17) NH; *Braun 455* (17) PRE; *Codd & Dyer 6250* (17) PRE; *Compton 27211* (17) PRE; *Cooke 20* (17) NH; *Edwards & Potgieter 1692* (17) NH; *Fairall 57* (17) NBG; *Fakude 15* (17) NH; *Greene 415* (17) NH; *Hilliard & Burtt 13729* (17) PRE; *Hilliard & Burtt 18644* (17) PRE; *Hutchinson, Forbes & McClean 52* (17) NH; *Jacobsz 3943* (17) PRE; *Lansdell NH34266* (17) NH; *Lawn 783* (17) NH; *Lawn 1746* (17) NH; *Levett 25* (17) NH; *Makötter 8692* (17) NH; *Milner NH23260* (17) NH; *Mogg 3449* (17) PRE; *Ngwenya 419* (17) NH; *Ngwenya 486* (17) NH; *Ngwenya 3189* (17) NH; *Ram s.n.* - Mar. 1974 (17) J; *Rogers 24583* (17) NH; *Ross 159* (17) NH; *Rudatis 1748* (17) PRE; *Schonland 4144* (17) GRA; *Singh & Baijnath 419* (17) NH; *Singh & Wiland 695* (17) NH; *Strey 5170* (17) NH; *Symons s.n.* TM15702 (17) PRE; *Taylor 5376* (17) NBG; *Thode 2533* (17) NH, PRE; *Trauseld 869* (17) PRE; *Ward 1448* (17) NH; *Ward 1655* (17) NH; *Williams 536* (17) NH; *Wood 327* (17) NH; *Wood, S.E. 77* (17) J; *Wood, S.E. 78* (17) J; *Wood, S.E. 83* (17) J; *Wylie NH28020* (17) NH; *Young 2255* (17) PRE.

Abbott 1245 (18a) PRU; *Acocks 11071* (18a) PRE; *Acocks 12946* (18a) NH; *Adamson D279* (18a) PRE; *Archibald 3825* (18a) GRA; *Archibald 3843* (18a) GRA; *Archibald 4546* (18a) GRA; *Archibald 5087* (18a) GRA; *Balkwill & Balkwill 9375* (18a) J; *Barker 2124* (18a) NBG; *Bayliss 5649* (18a) PRE; *Bester 1187* (18a) NH; *Beyde 301* (18a) NBG; *Bolus 198* (18a) BOL; *Botha 2868* (18a) PRE; *Bredenkamp 76* (18a) PRU; *Chan 51* (18a) GRA; *Cloete 511* (18a) NH; *Cloete 1565* (18a) GRA, NH; *Coleman 748* (18a) NH; *Cotterrell 63* (18a) GRA; *Court 432* (18a) GRA; *Creed 2* (18a) GRA; *Daly & Cherry 944* (18a) GRA; *Daly & Cherry* NH12735; *Daly & Sole 304* (18a) GRA; *Daly 766* (18a) GRA; *Devenish 1776* (18a) PRE; *Dieterlen 176* (18a) NBG; *Dieterlen 176* (18a) PRE; *Dold & Booi 477* (18a) GRA; *Dold 1134* (18a) GRA; *Dold 883* (18a) GRA; *Du Toit 55* (18a) PRE; *Engelbrecht 809* (18a) PRE; *Esterhuysen 6562* (18a) BOL; *Fourcade 4424* (18a) BOL; *Galpin 1814* (18a) GRA; *GeoPotts 649* (18a) BLFU; *Gilliland s.n.* - Nov. 1952 (18a) J; *Gonlimis s.n.* - April 1944 (18a) BOL; *Goossens 192* (18a) PRE; *Granger 3870* (18a) KEI; *Green 265* (18a) NH; *Hargreaves 3840* (18a) NU; *Heideman s.n.* - April 1978 (18a) J; *Hill 16* (18a) GRA; *Hobson 1255* (18a) GRA; *Hobson 1275* (18a) GRA; *Johnson 764* (18a) GRA; *Keytel 28* (18a) PRE; *Köhler 14* (18a) PRU; *Leighton 835/33* (18a) BOL; *Lucas 19* (18a) J; *Maguire 25552* (18a) J; *Mauve 3* (18a) NU; *Mogg 16223* (18a) PRE; *Mogg 3479* (18a) PRE; *Mogg 3449A* (18a) PRE; *Mogg 34572* (18a) J; *Moss 10819* (18a) J; *Moss 11932* (18a) J; *Moss 13492* (18a) J; *Moss 5576* (18a) J; *MRL 3154* (18a) BOL; *Ngwenya 1478* (18a) NH;*Nicholas 1055* (18a) NH; *Nombekela 118* (18a) NH; *Nombekela 13* (18a) NH; *Pahl 370* (18a) GRA; *Peacock SBP 062* (18a) NH; *Peeters, Gericke & Burelli 347* (18a) J; *Pegler 689* (18a) BOL; *Pienaar 72A*(18a) NU; *Reddy, Reddy & Reddy 726* (18a) NH; *Reed 73* (18a) GRA; *Rennie 222* (18a) GRA; *Repton 3604* (18a) PRU; *Riddles 45* (18a) PRE; *RVC Biology Camp s.n.* - Feb 1944 (18a) GRA; *Saaiman 277* (18a) PRE; *Schlechter 2492* (18a) GRA; *Schlechter 2492* (18a) J; *Schlechter 2948* (18a) NH; *Schmitz 6218* (18a) PRE; *Schmitz 6732* (18a) PRE; *Schmitz 8021* (18a) PRE; *Scully 107* (18a) NBG; *Sim 673* (18a) NU; *Singh & Baijnath* 239 (18a) NH; *Singh & Baijnath 249* (18a) NH; *Singh & Baijnath 260* (18a) NH; *Singh & Baijnath 420* (18a) NH; *Singh & Baijnath 700* (18a) NH; *Singh & Wiland 229*

(18a) NH; *Singh & Wiland 661* (18a) NH; *Singh & Wiland 664* (18a) NH; *Singh & Wiland 719* (18a) NH; *Singh & Wiland 745* (18a) NH; *Singh & Wiland 749* (18a) NH; *Singh & Wiland 752* (18a) NH; *Singh 532* (18a) NH; *Singh 536* (18a) NH; *Singh 537* (18a) NH; *Singh 795* (18a) NH; *Singh 818* (18a) NH; *Singh 822* (18a) NH; *Singh 829* (18a) NH; *Singh, Baijnath & Johnson 211* (18a) NH; *Smook 2135* (18a) PRE; *Sole 393* (18a) GRA; *Story 2115* (18a) PRE; *Strever 249* (18a) NH; *Strey 10524* (18a) NH; *Survey: Thos Baines Nature Reserve s.n.* - April 1969 (18a) GRA; *Sutton 501* (18a) GRA; *Taylor 108* (18a) J; *Taylor 5946* (18a) NBG; *Theron 780* (18a) PRU; *Thode 2545* (18a) PRE; *Thode A703* (18a) NH; *Tuko 1* (18a) NH; *Tyson 1095* (18a) BOL; *Tyson 1095* (18a) NBG; *Tyson 480* (18a) BOL; *Van Ginkel 294* (18a) PRE; *Van Rensburg s.n.* (18a) J; *Van Rooyen 2524* (18a) PRU; *Van Wyk 2376* (18a) PRU; *Venter s.n.* - Nov. 1985 (18a) PRU; *Victor 857* (18a) GRA; *Walker s.n.* - Oct. 1952 (18a) J; *Walker s.n.* - Oct. 1952 (18a) PRE; *Werger 281* (18a) PRE; *Werger 315* (18a) PRE; *Wirminghaus 372* (18a) GRA; *Zeyher 950* (18a) NBG.*Zietsman 2586* (18a) NH;

Abbott 152 (18b) PRU, UMTAMVUNA; *Abbott 1245* (18b) NH *Abbott 4688* (18b) NH, PRU UMTAMVUNA; *Abbott 6124* (18b) NH; *Balkwill, Hartley & Reddy 8352* (18b) J; *Balkwill, Hartley & Reddy 8366* (18b) J; *Barrett 446* (18b) PRE; *Bayliss 8072* (18b) GRA; *Bester 924* (18b) NH, PRU; *Bezuidenhout 105* (18b) PRE; *Blenkinson sub Moss 14498* (18b) J; *Brusse s.n.* - Dec 1978 (18b) J; *Burtt-Davy 15033* (18b) J; *Codd 1849* (18b) PRE; *Collins s.n.* TM 7017 (18b) PRE; *De Lange FA1316* (18b) (KMG); *De Lange FA1334* (18b) PRE ; *Dieterlen 536* (18b) PRE; *Dieterlen s.n.* - Oct. 1918 (18b) PRE; *Du Preez 693* (18b) BLFU; *Evans 3998* (18b) BOL; *Flanagan 1174* (18b) PRE; *Frankish 255* (18b) NBG; *Freer 30* (18b) GRA; *Galpin 13840* (18b) PRE; *Galpin s.n.* - Oct 1934 (18b) BOL; *GeoPotts 5114* (18b) BLFU; *GeoPotts 548* (18b) BLFU; *Gillett 4599* (18b) BOL; *Gilliland s.n.* - Nov. 1951 (18b) J; *Hall 27* (18b) NH; *Jacobsz 2155* (18b) NBG; *Lewis 755* (18b) NBG; *Louw 686* (18b) PRE; *Ludick 6* (18b) PRU; *Macnae 1389* (18b) J; *MacOwan 1649* (18b) NBG; *Meldrum 49* (18b) GRA; *Mogg 3479A* (18b) PRE; *Moll 4672* (18b) NH; *Moloi & Hiralal 8* (18b) NH; *Moss & Rogers 996* (18b) J; *Moss 14121* (18b) J; *Moss 17072* (18b) J; *Moss 17653* (18b) J; *Moss 17676* (18b) J; *Ngwenya 1533* (18b) NH; *Peters & Maguire s.n.* - Jan. 1995 (18b) J; *Phillip 932* (18b) NBG; *Phillips s.n.* PRE38026 (18b) PRE; *Retief 992* (18b) PRE; *Ross 45* (18b) NBG; *Rudatis 75* (18b) PRE; *Sandman s.n.* - Sept 1958 (18b) NBG; *Schlechter 2948* (18b) GRA; *Schmitz 9095* (18b) PRE; *Shirley s.n.* - Oct. 1964 (18b) NBG; *Singh 281* (18b) NH; ~~*Singh 286* (18b) NH~~; *Singh 290* (18b) NH; *Singh 362* (18b) NH; *Singh 425* (18b) NH; *Singh 434* (18b) NH; *Singh 569* (18b) NH; *Singh 616* (18b) NH; *Singh & Baijnath 240* (18b) NH; *Singh, Baijnath & Johnson 212* (18b) NH; *Singh & Baijnath 259* (18b) NH; *Singh & Baijnath 268* (18b) NH; *Singh & Govender 557* (18b) NH; *Smook 6023* (18b) PRE; *Smook 6436* (18b) PRE; *Steyn 933* (18b) NBG; *Stokoe s.n.* - Nov. 1949 (18b) NBG; *Strey 5986* (18b) NH; *Strey 7261* (18b) NH; *Thode A1296* (18b) NH; *Tyson 1095* (18b) NBG; *Tyson 480* (18b) NBG; *Van Dam s.n.* - April 1917 (18b) PRE; *Van Staden 1327* (18b) GRA; *Van Wyk 3865* (18b) PRU; *Victor 886* (18b) PRE; *Williams 481* (18b) NH; *Wood 101* (18b) NBG; *Wylie NH27957* (18b) NH; *Young & Moss 567* (18b) J; *Young 1105* (18b) J; *Zietsman 2483a* (18b) (KMG).

Bremer & Ackerman 43 (19) J; *Burgoyne 422* (19) PRU; *Burgoyne 703* (19) PRU; *Burn 2121* (19) PRE; *Burrows 4744* (19) J; *Compton 24578* (19) NBG; *Compton 25210* (19) PRE; *Compton 26991* (19) NBG; *Compton 26991* (19) PRE; *Compton 30100* (19) PRE; *Compton 32165* (19) PRE; *Curator Pretoria Botanic*

Garden 1399 (19) PRE; *Davidson s.n.* (19) J; *Dold 2631* (19) GRA; *Drews 105* (19) PRE; *Galpin s.n.* - Nov 1937 (19) BOL; *Jacobsz 2982* (19) PRE; *Moss 15426* (19) J; *Raal 1006* (19) PRE; *Smit 1091* (19) PRU; *Van der Zeyde s.n.* NBG196/72 (19) NBG; *Venter 10890* (19) UNIN; *Venter 11137* (19) PRU; *Venter 11137* (19) UNIN; *Young 1787* (19) J.

Morley 84 (20) PRE; *Paterson 3395* (20) GRA; *Schönberg s.n.* - Sept. 1899 (20) GRA; *Singh 624* (20) NH.

Compton 19195 (21) NBG; *Lewis 3009* (21) NBG; *Muir 2843* (21) PRE; *Sim 653* (21) NU; *Sim 1500* (21) BOL; *Stokoe s.n.* - May 1950 NBG; *Wilman 975* (21) BOL; (21).

Devenish 1174 (22) NH; *Heideman 110* (22) J; *Jenkins s.n.* - Nov. 1910 (22) PRE; *McDonald 246* (22) NU; *Moss 13657* (22) J; *Moss 17735* (22) J; *Moss 7982* (22) J; *Moss 8378* (22) J; *Robertse 636* (22) PRU; *Singh 157* (22) NH; *Singh 456* (22) NH; *Wood, S.E. 130* (22) NU.

Abbott 2089 (23) NH, UMTAMVUNA; *Abbott 5417* (23) NH, PRU, UMTAMVUNA; *Abbott 5545* (23) PRU, UMTAMVUNA; *Acocks & Hafstrom 256* (23) PRE; *Acocks 10587* (23) NH; *Acocks 9301* (23) PRE; *Acocks 11771* (23) NH; *Arkell & Abbott 138* (23) NH; *Baijnath 187* (23) PRE; *Balkwill 7855* (23) J; *Balkwill 9423* (23) J, PRE; *Balkwill M.S. 1.51* (23) J; *Balkwill & Balkwill 4735* (23) J; *Balkwill & Balkwill 5220* (23) J; *Balkwill, Balkwill & Green 5366* (23) J; *Bayliss 2379* (23) NBG; *Beattie 45* (23) NU; *Bester 23* (23) PRU; *Bester 1187* (23) PRU; *Beverley 347* (23) PRE; *Bews 647* (23) NU; *Bloem 186* (23) PRE; *Bodenstein 129* (23) NH; *Bolus 8711* (23) BOL, PRE; *Bolus 10656* (23) BOL; *Bolus 12359* (23) BOL; *Bradfield s.n.* - Sept. 1934 (23) PRE; *Breyer 17953* (23) PRE; *Breyer s.n.* - Jan. 1918 (23) PRE; *Brown & Shapiro 16* (23) PRE; *Buitendag 407* (23) PRE; *Burgoyne 499* (23) PRU; *Burgoyne 682* (23) PRU; *Burrows & Burrows 5005* (23) PRE; *Cloete 862* (23) NH; *Codd & Winter 3289* (23) PRE; *Codd 3181* (23) PRE; *Codd 5750* (23) PRE; *Codd 6659* (23) PRE; *Collins s.n.* - Nov. 1912 (23) PRE; *Collins TM13202* (23) PRE; *Compton 19724* (23) NBG; *Compton 24518* (23) NBG; *Compton 26129* (23) NH; *Compton 27149* (23) NBG, NH; *Compton 28249* (23) NBG, NH; *Compton 29266* (23) NBG, NH; *Cron 204* (23) J; *Crook 52* (23) NH; *Culverwell 570* (23) PRE; *Davidson 2007* (23) J; *Davidson 2450* (23) UMTAMVUNA; *Davidson s.n.* - Oct. 1978 (23) J; *Deall 2616* (23) PRE; *Devenish 691* (23) PRE; *Devenish 765* (23) PRE; *Devenish 1521a* (23) NU; *Devenish 1757* (23) PRE; *Dieterlen 650* (23) NH, NBG, PRE; *Dold 997* (23) GRA; *Dold, Cloete & White 2973* (23) GRA; *Dove 16* (23) NBG, PRE; *Drews 11* (23) PRE; *Du Plessis 581* (23) PRE, PRU; *Du Plessis 1220* (23) PRU; *Du Preez 1128* (23) BLFU; *Dyer 1763* (23) GRA; *Dyer s.n.* (23) J; *Ellery & Ellery 92/207* (23) J; *Esterhuysen 28034* (23) BOL; *Everson 212* (23) PRE; *Flanagan 2771* (23) NBG; *Forrester & Gooyer 75* (23) PRE; *Fourcade 4475* (23) BOL, NBG; *Galpin 1101* (23) BOL, NBG, NH, PRE; *Galpin 10244* (23) PRE; *Galpin s.n.* - Aug. 1932 (23) BOL; *Gerstner 2597* (23) BOL; *Getliffe, Hearne & Kerfoot 54* (23) J; *Gilfilland 1424* (23) PRE; *Glen 2315* (23) NH, PRE; *Goodman s.n.* (23) J; *Gordon 121* (23) NH; *Greene 1166* (23) NH; *Greene 1169* (23) NH; *Harrison 21* (23) NH; *Hartley 1468* (23) J; *Haygarth 75* (23) NH; *Henrici 1038* (23) PRE; *Henrici 1161* (23) PRE; *Hewitt PRE57481* (23) PRE; *Hillary 6* (23) NU; *Hilliard 8170* (23) NU;

Hilliard & Burtt 6239 (23) NU; *Hilliard & Burtt 9508* (23) NU; *Hilliard & Burtt 11766* (23) PRE; *Hilliard & Burtt 17791* (23) PRE; *Hilliard & Burtt 18783* (23) NU; *Hilliard & Burtt 19063* (23) NU; *Hobson 258* (23) GRA; *Hobson 547* (23) GRA; *Holt 27* (23) PRE; *Hone 28* (23) PRE; *Hutchings 663* (23) KEI, NU; *Hutchings & Plumstead 1768* (23) KEI; *Isaacs 297* (23) PRE; *Jacobsen 1437* (23) PRE; *Jacobsz 1300* (23) PRE; *Jacobsz 1661* (23) PRE; *Janse 3023* (23) PRE; *Jordaan 634* (23) NH; *Jordaan 1091* (23) NH; *Jordaan 2497* (23) PRE; *Junod 159* (23) PRE; *Junod 4132* (23) PRE; *Kerfoot* s.n. - Oct. 1979 (23) J; *Killick & Strey 2697* (23) PRE; *King 291* (23) PRE; *Kluge 1377B* (23) PRE; *Kluge 1385* (23) PRE; *Kluge 1402* (23) PRE; *Kowarsky sub Moss 12082* (23) J; *Lawn 53* (23) NH; *Lawn 1187* (23) NH; *Leendertz 4071* (23) PRE; *Leendertz 7350* (23) PRE; *Leendertz TM7907* (23) PRE; *Leibenberg 7499* (23) PRE; *Leipoldt s.n.* - Nov. 1917 (23) PRE; *Linley 209* (23) J; *Lubke 415* (23) NH, PRU; *MacDevette 1798* (23) NH; *Maguire s.n.* - Nov 1943 (23) J; *Maguire s.n.* - Oct. 1943 (23) J; *Martin 63* (23) NU; *Martin 476* (23) NBG; *Martin 8948* (23) GRA; *Matthews 1234* (23) NH, PRU; *Matthews 1257* (23) NH, PRU; *Matthews 337* (23) PRE, PRU; *Matthews 719* (23) PRE; *Matthews 931* (23) PRE, PRU; *Mauve & Venter 5198* (23) PRE; *Mbhele 4* (23) NH; *McClean 11a* (23) NH; *McKnown 54* (23) NU; *Mes PRE57482* (23) PRE; *Meyer 2654* (23) PRE; *Miller 3010* (23) PRE; *Mogg 4485* (23) PRE; *Mogg 4486* (23) PRE; *Mogg 5882* (23) PRE; *Mogg 33288* (23) J; *Moll 251* (23) NU; *Moll 2545* (23) PRE; *Moll 3394* (23) PRE; *Moll 4755* (23) NH; *Moss 3334* (23) J; *Moss 15428* (23) J; *Moss 15428* (23) PRE; *Moss 17125* (23) J; *Moss sub Moss 18515* (23) J; *Mugwedi 1478* (23) J, PRE; *Muller & Viljoen 2* (23) PRE; *Ngcobo 109* (23) NH; *Ngwenya 420* (23) NH; *Ngwenya 683a* (23) NH; *Ngwenya 790* (23) NH, PRE; *Ngwenya 1058* (23) NH; *Ngwenya 1468* (23) NH; *Ngwenya 1740* (23) NH; *Nicholas & Button 1981* (23) NH; *Nicholas & Smook 2443* (23) NH, PRE; *Niekerk 7524* (23) PRE; *Noome TM20786* (23) PRE; *Page sub Moss 15934* (23) J; *Peacock 86* (23) NH; *Phillipson 3199* (23) GRA, PRE; *Phillipson & Furness 95* (23) PRE; *Pienaar 72* (23) NU; *Pooley 2287* (23) NU; *Pott-Leendertz 4686* (23) PRE; *Pott-Leendertz 5167* (23) BOL, PRE; *Pott-Leendertz 5456* (23) PRE; *Prior 247* (23) PRE; *Puff 781224 – 3/1* (23) J; *Reid 413* (23) PRE; *Reid 1768* (23) PRE; *Reid 1922* (23) PRE; *Rennie 85* (23) NU; *Rennie 687* (23) NU; *Repton 3512* (23) PRE; *Repton 4090* (23) PRE; *Repton 4725* (23) PRE; *Repton 5780* (23) PRE; *Reynolds s.n.* (23) PRE; *Robbertse 634* (23) PRU; *Rogers 2539* (23) GRA; *Rogers 21416* (23) GRA; *Ross 5* (23) NH; *Rudatis 1151* (23) NH; *Ruddock 41* (23) NU; *Saunders s.n.* (23) BOL; *Schelpe 920* (23) NH, NU; *Schmitz 7037* (23) PRE; *School, College 48* (23) PRE; *Schrire 595* (23) NH; *Schrire 597* (23) NH; *Schrire 612* (23) NH; *Shirley 90* (23) NU; *Siebert & Siebert 2236* (23) PRE; *Sikhakhane 186* (23) NH; *Sim 644* (23) NU; *Singh 305* (23) NH; *Singh 388* (23) NH; *Singh 443* (23) NH; *Singh 454* (23) NH; *Singh 592* (23) NH; *Singh 601* (23) NH; *Singh 644* (23) NH; *Singh 821* (23) NH; *Singh & Baijnath 270* (23) NH; *Singh & Cloete 586* (23) NH; *Singh & Govender 427* (23) NH; *Singh & Wiland 750* (23) NH; *Smit 73* (23) PRE, PRU; *Smit 1331* (23) PRU; *Soloman 61* (23) NU; *Spies 1472* (23) PRE; *Stalmans 235* (23) PRE; *Steyn 973* (23) NBG; *Stirton 203* (23) NU; *Stirton 444* (23) NU; *Strey 2850* (23) PRE; *Strey 4474* (23) NH; *Strey 5538* (23) NH; *Strey 6838* (23) PRE; *Strey 10023* (23) NH; *Strey 10522* (23) NH; *Taylor 5047A* (23) NBG; *Thode 2535* (23) NH, PRE; *Thode 2536* (23) NH, PRE; *Thode A1646* (23) NH, PRE; *Thom & Gillham 3320* (23) PRE; *Thomas 23* (23) NBG; *Van Dam TM26307* (23) PRE; *Van der Zeyde 594* (23) NBG; *Van der Zeyde s.n.* - Nov. 1969 (23) NBG; *Van Rensburg s.n.* - Nov. 1939 (23) J; *Van Wyk 12534* (23) PRU; *Venter 950* (23) PRE; *Venter 10896* (23) UNIN; *Venter 11093* (23) PRE, UNIN; *Ward 1484* (23) NH; *Ward 4284* (23) NH, NU; *Ward & Begg 11349* (23) NH, PRE; *Ward & Rajh 11673* (23) NH; *Ward, M.C. 1553* (23) NH;

Wiley NH21683 (23) NH; *Williams 480* (23) NH; *Williams 689* (23) NH; *Williams 1135* (23) NH; *Williams 1141* (23) NH; *Williamson 324* (23) J; *Wilsenach s.n.* - Oct. 1958 (23) J; *Wilson 31* (23) NU; *Wood, S.E. 81* (23) J; *Wood, S.E. 101* (23) J; *Wood, S.E. 126* (23) NU; *Wood, S.E. 151* (23) NU; *Wood, S.E. 163* (23) NU; *Wood 1030* (23) NH, NBG; *Wood 4660* (23) NBG (Rhodohypoxis); *Wood 9293* (23) NH; *Wright 1566* (23) NU; *Wright 1958* (23) NU; *Wright 2258* (23) NU; *Young A146* (23) PRE; *Young A159* (23) PRE; *Young A257* (23) PRE; *Young A437* (23) PRE; *Young 1863* (23) PRE; *Young & Young 1402* (23) J; *Youthed 193* (23) PRE.

Balkwill, Manning & Meyer 1075 (24) NU; *Devenish 1521* (24) NU; *Hoener 1623* (24) PRE; *Strever 1376* (24) NH.

Abbott 657 (25) NH, UMTAMVUNA; *Abbott 2266* (25) UMTAMVUNA; *Barker 17716* (25) NBG; *Gordon-Gray 949* (25) NU; *Strever 1376* (25) NH; *Strey 5990* (25) NH, PRE; *Van Wyk 5111* (25) PRU.

Abbott 403 (26a) NH; *Abbott, 644* (26a) NH, UMTAMVUNA; *Abbott, 2863* (26a) PRU, UMTAMVUNA; *Abbott, 3323* (26a) UMTAMVUNA; *Abbott, 6519* (26a) PRU, UMTAMVUNA; *Acocks 9331* (26a); *Acocks 9517* (26a) PRE; *Acocks 10832* (26a) PRE; PRE; *Baker s.n.* TM 14173 (26a) PRE; *Bankes 1326/28* (26a) BOL; *Barker 7951* (26a) NBG; *Bokelmann 1-PL9* (26a) NBG; *Botany III field trip (Puff)* (26a) *55* J; *Bourquin 147* (26a) NU; *Britten, 853* (26a) GRA; *Bross s.n.* (26a) NU; *Cawe 206* (26a) UNIN; *Codd 8157* (26a) PRE; *Dahlstrand 1793* (26a) GRA; *Dahlstrand 1793* (26a) PRE; *Dieterlen 536* (26a) PRE; *Dieterlen 639* (26a) NBG, PRE; *Dlamini 11* (26a) NH; *Dold, 584* (26a) GRA; *Drummer 2437a* (26a) NBG; *Duthie 735* (26a) J; *Flanaganii 1174* (26a) NBG; *Fourcade 535* (26a) GRA; *Furness & Phillipson 342* (26a) PRE; *Galpin 3343* (26a) PRE; *Garabedien s.n.* (26a) NBG; *Gemmell s.n.* (26a) BLFU; *Geo Potts 2877* (26a) BLFU; *Germishuizen 3143* (26a) PRE; *Gordon-Gray 696* (26a) NH; *Gordon-Gray 1015* (26a) GRA; *Gordon-Gray 237* (26a) NU; *Guillarmod 387* (26a) PRE; *Haygarth s.n.* TM 22309 (26a) PRE; *Hemm 390* (26a) J; *Hilliard & Burtt 11899* (26a) PRE; *Hobson 576* (26a) GRA; *Howlett & Howlett 36468* (26a) PRE; *Hutchings 752* (26a) NU; *Hutchings 752* (26a) UNIN; *Hutchings 943* (26a) UNIN; *Karsten s.n.* PRE61038 (26a) PRE; *Kerfoot K7225* (26a) J; *Liebenberg 6787* (26a) PRE; *Lillieciona 6* (26a) NU; *Lubbe, 137* (26a) PRU; *Lussem 50* (26a) NBG; *Mogg 13316* (26a) PRE; *Mogg 13946* (26a) PRE; *Mogg 27231* (26a) J; *Mogg 27348* (26a) J; *Mogg 27455* (26a) J; *Mogg 28321* (26a) J; *Mogg 29870* (26a) J; *Mogg 29926* (26a) J; *Mogg s.n.* (26a) PRE; *Moll 251* (26a) NBG; *Moll 2860* (26a) PRE; *Moss & Rogers 483* (26a) J; *Moss & Rogers 931* (26a) J; *Moss 19744* (26a) J; *Moss s.n.* - Jul 1944 (26a) J; *Muller 2073* (26a) PRE; *Müller 333* (26a) NBG; *Müller 369* (26a) NBG; *Nass s.n.* (26a) NBG; *Nicholas & Perks 1495* (26a) PRE; *Nicholas & Smook 2414* (26a) UNIN; *O'connor 102* (26a) PRE; *Oliver 6733* (26a) PRE; *Peeters, Gericke & Burelli 611* (26a) PRE; *Peters, Gericke & Burelli 611* (26a) J; *Phillips 679* (26a) NBG; *Phillips 729* (26a) NBG; *Phillips 744* (26a) NBG; *Pienaar 678* (26a) PRE; *Pooley 105* (26a) NU; *Puff 78/220 - 1/3* (26a) J; *Roberts 2349* (26a) PRE; *Scheepers 34* (26a) PRE; *Schmitz 4472* (26a) PRE; *Schyff 4679* (26a) PRU; *Schyff 5908* (26a) PRU; *Sim 642* (26a) NU; *Stalmans 269* (26a) PRE; *Stam 39* (26a) PRE; *Strever 804* (26a) PRE; *Strey 5974* (26a) NU; *Strey 9149* (26a) PRE; *Tod 18* (26a) NU; *Vahrmeijer & Tolken 908* (26a) PRE; *Van der Meulen 611-128* (26a) PRE; *Van der Schiff 5908* (26a) PRE; *Venter 2638* (26a) PRE; *Von Fintel 52* (26a) NH; *Vorster 328e* (26a) PRE; *Ward 4131* (26a) NU; *Weintraub sub Moss 17124* (26a) J; *Weintraub* *sub Moss 17328* (26a) J; *Williams 944* (26a) NH; *Wilsenach s.n.* - Dec 1963 (26a) J; *Wilsenach s.n.* (26a) PRE; *Wood 6633* (26a) NH*; Wylie s.n.* TM 34325 (26a) PRE; *Young 15016* (26a) J.

Abbott, 644 (26b) UMTAMVUNA; *Abbott 2863*(26b) NH; *Abbott 5374* (26b) NH; *Archibald 4946* (26b) GRA; *Arkell & Abbott 122*(26b) NH; *Braun 1247* (26b) PRE; *Braun 896* (26b) PRE; *Cloete 5819*(26b) NH; *Cloete 5859*(26b) NH; *De Vries 85* (26b) PRE; *Edwards 261* (26b) NU; *Edwards 850* (26b) PRE; *Gerstner NH22261*(26b) NH; *Hall 16* (26b) NU; *Haygarth 70*(26b) NH; *Hilliard & Burtt 18832* (26b) NU; *Hutchings 648* (26b) KEI; *Kluge 320* (26b) PRE; *Kluge 320* (26b) PRU; *Leendertz s.n.* TM11975 (26b) PRE; *Louw 2415* (26b) PRE; *MacDevette 284* (26a) NH; Matthews 1134 (26a) NH; *Mogg 4487* (26b) PRE; *Mogg 881* (26b) PRE; *Nicholas & Smook 2463* (26b) PRE; *Nicholson 2525*(26b) NH; *Ngwenya 1741*(26b) NH; *Peacock s.n.* - Jan 1953 (26b) NBG; *Pegler 690* (26b) BOL; *Pegler 690* (26b) PRE; *Phillipson 1194* (26b) PRE; *Rudatis 1467*(26b) NH; *Singh 590* (26b) NH; *Singh 449* (26b) NH; *Singh & Baijnath 483* (26b) NH; NH; *Singh & Wiland 759* (26a) NH; *Strey 4386* (26a) NH; *Strey 6879* (26b) NH, PRE; *Strey 9146* (26b) NH; *Venter 1038* (26b) PRE; *Ward 10983* (26b) NH, NU; *Wood 426*(26b) NH; *Wood, S.E 146* (26b) NU; *Wood, S.E 180* (26b) NU; *Wylie NH27962*(26b) NH.

Abbott 638 (27) PRU, UMTAMVUNA; *Abbott 6528* (27) PRE; *Bourquin 708* (27) PRE; *Davidson 2548* (27) J, UMTAMVUNA; *Dold 1439* (27) GRA; *Flanagan 1172* (27) GRA; *Flanagan 1172* (27) NBG; *Galpin 5810* (27) GRA; *Galpin 5810* (27) NBG; *Glen 274* (27) GRA, NH; *Glen 274* (27) J; *Glen 274* (27) UMTAMVUNA; *Hilliard s.n.* - Mar 1964 (27) NU; *Hutchings 956* (27) KEI; *Kloppers s.n.* PRE33560 (27) PRE; *Nicholson 713* (27) PRE; *Ngwenya 481* (27) NH; *Nombekela 366* (27) NH; *Ottley 2545* (27) J; *Pegler 109C* (27) PRE; *Rudatis 1196* (27) NH; *Smith 3770* (27) PRE; *Strey 10241* (27) NH, PRE; *Taylor 3710* (27) NBG; *Thorncroft 634 (27) NH*; *Thorncroft 1063* (27) J; *Tyson 2880* (27) BOL; *Tyson 2880* (27) NBG.

Abbott 4764 (28a); *Abbott 6592* (28a); *Abbott 5429* (28a); *Acocks 11833* (28a) NH; *Balkwill & Balkwill 5194* (28a) J; *Bester 1825* (28a) NH; *Compton 27243* (28a) NBG; *Compton 27243* (28a) PRE; *Compton 29335* (28a) NBG; *Cron et al. 150* (28a) J; *Davidson s.n.* J074537 (28a) J; *Galpin 10382* (28a) PRE; *Greene 426* (28a) NH ; *Greene 886* (28a) NH; *Hilliary 60* (28a) NU; *Hutton 122* (28a) GRA; *Jacobz 4865* (28a) NBG, PRE; *Maurice & Evans 438* (28a) NH; *Mohle 96* (28a) PRE; *Moss 15429* (28a) J; *Paton 332* (28a) PRE; *Saltmarsh 1049* (28a) PRE; *Trauseld 683* (28a) NU; *Thode 5293* (28a) NH; *Van Der Schyff 4818* (28a) PRE; *Van Der Schyff 4818* (28a) PRU; *Van Wyk 2849* (28a) PRE; *Van Wyk 2849* (28a) PRU; *Venter 11084* (28a) UNIN; *Venter 11138* (28a) UNIN; *Von Fintel 646* (28a) NH; *West 1404* (28a) NH; *Wood 862* (28a) NH; *Wood s.n.* NBG22265 (28a) NBG; *Wood s.n.* TM12833 (28a) PRE; *Wright 2388* (28a) NU.

Abbott 4764 (18b) NH; *Abbott 5429* (28b) NH, UMTAMVUNA; *Abbott 6592* (18b) NH; *Acocks 11833* (28b) NH; *Balkwill & Balkwill 4988* (28b) J; *Balkwill & Cadman 2792* (28b) J; *Bamps 7145* (28b) PRE; *Bester 1825* (28b) NH; *Bokkelman 9* (28b) NBG; *Fisher 724* (28b) NH; *Greene 426* (28b) NH; *Greene 886* (28b) NH; *Hilliard & Burtt 9058* (28b) NU; *MacDavette 1374* (28b) PRE; *Marais 1428* (28b) PRE; *Maurice & Evans 438* (28b) NH; *Thode 5293* (28b) NH ; *Thomas 17* (28b) NBG; *Van Wyk 12541* (28b) PRU; *Van Wyk 7170* (28b)

PRU; *Venter 11344* (28b) PRU; *Venter 11344* (28b) UNIN; *Von Fintel 646* (28b) NH; *West 1404* (28b) NH; *Wood 862* (28b) NH; *Wood 3940* (28b) NH; *Wood 12077* (28b) NH; *Wright 1567* (28b) NU; *Wright 1600* (28b) NU.

NATAL HERBARIUM
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NATAL HERBARIUM (NH)

Accession no: NH 121910.0

2730CA	Grid ref.	Regio	KwaZulu-Natal, S Africa
SINGH, Y.	Legit	Date	18/11/1997
291	and no.	Alt.	1900 m

Hypoxis acuminata Baker

Utrecht, Balele Mountain Range, c. 500m SE of Balele Mountain Lodge.

Height: 25 cm. Growth form: herb. Flower colours: 1. green; 2. yellow. Aspect: E.
Substrate: soil. Moisture: well-drained. Vegetation: grassland.
Cormous erect herb. Perianth segments green on outer surface, yellow on inner surface.
Occasional. Vegetation type - rocky grassland. Exposure - full sun. Slope - gentle.

Det. Y. Singh 1230000

Figure 12.1A.—*Hypoxis acuminata (Singh 291).*

Figure 12.1B.—*Hypoxis acuminata*.

Figure 12.2A.—*Hypoxis angustifolia* var. *angustifolia* (*Lussem 50*).

NATAL HERBARIUM
Encoded as
No. 129118.3
DURBAN

NATAL HERBARIUM (NH) NH 129118.3

[29° 52' 30"S 30° 52' 30"]E 2930DD	Grid ref.	Regio	KwaZulu-Natal, South Africa
Singh, Y. & Baijnath, H., Dr.	Legit	Date	22/10/1999
484	& no.	Alt.	100 m

Hypoxis angustifolia Lam. var. angustifolia

Chatsworth. Kenneth Stainbank Nature Reserve, 100m from picnic site towards entrance gate.

Point data correct to centroid of ¼° grid.
Cormous erect herb. Corm white within. Flowers yellow. Plant height: 30cm. Vegetation type: shrubland. Substrate: soil. Moisture regime: slightly moist. Exposure: full shade. Slope: level ground. Notes: taller than plants growing in full sun. Local abundance: common. Altitude: c. 100m.

Det. Y. Singh Genspec no. 1230000 2

Hypoxis angustifolia Lam. var. *buchananii* Baker
Det./Conf. Y. Singh 2006/01/12

Figure 12.3A.—*Hypoxis angustifolia.* var. *angustifolia (Singh & Baijnath 484).*

Figure 12.3B,C.—*Hypoxis angustifolia.* var. *buchananii*.

Singh, Y
508
Label

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DURBAN

NATAL HERBARIUM (NH)

NH 129144.0

32° 11' 9"S 27° 5' 14"E [3227AA]	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	27/11/1999
508	& no.	Alt.	1140 m

Hypoxis argentea Harv. ex Baker var. argentea

Cathcart. Farm Ellington. Along the R30 between Stutterheim and Cathcart, 3.9km before Cathcart.

Point data correct to 0-10m.
Cormous erect herb, solitary. Tepals yellow. Capsules green. Plant height: 10cm. Vegetation type: grassland. Substrate: soil. Moisture regime: well-drained. Lithology: dolerite. Exposure: full sun. Slope: level ground. Local abundance: occasional.

Det. Y. Singh Genspec no. 1230000 5

Figure 12.4A.—*Hypoxis argentea* var. *argentea* (*Singh 508*).

Figure 12.4B.—*Hypoxis argentea* var. *argentea*.

NATAL HERBARIUM
Encoded as
No. 129147
DURBAN

NATAL HERBARIUM (NH)

NH 129147.0

[30° 52' 30"S 28° 7' 30"]E 3028CC	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	2/12/1999
542	& no.	Alt.	1500 m

Hypoxis argentea Harv. ex Baker var. sericea Baker

Maclear. Drakensberg Mountains. Woodcliffs Farm, Joëlshoek, c. 2km above bridge across Little Pot River, North of Woodcliffs Farm House.

Point data correct to centroid of ¼° grid.
Cormous erect herb. Tepals yellow. Plant height: 8-12cm. Vegetation type: rocky grassland. Substrate: soil. Moisture regime: well-drained. Exposure: full sun. Aspect: South. Slope: moderate. Biotic effect: grazed. Local abundance: common in patches. Altitude: c. 1500m.

Det. Y. Singh   Genspec no. 1230000 6

Figure 12.5A.—*Hypoxis argentea* var. *sericea (Singh 542).*

Figure 12.5B.—*Hypoxis argentea* var. *sericea*.

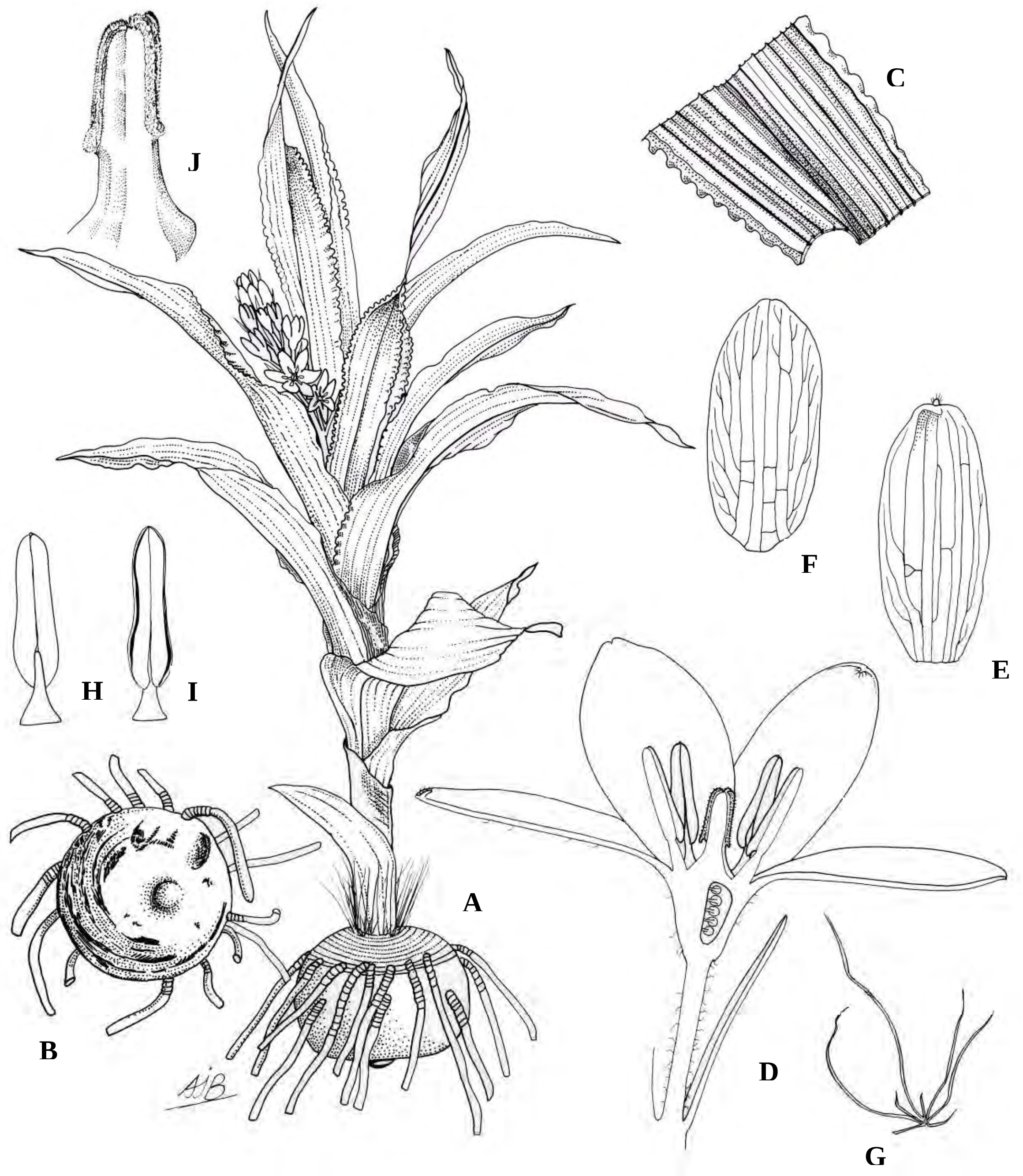

Figure 12.6A.—*Hypoxis colchicifolia*. A. Habit x 0.5; B, View of corm from lower side x 0.5; C, Leaf, section, upper surface x 1; D, Half flower x 4; E, Outer tepal, abaxial view x 4; F, Inner tepal, abaxial view x 4; G, Tepal hair x 15; H, Stamen, back view x 6; I, Stamen, front view x 6; J, Stigma x 10. Illustration A–F ex hort, G, *Wood 161* (NU). Artist: A.J. Beaumont.

NATAL HERBARIUM (NH)

Accession no: NH 122086.0

2930CB	Grid ref.	Regio	KwaZulu-Natal, S Africa
SINGH, Y.; BAIJNATH, H.	Legit	Date	4/11/1997
264	and no.	Alt.	920 m

Hypoxis colchicifolia Baker

Pietermaritzburg. Thorneville. Along R56 from PMB to Richmond, c. 5km before turnoff to Umlaas Road.

Height: 30 cm. Growth form: herb. Flower colours: 1. green; 2. yellow. Aspect: Level. Substrate: soil. Moisture: well-drained. Vegetation: grassland. Cormous erect herb. Perianth segments green on outer surface, yellow on inner surface. Plant height - c. 30cm. Occasional. Exposure - full sun. Altitude - c. 920m.

Figure 12.6B.—*Hypoxis colchicifolia* (*Singh & Baijnath 264*).

Figure 12.6C.—*Hypoxis colchicifolia*.

NATAL HERBARIUM (NH)

Accession no: NH 121889.0

2730CA	Grid ref.	Regio	KwaZulu-Natal, S Africa
SINGH, Y.	Legit	Date	18/11/1997
300	and no.	Alt.	2055 m

Hypoxis costata Baker

Utrecht, Balele Mountain Range, Vaalkop, c. 1km NE of trigbeacon along untarred track.

Height: 6 cm. Growth form: herb. Flower colours: 1. green; 2. yellow. Substrate: soil. Moisture: well-drained. Vegetation: grassland.
Cormous erect herb. Perianth segments green on outer surface yellow on inner surface. Abundant. Exposure - full sun. Slope - level ground.

Det. Y. Singh 1230000

Figure 12.7A.—*Hypoxis costata* (*Singh 300*).

Figure 12.7B.—*Hypoxis costata*.

NATAL HERBARIUM
Encoded as
No. 125922
DURBAN

NATAL HERBARIUM (NH)

NH 125922.0

[28° 22" 30'S 28° 52" 30']E 2828BD	Grid ref.	Regio	Free State, S Africa
Singh, Y.	Legit	Date	6/1/1999
462	& no.	Alt.	1860 m

Hypoxis filiformis Baker

Qwaqwa. Qwaqwa National Park. Tweedegeluk Farm, plateau.

Point data correct to Centroid of ¼" grid.
Cormous erect herb growing singly. Flowers: tepals yellow. Plant height - 15-20cm. Occasional. Grassland. Soil. Moist. Full sun. Aspect - North-east. Slope - gentle.

Det. Y. Singh Genspec no. 1230000 15

Figure 12.8A.—*Hypoxis filiformis* (*Singh 462*).

Figure 12.8B.—*Hypoxis filiformis*.

SINGH, Y.
807 ·

Label

NATAL HERBARIUM
Encoded as
No: 130482
DURBAN

NATAL HERBARIUM (NH)

NH 130482.0

Regio Eastern Cape, South Africa
Grid ref. 31° 23' 6"S 29° 52' 36"E [3129BD]
Alt. 496 m
Asp.
Legit Singh, Y.
& no. 807
Date 27/11/2002

Hypoxis flanaganii Baker

Lambazi. Along road to Lambazi Lodge. 3,5km from lodge.

Point data correct to 0-10m. Biome: grassland. Vegetation type: rocky outcrop. Substrate: soil. Moisture: well-drained. Soil type: loam. Exposure: full sun. Life form: herb and geophyte. Delicate herb. Inflorescence single flowered. Tepals yellow. Plant height: 2-4cm. Common in patches.

Det. Y. Singh
Genspec no. 1230000 16

Figure 12.9A.—*Hypoxis flanaganii* (*Singh 607*).

Figure 12.9B.—*Hypoxis flanaganii*.

3419AB

HERBARIUM MUSEI AUSTRO-AFRICANI

No. 63757 Fl. May 1950 Alt
Hypoxis floccosa Bkr.
Caledon Div., foothills of Riviersonderend Mtns.
Legit G.J. Lewis 3009

Figure 12.10.—*Hypoxis floccosa* (*Lewis 3009*).

AM Ngwenya
1504
label

Encoded as

NATAL HERBARIUM
No. 121 198
DURBAN

NATAL
NATALSE HERBARIUM DURBAN

3029 AB Grid Ref./Ruitverw.
A.M.Ngwenya
1504 Legit & No.
Regio Eastern Cape
Anno 11.11.1996
Alt. 5900ft.

Hypoxis galpinii Baker

Mzimkulu District, Nsikeni Nature Reserve
S.30°11 354 E.29°27 716
Well drained rocky grassland, soil
Full sun, south western aspect, moderate slope, recently burnt
Erect herb, tuber orange inside, turning brown as it dries, and eventually black. Flowers bright yellow with purplish maroon at the back of outer tepals. Inner tepals with broad green lines at the back. Common, c.18cm high
A.M.Ngwenya Det.
Ref./Verw. 1230
GP-S–(F)–B

Figure 12.11A.—*Hypoxis galpinii* (*Ngwenya 1504*).

Figure 12.11B.—*Hypoxis galpinii*.

Figure 12.12A.—*Hypoxis gerrardii* (*Singh & Baijnath 419*).

Figure 12.12B.—*Hypoxis gerrardii*.

SINGH, Y.
631

Label

NATAL HERBARIUM
Encoded as
No: 130612
DURBAN

NATAL HERBARIUM (NH)

NH 130612.0

Regio	KwaZulu-Natal, South Africa	Legit	Singh, Y.
Grid ref.	29° 48' 3" 30° 11' 17"E [2930CC]		
Alt.	200 m		
Asp.	NE	& no.	631 — Date 10/7/2000

Hypoxis hemerocallidea Fisch. & Avé-Lall.

Westville, Atholl Heights, Glengarny Place, about 500m from turnoff in to Scone Place.

Point data correct to 0-10m. Vegetation type: grassland. Substrate: soil. Moisture regime: well-drained. Exposure: full sun. Aspect: North-East. Slope: moderate. Cormous erect, solitary, herb. Corm yellow within. Plant height: 14cm. Locally occasional. Tepals yellow. Recently burnt. Represent older plant in population.

Det. Y. Singh

Genspec no. 1230000 21

Figure 12.13A.—*Hypoxis hemerocallidea* (*Singh 631*).

Figure 12.13B.—*Hypoxis hemerocallidea*.

Coll. Y Singh
Nº 613
label

NATAL HERBARIUM
Encoded as
No: 129450.1
DURBAN

NATAL HERBARIUM (NH)

NH 129450.0

[30° 7' 30"S 29° 52' 30"]E 3029BB Singh, Y. 613	Grid ref. Legit & no.	Regio Date Alt.	KwaZulu-Natal, South Africa 11/2/2000

Hypoxis cf. woodii Baker

Kokstad. Mt. Currie Nature Reserve. Adam Kok Road.

Point data correct to centroid of ¼° grid.
Cormous erect herb. Corm yellow green. Leaves glabrous. Post flowering and fruiting. Plant height: 12cm. Vegetation type: grassland. Substrate: soil. Moisture regime: well-drained. Exposure: full sun. Aspect: East. Slope: gentle. Local abundance: occasional.

Det. Y. Singh Genspec no. 1230000 54

Hypoxis interjecta Nel
Det./Conf. Y. Singh 2006/01/12

Figure 12.14A.—*Hypoxis interjecta* (*Singh 613*).

Figure 12.14B.—*Hypoxis interjecta*.

Figure 12.15A.—*Hypoxis kraussiana* (*Singh 636*).

Figure 12.15B.—*Hypoxis kraussiana*.

coll. Y. Singh
H. Baijnath
N° 315
labal

NATAL HERBARIUM
Encoded as
No. 125 170.1
DURBAN

NATAL NATALSE HERBARIUM DURBAN

2628 AD	Grid Ref./ Ruitverw.	Regio	Gauteng
Y.Singh & H.Baijnath 315	Legit & No.	Anno Alt.	2.12.1997 1615m

Hypoxis rigidula Bak.
var. rigidula

Heidelberg, along N3 between Villiers & Heidelberg, c.11.1/2 km before turnoff to R23 to Balfour
S26°56'840" E28°33'886"
Well drained grassland, soil
Full sun, level ground
Cormous erect herb
Fruit green with white hairs
Common
c.45cm high
Y.Singh
Det. Ref./Verw. 1230
GP-S-(F)-8

Hypoxis longifolia Baker ex. Hook.f
Det./~~Conf~~. Y. Singh 2006/1/27

Figure 12.16A.—*Hypoxis longifolia* (*Singh & Baijnath 315*).

Figure 12.16B—*Hypoxis longifolia*.

Singh .Y
540
LABEL

NATAL HERBARIUM
Encoded as
No. 129125.2
DURBAN

NATAL HERBARIUM (NH)

NH 129125.2

[30° 52' 30"S 28° 7' 30"]E 3028CC	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	1/12/1999
540	& no.	Alt.	1500 m

Hypoxis sp.

Maclear. Drakensberg Muntains. Woodcliffs Farm, Joëlshoek, c. 2km West of Guest Cottge towads Freshwater Farm.

Point data correct to centroid of ¼° grid.
Cormous erect herb. Flowers: tepals yellow. Capsules green. Plant height: 30cm. Vegetation type: rocky grassland. Substrate: soil. Moisture regime: well-drained. Exposure: full sun. Aspect: North East. Slope: steep. Local abundance: occasional. Altitude: c. 1500m.

Det. Y. Singh Genspec no. 1230000 0

Hypoxis ludwigii Baker
Det /Conf. Y. Singh 20.06/11/01

Figure 12.17A.—*Hypoxis ludwigii* (*Singh 540*).

Figure 12.17B—*Hypoxis ludwigii*

NATAL HERBARIUM
Encoded as
No: 130469.4
DURBAN

NATAL HERBARIUM (NH) NH 130469.0

Regio Eastern Cape, South Africa
Grid ref. 31° 23' 28"S 29° 52' 12"E [3129BD]
Alt. 100 ft
Asp.
Legit Singh, Y.
& no. 826
Date 29/11/2002

Hypoxis membranacea Baker

Mateku. Tezana River, adjacent to Lambazi Lodge.

Point data correct to 0-10m. Biome: forest. Habitat: cliff face. Substrate: soil. Moisture regime: moist/damp. Soil type: loam. Exposure: shade. Aspect: South West. Slope: steep. Life form: herb and geophyte. Rhizome with stolons spreading laterally. Flowers white. Plant height: 10cm. Abundant in colonies in sphagnum. Growing with H. angustifolia, but no hybrids recorded.

Det. Y.Singh
Genspec no. 1230000 30

Sheet 4 of 4

Figure 12.18A.—*Hypoxis membranacea* (*Singh 826*).

Figure 12.26A.—*Hypoxis rigidula* var. *pilosissima* (*Singh & Wiland 755*).

Figure 12.18B.—*Hypoxis membranacea*.

Figure 12.31.—*Hypoxis tetramera* (*Hilliard & Burtt 16798*).

NATAL HERBARIUM
Encoded as
No: 133303.1
DURBAN

NATAL HERBARIUM (NH)

NH 133303.0

Regio KwaZulu-Natal, South Africa
Grid ref. 31° 2' 47"S 30° 10' 7"E [3130AA]
Alt.
Asp. W
Legit Singh, Y.
& no. 888
Date 19/10/2005

Hypoxis nivea Y.Singh

Umtamvuna. (31º02'781" S 30º10'116" E)

Biome: forest. Vegetation type: rocky understorey of forest. Habitat: mountain slope, cliff face. Substrate: soil. Moisture regime: well-drained. Soil type: sand, humus. Exposure: partial shade. Aspect: W. Slope: moderate, steep. Life form: geophyte, 5-12cm in height. Plant features: Delicate herb with tiny corms, growing singly. Leaves in shade broader than those in sunlight. Flowers white. Notes: Usually on rocks where the light comes through the canopy. Occurrence: abundant. Voucher: spirit; leaves.

Det. Singh, Yashica
Genspec no. 1230000 2007

Figure 12.20A.—*Hypoxis nivea* (*Singh 888*).

Figure 12.20B.—*Hypoxis nivea*.

Singh, Y.
512
Label

NATAL HERBARIUM
Encoded as
No: 129127
DURBAN

NATAL HERBARIUM (NH) NH 129127.0

32° 14' 52"S 27° 16' 40"E [3227AB] Singh, Y. 512	Grid ref. Legit & no.	Regio Date Alt.	Eastern Cape, South Africa 27/11/1999 1200 m

Hypoxis zeyheri Baker

Stutterheim. Farm Undula. Along secondary road from Cathcart to Toise via Bitterne. c. 850m before turnoff to Stutterheim.

Point data correct to 0-10m.
Solitary cormous erect herb. Corm yellow within. Tepals yellow. Intermingled with Y. Singh 511 and Y. Singh 513. Plant height: 6cm. Vegetation type: rocky grassland. Substrate: soil. Moisture regime: well-drained. Lithology: dolerite. Exposure: full sun. Aspect: North,East. Slope: steep. Local abundance: frequent, often many plants in a aclump. Altitude: c. 1200m.

Det. Y. Singh Genspec no. 1230000 55

Hypoxis obliqua Jacq.
Det./Conf. Y. Singh 2006/01/13

Figure 12.21A.—*Hypoxis obliqua* (*Singh 512*).

Figure 12.21B, C.—*Hypoxis obliqua*.

NATAL HERBARIUM
Encoded as
No: 129112
DURBAN

NATAL HERBARIUM (NH)

NH 129112.0

32° 14' 52"S 27° 16' 40"E [3227AB]	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	27/11/1999
517	& no.	Alt.	1200 m

Hypoxis obtusa Burch. ex Edwards

Stutterheim. Farm Undula. Along secondary road from Cathcart to Toise via Bitterne. c. 850m before turnoff to Stutterheim.

Point data correct to 0-10m.
Solitary cormous erect herb. Corm pale yellow. Flowers: tepals yellow. Plant height: 15cm. Vegetation type: rocky grassland. Substrate: soil. Moisture regime: well-drained. Soil type: dolerite. Exposure: full sun. Aspect: North East. Slope: steep. Local abundance: occasional. Altitude: c. 1200m.

Det. Y. Singh Genspec no. 1230000 36

Figure 12.22A.—*Hypoxis obtusa* (*Singh 517*).

Figure 12.22B.—*Hypoxis obtusa*.

SINGH, Y.
470
Label

NATAL HERBARIUM
Encoded as
No: 132104
DURBAN

NATAL HERBARIUM (NH)

NH 132104.0

Regio Mpumalanga, South Africa
Grid ref. 25° 13' 53"S 30° 8' 26"E [2530AA]
Alt. 2228 m
Asp. W
Legit Singh, Y.
& no. 470
Date 3/2/1999

Hypoxis sp.

Lydenburg, Steenkampsberg. "Die Berg" Farm. 700m along road to tower, then 200m West of first concrete bridge.

Cormous erect herb. Corm white within. Flowers yellow. Plant height: 10cm. Occasional. Rocky grassland. Soil. Moisture regime: moist, vlei. Exposure: full. Aspect: West. Slope: gentle. Grid ref.: S25 degrees 13.898' E30 degrees 08.449'.

Det. Y. Singh
Genspec no. 1230000 0

Hypoxis parvifolia Baker
Det./Conf. Y. Singh 2006/01/12

Figure 12.23A.—*Hypoxis parvifolia* (*Singh 470*).

Figure 12.23B.—*Hypoxis parvifolia*.

Figure 12.24A.—*Hypoxis parvula* var. *albiflora* (*Williams 1185*).

NATAL HERBARIUM
Encoded as
No: 129098·1
DURBAN

NATAL HERBARIUM (NH)

NH 129098.1

[30° 52' 30"S 28° 7' 30"]E 3028CC	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	2/12/1999
545	& no.	Alt.	1500 m

Hypoxis parvula Baker var. parvula

Maclear. Drakensberg Mountains. Woodcliff's Farm, Joëlshoek, c. 2km above bridge across Little Pot River, North of the Woddcliffe Farm House.

Point data correct to centroid of ¼° grid.
Growing with Rhodohypoxis baurii. No hybrids between the two taxa were recorded. Plant height: 4cm. Vegetation type: rocky grassland. Substrate: soil on rocks. Moisture regime: slightly moist. Exposure: in partial shade or full sun. Aspect: South. Slope: steep. Local abundance: common in clumps. Altitude: c. 1500m.

Det. Y. Singh

Genspec no. 1230000 40

Figure 12.25A.—*Hypoxis parvula* var. *parvula* (*Singh 545*).

Figure 12.25B.—*Hypoxis parvula* var. *parvula*.

Singh, Y. +
Wiland, J.
755

Label.

NATAL HERBARIUM
Encoded as
No: 129185.1
DURBAN

NATAL HERBARIUM (NH)

NH 129185.1

31° 11' 40"S 29° 55' 13"E [3129BB] Singh, Y..& Wiland, J. 755	Grid ref. Legit & no.	Regio Date Alt.	Eastern Cape, South Africa 23/1/2002 490 m

Hypoxis rigidula Baker var. pilosissima Baker

Transkei. Mkambati, outside reserve. Mtentu Gorge, North East of road parallel to gorge.

Point data correct to 251-500m.
Cormous erect herb. Corm yellow within. Leaves silvery green, carinate. Tepals yellow on inner surface. Seeds black and glossy. Plant height: 50cm. Vegetation type: grassland. Substrate: soil. Moisture regime: well-drained. Soil type: sandy loam, pH = 6. Exposure: full sun. Slope: level ground. Local abundance: common in patches.

Det. Y. Singh Genspec no. 1230000 42

Figure 12.26A.—*Hypoxis rigidula* var. *pilosissima* (*Singh & Wiland 755*).

Figure 12.26B.—*Hypoxis rigidula* var. *pilosissima*.

Coll. Y. Singh &
N° 660
label

NATAL HERBARIUM
Encoded as
DURBAN

NATAL HERBARIUM (NH)

NH 129297.1

29° 56' 20"S 29° 29' 9"E [2929CD]	Grid ref.	Regio	KwaZulu-Natal, South Africa
Singh, Y. & Wiland, J.	Legit	Date	8/1/2002
660	& no.	Alt.	1780 m

Hypoxis rigidula Baker var. rigidula

Coleford. Along secondary road between Bulwer and Coleford Nature Reserve, 3.5km from Ngwangwane River bridge.

Point data correct to 251-500m.
Cormous erect herb, growing singly, sometimes clumping. Corm light orange. Leaves green with white stripes of indumentum. Capsule green, seeds black, semi glossy. Plant height: 60 cm. Vegetation type: rocky grassland. Substrate: soil. Moisture regime: well-drained. Soil type: sandy-loam. Exposure: full sun. Aspect: West. Slope: moderate. Local abundance: frequent. Notes: leaves eaten by insects. Growing with Hypoxis rigidula and Hypoxis acuminata.

Det. Y. Singh

Genspec no. 1230000 43

Figure 12.27A.—*Hypoxis rigidula* var. *rigidula* (*Singh & Wiland 660*).

Figure 12.27B.—*Hypoxis rigidula* var. *rigidula*.

0096109 == 3325CA
SCHARF, H.T.
01644 == 1074

NATIONAL HERBARIUM PRETORIA
PRETORIA
PRE.............
R.S.A.
NASIONALE HERBARIUM

NATIONAL
NASIONALE HERBARIUM PRETORIA

3325 CA Port Elizabeth	Grid Ref./ Ruitverw.	Regio	Cape
H.T.SCHARF 1074	Legit & No.	Anno Alt.	18.12.74 1700'

Hypoxis rooperii S. Moore

Watered Ravine West of Nounek; Groendal Wilderness Area; Uitenhage district; Kwa Zunga (Upper Zwartkops) catchmt. basin. Riverine Ravine; S.slope 80°; Fynbos/Grassland; Fair amount of organic material on this mesocline.
Herb; Leaves- hairy; Flower-yellow.
Not prominent in the landscape.

Det. Ref./Verw.

GP-S-(F)-8 LTD 1506

Hypoxis sobolifera Jacq. var. *pannosa* (Baker) Nel
Det./Conf. Y. Singh 20.06/01/13

Figure 12.28A.—*Hypoxis sobolifera* var. *pannosa* (*Scharf 1074*).

Figure 12.28B.—*Hypoxis sobolifera* var. *pannosa*.

Coll. Y. Singh.
N° 622
labal.

NATAL HERBARIUM
Encoded as
No: 129355
DURBAN

NATAL HERBARIUM (NH)

NH 129355.0

33° 24'S 26° 2[illegible]E [3326AD]	Grid ref.	Regio	Eastem Cape, South Africa
Singh, Y.	Legit	Date	24/5/2000
622	& no.	Alt.	400 m

Hypoxis villosa L.f.

Grahamstown. Along N2 between Grahamstown and Port Elizabeth in vicinity of Lockerbie, 20km from Grahamstown, 300m after turnoff to Alicedale.

Point data correct to 501-1000m.
Cormous erect, clump forming herb. Flowers yellow, lower surface of tepals with red midrib. Plant height: 20cm. Vegetation type: rocky grassland. Substrate: soil. Moisture regime: well-drained. Exposure: full sun. Slope: level ground. Local abundance: abundant. Altitude: c. 400m.

Det. Y. Singh Genspec no. 1230000 51

Hypoxis sobolifera Jacq. var. *sobolifera*

Det./Conf. Y. Singh 20 06/1/12

Figure 12.29A—*Hypoxis sobolifera* var. *sobolifera* (*Singh 622*).

Figure 12.29B.—*Hypoxis sobolifera* var. *sobolifera*.

Figure 12.30A.—*Hypoxis stellipilis.* A. Habit x 0.55; B, Leaf section x 3; C, Leaf hairs x 30; D, Half flower x 4.5; E, Outer tepal, abaxial view x 4; F, Inner tepal, abaxial view x 4; G, Tepal hair x 14; H, Fruit x 1, I, Seed, side view x 30; J, Seed, front view x 30. A–G, *Menne s.n.*; H–J, *Deacon s.n* (GRA). Artist: A.J. Beaumont.

NATAL HERBARIUM
Encoded as
No: 129353.2
DURBAN

NATAL HERBARIUM (NH)

NH 129353.2

[33° 37' 30"S 25° 37' 30"]E 3325DA	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	23/5/2000
621	& no.	Alt.	100 m

Hypoxis stellipilis Ker Gawl.

Port Elizabeth. Glenhurd. Bakensriver Conservancy. Along mountain bike trail close to 3rd Avenue, West bank of river.

Point data correct to centroid of ¼° grid.
Cormous erect herb, corm off-white within. Roots long and swollen. Tepals yellow. Plant height: 20cm. Vegetation type: rocky shrubland. Substrate: soil. Moisture regime: well-drained. Soil type: loam. Exposure: full sun. Aspect: North East. Slope: steep. Local abundance: occasional. Altitude: c. 100m.

Det. Y. Singh Genspec no. 1230000 48

Figure 12.30B.—*Hypoxis stellipilis* (*Singh 621*).

Figure 12.30C.—*Hypoxis stellipilis*.

Figure 12.31.—*Hypoxis tetramera* (*Hilliard & Burtt 16798*).

NATAL HERBARIUM
Encoded as
No: 129349
DURBAN

NATAL HERBARIUM (NH)

NH 129349.0

[33° 22' 30"S 27° 22' 30"]E 3327AD	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	26/5/2000
627	& no.	Alt.	100 m

Hypoxis sp.

Hamburg. Along dirt road between Hamburg and Bell, 2km from Hamburg Hotel in the direction towards Bell.

Point data correct to centroid of ¼° grid.
Cormous erect herb. Corm off-white within. Plant height: 5cm. Vegetation type: grassland. Substrate: soil. Moisture regime: slightly moist. Soil type: clay. Exposure: full sun. Aspect: South West. Slope: moderate. Local abundance: occasional. Altitude: c. 100m.

Det. Y. Singh Genspec no. 1230000 0

Hypoxis villosa L.f.
Det./Conf. Y. Singh 20.06/01/27

Figure 12.32.—*Hypoxis villosa* (*Singh 627*).

singh, Y.
534

Flower

NATAL HERBARIUM
Encoded as
No: 129152.2
DURBAN

NATAL HERBARIUM (NH)

NH 129152.2

[31° 22' 30"S 27° 52' 30"]E 3127BD	Grid ref.	Regio	Eastern Cape, South Africa
Singh, Y.	Legit	Date	30/11/1999
534	& no.	Alt.	1200 m

Hypoxis acuminata Baker

Transkei. Along R56 between Elliot and Ugie. 22km from Wildebeeshoek turnoff.

Point data correct to centroid of ¼° grid.
Solitary cormous erect herb, 7-30cm tall, leaves tristrichous. Corm light yellow within. Pedicels pink or green. Tepals yellow. Vegetation type: grassland, along stream. Substrate: soil. Moisture regime: moist. Exposure: full sun. Slope: level ground. Notes: prefers moist areas. Local abundance: common along stream bank. Altitude: c. 1200m.

Det. Y. Singh
Genspec no. 1230000 1

Hypoxis zeyheri Baker
Det./Conf. Y. Singh 20 06/01/12

Figure 12.33.—*Hypoxis zeyheri* (*Singh 534*).

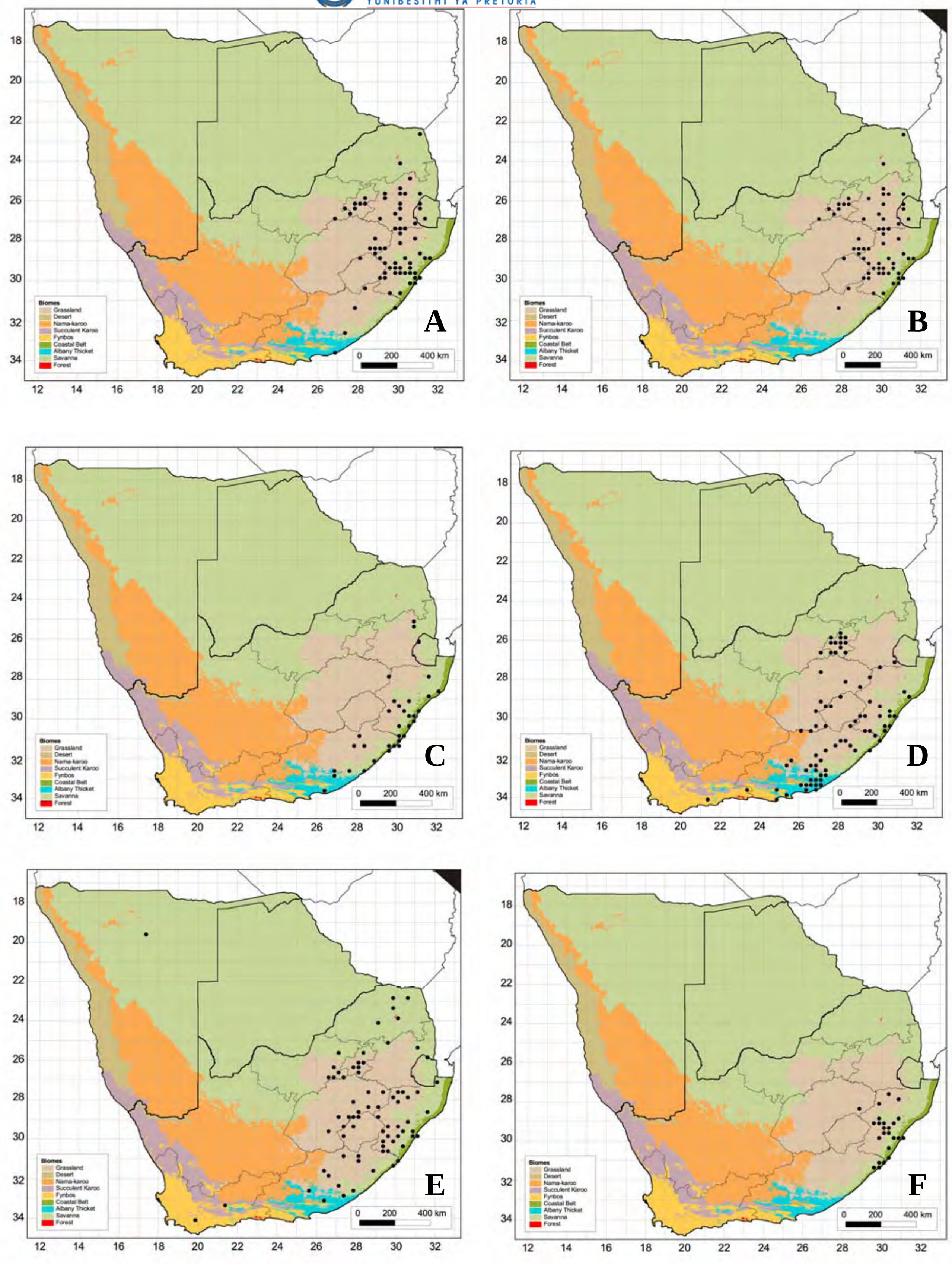

Figure 12.34.—Known distribution of *Hypoxis*. A, *H. acuminata*; B; *H. angustifolia* var. *angustifolia*; C, *H. angustifolia* var. *buchananii*; D, *H. argentea* var. *argentea*; E, *H. argentea* var. *sericea*; F, *H. colchicifolia*. Arrow indicates distribution into Tropical Africa.

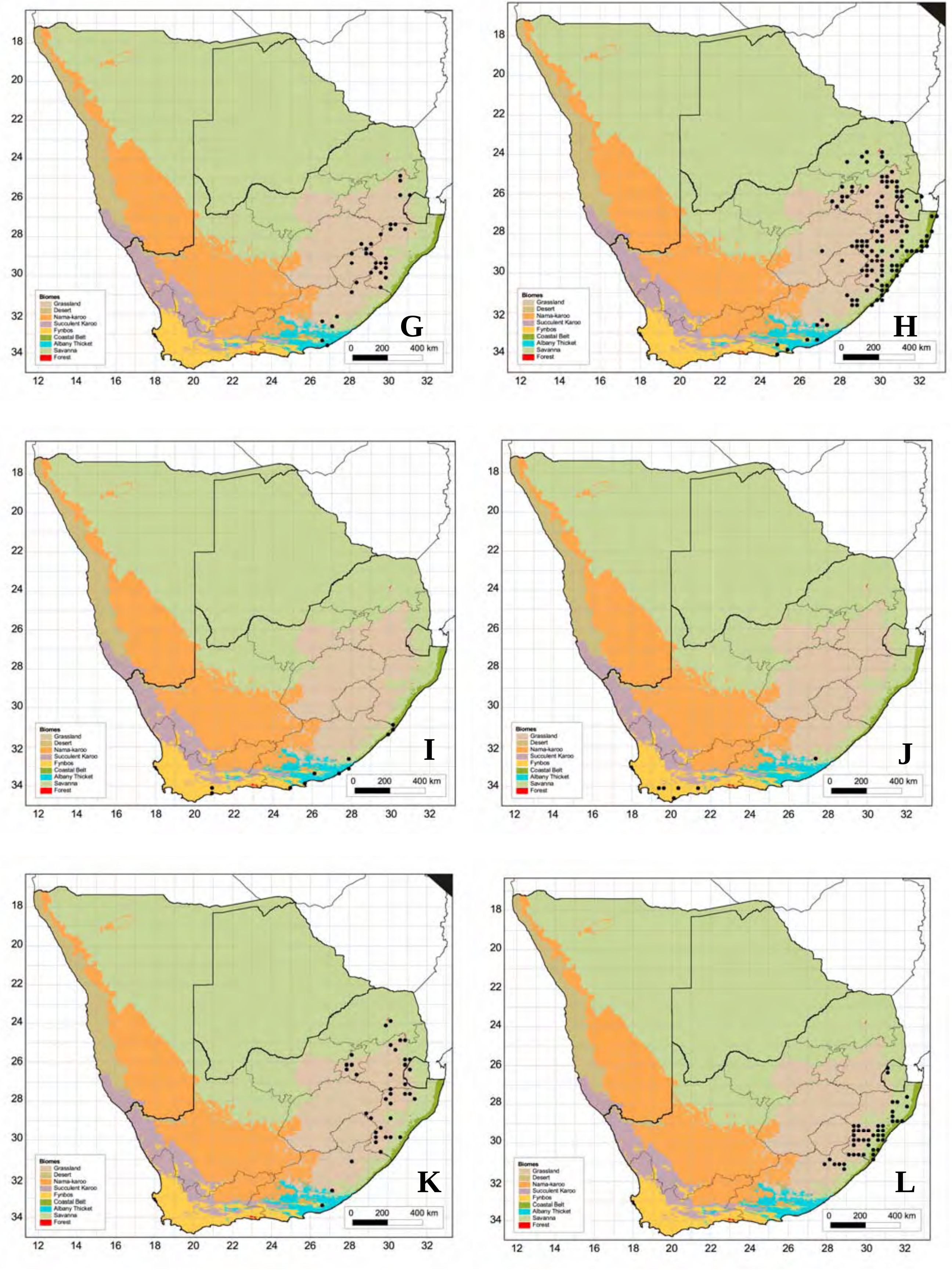

Figure 12.34 cont.—Known distribution of *Hypoxis*. G, *H. costata*; H, *H. filiformis*; I, *H. flanaganii*; J, *H. floccosa*; K, *H. galpinii*; L, *H. gerrardii*. Arrow indicates distribution into Tropical Africa.

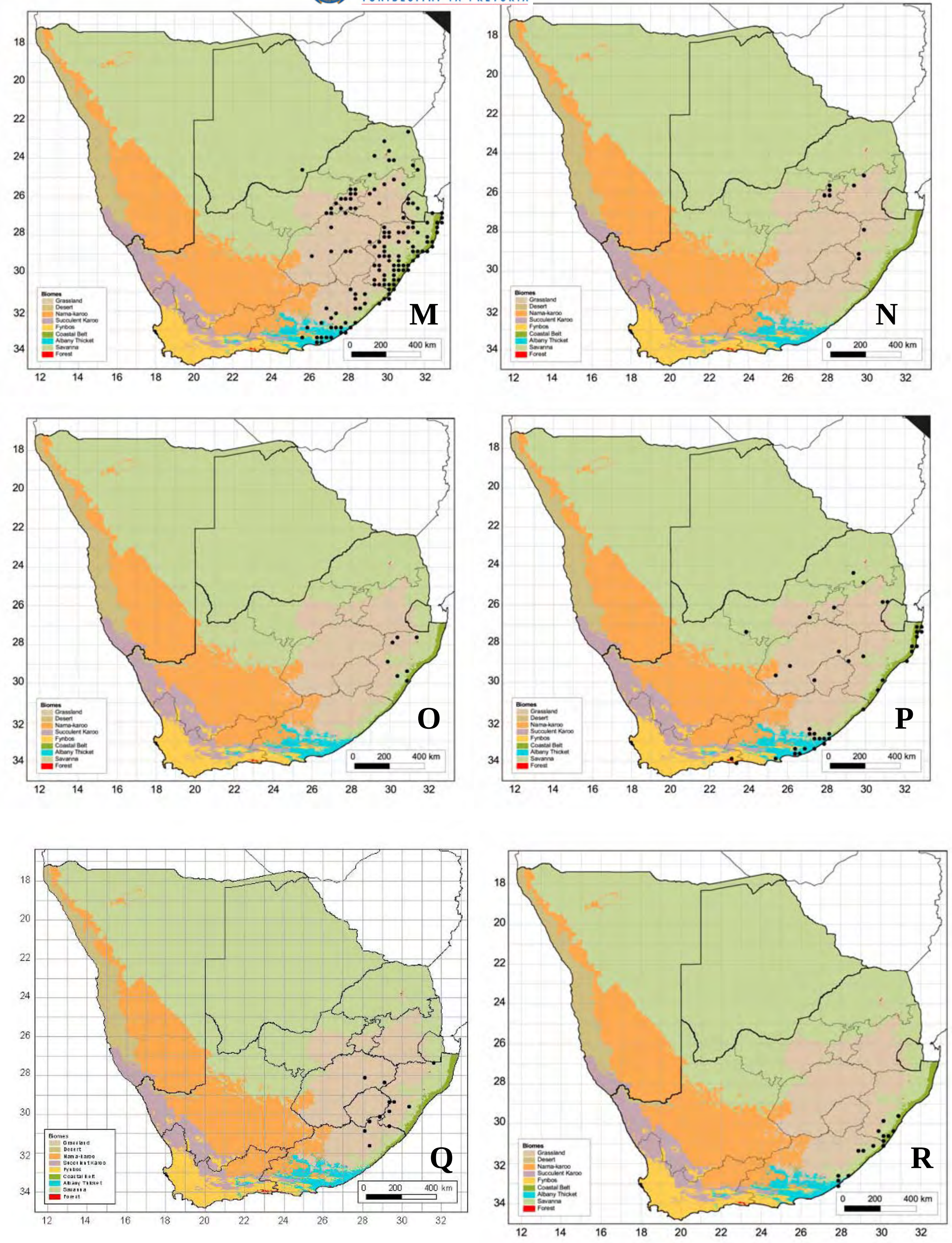

Figure 12.34 cont.—Known distribution of *Hypoxias*. M, *H. hemerocallidea*; N, *H. interjecta*; O, *H. kraussiana*; P; *H. longifolia*, Q, *H. ludwigii*; R, *H. membranacea*. Arrow indicates distribution into Tropical Africa.

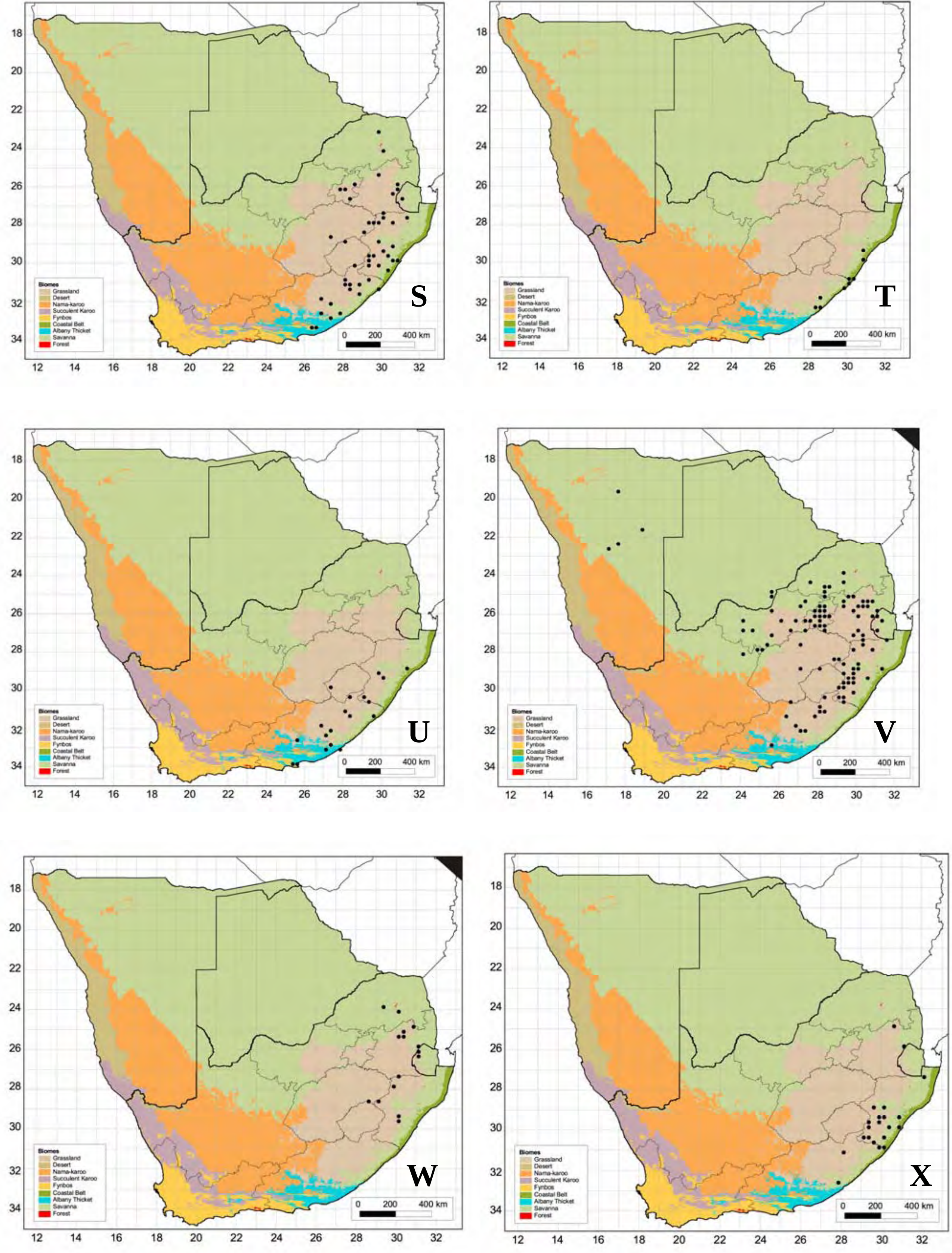

Figure 12.34 cont.—Known distribution of *Hypoxias*. S, *H. multiceps;* T, *H. nivea*; U, *H. obliqua*; V; *H. obtusa*; W, *H. parvifolia*; X, *H. parvula* var. *albiflora*; Arrow indicates distribution into Tropical Africa.

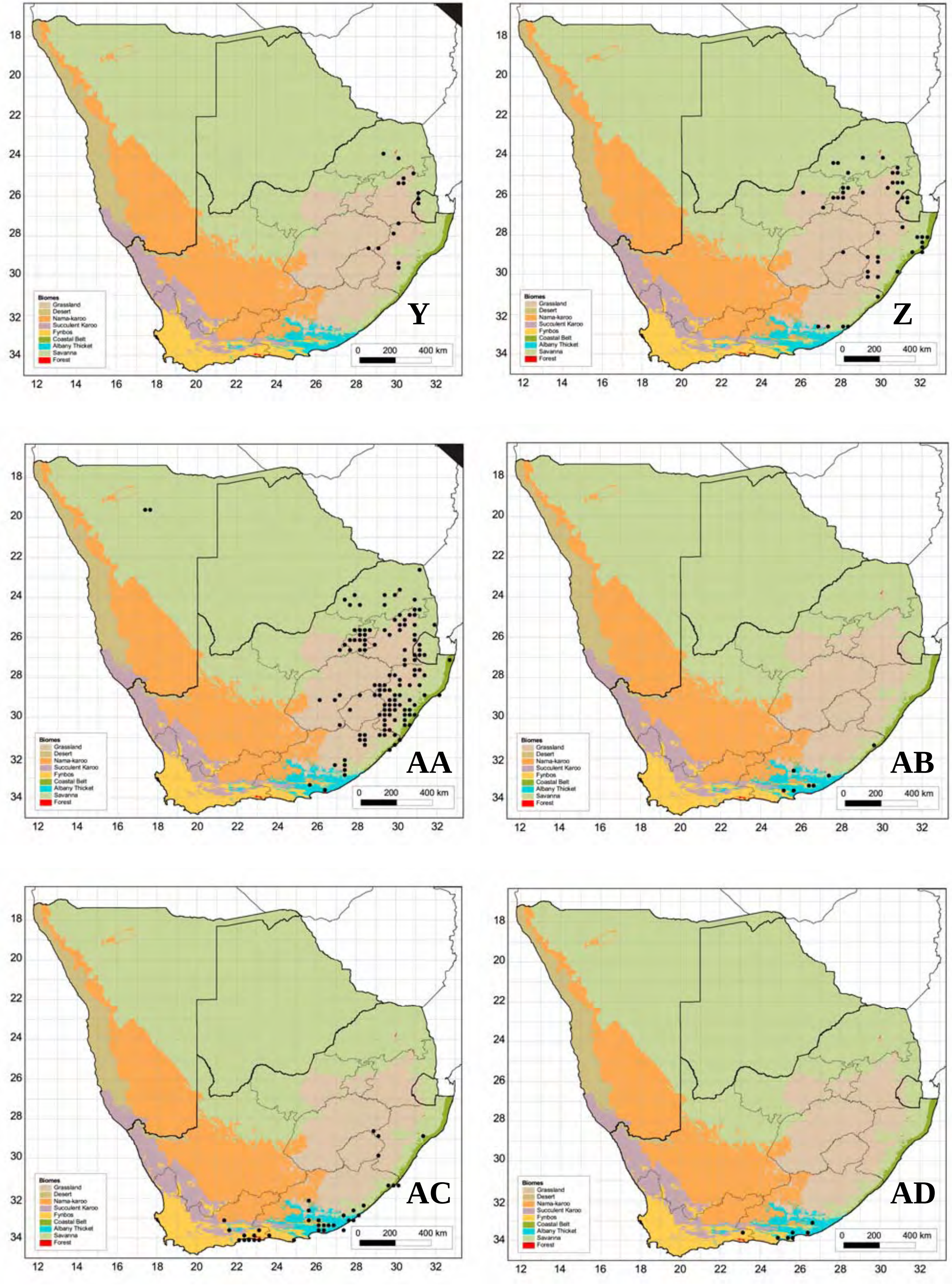

Figure 12.34 cont.—Known distribution of *Hypoxis*. Y, *H. parvula* var. *parvula*; Z; *H. rigidula* var. *pilossissima*; AA, *H. rigidula* var. *rigidula*; AB, *H. sobolifera* var. *pannosa*; AC; *H. sobolifera* var. *sobolifera*; AD, *H. stellipilis*. Arrow indicates distribution into Tropical Africa.

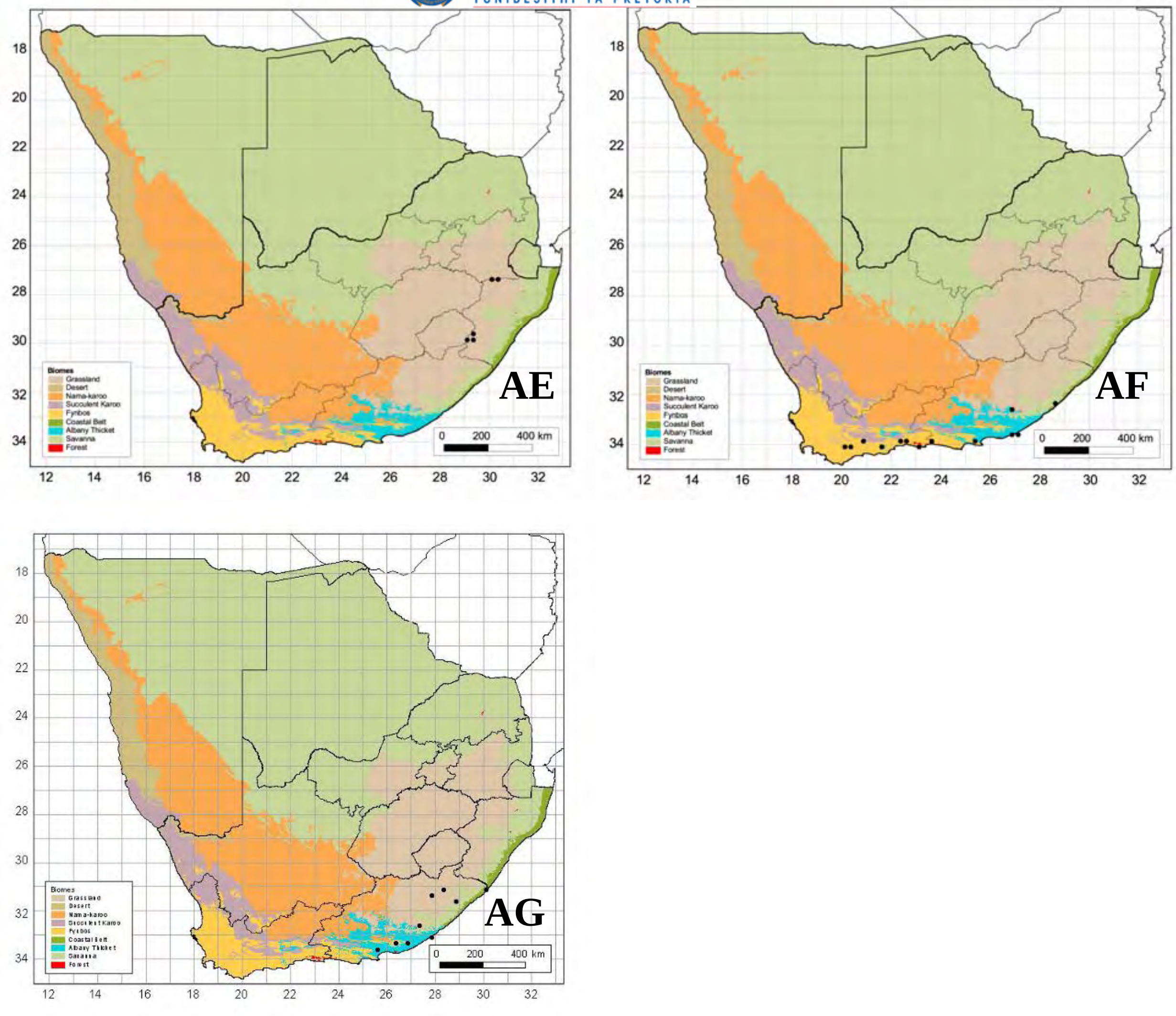

Figure 12.34 cont.—Known distribution of *Hypoxis*. AE, *H. tetramera*; AF; *H. villosa*; AG, *H. zeyheri*.

Bothalia 36,1: 13–23 (2006)

Hypoxis (Hypoxidaceae) in Africa: list of species and infraspecific names

Y. SINGH*†

Keywords: Africa, distribution, *Hypoxis* L., list, synonyms

ABSTRACT

A list of species and synonyms is presented for the African *Hypoxis* L. An abbreviated reference to the original publication of a species is included in the list. Distribution of taxa is indicated by the country in which they occur. A list of synonyms with accepted or suggested names and the reference to change in status of a taxon is provided. Subsequent publications on the treatment of a taxon are given to denote congruous and differing resolution of taxa by authorities.

INTRODUCTION

Numerous species names appear in the genus *Hypoxis* L., causing much confusion in nomenclature. Some redundant epithets are due to species in the related genera, *Curculigo* Gaertn., *Spiloxene* Salisb., *Saniella* Hilliard & B.L.Burtt and *Rhodohypoxis* Nel being initially recognized and described as species of *Hypoxis*. Others arose through new descriptions for species with names already in use. This is understandable for a group that displays great polymorphism during its growing season. Leaves in most species elongate after flowering, giving the plant a different appearance. Descriptions were often based on a single morph of the plant and these gave rise to a number of names for a single species. A further problem in the genus is that the reduction of species to synonymy was not always formalized in earlier studies on *Hypoxis* in Africa. For example, Nel (1914) in his major treatment of the Hypoxidaceae in Africa, indicated some synonyms by citing the type specimens of the synonym under what he considered to be valid species. He recorded other synonyms in the index at the end of his treatment. In addition, a few species reduced to synonymy appear as valid species in later publications without reference to its earlier reduced status or explanation for change in status.

To clarify the nomenclature of *Hypoxis*, a list of species in Africa is presented. The intention is to provide a consolidated list of all names applied to African *Hypoxis* since the description of the first African species, *H. villosa* L.f. in 1782. The list is proposed as a start towards a possible World checklist for the small family Hypoxidaceae, similar to that produced for the Araceae (Frodin & Govaerts 2002). Data for the southern African (South Africa, Swaziland, Lesotho, Botswana and Namibia) species are based on a taxonomic revision by the author (Singh in prep.) and on the contribution on Hypoxidaceae by Snijman & Singh (2003) in *Plants of southern Africa*: *an annotated checklist*. For the species in tropical Africa, data were extracted from published literature. Having examined most of the type material and early literature, a few discrepancies have come to light: for example, the confusion with the concept of the distinct species *H. obtusa* Burch. ex Ker Gawl. and *H. villosa* L.f. where the names were used interchangeably for specimens belonging to the taxa. These discrepancies will be elaborated upon in subsequent publications.

The IPNI electronic database (www.ipni.org./index.html) was used as the starting point to compile a list of all species names applied to *Hypoxis* on the African continent. Accepted names were extracted into a list and all synonyms and uncertain names were placed in Table 1. All names proposed in manuscripts, dissertations and herbarium sheets were added to the list of names in the table, and where possible, the status of taxa was verified. References on *Hypoxis* in Africa including those given in the IPNI database for each taxon were sought. All species reduced to synonyms were cross-referenced in the literature and noted with a reference in the table. Based on knowledge gained through the study of African type material and descriptions, the reduction of species by authors was either accepted or rejected.

Structure of the list

The list includes 69 species and 21 infraspecific taxa of African *Hypoxis*, with synonymy, reference and distribution. Species are listed alphabetically with accepted names in **bold**. Synonyms are listed per species in *italics* and are also in alphabetical order. The reference to the original description of a species is given in abbreviated format stating the author, page number and year of publication (see references for details). Author names are according to Brummitt & Powell (1992). Distribution of taxa are indicated by the countries in which they occur and the countries are abbreviated here alphabetically and in the list as follows: A, Angola; B, Burundi; Bot, Botswana; Cam, Cameroon; CAR, Central African Republic; Ch, Chad; DRC, Democratic Republic of Congo; E, Eritrea; Eth, Ethiopia; G, Gabon; Gu, Guinea; K, Kenya; L, Lesotho; Lib, Liberia; Mad, Madagascar; Mal, Malawi; Mau, Mauritius; Moz, Mozambique; N, Namibia; Nig, Nigeria; Rè, Rèunion; Rwa, Rwanda; SA, South Africa; SL, Sierra Leone; Som, Somalia; Sud, Sudan; Swa, Swaziland; T, Tanzania; U, Uganda; Zam, Zambia; Zim, Zimbabwe. Where the locality of a taxon is uncertain, a question mark is used after the suggested country e.g. Mal?.

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Structure of the accompanying table

Table 1 is a listing of synonyms with accepted or suggested names based mainly on literature and the reference to where the status of a species was changed. Column 1 of the table is a list of synonyms and uncertain species in alphabetical order. Column 2 gives the accepted names in **bold** and unaccepted names in *italics*. For taxa where the status could not be confirmed, suggested names are marked with an asterisk. Column 3 gives the publication in which the status of a taxon was first changed. Subsequent publications on the treatment of a taxon are given in chronological order and this is included to denote congruous and differing resolution of taxa by authorities. The references are restricted mainly to revisions, regional treatments and enumeration lists for *Hypoxis* in Africa.

References

References are restricted to taxonomic works on African *Hypoxis*. These are abbreviated in the list and table, and are arranged chronologically in the reference column of the table. A list of references is appended.

Hypoxis *L.*
Subgenus *Hypoxis* Baker: 99 (1878b)
Section *Hypoxis* Geerinck: 75 (1969)
aculeata Nel: 327 (1914); Mal
acuminata Baker: 3 (1889); Les, SA, Swa
angolensis Baker: 266 (1878a); Ang, DRC, T, Zam
angustifolia Lam.: 182 (1789)
biflora Baker: 181 (1876), non De Wild.
djalonensis Hutch. in Hutch. & Dalziel: 394 (1931)
var. **angustifolia**; Mau, Rè, SA
lata Nel: 324 (1914)
var. **buchananii** Baker: 111 (1878b); SA, Swa
obliqua Jacq. var. *woodii* (Baker) Nel: 309 (1914)
woodii Baker: 3 (1889)
var. **luzuloides** (Robyns & Tournay) Wiland: 148 (2002); B, Cam, CAR, Ch, DRC, Eth, G, GU, K, Mad, Moz, Nig, Rwa, SA?, SL, Sud, T, U, Zam, Zim
luzuloides Robyns & Tournay: 254 (1955)
var. **madagascariensis** Wiland: 148 (2002); Mad
araneosa Nel: 310 (1914); K
arenosa Nel: 325 (1914); T
argentea Harv. ex Baker: 110 (1878b)
var. **argentea**; Les, SA, Swa
var. **sericea** Baker: 110 (1878b); Les, N, SA, T
dinteri Nel: 302 (1914)
parviflora Dinter ex Sölch: 115 (1960), nom. nud.
sericea Baker: 111 (1878b)
sericea Baker var. *dregei* Baker: 112 (1878b), pro parte quoad specim. *Drège 8525* (K)
sericea Baker var. *flaccida* Baker: 112 (1878b)
bampsiana Wiland: 207 (1997c); DRC, Mal, T, Zam
multiceps sensu Zimudzi: 14 (1996), non Buchinger ex Baker
sp. A pro parte quoad *Bullock 2045* Nordal et al.: 29 (1985)
camerooniana Baker 7: 577 (1898); Cam
lanceolata Nel: 335 (1914)
ledermannii Nel: 314 (1914)
petrosa Nel: 325 (1914)
recurva Hook.f.: 223 (1864)
thorbeckei Nel: 328 (1914)
villosa L.f. var. *recurva* (Hook.f.) Baker: 114 (1878b)
villosa auct. non L.f. ‘var. *foliis recurvis’* Hook.f.: 223 (1864)
campanulata Nel: 314 (1914); T
canaliculata Baker: 265 (1878a); A, DRC, Mal, Zam, Zim
colchicifolia Baker: 3 (1889); SA
distachya Nel: 322 (1914)
gilgiana Nel: 322 (1914)
latifolia Hook.: t. 4817 (1854)
oligotricha Baker: 3 (1889)
costata Baker: 119 (1878b); Les, SA, Swa
cryptophylla Nel: 316 (1914); Rwa, T
cuanzensis Welw. ex Baker: 265 (1878a); A, K, T, Zam, Zim
macrocarpa E.M.Holt & Staubo in Nordal et. al.: 25 (1985)
demissa Nel: 328 (1914); T
exaltata Nel: 331 (1914); SA
filiformis Baker: 109 (1878b); A, B, DRC, Les, Mal, Moz, SA, Swa, T, U, Zam, Zim
caespitosa Baker: 858 (1901)
dregei (Baker) Nel: 306 (1914)
dregei Baker var. *biflora* (De Wild.) Nel: 306 (1914)
münznerii Nel: 307 (1914)
sericea Baker var. *dregei* Baker: 112 (1878b), pro parte quoad specim. *Cooper 1811* (TCD)
fischeri Pax: 143 (1893); Cam, Zam
flanaganii Baker: 179 (1896); SA
floccosa Baker: 357 (1894); SA
ecklonii Baker: 859 (1901) as *eckloni*
galpinii Baker: 188 (1896); SA, Swa, Zim
costata sensu Norl.: 164 (1937)
pungwensis Norl.: 165 (1937)
stricta Nel: 321 (1914)
gerarrdii Baker: 110 (1878b); Les, SA, Swa
junodii Baker: 859 (1901) as *junodi*
goetzei Harms: 276 (1901); DRC, K, Mal, Moz, T, Zam, Zim
esculenta De Wild.: 537 (1913)
rubiginosa Nel: 320 (1914)
turbinata Nel: 329 (1914)
graminea Willd. ex Schult.: 768 (1829); Mad
gregoriana Rendle: 407 (1895); K
hemerocallidea Fisch., C.A.Mey. & Avé-Lall.: 64, 65 (1842); Bot, Les, Moz, SA, Swa, Zim
elata Hook.f.: t. 5690 (1868), non Schult.f.
obconica Nel: 318 (1914)
patula Nel: 333 (1914)
phoenica Nel, ined. based on specim. *Wood 184* (K), nom. nud.
rigidula Baker var. *hemerocallidea* (Fisch., C.A.Mey. & Avé-Lall.) Heideman: 892 (1983)
rooperii T.Moore: 65 (1852) as *rooperi*
rooperii T.Moore var. *forbesii* Baker: 118 (1878b)
hockii De Wild.: 537 (1913)
pedicellata Nel ex De Wild.: 315 (1914)
var. **hockii** Wiland: 321 (2001); DRC
var. **colliculata** Wiland: 321 (2001); DRC
var. **katangensis** (Nel) Wiland: 322 (2001); DRC, Zam
katangensis Nel ex De Wild.: 312 (1914)
infausta Nel: 319 (1914); T
interjecta Nel: 321 (1914); SA
pretoriensis Goossens, ined. description attached to specim. *Goossens 91* (K), nom. nud.
kilimanjarica Baker: 378 (1898)
subsp. **kilimanjarica**; B, DRC, K, Rwa, T
alpina R.E.Fr.: 78 (1948)
incisa Nel: 301 (1914)
subsp. **prostrata** E.M.Holt & Staubo in Nordal et al.: 26 (1985); K, T
kraussiana Buchinger: 311 (1845); DRC?, SA, Swa
laikipiensis Rendle: 407 (1895); T?
lejolyana Wiland: 418 (1997b); DRC, Zam
longifolia Baker ex Hook.f.: t. 6035 (1873); Les, Moz, SA
filifolia Nob., ined. name applied to specim. *Mund & Maire s.n.* (B) by Nel, nom. nud.
longifolia Baker var. *thunbergii* Baker: 116 (1878b)
villosa L.f. var. δ Thunb. ex Baker: 116 (1878b)
zuluensis S.E.Wood, ined. name applied to specim. *Gerstner 4936* (PRE)
zululandensis S.E.Wood: 66 (1976), MS.*
ludwigii Baker: 181 (1876); Les, SA
lusalensis Wiland: 421 (1997b); DRC
malaissei Wiland: 418 (1997b); DRC
malosana Baker: 284 (1897); B, Bot, DRC, Mal, Moz, SA?, T, U, Zam, Zim
biflora De Wild. : 537 (1913), nom. illeg.
matengensis G.M.Schulze: 376 (1939); T
membranacea Baker: 106 (1878b); A, Swa
monanthos Baker: 266 (1878a); A, B, DRC, Mal

muhilensis Wiland: 412 (1997b); DRC
subsp. **kansimbensis** Wiland: 414 (1997b); Z
subsp. **muhilensis** Wiland: 412 (1997b); Z
multiceps Buchinger: 311 (1845); Les, SA, Swa
neliana Schinz: 136 (1926); Les, SA
nyasica Baker: 284 (1897); Mal, Moz, T, Zam, Zim
canaliculata sensu Brenan: 86 (1954) quoad *Brass 17598*
engleriana Nel: 315 (1914)
engleriana Nel var. *scottii* Nel: 315 (1914)
ingrata Nel: 311 (1914)
probata Nel: 317 (1914)
retracta Nel: 312 (1914)
villosa sensu Zimudzi: 17 (1996)
obliqua Jacq.: 54 (1796): t. 371 (1786–1793); Les, SA
villosa var. *obliqua* (Jacq.) Baker: 114 (1878b)
obtusa Burch. ex Ker Gawl.: t. 159 (1816); A, Bot, K, Les, Mal, Moz, Nam, SA, Swa, T, Zam, Zim
iridifolia Baker: 117 (1878b)
nitida I.Verd.: t. 1058 (1949)
obtusa Burch. MS. ined. et auct. Plur.—vix Ker Gawl.
obtusa Burch. ex Ker Gawl.
var. *chrysotricha* Nel: 334 (1914)
var. *nitida* (I.Verd.) Heideman: 892 (1983)
var. *obtusa*: Heideman: 892 (1983)
villosa L.f. var. *obtusa* (Burch. ex Kew Gawl.) T.Durand & Schinz: 236 (1895)
villosa sensu Eyles: 328 (1916), quoad specim. *Gibbs 192*
villosa sensu Zimudzi: 17 (1996)
parvifolia Baker: 183 (1896); Mal, SA, Swa, Zim
parvula Baker: 113 (1878b)
var. **parvula**; Les, SA, Swa
brevifolia Baker: 183 (1896)
limicola B.L.Burtt: 188 (1988)
membranacea auct. non Baker
var. **albiflora** B.L.Burtt: 190 (1988); SA
polystachya Welw. ex Baker: 266 (1878a)
completa Nel, ined. name applied to specim. *Allen 30* (B), nom.nud.
multiflora Nel: 317 (1914)
obtusa auct. non Burch. ex Ker Gawl. (Nordal & Zimudzi 2001:14)
orbiculata Nel: 313 (1914)
var. **polystachya**; A
var. **andongensis** Baker: 266 (1878a); A
protrusa Nel: 336 (1914); T
rigidula Baker: 116 (1878b)
acuminata sensu Norl.: 163 (1937), quoad specim. *4833*
longifolia Dinter ex Sölch: 2 (1960), nom. nud.
oblonga Nel: 332 (1914)
obtusa auct. non Burch. ex Ker Gawl. (Nordal & Zimudzi 2001:12)
volkmanniae Dinter: 257 (1931)
var. **pilosissima** Baker: 117 (1878b); SA, Swa, Les
arnottii Baker: 552 (1877)
var. **rigidula** Baker: 116 (1878b); Les, Moz, Nam, SA, Swa, T?, Zim
cordata Nel: 331 (1914)
elliptica Nel: 332 (1914)
longifolia Baker: 176 (1904) based on specim. *Junod 1445* (Z), nom. illeg.
rigidula Baker var. *hemerocallidea* (Fisch., C.A.Mey. & Avé-Lall.) Heideman: 892 (1983)
robusta Nel: 313 (1914); DRC
sagittata Nel: 323 (1914); SA
schimperi Baker: 110 (1878b); Eth
villosa auct. non L.f. (Cufodontis 1971: 1578)
sobolifera Jacq.: 53 (1796): t. 372 (1786–1793)
var. **pannosa** (Baker) Nel: 309 (1914); SA
pannosa Baker: 130 (1874)
villosa L.f. var. *pannosa* (Baker) Baker: 114 (1878b)
var. **sobolifera** (Jacq.) Nel: 309 (1914); SA
canescens Fisch. in Fisch. & C.A.Mey.: 50 (1845)
decumbens β & γ Thunb. ex Baker: 114 (1878b)
krebsii Fisch. in Fisch. & C.A.Mey.: 72 (1846)
schweinfurthiana Nel: 329 (1914)
sobolifera Jacq. var. *accedens* Nel: 310 (1914)
villosa L.f. var. *canescens* (Fisch.) Baker (1878b)
villosa L.f. var. *schweinfurthii* Harms: 72 (1895)
villosa L.f. var. *sobolifera* (Jacq.) Baker: 114 (1878b)
sp. A Nordal & Zimudzi: 15 (2001); Mal, Moz, Swa?, Zim
stellipilis Ker Gawl.: t. 663 (1822); SA
lanata Eckl. ex Baker: 118 (1878b)
subspicata Pax: 143 (1893); A, DRC, Mal, Zam
sp. A of Nordal et al., (pro parte quoad *Davies 742*) Nordal et al.: 29 (1985)
suffruticosa Nel: 335 (1914); Cam
urceolata auct. non Nel (Nordal & Iversen 1987: 37)
symoensiana Wiland: 421 (2001); DRC
tetramera Hilliard & B.L.Burtt: 299 (1983); Les, SA
uniflorata Markötter: 15 (1930); SA
upembensis Wiland: 414 (1997); DRC
urceolata Nel: 336 (1914); DRC, Rwa, Zim
apiculata Nel: 327 (1914)
bequaertii De Wild.: 49 (1921b)
crispa Nel: 334 (1914)
villosa L.f.: 326 (1781) sensu lato; K?, Les, Mal, Moz, SA, Swa, Moz, Zam, Zim
abyssinica Hochst.: 32 (1844)
boranensis Cufod.: 328 (1939)
bowriana Baker, ined. name applied to specim. *Bowrie s.n.* (BM), nom. nud.
decumbens Lam.: 172 (1789)
jacquinii Baker: 112 (1878b)
microsperma Lallem. in Fisch. & C.A.Mey.: 50 (1845)
petitiana A.Rich.: 315 (1851)
scabra Lodd.: t. 970 (1824)
simensis Hochst.: 32 (1844)
textilis Nel: 326 (1914)
tomentosa Lam.: 112 (1789)
tysonii Schönland ex Bruce-Miller: 36 (1995), MS.*, nom. nud.
var. *fimbriata* Nel: 310 (1914)
var. *scabra* (Lodd.) Baker: 114 (1878b)
volkensii Harms ex Engl.: 733, 734 (1906), nom. nud.
zernyi Schulze: 375 (1939); T
zeyheri Baker: 112 (1878b); SA
setosa Baker: 113 (1878b)

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* MS., manuscript.

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors

Taxon	Accepted or suggested name	Reference or comment
abyssinica Hochst.	**H. villosa** L.f.	Richard: 314 (1851); Baker: 113 (1878b); Cufodontis: 1580 (1972).
	H. villosa complex	Nordal: 86 (1997).
acida (Nel) Geerinck	**Spiloxene acida** (Nel) Garside	Garside: 268 (1936); Snijman: 110 (2000).
aculeata Nel as *aculeolata*	*H. obtusa* Burch. complex * H. aculeata Nel	Nordal et al. 28 (1985).
acuminata Eckl. (1827), nom. nud.	*H. stellata L.* var. *linearis* (Andrews) Baker = **Spiloxene capensis** (L.) Garside	Baker: 178 (1896); Nordenstam: 294 (1972).
acuminata sensu Norl., quoad specim. *4833*	**H. rigidula** Baker	Nordal & Zimudzi: 12 (2001).
aemulans (Nel) Geerinck	**Spiloxene aemulans** (Nel) Garside	Garside: 269 (1936); Snijman: 110 (2000).
affinis Schult.f.	*H. alba* L.f. = **Spiloxene alba** (Thunb.) Fourc.	Baker: 102 (1878b).

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors (cont.)

Taxon	Accepted or suggested name	Reference or comment
alba (Thunb.) L.f.	**Spiloxene alba** (Thunb.) Fourc.	Garside: 268 (1936).
alba L.f.	*Spiloxene alba* (L.f.) Fourc. = **Spiloxene alba** (Thunb.) Fourc.	Fourcade: 76 (1934).
alba L.f. var. γ Thunb.	*H. alba* L.f. var. *burkei* Baker = **Spiloxene alba**. (Thunb.) Fourc.	Baker: 102 (1878b)
alba sensu Lodd.	*H. alba* var. *gracilis* Baker = **Spiloxene alba** (Thunb.) Fourc..	Baker: 102 (1878b)
alpina R.E.Fr.	**H. kilimanjarica** Baker	Nordal et al.: 26 (1985).
	H. kilimanjarica Baker subsp. **kilimanjarica**	Lebrun & Stork: 106 (1995).
andrewsii Baker	*Janthe andrewsii* (Baker) Nel = **Spiloxene**	Nel: 337 Index (1914).
angolensis Baker	* H. obtusa Burch. ex Ker Gawl.	Nordal & Zimudzi: 13 (2001).
angustifolia auct. non Lam., quoad. specim. *Noirfalise 287*	**Curculigo pilosa** (Schum. & Thonn.) subsp. **minor** (Guinea E.) Wiland	Wiland: 16 (1997a).
angustifolia Lam. var. *cernua* Nel, ined. name applied to specim. *Rehmann 7238* (Z), nom. nud.	H. sp.	Singh in prep.
apiculata Nel	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	H. villosa complex	Nordal: 86 (1997).
	H. urceolata Nel	Wiland-Szymańska: 345 (2001).
aquatica L.f.	**Spiloxene aquatica** (L.f.) Fourc.	Fourcade: 76 (1934); Garside 268 (1936); Snijman: 109 (2000).
araneosa Nel	*H. obtusa* Burch. complex * H. araneosa Nel	Nordal et al.: 28 (1985).
arenosa Nel	*H. obtusa* Burch. complex * H. arenosa Nel	Nordal et al.: 28 (1985).
arnottii Baker	**H. rigidula** Baker var. **pilosissima** Baker	Nel: 331 (1914). Nel cited type of *H. arnottii* as *H. rigidula* var. *pilosissima*; Singh in prep.
aurea Eckl. (1827), nom. nud.	**Spiloxene capensis** (L.) Garside	Nordenstam: 294 (1972).
baguirmiensis A.Chev.	*H. angustifolia* Lam. = **Curculigo baguirmiensis** (A.Chev.) A.Chev.	Lebrun & Stork 3: 106 (1995); Chevalier: 305 (1913).
baurii Baker	**Rhodohypoxis baurii** (Baker) Nel	Nel: 300 (1914).
bequaertii De Wild.	*H. subspicata* Pax	Lebrun & Stork: 106 (1995).
	H. urceolata Nel	Troupin: 277 (1971); Wiland-Szymańska: 345 (2001).
beyrichii Nel	*H. villosa* L.f.	Zimudzi: 17 (1996).
	* H. rigidula Baker	Singh in prep. Insufficiently known, known only from type having inadequate material.
biflora Baker non De Wild.	**H. angustifolia** Lam.	Baker: 111 (1878b).
biflora De Wild., nom. illeg.	*H. dregei* var. *biflora* (De Wild.) Nel	De Wildeman: 8 (1914).
	H. malosana Baker	Nordal et al.: 27 (1985); Lebrun & Stork: 106 (1995); Wiland-Szymańska: 329 (2001).
	H. filiformis Baker	Nordal & Zimudzi: 10 (2001).
boranensis Cufod.	*H. villosa* complex * H. villosa L.f.	Nordal: 86 (1997).
bowriana Baker, ined. name applied to specim. *Bowrie s.n.* (BM), nom. nud.	**H. villosa** L.f.	Singh in prep.
brevifolia Baker	*H. membranacea* Baker	Nel: 338 (1914).
	H. parvula Baker var. **parvula**	Burtt: 190 (1988).
caerulescens DC.	*H. stellata* (Thunb.) L.f. var. *elegans* (Andrews) Baker = * Spiloxene capensis (L.) Garside	Baker: 101 (1878b).
caespitosa Baker	**H. filiformis** Baker	Nel: 305 (1914).
camerooniana Baker	*H. angustifolia* Lam.	Cufodontis: 1577 (1971).
campanulata Nel	*H. obtusa* Burch. complex * H. campanulata Nel	Nordal et al.: 28 (1985).
canaliculata sensu Brenan quoad *Brass 17598*	**H. nyasica** Baker	Nordal & Zimudzi: 16 (2001).
canescens Fisch.	*H. villosa* L.f. var. *canescens* (Fisch.) Baker	Baker: 114 (1878b).
	H. sobolifera Jacq. var. **sobolifera** (Jacq.) Nel	Nel: 339 (1914).
completa Nel, ined. name applied to specim. *Allen 30* (B), nom. nud.	*H. orbiculata* Nel = **H. polystachya** Welw. ex Baker	Nel struck off *H. completa* and replaced it by *H. orbiculata* on specim. *Allen 30* (B).
	H. completa Nel	De Wildeman: 8 (1914); 34 (1921a).
cordata Nel	*H. rigidula* Baker var. *hemerocallidea* (Fisch., C.A. Mey. & Avè-Lall.) Heideman	Heideman: 892 (1983).
	H. rigidula Baker var. **rigidula**	Singh in prep.
costata sensu Norl.	**H. galpinii** Baker	Nordal & Zimudzi: 11 (2001).
crassifolia Pappe in Baker	*H. alba* L.f. = **Spiloxene alba** (Thunb.) Fourc.	Baker: 102 (1878b).
crispa Nel	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	H. urceolata Nel	Wiland-Szymańska: 345 (2001).
cryptophylla Nel	*H. obtusa* Burch. complex * H. cryptophylla Nel	Nordal et al.: 28 (1985).
curculigioides Bolus	**Spiloxene curculigoides** (Bolus) Garside	Garside: 269 (1936); Snijman: 110 (2000).
cuspidata (Nel) Geerinck	* Spiloxene ovata (L.f.) Garside	Snijman: 110 (2000).
declinata (Nel) Geerinck	* Spiloxene curculigoides (Bolus) Garside	Snijman: 110 (2000).

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors (cont.)

Taxon	Accepted or suggested name	Reference or comment
decumbens β & γ Thunb. ex Baker non L.	*H. villosa* var. *canescens* (Fisch.) Baker	Baker: 114 (1878b).
	H. sobolifera Jacq. var. **sobolifera** (Jacq.) Nel	Singh in prep.
decumbens Lam.	**H. villosa** L.f.	Schult.f. in Schultes & Schultes: 765 (1830).
demissa Nel	*H. obtusa* Burch. complex * H. demissa Nel	Nordal et al.: 28 (1985).
dielsiana (Nel) Geerinck	**Spiloxene dielsiana** (Nel) Garside	Garside: 268 (1936); Snijman: 110 (2000).
dinteri Nel	*H. villosa* L.f.	Zimudzi: 17 (1996).
	H. argentea Harv. ex Baker var. **sericea** Baker	Singh in prep.
distachya Nel	**H. colchicifolia** Baker	Singh in prep.
djalonensis Hutch.	**H. angustifolia** Lam.	Hepper: 172 (1968); Nordal & Iversen: 34 (1987).
dregei (Baker) Nel	**H. filiformis** Baker	Zimudzi: 15 (1996); Nordal & Zimudzi: 10 (2001).
dregei (Baker) Nel var. *biflora* (De Wild.) Nel, nom. illeg.	*H. malosana* Baker	Nordal et al.: 27 (1985); Lebrun & Stork: 106 (1995).
	H. filiformis Baker	Nordal & Zimudzi: 10 (2001).
dubia Schult.f.	*H. alba* L.f. = **Spiloxene alba** (L.f.) Fourc.	Baker: 102 (1878b).
eckloniana Schult.f.		Insufficiently known.
ecklonii Baker as *eckloni*	**H. floccosa** Baker	Singh in prep.
elata Hook.f. non Schult.f., nom. illeg.	**H. hemerocallidea** Fisch. & C.A. Mey. & Avé-Lall.	Baker: 119 (1878b).
elata Schult.f. non Hook.f.	*H. stellata L.* var. *albiflora* Baker = **Spiloxene**	Baker: 101 (1878b).
elegans Andrews	*H. stellata* L. var. *elegans* (Andrews) Baker = * Spiloxene capensis (L.) Garside	Baker: 101 (1878b); Garside: 269 (1936).
elliptica Nel	**H. rigidula** Baker	Zimudzi: 16 (1996); Nordal & Zimudzi: 12 (2001).
	H. rigidula Baker var. **rigidula**	Singh in prep.
engleriana Nel	*H. villosa* L.f.	Zimudzi: 17 (1996).
	H. nyasica Baker	Nordal & Zimudzi: 16 (2001).
engleriana Nel var. *scottii* Nel	**H. nyasica** Baker	Nordal & Zimudzi: 16 (2001).
esculenta De Wild.	*H. subspicata* Pax	De Wildeman: 34 (1921a); Nordal et al.: 25 (1985); Lebrun & Stork: 106 (1995).
	H. goetzei Harms	Zimudzi: 14 (1996); Nordal & Zimudzi: 8 (2001); Wiland-Szymańska: 319 (2001).
filifolia Eckl. (1827), nom. nud.	**Spiloxene** sp.	Nordenstam: 294 (1972).
filifolia Nob., ined. name applied to specim. *Mund & Maire s.n.* (B) by Nel, nom. nud.	**H. longifolia** Baker ex Hook.f.	Singh in prep.
fischeri Pax	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	H. fischeri Pax	Nordal & Iversen: 40 (1987).
flaccida (Nel) Geerinck	**Spiloxene flaccida** (Nel) Garside	Garside: 269 (1936); Snijman: 109 (2000).
flavescens Eckl. (1827), nom. nud.	**Spiloxene capensis** (L.) Garside	Nordenstam: 294 (1972).
flavopetala Eckl. (1827), nom. nud.	**Spiloxene capensis** (L.) Garside	Nordenstam: 294 (1972).
geniculata Eckl. (1827), nom. nud.	*H. stellata* L. var. *linearis* (Andrews) Baker = **Spiloxene capensis** (L.) Garside	Baker: 178 (1896); Nordenstam: 294 (1972).
gilgiana Nel	**H. colchicifolia** Baker	Singh in prep.
gracilipes Schltr.	* Spiloxene ovata (L.f.) Garside	Snijman: 109 (2000).
gregoriana Rendle	*H. obtusa* Burch. complex * H. gregoriana Rendle	Nordal et al.: 28 (1985).
hemerocallidea Fisch., C.A.Mey. & Avè-Lall.	*H. rigidula* Baker var. *hemerocallidea* (Fisch., C.A. Mey. & Avè-Lall.) Heideman	Heideman: 892 (1983).
hockii De Wild.	*H. subspicata* Pax	Lebrun & Stork: 106 (1995).
	H. hockii De Wild.	Wiland: 321 (2001).
incisa Nel	**H. kilimanjarica** Baker	Nordal et al.: 26 (1985); Wiland-Szymańska: 324 (2001).
	H. kilimanjarica Baker subsp. **kilimanjarica**	Lebrun & Stork: 106 (1995).
infausta Nel	*H. obtusa* Burch. complex * H. infausta Nel	Nordal et al.: 28 (1985).
ingrata Nel	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	H. nyasica Baker	Nordal & Zimudzi: 16 (2001).
iridifolia Baker	*H. villosa* L.f.	Zimudzi: 17 (1996).
	H. obtusa Burch. ex Ker Gawl.	Nordal & Zimudzi: 13 (2001).
jacquinii Baker as *jacquini*	* H. villosa L.f.	Insufficiently known; Singh in prep.
juncea Eckl. (1827), nom. nud.	*H. stellata* L. var. *linearis* (Andrews) Baker = **Spiloxene capensis** (L.) Garside	Baker: 101 (1878b); Nordenstam: 294 (1972).
junodii Baker as *junodi*	*H. dregei* Baker	Nel: 338 (1914); Bews: 64 (1921).
	H. gerrardii Baker	Burtt: 188 (1988).
katangensis Nel ex De Wild.	*H. subspicata* Pax	Lebrun & Stork: 106 (1995).
	H. polystachya Welw. ex Baker	Nordal & Zimudzi: 14 (2001).
	H. hockii De Wild. var. **katangensis** (Nel ex De Wild.) Wiland	Wiland-Szymanska: 324 (2001).
krebsii Fisch.	*H. villosa* L.f. var. *sobolifera* Jacq. = **H. sobolifera** Jacq. var. **sobolifera** (Jacq.) Nel	Baker: 114 (1878b); Cufodontis: 1580 (1972).
laikipiensis Rendle	*H. obtusa* Burch. complex. * H. laikipiensis Rendle	Nordal et al.: 28 (1985).

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors (cont.)

Taxon	Accepted or suggested name	Reference or comment
lanata Eckl. ex Baker	**H. stellipilis** Ker Gawl.	Baker: 118 (1878b); 187 (1896).
lanceolata Nel	*H. recurva* Hook.f.	Hepper: 172 (1968).
	H. camerooniana Baker	Nordal & Iversen: 38 (1987).
latifolia Hook.	**H. colchicifolia** Baker	Burtt: 201 (1986).
lata Nel	**H. angustifolia** Lam. var. **angustifolia**	Singh in prep.
laxa Eckl.(1827), nom. nud.	*H. stellata* L. var. *linearis* (Andrews) Baker = **Spiloxene capensis** (L.) Garside	Baker: 178 (1896); Nordenstam: 294 (1972).
ledermannii Nel	*H. recurva* Hook.f.	Hepper: 172 (1968).
	H. camerooniana Baker	Nordal & Iversen: 37 (1987).
leucotricha Fritsch (1901)		Insufficiently known.
limicola B.L.Burtt	**H. parvula** Baker var. **parvula**	Singh in prep.
linearis Andrews	*H. serrata* (Thunb.) L.f.	Ker Gawler: t. 917 (1806).
	Spiloxene stellata (Thunb.) L.f. var. *linearis* (Andrews) Baker	Baker: 101 (1878b).
	Spiloxene linearis (Andr.) Garside	Garside: 268 (1936).
	Spiloxene serrata (Thunb.) Garside var. **serrata**	Snijman: 110 (2000).
longifolia Baker, based on specim. *Junod 1445* (Z), nom. illeg..	*H. cordata* Nel	Nel: 331 (1914)
	H. rigidula Baker var. **rigidula**	Singh in prep.
longifolia Dinter ex Sölch, nom. nud.	**H. rigidula** Baker	Merxmüller: 2 (1969).
longifolia Eckl. (1827), nom. nud.	**Spiloxene capensis** (L.) Garside	Nordenstam: 294 (1972).
longifolia Baker ex Hook.f. var. *thunbergii* Baker	**H. longifolia** Baker ex Hook.f.	Singh in prep.
longipes Baker	* H. obtusa Burch. ex Ker Gawl.	Insufficiently known.
ludwigii sensu Nel (is the same as **ludwigii** Baker)	*H. obtusa* Burch. ex Ker Gawl.	Nordal & Zimudzi: 13 (2001).
	H. ludwigii Baker	Singh in prep.
luzulaefolia DC.	*Curculigo plicata* Dryand.	Baker: 122 (1878b).
	Curculigo scorzonerifolia (Lam.) Baker	Hilliard & Burtt: 307 (1973).
luzulaefolia Eckl. (1827), nom. nud.	*H. serrata* L. = **Spiloxene serrata** (Thunb.) Garside	Baker: 103 (1878b); Nordenstam: 294 (1972).
luzulifolia DC.	**Curculigo scorzonerifolia** (Lam.) Baker	Hilliard & Burtt: 307 (1973).
luzuloides Robyns & Tournay	**H. angustifolia** Lam.	Nordal: 24 (1985); Nordal & Iversen: 34 (1987); Zimudzi: 15 (1996); Wiland-Szymańska: 309 (2001).
	H. angustifolia Lam. var. **luzuloides** (Robyns & Tournay) Wiland	Nordal & Zimudzi: 6 (2001); Wiland-Szymańska & Adamski: 148 (2002).
macrocarpa E.M.Holt & Staubo	**H. cuanzensis** Welw. ex Baker	Zimudzi: 15 (1996).
	H. schimperi Baker	Nordal & Zimudzi: 7 (2001); Nordal: 89 (1997).
malosana Baker	*H. dregei* Baker	Nel: 339 (1914).
	H. filiformis Baker	Zimudzi: 15 (1996); Nordal & Zimudzi: 10 (2001).
	H. malosana Baker	Wiland-Szymańska: 309 (2001).
matengensis G.M.Schulze	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	* H. matengensis G.M.Schulze	
maximiliani Schltr.	* Spiloxene umbraticola (Schltr.) Garside	Snijman: 109 (2000).
membranacea auct. non Baker	*H. limicola* B.L.Burtt = **H. parvula** Baker var. **parvula**	Burtt: 188 (1988); Singh in prep.
microsperma Lallem.	*H. villosa* L.f. var. *pannosa* (Baker) Baker	Baker: 184 (1896).
	H. villosa L.f.	Singh in prep.
milloides Baker	*Rhodohypoxis baurii* (Baker) Nel var. *milloides* (Baker) Nel	Nel: 300 (1914).
	Rhodohypoxis milloides (Baker) Hilliard & B.L. Burtt	Hillard & Burtt: 59 (1978).
minor Eckl. (1827), nom. nud.	*H. alba* L.f. var. *gracilis* Baker = **Spiloxene alba** (Thunb.) Fourc.	Baker: 176 (1896).
minuta (L.) L.f.	**Spiloxene minuta** (L.) Fourc.	Fourcade: 76 (1934); Garside: 269 (1936); Snijman: 109 (2000).
mollis Baker		Insufficiently known.
monophylla Schltr. ex Baker	**Spiloxene monophylla** (Schltr.) Garside	Garside: 269 (1936); Snijman: 110 (2000).
multiceps sensu Zimudzi non Buchinger ex Baker	**H. bampsiana** Wiland	Nordal & Zimudzi: 8 (2001).
multiflora Nel	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	? *H. fischeri* Pax	Lebrun & Stork: 106 (1995).
	H. polystachya Welw. ex Baker	Nordal & Zimudzi: 14 (2001).
münznerii Nel as *münzneri, muenzneri*	*H. malosana* Baker	Nordal et al.: 27 (1985); Lebrun & Stork: 106 (1995).
münznerii Nel as *munzneri, muenznerii*	**H. filiformis** Baker	Zimudzi: 17 (1996); Nordal & Zimudzi: 10 (2001).
nana E.Mey. in herb. Drège, nom. nud.	Pauridia hypoxidoides Harv. = **P. minuta** (L.f.) T.Durand & Schinz	Baker: 126 (1878b); Thompson: 621 (1979).
natalensis Klotzsch	* H. colchicifolia Baker	Insufficiently known.
neghellensis Cufod.	*H. villosa* complex	Nordal: 87 (1997).
neocanaliculata Geerinck	**Spiloxene canaliculata** Garside	Snijman: 110 (2000).
nigricans Conrath	* H. obtusa Burch. ex Ker Gawl.	Insufficiently known.

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors (cont.)

Taxon	Accepted or suggested name	Reference or comment
nitida I.Verd.	*H. obtusa* Burch. ex Ker Gawl. var. *nitida* (I.Verd.) Heideman	Heideman: 892 (1983).
	H. iridifolia Baker	Burtt: 204 (1986).
	H. villosa L.f.	Zimudzi: 17 (1996).
	H. obtusa Burch. ex Ker Gawl.	Nordal & Zimudzi: 14 (2001).
nyasica Baker as *nyassica*	*H. villosa* L.f.	Zimudzi: 17 (1996).
	H. nyasica Baker	Nordal & Zimudzi: 16 (2001).
obconica Nel	**H. hemerocallidea** Fisch., C.A.Mey. & Avè-Lall.	Singh in prep.
obliqua Andrews non Jacq.	*H. andrewsii* Baker = * Spiloxene	Baker: 104 (1878b).
obliqua Eckl. & Zeyh. non Jacq.	*H. alba* L.f. = **Spiloxene alba** (L.f.) Fourc.	Baker: 102 (1878b).
obliqua Jacq. non Andrews	*H. villosa* L.f. var. *obliqua* Jacq.	Baker: 114 (1878b); Singh in prep.
	H. obliqua Jacq.	
obliqua Jacq. var. *woodii* (Baker) Nel	**H. angustifolia** Lam. var. **buchananii** Baker	Wood: 88 (1976); Singh in prep.
oblonga Nel	**H. rigidula** Baker	Zimudzi: 16 (1996); Singh in prep.
obtusa auct. non Burch. ex Ker Gawl.	partly **H. rigidula** Baker and partly **H. polystachya** Welw. ex Baker	Nordal & Zimudzi: 12, 14 (2001).
obtusa Burch. MS.	*H. villosa* L.f. var. *obtusa* (Burch.) T.Durand & Schinz	Durand & Schinz: 236 (1895).
	H. iridifolia Baker = **H. obtusa** Burch. ex Ker Gawl.	Burtt: 204 (1986); Lebrun & Stork: 106 (1995).
obtusa Burch. ex Ker Gawl.	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	H. villosa L.f.	Zimudzi: 17 (1996).
	H. villosa complex	Nordal: 86 (1997).
	H. obtusa Burch ex Ker Gawl.	Singh in prep.
obtusa Burch. ex Ker Gawl. var. *chrysotricha* Nel	**H. obtusa** Burch. ex Ker Gawl.	Singh in prep.
obtusa Burch. var. *nitida* (I.Verd.) Heideman	**H. obtusa** Burch. ex Ker Gawl.	Singh in prep.
obtusa Burch. var. *obtusa*	**H. obtusa** Burch. ex Ker Gawl.	Singh in prep.
obtusa complex sensu Nordal et al. (1985)	*H. obtusa* Burch. ex Ker Gawl.	Nordal & Zimudzi: 14 (2001).
oligophylla Baker		Insufficiently known.
oligotricha Baker	**H. colchicifolia** Baker	Burtt: 202 (1986)
olivacea Engl., nom. nud.		Insufficiently known.
orbiculata Nel	*H. subspicata* Pax	Lebrun & Stork: 106 (1995).
	H. villosa L.f.	Zimudzi: 17 (1996).
	H. polystachya Welw. ex Baker	Nordal & Zimudzi: 14 (2001).
ovata L.f.	**Spiloxene ovata** (L.f.) Garside	Garside: 268 (1936); Snijman: 110 (2000).
pannosa Baker	**H. sobolifera** L.f. var. **pannosa** (Baker) Baker	Baker: 114 (1878b).
parviflora Dinter ex Sölch, nom. nud.	*H. dinteri* Nel	Merxmüller: 2 (1969).
	H. argentea Harv. ex Baker var. **sericea** Baker	Singh in prep.
patula Nel	**H. hemerocallidea** Fisch., C.A.Mey. & Avé-Lall.	Singh in prep.
pavonina Salisb.	*H. stellata* L. var. *elegans* (Andrews) Baker = * Spiloxene capensis (L.) Garside	Baker: 101 (1878b)
pedicellata Nel ex De Wild.	*H. subspicata* Pax	Lebrun & Stork: 106 (1995).
	H. villosa L.f.	Zimudzi: 17 (1996).
	H. polystachya Welw. ex Baker	Nordal & Zimudzi: 14 (2001).
	H. hockii De Wild.	Wiland-Szymańska: 320 (2001).
petitiana A.Rich.	**H. villosa** L.f.	Baker: 113 (1878b).
	H. villosa complex	Nordal: 86 (1997).
petitiana A.Rich. forma *petitiana*	*H. villosa* complex * H. villosa L.f.	Nordal: 86 (1997).
petrosa Nel	**H. camerooniana** Baker	Nordal & Iversen: 37 (1987).
phoenica Nel, ined. name applied to specim. *Wood 184* (K), nom. nud.	**H. hemerocallidea** Fisch., C.A.Mey. & Avé-Lall.	Singh in prep.
platypetala Baker	**Rhodohypoxis baurii** (Baker) Nel var. **platypetala** (Baker) Nel	Nel: 300 (1914).
plicata (Thunb.) L.f.	*Curculigo plicata* (Thunb.) Dryand.	Baker: 122 (1878b).
	Empodium plicatum (Thunb.) Garside	Hilliard & Burtt : 313 (1973).
plicata Jacq. non (Thunb.) L.f.	*Curculigo veratrifolia* Baker	Baker: 123 (1878b).
	Empodium veratrifolium (Willd.) Thompson	Thompson: 163 (1972).
pretoriensis Goossens, ined. description attached to specim. *Goossens 91* (K), nom. nud.	**H. interjecta** Nel	Heideman: 87 (1979); Singh in prep.
probata Nel	*H. obtusa* Burch. complex	Nordal et al. 28 (1985).
	H. nyasica Baker	Nordal & Zimudzi: 16 (2001).
protusa Nel	*H. obtusa* Burch. complex * H. protrusa Nel	Nordal et al.: 28 (1985).
pumila Lam.	*H. minuta* (L.) L.f. = **Spiloxene minuta** (L.) Fourc.	Baker: 101 (1878b); Snijman: 109 (2000).
pungwensis Norl	*H. villosa* L.f.	Zimudzi: 17 (1996).
	H. galpinii Baker	Nordal & Zimudzi: 11 (2001).
recurva Hook.f.	*H. villosa* L.f. var. *recurva* (Hook. f.) Baker	Baker: 114 (1878b).
	H. camerooniana Baker	Nordal & Iversen: 37 (1987).
retracta Nel	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
	H. nyasica Baker	Nordal & Zimudzi: 16 (2001).
rigidula Baker var. *hemerocallidea* (Fisch., C.A.Mey. & Avé-Lall.) Heideman based on *Junod 1445* (Z)	**H. rigidula** Baker var. **rigidula**	Singh in prep.

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors (cont.)

Taxon	Accepted or suggested name	Reference or comment
triandra Pappe, MS.	*Pauridia hypoxidoides* Harv. = **Pauridia minuta** (L.f.) T.Durand & Schinz	Baker: 126 (1878b); Thompson: 621 (1979).
tridentata DC.	*H. stellata* (Thunb.) L.f. var. *elegans* (Andrews) Baker = **Spiloxene**	Baker: 101 (1878b).
triflora Harv., MS.	*H. minuta* L.f. = **Spiloxene minuta** (L.) Fourc.	Baker: 102 (1878b).
trifurcillata (Nel) Geerinck	**Spiloxene trifurcillata** (Nel) Fourc.	Fourcade: 76 (1934); Snijman: 109 (2000).
tristycha Cufod.	*H. villosa* complex * H. villosa L.f.	Nordal: 87 (1997).
truncata Thunb. ex Schult.	*Pauridia hypoxidoides* Harv. as *hypoxidioides* = **Pauridia minuta** (L.f.) T.Durand & Schinz	Baker: 126 (1878); Thompson: 621 (1979).
turbinata Nel	*H. villosa* L.f. **H. goetzei** Harms	Zimudzi: 17 (1996). Nordal & Zimudzi: 8 (2001).
tysonii Schönland ex Bruce-Miller, ined. name applied to specim. *Tyson s.n.* May 1916 (PRE), nom. nud.	**H. villosa** L.f.	Singh in prep.
umbraticola Schltr.	**Spiloxene umbraticola** (Schltr.) Garside	Garside: 269 (1936); Snijman: 109 (2000).
urceolata auct. non Nel	**H. suffruticosa** Nel	Nordal & Iversen: 37 (1987); Lebrun & Stork: 106 (1995).
urceolata Nel	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
veratrifolium Willd.	*Curculigo veratrifolia* (Willd.) Baker = **Empodium veratrifolium** (Willd.) Thompson	Baker: 123 (1878b); Thompson: 163 (1972).
villosa auct. non L.f.	**H. schimperi** Baker	Cufodontis: 1578 (1971).
villosa auct. non L.f. 'var. *foliis recurvis*' Hook.f.	*H. recurva* Hook.f. **H. camerooniana** Baker	Hepper: 172 (1968). Nordal & Iversen: 38 (1987).
villosa complex	partly **H. polystachya** Welw. ex Baker and partly **H. rigidula** Baker	Nordal & Zimudzi: 14 (2001).
villosa Jacq. non Thunb., non L.f.	*H. jacquini* Baker as *Jacquini* * H. villosa L.f.	Baker: 112 (1878b). Insufficiently known.
villosa L.f. var. δ Thunb. ex Baker	*H. longifolia* Baker ex Hook.f. var. *thunbergii* Baker **H. longifolia** Baker ex Hook.f.	Baker: 116 (1878b). Singh in prep.
villosa L.f. var. *canescens* (Fisch.) Baker	**H. sobolifera** Jacq. var. **sobolifera** (Jacq.) Nel	Singh in prep.
villosa L.f. var. *fimbriata* Nel	**H. villosa** L.f.	Singh in prep.
villosa L.f. var. *obliqua* (Jacq.) Baker	**H. obliqua** Jacq.	Singh in prep.
villosa L.f. var. *obtusa* (Burch. ex Ker Gawl.) T.Durand & Schinz	**H. obtusa** Burch. ex Ker Gawl.	Cufodontis: 1578 (1971); Singh in prep.
villosa L.f. var. *pannosa* (Baker) Nel	**H. sobolifera** Jacq. var. **pannosa** (Baker) Nel	Nel: 309 (1914).
villosa L.f. var. *recurva* (Hook.f.) Baker	*H. recurva* Hook.f. **H. camerooniana** Baker	Nel: 325 (1914). Nordal & Iversen: 38 (1987).
villosa L.f. var. *scabra* (Lodd.) Baker	**H. villosa** L.f.	Singh in prep.
villosa L.f. var. *schweinfurthii* Harms	*H. villosa* L.f. var. *sobolifera* = **H. sobolifera** Jacq. var. **sobolifera** (Jacq.) Nel *H. villosa* complex	Cufodontis: 1580 (1972); Nel: 309 (1914). Nordal: 86 (1997).
villosa L.f. var. *sobolifera* (Jacq.) Baker	**H. sobolifera** Jacq. var. **sobolifera** (Jacq.) Nel	Nel: 309 (1914).
villosa sensu Baker (1898), partly not of L.f.	*H. recurva* Hook.f.	Hepper: 172 (1968)
villosa sensu Eyles, quoad specim. *Gibbs 192*	**H. obtusa** Burch. ex Ker Gawl.	Nordal & Zimudzi: 13 (2001).
villosa sensu Zimudzi	**H. obtusa** Burch. ex Ker Gawl. **H. nyasica** Baker	Nordal & Zimudzi: 14 (2001). Nordal & Zimudzi: 16 (2001).
volkensii Harms ex Engl., nom. nud.	**H. villosa** L.f.	Cufodontis: 1579 (1972).
volkmanniae Dinter	**H. rigidula** Baker *H. villosa* L.f.	Sölch: 2 (1960). Zimudzi: 17 (1996).
woodii Baker	*H. obliqua* Jacq. var. *woodii* (Baker) Nel **H. angustifolia** Lam. var. **buchananii** Baker	Nel: 309 (1914). Wood: 88 (1976); Singh in prep.
zernyi G.M. Schulze	*H. obtusa* Burch. complex	Nordal et al.: 28 (1985).
zuluensis S.E.Wood, ined. name applied to specim. *Gerstner 4936* (PRE)	*H. zululandensis* S.E.Wood = **H. longifolia** Baker ex Hook.f.	Singh in prep.
zululandensis S.E.Wood, ined. MS., nom. nud.	**H. longifolia** Baker ex Hook.f.	Singh in prep.

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Hypoxis (Hypoxidaceae) in southern Africa: Taxonomic notes

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Abstract

Several *Hypoxis* species and infraspecific taxa in southern Africa were found to be conspecific with the taxa described earlier. In this paper, thirteen validly published names are reduced to synonyms. Nine currently recognized taxa out of about 30 species in the Flora of southern Africa region are listed together with their new synonyms and important literature, and a brief discussion is given for each change in name status. The nine taxa discussed (with synonyms) are: *Hypoxis angustifolia* var. *buchananii* Baker (= *H. obliqua* var. *woodii* (Baker) Nel); *Hypoxis argentea* var. *sericea* Baker (= *H. argentea* var. *flaccida* Baker, *H. dinteri* Nel); *H. colchicifolia* Baker (= *H. distachya* Nel, *H. gilgiana* Nel); *H. floccosa* Baker (= *H. ecklonii* Nel); *H. hemerocallidea* Fisch., C.A.Mey. & Ave-Lall. (= *H. obconica* Nel, *H. patula* Nel, *H. rooperi* var. *forbesii* Baker); *H. longifolia* Baker ex Hook.f. (= *H. longifolia* var. *thunbergii* Baker); *H. obtusa* Ker Gawl. (= *H. obtusa* var. *chrysotricha* Nel); *H. rigidula* var. *rigidula* Baker (= *H. cordata* Nel); *H. rigidula* var. *pilosissima* Baker (= *H. arnottii* Baker).

Keywords: Hypoxis; Hypoxidaceae; Nomenclature; Southern Africa; Synonymy; Taxonomy

Hypoxis L. is the largest genus of the Hypoxidaceae, a family of 'lower' Asparagales (Nordal, 1998; Fay et al., 2000). The genus comprises about 90 species and is distributed on all the continents except Europe. In the Flora of southern Africa (FSA) region that includes South Africa, Namibia, Botswana, Lesotho and Swaziland, and hereafter referred to as southern Africa, there are about 30 species, the majority confined to the eastern parts of the subcontinent. The taxonomy of the genus has always presented a challenge due to a lack of distinct diagnostic characters that readily define species and infraspecific taxa.

Over a period of 30 years, Baker (1874, 1877, 1878a,b, 1889, 1894, 1896, 1901, 1904) described 38 species of *Hypoxis* in Africa, 21 being endemic to southern Africa. For species demarcation he used mainly leaf characters and inflorescence type. The next major revision of *Hypoxis* in southern Africa was by Nel (1914) as part of a taxonomic treatment of the Hypoxidaceae in Africa. Nel recognized 83 species of *Hypoxis* in Africa, no less than 45 being newly described by him. Nel's work is valuable in that it provides much insight into floral characters and leaf venation patterns and their use in grouping species into sections. However, Nel attributed inordinate taxonomic significance to two characters, namely the anther tips and leaf venation. Based mainly on these two characters, Nel (1914) described 14 new species from southern Africa. Although Nel provided the descriptions for the newly proposed sections and species, he omitted descriptions of previously described species and this makes it difficult to fully understand his species concepts. There is therefore much reliance on studying the herbarium specimens cited by Nel to interpret his concept of the various species.

Hilliard and Burtt (1983) and Burtt (1986, 1988) provided useful comments on the status and nomenclature of individual species of *Hypoxis* based on their extensive field knowledge of the group in South Africa and Lesotho. Recent studies by Nordal (1997), Nordal and Zimudzi (2001) and Wiland-Szymańska (2001) have partially resolved the infrageneric taxonomy of *Hypoxis* in tropical Africa. A new revision of the genus in Africa, which is the primary centre of diversity for the genus, is very desirable. Such a study will help to reveal species complexes, especially those that are in special need of resolution.

Until recently (Wiland, 1997), there has been much reluctance among taxonomists to describe further new species in *Hypoxis* due largely to a lack of understanding of the seemingly chaotic patterns of morphological variation that tend

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to obscure species limits. In fact, most regional treatments of the genus in Africa indicate a reduction to synonymy of published taxa. Work on *Hypoxis* in tropical Africa by Hepper (1968), Geerinck (1971), Nordal et al. (1985), Nordal and Iversen (1987) and more recently Zimudzi (1996), Nordal and Zimudzi (2001) and Wiland-Szymańska (2001) have reduced 15 of Nel's (1914) species to synonymy (see also Singh, 2006). Snijman and Singh (2003) provide a synopsis of the *Hypoxis* taxa recognized in southern Africa in recent years.

An ongoing taxonomic revision of *Hypoxis* in southern Africa by the author (Singh, in preparation) has shown several taxa to be synonymous with the other already published species. The present paper provides notes on the change in status of thirteen validly published names. Nine of the newly proposed synonyms were first described by Nel (1914). Note that in the present paper the full synonymy is not supplied for each of the recognized taxa, but names newly placed in synonymy and those synonyms referred to for comparison are listed. Full synonymy for species will appear in the taxonomic treatment of the genus for southern Africa (Singh, in preparation).

Hypoxis angustifolia var. **buchananii** Baker in Journal of the Linnean Society 17: 111 (1878b); Durand and Schinz: 231 (1895); Baker in Thiselton-Dyer: 180 (1896); Wood: 132 (1907); Bews: 64 (1921); Wood, S.E.: 88 (1976). Type: South Africa, without exact locality, *Buchanan s.n.* (K!, holo.).

H. obliqua var. *woodii* (Baker) Nel: 309 (1914), syn. nov., Bews: 64 (1921); Ross: 132 (1972). *H. woodii* Baker: 3 (1889); Durand and Schinz: 236 (1895); Baker in Thiselton-Dyer: 183 (1896); Wood: 132 (1907), Type: South Africa, [KwaZulu-Natal], Inanda, *Medley Wood, 426a* (K!, image).

Baker (1889) described *H. woodii* based on a specimen *Medley Wood 426a* in Kew. In his treatment of *Hypoxis* in Flora Capensis, Baker (1896) correctly cited another sheet in Kew, *Medley Wood 426*, under *H. angustifolia* var. *buchananii*. In an unpublished thesis, Ms S.E. Wood pointed out that both *Medley Wood 426* and *426a* are conspecific, making the name *H. woodii* a synonym of *H. angustifolia* var. *buchananii*. Examination of the two sheets in Kew confirms Ms Wood's observation.

Based on *Medley Wood 426a* and *Pegler 690* (BOL, PRE), Nel (1914) reduced *H. woodii* as a variety of *H. obliqua*. Both *Medley Wood 426a* and *Pegler 690* are determined as *H. angustifolia* var. *buchananii*. *H. obliqua* var. *woodii* is therefore placed in synonymy under *H. angustifolia* var. *buchananii*.

Hypoxis argentea var. **sericea** (Baker) Baker in Thiselton-Dyer, Flora Capensis 6: 182 (1896). *H. sericea* Baker in Journal of the Linnean Society 17: 112 (1878b). Type: South Africa, [Eastern Cape], Uitenhage, *Zeyher 950* (K!, lecto., selected here, image; BM!, isolecto.).

H. sericea var. *dregei* Baker: 112 (1878b). Type: South Africa, [Eastern Cape], Stockenstrom Division, Katberg, *Drège 8525* (K!, lecto., selected here, image; BM!, isolecto).

H. argentea var. *flaccida* (Baker) Baker: 182 (1896), syn. nov., Durand and Schinz: 234 (1895). *H. sericea* var. *flaccida* Baker: 112 (1878b); Durand and Schinz: 234 (1895). Syntypes: South Africa, [Eastern Cape], Albany, *Williamson s.n* (K); South Africa, [Free State], 'Seven Fountains', *Burke s.n.* (K!).

H. dinteri Nel: 302 (1914), syn. nov. Type: Namibia, Otavital, *Dinter 634* (B!, SAM!, isolecto).

Hypoxis dinteri is known only from the type specimens. In this study, the specimens are identified as *H. argentea* var. *sericea*. The leaves in *H. argentea* are usually folded lengthwise in pressed specimens. In *Dinteri 634*, the leaves are pressed flat and it is unusual to see the leaves pressed in this way. The distinct long, fine, silky bifurcate hairs of *H. argentea* are present in the specimens. *Dinter 634* also bears a single flower per inflorescence, but with two bracts. This arrangement has been observed in other specimens of *H. argentea*.

A study of specimens in the East African Herbarium [EA], Nairobi, indicates that *Guebson 947* from Nachingwea and *Robertson 374A* from the Nguru Mountains, both in Tanzania, match *H. argentea* var. *sericea*. Wiland-Szymańska (2001) recorded for the first time that *H. dinteri* also occurs in the Democratic Republic of Congo and Zambia. Unfortunately, the specimens cited by Wiland-Szymańska from BR and MO were not seen by me and it is therefore not possible to confirm if these central African specimens are conspecific with *H. argentea* var. *sericea*, although this is expected based on the presence of the latter in East Africa.

In 1878, Baker described *H. argentea* and *H. sericea* as separate species. He separated *H. sericea* from *H. argentea* by its many more leaves that are longer and wider, in having distinct veins, and with the lower surface of leaves covered in sericeous, appressed hairs. In the same publication, Baker also established two varieties in addition to the typical variety in *H. sericea*, namely var. *dregei* and var. *flaccida*. In 1896, Baker himself reduced *H. sericea* as a variety under *H. argentea*. He placed *H. sericea* var. *sericea* and *H. sericea* var. *dregei* under *H. argentea* var. *sericea*. He also created the combination *H. argentea* var. *flaccida* as a third variety and sank *H. sericea* var. *flaccida* into this. In an unpublished thesis, Wood, S.E. (1976) found *Burke s.n.*, syntype of *H. argentea* var. *flaccida* to be synonymous with *H. argentea* var. *sericea*. The present study confirms Ms Wood's observation and *H. argentea* var. *flaccida* is therefore formally reduced to *H. argentea* var. *sericea*.

In the protologue, Baker cites five different gatherings for *H. sericea*, with no indication that one of them has a better claim to type status than the others. All of them may therefore be regarded as syntypes, and it becomes necessary to choose a lectotype. One of these specimens, namely *Zeyher 950*, has been annotated with the word 'type' in N.E. Brown's handwriting. Brown's reason for selecting this specimen is not entirely clear (he left no notes on the question), and it appears that this choice was never formally published. The specimen is entirely typical of the species, and there is no reason to disagree with Brown's implicit lectotypification. This publication therefore formalises the choice of *Zeyher 950* as lectotype of this taxon. In consequence of this choice, the specimens *Ecklon & Zeyher 6*, *Barber 708*, *MacOwan 1593b* and *Bolus 176* become lectoparatypes.

Hypoxis sericea var. *dregei* was based on the syntypes *Cooper 1811* (TCD) and *Drège 8525* (K) (Baker 1878b). Nel (1914) raised *H. sericea* var. *dregei* to full species as *H. dregei* based on *Cooper 1811*. Burtt (1988) clarifies the use of the name *H. dregei* and comments on the lectotype *Cooper 1811* chosen by Nel. Based on *Cooper 1811* as the lectotype for *H. sericea* var. *dregei* and *H. dregei*, these two taxa were correctly reduced to synonymy under *H. filiformis* by Nordal and Zimudzi (2001). The lectoparatype specimen, *Drège 8525* represents *H. argentea* var. *sericea*, and is therefore excluded from this species.

Hypoxis colchicifolia Baker in Journal of Botany: 3 (1889); Durand and Schinz: 231 (1895); Baker in Thiselton-Dyer: 186 (1896); Burtt: 201 (1986). Type: South Africa, Cape, without exact locality, hort. *Bull s.n.* Nov. 1884 (K!, holo.).

H. oligotricha Baker: 3 (1889); Durand and Schinz: 233 (1895); Baker in Thiselton-Dyer: 187 (1896); Nel: 321. Type: South Africa, [KwaZulu-Natal], Inanda, *Medley Wood 1170* (K!).

H. distachya Nel: 322 (1914), syn. nov. Type: South Africa, [KwaZulu-Natal], Pinetown, *Thode s.n.* August 1893 (B!).

H. gilgiana Nel: 322 (1914), syn. nov. Type: South Africa, without exact locality, *Ecklon*? *4529* (B!).

Nel (1914) listed *H. colchicifolia* as one of the species for which he did not see any original material. He classified *H. distachya* and *H. gilgiana* with *H. oligotricha* in Section *Oligotrichae* Nel. *H. distachya* and *H. gilgiana* were separated from *H. oligotricha* by their villous ovaries in comparison to a glabrous ovary in *H. oligotricha*. Burtt (1986), however, reduced *H. oligotricha* to *H. colchicifolia*, a decision subsequently widely accepted by taxonomists and supported by the present study. The ovaries in *H. colchicifolia* are variable in hair density. Nel (1914) considered the leaves of *H. distachya* to be ovate-lanceolate and ±80 mm long in comparison to oblong-lanceolate leaves, 300–400 mm long in *H. gilgiana*. These leaf dimensions are within the range for *H. colchicifolia* where the leaves are (80–) 200–500 mm long. *H. distachya* and *H. gilgiana* are therefore considered synonyms of *H. colchicifolia*.

Hypoxis floccosa Baker in Kew Bulletin: 357 (1894); Baker in Thiselton-Dyer: 181 (1896); Nel: 303 (1914). Type: South Africa, [Western Cape], Swellendam, *Bolus 7469* (BOL!, holo., K!, isolecto).

H. ecklonii Baker: 859 (1901) [as *eckloni*], syn. nov., Nel: 307 (1914). Type: South Africa, [Eastern Cape], Zwarteberg, *Ecklon & Zeyher 4136* (K!, image, B!, Z!).

Comparison of the types of *H. floccosa* and *H. ecklonii* indicates that there is similarity in leaf shape, leaf indumentum and the inflorescences, and there are no consistent differences. Plants of the type specimens of both species have leaves 50–75 mm long and are floccose on one or both surfaces with hairs in tufts. Moreover, on the type sheets of both species, plants have inflorescences that are single-flowered (rarely two-flowered). It is concluded that *H. floccosa* and *H. ecklonii* are conspecific and the latter name is placed in synonymy under the older *H. floccosa*.

Hypoxis hemerocallidea Fisch., C.A.Mey. & Avé-Lall. in Index Seminum quae Hortus Botanicus Imperialis Petropolitanus 8: 64 (1842); Baker: 119 (1878b); Durand and Schinz.: 232 (1895); Baker in Thiselton-Dyer: 188 (1896); Nel: 316 (1914); Burtt: 202 (1986). Type: South Africa, Cape of Good Hope, cult. in Hort. Bot. Petrop. (LE!, image).

H. obconica Nel: 330 (1914), syn. nov. Syntypes: South Africa, [KwaZulu-Natal], Verulam, *Schlechter 2898* (B!, BOL!, ZT!); [KwaZulu-Natal], Pinetown, *Thode s.n.* July 1893 (B!); *Medley Wood 184* (K).

H. patula Nel: 333 (1914), syn. nov. Type: South Africa, [Mpumalanga], Barberton, Saddleback Range, *Galpin 1100* (K!, holo. image; PRE!, isolecto).

H. rooperi var. *forbesii* Baker: 118 (1878b), syn. nov., Durand and Schinz: 234 (1895); Baker in Thiselton-Dyer: 189 (1996). Type: Mozambique, Delagoa Bay, *Forbes s.n.* (1822) (K!, image).

H. rooperi T. Moore: 65 cum icone (1852); Baker in Thiselton-Dyer: 188 (1897); Nel: 337 (1914); Type: cult. by T. Rooper October 1850 from a plant collected in the Eastern Cape in July 1837 (K, scan!).

Hypoxis obconica is known only from the syntypes collected by Schlechter, Thode and Medley Wood in KwaZulu-Natal. The collections are morphologically similar to *H. hemerocallidea* except the plants are smaller in stature and bear only two flowers per inflorescence. Nel (1914) considered *H. obconica* to be closer to *H. rigidula* and placed it in Section *Rigidulae* Nel. He described the two-flowered inflorescences in *H. obconica* as subumbellate and the many-flowered inflorescences of *H. rigidula* as racemose. Field observations of *H. hemerocallidea* in South Africa indicate that young plants in a population may bear two flowers on short or long pedicels, and inflorescences in these plants appear delicate. In older plants of the same population, flower numbers vary from 4 to 12, pedicel lengths are variable and scapes and pedicels are firm. The two-flowered inflorescence state has also been noted in other species with racemose inflorescences, including *H. rigidula*. Leaves of *H. obconica* are linear-lanceolate, soft and recurved as in *H. hemerocallidea* in comparison to the linear, rigid and erect or bending leaves of *H. rigidula*. The distribution and type of hairs on leaves in *H. obconica* also match those in *H. hemerocallidea*. In both species, the leaf blades have an even distribution of long weak hairs that are mostly bifurcate. Due to these similarities in leaf and indumentum characters with *H. hemerocallidea*, and the observed age-related variation in inflorescence morphology, *H. obconica* is placed in synonymy under the latter species.

Hypoxis patula is known only from the type specimen. Nel (1914) considered *H. patula* to be closely related to *H. rooperi* as he placed both species in section *Obtusae* Nel. He considered *H. patula* to have subspicate inflorescences and flowers with short pedicels, 5–6 mm long. *H. rooperi* and five other species in the same section were described as being pedicellate and with pedicels 10 mm long. *H. rooperi* was subsequently reduced to *H. hemerocallidea* by Burtt (1986), a decision supported by the present study. Observations of the populations of *H. hemerocallidea* in South Africa indicate that the first few inflorescences of the new season bear two flowers with short or long pedicels [e.g. *Codd 1822* (PRE); *Hutchings 620* (KEI); *Bourquin 458* (NU); *Clark 1* (NU); *Wylie s.n.* BH 22372 (BOL); *Palmer 2647* (GRA)]. Subsequent inflorescences in the same season on the same plants develop racemes with many flowers on long pedicels. The subspicate state in *H. hemerocallidea* commonly varies from the usual racemose state in the species. *H. patula* matches *H. hemerocallidea* in leaf characters and shares the subspicate state of inflorescence. *H. patula* is therefore reduced to synonymy under *H. hemerocallidea*.

Baker (1878b) separated *H. rooperi* from *H. hemerocallidea* on its corymbose inflorescences in contrast to that in *H. hemerocallidea* being racemose. Based on the smaller stature of the plant in *Forbes s.n.* (K) from Mozambique, Baker (1878b) proposed a var. *forbesii* under *H. rooperi*. Burtt (1986) clarified the concept of *H. hemerocallidea* and reduced *H. rooperi* as a synonym of *H. hemerocallidea*. He also discussed the problems around Heideman's (1983) concept of *H. rigidula* and *H. hemerocallidea*. Heideman (1979, 1983) maintained the two varieties in *H. rooperi,* namely var. *rooperi* and var. *forbesii*. She interpreted the small plants represented by var. *forbesii* as those bearing new leaves in the growing season e.g. *Leisegang 46* (NU). During fieldwork in South Africa, plants of *H. hemerocallidea* were found to display considerable variation in leaf dimensions, numbers of flowers and dimensions of pedicels. It is extremely difficult to define limits for leaf dimensions to demarcate varieties in *H. hemerocallidea*. Younger plants of *H. hemerocallidea* appear different from older ones in a population and if collected independently, can easily be mistaken for a separate taxonomic entity. This type of infraspecific variation has also been observed in *H. rigidula*. Therefore, the approach in this study has been to broaden the limits of variability for a species to also accommodate the different facies due to developmental variation. Variety *forbesii* is considered to be well within the limits of *H. hemerocallidea*.

Hypoxis longifolia Baker ex Hook.f. in Curtis Botanical Magazine 26: t. 6035 (1873), non Baker (1904); Baker: 115 (1878b); Durand and Schinz: 231 (1895), Baker in Thiselton-Dyer: 185 (1896). Type: South Africa, [Free State], *Burke s.n.* Fat River (K!, lecto., selected here).

H. longifolia var. *thunbergii* Baker: 116 (1878b), syn. nov., Durand and Schinz: 231 (1895). Type: South Africa, Cape, *Thunberg s.n.* (UPS-THUNB!, image no. 8269) as *H. villosa* var. δ.

Hooker f. (1873) described *H. longifolia* in Curtis's Botanical Magazine using Baker's manuscript name and based his description on a *Cooper s.n.* specimen from Algoa Bay grown at Kew (specimen not yet located; not at K). He also cited a similar specimen *Burke s.n.* (K) collected at Fat River [Vet River or *Vetrivier*] in the Free State. Further, he mentioned that Mr Baker had named this species. In 1904, Baker described four new species of *Hypoxis*, three closely allied to *H. obtusa* and one to *H. angustifolia*. He named the one *H. longifolia* based on the specimen *Junod 1445* (Z) but he made no mention of his manuscript name or Hooker's (1873) publication of this name. *Junod 1445* closely resembles *H. rigidula* var. *rigidula* and does not fit the description of *H. longifolia* by Hooker f. Since Baker (1904) used the identical epithet as in the younger Hooker's publication for a different plant, Baker's name is a later homonym and therefore invalid.

Nel (1914) described the specimen *Junod 1445* as a species separate from *H. longifolia* and called it *H. cordata*. In the present study, *H. cordata* is regarded as a synonym of *H. rigidula* var. *rigidula*. See *H. rigidula* for details on *H. cordata*. Baker (1878b) described *H. longifolia* var. *thunbergii* based on a Thunberg specimen from the Cape Colony. He separated it from the typical variety by its leaves having simple white ascending hairs, 2–3 mm long. Among the specimens examined in the present study, no distinction into varieties could be made on differences in hairs. Baker indicated that the typical variety has a few short whitish hairs on the margins and keel of the lower leaf surface and cited *Burke s.n.* in support. The Burke specimen has many short stellate hairs on the margins and keel and a similar distribution and type of hair is found in *Moll 4740*, which Wood (1976) regarded as typical of the manuscript name *H. zululandensis* S.E.Wood. Baker (1896) did not mention var. *thunbergii* in his treatment of Hypoxidaceae in Flora Capensis.

Hypoxis obtusa Ker Gawl. in Botanical Register 2: tab. 159. (1816). Baker: 114 (1878b), Durand and Schinz: 233 (1895); Baker in Thiselton-Dyer: 184 (1896); Heideman: 892 (1983); Burtt: 205 (1986); Nordal and Zimudzi: 13 (2001). *H. villosa* var. *obtusa* (Ker Gawl.) Durand and Schinz: 236 (1985). Type: Bot. Reg. tab. 159, icono.!

H. obtusa var. *chrysotricha* Nel in Bot. Jahrb.: 334 (1914), syn. nov. Type: South Africa, [KwaZulu-Natal], Newmarket, *Krook 405* (W)-type lost in World War II.

H. iridifolia Baker: 117 (1878b); Burtt: 204 (1986); Nordal and Zimudzi: 13 (2001) Type: "Tropical South Africa", *Baines* s.n. Oct 1872, (K!, holo.).

In Durand and Schinz (1895), *H. obtusa* is listed as species number 31 on page 233 and as a variety of *H. villosa* on page 236. Under the variety, these authors indicate the reduction of *H. obtusa* to synonymy. It is most probable that this has come about through an error in transcribing the six varieties of *H. villosa* from Baker (1878b). In Baker (1878b), *H. obtusa* is listed as a species immediately below the varieties of *H. villosa* and in Durand and Schinz, it was possibly copied across as a variety.

Hypoxis obtusa is very distinct in leaf characters, making it an easy species to identify. Its leaves are coriaceous with many evenly spaced prominent veins. The lamina is glabrous, except at the bases. Leaf hairs form a white conspicuous band along the margins and midrib beneath. The species is also very floriferous, producing mostly 5–11 flowers per inflorescence.

Burtt (1986) discussed the differences between Burchell's and Ker Gawler's concepts of *H. obtusa* and concluded that the Burchell specimen named *H. obtusa* represents *H. iridifolia* and not *H. obtusa* Ker Gawl. I follow Burtt (1986) in accepting the type of *H. obtusa* as Ker Gawler's illustration. Nordal and Zimudzi (2001) reduced *H. iridifolia* to synonymy under *H. obtusa*. The present study confirms that there are difficulties in maintaining *H. iridifolia* as a species distinct from *H. obtusa*. Since the character of the hairs forming a band on the margins and midrib is distinct in both *H. iridifolia* and *H. obtusa*, and that the width of leaves were found to be variable in the species as well as in the related species *H. hemerocallidea* and *H. rigidula*, it is proposed that *H. iridifolia* be accepted as a synonym of *H. obtusa* as proposed by Nordal and Zimudzi (2001).

Nel (1914) did not mention *H. iridifolia* in his treatment, but he described *H. obtusa* var. *chrysotichya*. He considered the longer leaves and tepals covered with golden hairs, to be distinct from the typical variety. Unfortunately, the type specimen of var. *chrysotichya* formed part of the collection at W that was destroyed in World War II (Dr Bruno Wallnöfer, Curator of Vascular Collections, W, pers. comm., 2005). From the vague description provided by Nel, var. *chrysotichya* appears to be the same as *H. obtusa*, a species for which no infraspecific taxa are formally recognized in the present study.

Hypoxis rigidula Baker in Journal of the Linnean Society, Botany 17: 116 (1878b); Durand and Schinz.: 233 (1895); Baker in Thiselton-Dyer: 186 (1896); Nel: 331 (1914); Zimudzi: 16 (1996) pro parte; Nordal and Zimudzi: 12 (2001). Type: South Africa, [Free State], *Cooper 883* (K!, lecto., selected here).

H. cordata Nel: 331 (1914), syn. nov. Type: South Africa, [Limpopo Province], Shiluvane, *Junod 1445* (Z!, holo.).

H. elliptica Nel: 332 (1914); Ross: 132 (1972). Syntypes: South Africa, [Eastern Cape], Alexandria, *Rudatis 688* (B!); South Africa, [KwaZulu-Natal], Pietermaritzburg, *Schlechter 3303* (B!).

Nel (1914) placed *H. rigidula*-like plants with broad leaves, 16–18 mm wide into a new species called *H. cordata*. In contrast, he defined *H. rigidula* as having leaves up to 15 mm broad. Except for leaf width, *H. cordata* is similar to *H. rigidula* in all characters and is best accommodated in a slightly wider concept of *H. rigidula*.

Zimudzi (1996) reduced *H. elliptica* to *H. rigidula*. The present study supports this decision.

H. rigidula var. **pilosissima** Baker in Journal of the Linnean Society, Botany 17: 117 (1878b), Durand and Schinz: 234 (1895), Baker in Thiselton-Dyer: 186 (1896), Nel: 331 (1914). Type: South Africa, [Gauteng], Magalies Berg [Magliesberg], *Burke 156* (K!, lecto., selected here).

H. arnottii Baker: 552 (1877), syn. nov., Baker: 112 (1878b); Baker in Thiselton-Dyer: 182 (1896) Type: South Africa, [Eastern Cape], Colesberg, *Arnott s.n.* (not yet traced, seemingly not at K), June 1870, Hort. Kew.

A group of specimens collected by *Rehmann*, namely his numbers *4312*, *4313*, *4768* and *5809*, all housed at the Herbarium der Universitat (Z) were determined in an unknown handwriting as *H. arnottii* Baker. In trying to resolve the concept of *H. arnottii*, these specimens were examined by the present author. Nel (1914) cited *Rehmann 4312* and *5809* as *H. rigidula* var. *pilosissima*. On the sheet of *Rehmann 5809*, Nel wrote that this specimen of *H. arnottii* is found with *H. elliptica* on the sheet of *Schlechter 3303* (Z) and that this specimen is *H. rigidula* var. *pilosissima*. Nel also determined *Rehmann 4313* and *4768* (Z) as *H. rigidula* var. *pilosissima* in the form of hand written notes on the specimens. The present study concurs with Nel's determination of these specimens. From the description, *H. arnottii* matches *H. rigidula* var. *pilossisima* especially in the leaves clasping at the base for up to 300 mm when flowering, and in the long, soft, ascending hairs. It is therefore proposed that the name *H. arnottii* be reduced to a synonym of *H. rigidula* var. *pilossisima*. The type specimen of *H. arnottii*, however, remains unseen.

Zimudzi (1996) reduced variety *pilosissima* to *H. rigidula* and considered *H. rigidula* to have no infraspecific taxa. The present study recognizes var. *pilosissima* as a distinct and easily recognized taxon in southern Africa. The leaves of var. *pilosissima* are covered in a layer of dense hairs with no spaces between the hairs. In the typical variety, leaves are subglabrous to hairy, but not as dense as in var. *pilosissima*. Also in var. *pilosissima*, hairs are mostly ascending and give the leaf a felt-like texture; while those of var. *rigidula* are appressed.

List of names placed in synonymy in this paper. Accepted names are in bold face.

H. argentea var. *flaccida* Baker **H. argentea var. sericea**
H. arnottii Baker **H. rigidula var. pilosissima**
H. cordata Nel **H. rigidula var. rigidula**
H. dinteri Nel **H. argentea var. sericea**
H. distachya Nel **H. colchicifolia**
H. ecklonii Nel **H. floccosa**
H. gilgiana Nel **H. colchicifolia**
H. longifolia var. *thunbergii* Baker **H. longifolia**
H. obconica Nel **H. hemerocallidea**
H. obliqua var. *woodii* (Baker) Nel **H. angustifolia var. buchananii**
H. obtusa var. *chrysotricha* Nel **H. obtusa**
H. patula Nel **H. hemerocallidea**
H. rooperi var. *forbesii* Baker **H. hemerocallidea**

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Hypoxis parvula, Incandu Forest Reserve, Newcastle. Photo: Yashica Singh.

HYPOXIS

Yellow stars of horticulture, folk remedies and conventional medicine.

by **Yashica Singh**, *Natal Herbarium, National Botanical Institute*

Hypoxis plants are usually easy to recognize by their bright yellow star-shaped flowers which have become known as yellow stars. For many years *Hypoxis* has been used by traditional healers to treat patients suffering from urinary-tract infections, infertility, impotency, anxiety and insanity. Recently considerable interest has been generated in the therapeutic properties of *Hypoxis* in treating prostatic hypertrophy and AIDS, and all of a sudden, knowledge about the plant is in great demand.

Classification

Hypoxis was previously placed in the Amaryllidaceae and Liliaceae, families, based on similarity in appearance to members within these families. However, we now know that it is quite different and is currently placed in a small family named after it, the Hypoxidaceae (star lily family). The Hypoxidaceae consists of 9 genera and about 152 species and occurs mainly in the southern hemisphere. About 60% of the 152 species belong to *Hypoxis*. Six of the genera (*Empodium*, *Hypoxis*, *Pauridia*, *Rhodohypoxis*, *Saniella* and *Spiloxene)* occur in southern Africa. All except *Hypoxis* are endemic to the region. *Pauridia*, *Rhodohypoxis*, *Saniella* and *Spiloxene* are restricted to South Africa. *Rhodohypoxis*, a genus with potential in the horticultural trade, is closely related to *Hypoxis* and may be distinguished from it by its white, pink or red flowers.

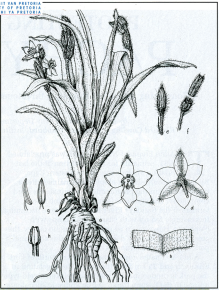
Distribution

Hypoxis occurs throughout most of the warm temperate and tropical zones of the world. It is absent from Europe, northern and central Asia, north Africa, extra-tropical South America and Canada. Thus far, no species is known to extend its distribution from one continent to another. In Africa, the genus is widespread south of the Sahara. The largest number of taxa (50) is found in southern Africa, where species are spread throughout the region, except in Botswana and the arid karroid regions of the Northern Cape and southern Namibia. All southern African taxa are represented in South Africa and grow mainly in the summer rainfall area. Seven taxa, (*Hypoxis angustifolia*, *H. argentea*, *H. floccosa*, *H. longifolia*, *H. setosa*, *H. stellipilis* and *H. villosa*) extend their range into the Western Cape. The centre of diversity for *Hypoxis* appears to be KwaZulu-Natal and the Eastern Cape. Each province has about 30 species.

Habitat

Hypoxis is a typical component of open grasslands. A few species are able to tolerate shaded conditions

THE MORPHOLOGY OF *HYPOXIS* using *H. hemerocallidea* as an example



Hypoxis plants are perennial geophytic herbs that are able to survive unfavourable conditions in the form of an underground vertical rootstock which is called a corm **(a)**. During favourable conditions (spring and summer) roots, leaves and flowering stems are produced from the rootstock. Corms are fleshy, mucilaginous and mostly single. In some species a corm may develop lateral branches and each branch in turn bears an aerial shoot thus creating a clump effect above the ground. Branching in corms may also arise when the apical point of a corm is damaged. Internally, corms are white, yellowish green, bright yellow or orange and the colour blackens with oxidation.

Leaves arise directly from the apex of the corm and are generally arranged one above the other in three defined vertical rows that radiate outwards from the centre of the plant. Leaf bases in some species are enclosed in a sheath which creates a column effect, known as a pseudostem or false stem. Leaves range from linear to broadly lanceolate, are erect or prostrate and are usually hairy **(b)**; except in a few species where hairs are lacking.
In some species younger leaves are markedly hairy which implies that at maturity hairs are deciduous while in other taxa, hairs are persistent in mature leaves.

Flowering stems are contemporary with leaves, axillary, hairy and are usually unbranched. The number of flowers per inflorescence varies from two to twelve. In a cluster, flowers may be opposite, alternate or in a whorl of three. Flowering stems may be broadly classified into two types: those with more than four flowers and those with less than four flowers. Each flower is borne on a short pedicel and is supported by a narrow hairy bract. Flowers are symmetrical, with usually six free tepals - three inner and three outer **(c)**. In open flowers, tepals are yellow or occasionally white on the upper surface and, green and hairy on the lower surface. Outer tepals are narrower and have a higher degree of greenness and hairiness on the lower surface than the inner tepals **(d)**. Six free stamens **(g)** are inserted at the base of the tepals. Generally, the style is short and thick, equal to or shorter that the robust stigma **(h)**. In contrast, *H. parvula* and *H. membranacea* are characterized by a long narrow style which is two or more times the length of the minute stigma. Both species have been noted to hybridize naturally with members of *Rhodohypoxis*.

The fruit in *Hypoxis* is referred to as a pyxis (a capsule in which the apical section splits off as a lid at maturity). In *Hypoxis*, the apical section is formed by a crown of persistent tepals **(e)** which drops off at dehiscence **(f)**. Seeds are subglobose, hard, black, glossy and smooth, or dull and papillate.

These intergeneric hybrids may well be worthy of cultivation as pot plants since many cultivars of *Rhodohypoxis* are already popular in Europe as pot plants.

Medicinal and other uses

For centuries *Hypoxis* species have been utilized as muthi by the different tribes in southern Africa. Roots or corms of *Hypoxis*, for instance are used by Zulu traditional healers in their treatment of intestinal parasites, infertility, urinary infections, heart weakness, cough, nausea, vomiting, palpitations and nervous disorders. An infusion of the tuber of *H. colchicifolia* (earlier name *H. latifolia*) is taken as an emetic against fearful dreams which is indicative of heart weakness. The Sotho use *Hypoxis* as a charm against thunder, lightning and storms. Leaves of *H. rigidula* and *H. hemerocallidea* are used to make rope. Local people in the Escourt area make a black polish from corms of *H. obtusa* which they apply to the floors of their huts (according to Fred Smith of Bushmansriver Gifts). In times of famine, corms of some species of *Hypoxis* are boiled or roasted for food by the Sotho and Xhosa people.

Sterols and sterolins from corms of *Hypoxis* boost the immunity of patients suffering from various ailments. One such sterol, hypoxoside is readily converted to rooperol, a biologically active compound that inhibits the proliferation of certain cancer cells and HIV-1. Around 1970, a drug based on B-Sitosterol-D-Glucoside, isolated from *Hypoxis* corms, proved to be effective in the treatment of prostate hypertrophy and became available in West Germany under a registered trade name. In 1997, the South African public was introduced, through the media (including the World Wide Web) to a miracle drug called 'Moducare'. This immunity booster is claimed to help patients suffering from prostatic hypertrophy, AIDS, TB, ME, arthritis and psoriasis. 'Moducare', which is advertised as the 'African Potato Plant' extract or tablet, is available from health shops and pharmacies without prescription. The drug was originally based on phytosterol extracts from corms of *H. hemerocallidea*. It is important to note that contrary to continual reports and advertising, sterols from *H. hemerocallidea* are no longer used in the manufacture of 'Moducare' capsules. Instead isolates from various other plant sources such as soya beans are being used in the production of this drug.

Acknowledgements
Ms Gill Condy of the National Herbarium, NBI, Pretoria is thanked for illustrating *Hypoxis hemerocallidea* and *Rhodohypoxis baurii* var. *platypetala*.

Above. ***Rhodohypoxis baurii* var. *baurii*, Ngele Nature Reserve, near Kokstad.** **Photo: Rosemary Williams.** Below. ***Rhodohypoxis baurii* var. *platypetala*.** **Drawing by Jill Condy.**

found in forest margins. *Hypoxis filiformis* and *H. acuminata* are examples of species that prefer moist depressions in vleis. Other species such as *H. parvula* and *H. membranacea* inhabit damp grassy banks and crevices in boulders. *Hypoxis* corms have a high tolerance to fire, in fact fire promotes the growth of new leaves and flowering in the genus. Plants of *H. hemerocallidea* (previously called *H. rooperi*) were observed to produce leaves and flowers shortly after a burn, irrespective of the month of burning (March to August). During the regular flowering period (September to January), those plants that had flowered earlier in the year were observed to flower again. The soil-stored seeds of *Hypoxis* also have fire-stimulated germination and it appears that seed dormancy is broken by smoke. Exactly which fire cue (physical or chemical) responsible for seed germination in *Hypoxis* is still unknown.

Etymology

Linnaeus, father of biological nomenclature, established the generic name *Hypoxis* in 1759. He coined the epithet *Hypoxis* from the Greek words *hypo* (below) and *oxy* (sharp) in reference to the ovary or fruit which is pointed at the base. In southern Africa, various vernacular names include star flower, star grass, gifbol, inkbol and sterretjie (Afrikaans); ilabatheka, inKomfe, inkomfe-enkula (Zulu); moli (Sesotho) and tshuka (Tswana).
In early 1997, media reports on the miracle drug based on *Hypoxis hemerocallidea*, introduced the common name 'African potato' (Afrika-patat in Afrikaans) for the plant. The coined name 'African potato' cannot be traced directly to any common name used in the past. Researchers involved in testing the effect of the drug in improving the immune system in cancer and AIDS patients were unable to afford the author any explanation for the origin of the name 'African potato'. Is the designation an imagination of journalists? It is possible that the word 'African' relates to the variety of uses of *Hypoxis* in African traditional medicine or to the fact that the plant occurs in Africa. *Solenostemon rotundifolius* (Lamiaceae) is aptly referred to as the 'Zulu round potato' or hausa potato as it is used as a substitute for potatoes in West Africa. Use of the term 'potato' for the *Hypoxis* corms is inappropriate as it alludes to a substantial staple food such as *Solanum tuberosum* (Solanaceae) or *Solenostemon rotundifolius*. In contrast, *Hypoxis* corms have an unpleasant bitter taste and it is unlikely that any member of the genus would ever become a food crop. Nevertheless, the designation 'African potato' has no doubt become a favourite among the South African public and despite its inappropriateness it will continue to be used.

Pollination

Flowers of *Hypoxis* are fairly short-lived. They open for approximately five to nine hours for one day only. Flowers open sequentially from the base to the apex of the inflorescence.
In *H. hemerocallidea*, mostly one to three flowers open per day with an interval of about an hour between opening which seemingly encourages cross pollination. There is an interval of a week between the development of new inflorescences on the same plant in this species. In *H. obtusa*, up to eight flowers per inflorescence open on the same day and flowers open simultaneously on several inflorescences in a single plant. This flowering strategy gives rise to fields of yellow in the Escourt and Weenen districts in summer. Solitary and honey bees are a common sight in flowers of *Hypoxis* during the early hours of the day. It is not uncommon for a bee to spend much time in the larger flowers such as those of *H. hemerocallidea*, usually with head facing the inside of the flower, loading its pollen sacs. The yellow pollen grains are easily visible through the transparent pollen sacs of bees. In the smaller flowered species, such as *H. argentea* and *H. filiformis* bee visits are expeditious and often impossible to photograph.

Horticulture

Yellow stars are used as garden ornamentals because of their showy flowers and their tolerance of dry conditions. At present only a few species of *Hypoxis* are in cultivation. *H. hemerocallidea*, *H. colchicifolia* and *H. angustifolia* have thus far entered the nursery trade. For showiness of colour, *H. obtusa* would also be worth promoting as a garden plant. Once in cultivation, yellow stars are relatively simple to maintain. It is however, difficult to rapidly germinate *Hypoxis* seeds under standard nursery conditions. Untreated seeds remain dormant for about one year before germination. Corm division is a more rapid and guaranteed form of propagation. *Hypoxis parvula* (with white or yellow flowers) and *H. membranacea* (white-flowered) hybridize with *Rhodohypoxis* in nature.

RHODOHYPOXIS, BEAUTY IN ABUNDANCE

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See page 86 for color plates.

Over the grassy zigzagging slopes of the mystical Drakensberg Mountains in the interior of southern Africa, resides the inherent beauty and splendour of some 400 plant genera. Many of these have their centre of diversity in the Drakensberg. One such genus is *Rhodohypoxis.* In the spring and summer months, the rose-colored, dainty flowers of *Rhodohypoxis* appear en masse (Fig. 1), staining the grassy hills and rocky outcrops. This small yet distinctive group of hardy perennial herbs has also found its place among the pot and landscape ornamentals in Europe, the United Kingdom, the United States and Japan, as it is excellent for alpine gardens. The purpose of this account is to introduce this fascinating genus, to reveal the characters of wild species, and to highlight their decorative potential.

Rhodohypoxis belongs in the Hypoxidaceae or star-lily family and is a close ally to the genus *Hypoxis* (Fig. 2). Plants of *Rhodohypoxis* were placed in *Hypoxis* up until 1914, when Gert Nel recognised that these rose-colored flowering herbs were in fact different from their yellow star-flowered counterparts. Nel established the genus *Rhodohypoxis* to accommodate the '*Hypoxis*' plants with white, pink or red flowers. At that stage, he recognised two species, *R. baurii* and *R. rubella.* The prefix *Rhodo-* refers to the rose-colored flowers of the genus and *hypoxis* to the structural similarity shared with plants in that genus. *Rhodohypoxis* differs from *Hypoxis* by virtue of its white, pink or red flowers, the presence of a perianth-tube, and stamens hidden and lacking well-defined filaments (Nel, 1914). In addition to this, Hilliard and Burtt (1978) pointed out that in *Rhodohypoxis* the 3 inner perianth-segments flex inwards to meet at the throat of the flower. Figures 3a & b illustrate the structural distinction between flowers of these 2 genera. A generic description of *Hypoxis* is given in Veld & Flora (Singh, 1999).

Rhodohypoxis is a small genus of 6 species with a distribution centered in the Eastern Region of the Drakensberg (Fig. 4). *R. baurii* and *R. milloides* have a wider distribution as they also inhabit outlying ranges of the Drakensberg, including the Mawahqua, Insizwe, Insikeni, Currie, Ngeli and Tabankulu Mountains in the Eastern Region of South Africa. The most

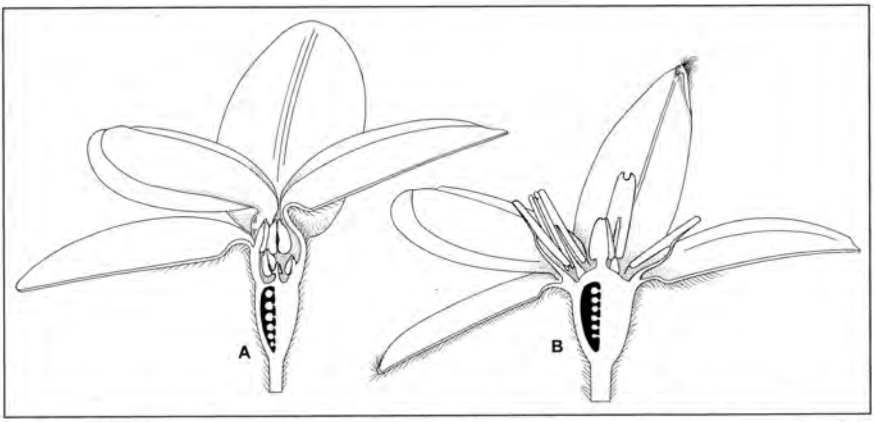

Fig. 3. Half flower drawings showing structural differences between A. *Rhodohypoxis baurii* var. *platypetala* and B. *Hypoxis setosa*

variable taxon, *R. baurii* var. *confecta*, is fairly widespread from the Eastern Cape Province through the corridor formed by the KwaZulu-Natal and Free State Provinces in South Africa, and Lesotho. Its distribution dwindles along the western border of Swaziland into South Africa's Northern Province. *R. thodiana* and *R. incompta* have a very narrow distribution restricted to the KwaZulu-Natal-Lesotho border at Giant's Castle and Sani Pass, respectively. These two KwaZulu-Natal Drakensberg endemics are considered to be near threatened and are protected in the uKhahlamba Drakensberg Park (Scott-Shaw, 1999).

On the Drakensberg itself, *Rhodohypoxis* plants grow in the grassy slopes and rock outcrops of the Little Berg and Main Escarpment. The vegetation belt of the Little Berg is subalpine, 1800-2800m, while that of the Main Escarpment is alpine, ca. 2800-3500m (Killick, 1990). The mountain is typified by black clay soils, cool to mild temperatures, fairly wet summers and relatively dry winters. Frost occurs almost daily in winter. Fire and wind also contribute to the ecological and floristic preservation of the mountain. Plants of *Rhodohypoxis*, like those of most monocots in the Drakensberg, are able to withstand frost and fire by means of an underground rootstock and seasonal growth pattern. In the Little Berg, *Rhodohypoxis* is a distinctive component in the predominantly short grasslands. The plants grow in peaty soil among the grasses and on rock surfaces, where they form carpets. These grasslands are intrinsically diverse, containing several species of forbs and grasses. On the Main Escarpment, *Rhodohypoxis* is restricted to bogs and sponges, where the soil is regularly moist to wet (Killick, 1990).

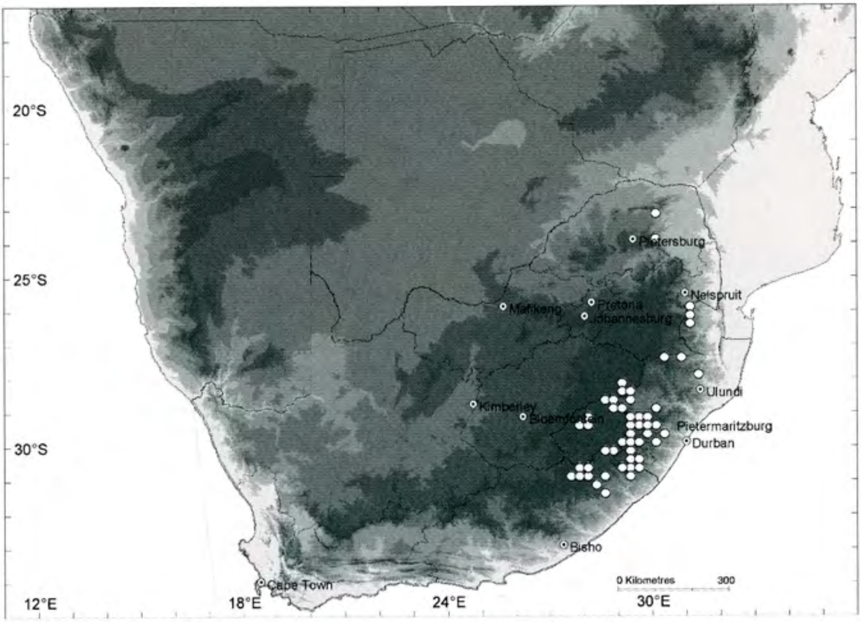

Fig. 4a. Distribution of *Rhodohypoxis*, centred in the Eastern Region of the Drakensberg.

Elevation (m)

⬜	Under 300
▨	300 - 600
▨	600 - 900
▨	900 - 1200
▨	1200 - 1500
⬛	Over 1500

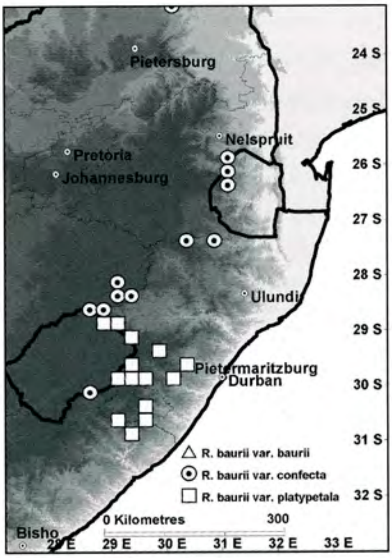

Fig. 4b. Distribution of the widespread *R. baurii* varieties extends to outlying ranges of the Drakensberg.

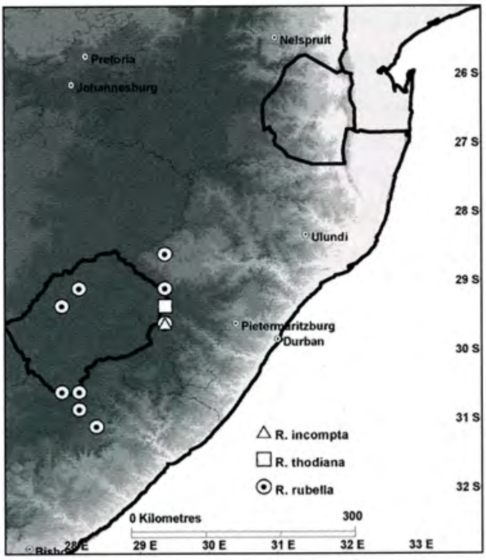

Fig. 4c. Distribution of the near threatened endemics *R. incompta* and *R. thodiana* and the more widespread *R. rubella*.

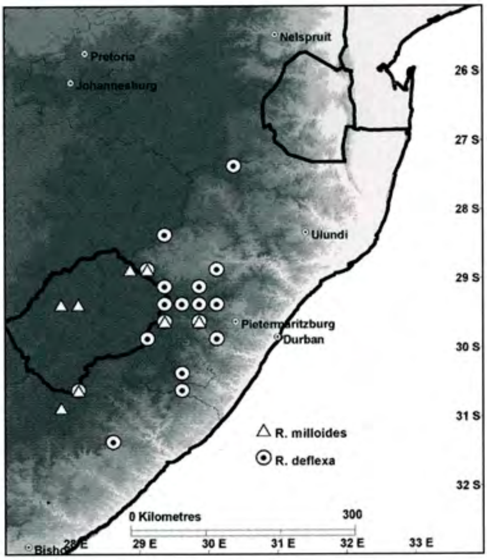

Fig. 4d. Distribution of *R. milloides*, extends to the outlying ranges of the Drakensberg, and *R. deflexa*, confined to high altitudes in Lesotho and surrounding Provinces in South Africa.

PLANT STRUCTURE

Plants of *Rhodohypoxis* are small perennial geophytes, to 15cm in height, that die back in winter. The underground vertical rootstocks or rhizomes are joined to one another by stolons. Five to ten leaves arise from the apex of each small rhizome. These triangular, linear-lanceolate to filiform leaves are bright or dull green and are usually hairy to a varying degree among taxa and age of the leaves. The number of inflorescences per plant is proportional to the number of leaves with up to ten per plant. The long and erect peduncles bear a single flower, but may be forked to support two flowers. Flowers consist of six perianth-segments in two series; the three inner ones being slightly narrower than the outer ones. The perianth-segments are either white, pink or red, or white and pink variegated. They fuse distally to form a short perigone tube. Just above the tube, the inner segments flex inwards to converge, closing the throat of the flower. Above the throat, the perianth-segments spread outwards and are persistent following fertilization. Six stamens arranged in two series arise from the perigone tube; the outer set lies above the inner. Anthers are hidden below the perianth-segments and are sessile to subsessile. The trilocular ovary is beaked or beakless and contains 4-6 ovules arranged axially in each locule. A very short style bears a 3-lobed stigma. The fruit is a thin, papery capsule with circumcissile dehiscence as in *Hypoxis*. In some taxa, the fruit breaks up irregularly below the apex. Seeds are round to oval, black, shiny and brittle. Plants flower between October and February.

Notes on species based on detailed site studies done by Hilliard and Burtt (1978):

Rhodohypoxis baurii var. *baurii* (Fig. 5). Widespread from Eastern Cape through to Northern Province, concentrated in KwaZulu-Natal. Leaves narrow, suberect and dull green. Flowers characteristically deep red, rarely white. Habitat moist, cliff faces and rocks. Hybridises with *Hypoxis parvula* var. *parvula*.

Rhodohypoxis baurii var. *confecta*. Widespread from the Eastern Cape to Northern Province. Leaves erect and bright green. Flowers white or pink with some reds; some flowers opening white, changing to pink and then to red with age. Habitat moist, grassy slopes, rock outcrops or plateau summits. Hybridises with *R. deflexa*, *R. thodiana* and *Hypoxis parvula* var. *parvula*.

Rhodohypoxis baurii var. *platypetala* (Fig. 6). Concentrated in KwaZulu-Natal. Leaves broad and flat, erect or spreading, grey green. Flowers mainly white, occasionally pale pink. Habitat dry, stony soil on rock sheets, rocky grassland. Hybridises with *R. milloides* and *Hypoxis parvula* var. *albiflora*.

Rhodohypoxis milloides. Distributed from the Eastern Cape to the northern border of KwaZulu-Natal. Leaves linear to lanceolate, subglabrous and bright green . Flowers crimson, rarely pink or white. Habitat marsh. Hybridises with *R. baurii* and *Hypoxis parvula* var. *albiflora.*

Rhodohypoxis deflexa. Occurs in Eastern Cape, KwaZulu-Natal and Lesotho. Leaves linear-lanceolate. Flowers bright reddish-pink or pale pink, very small. Habitat marsh.

Rhodohypoxis thodiana. Localised in Giant's Castle area at the KwaZulu-Natal-Lesotho border. Leaves lanceolate and flat. Flowers pale pink, scented. Habitat moist, grassy slopes. Hybridises with *R. rubella.*

Rhodohypoxis rubella. Occurs in Eastern Cape, KwaZulu-Natal and Lesotho. Miniature plants to 5cm. Leaves triangular-filiform and subglabrous. Flowers bright pink, rarely pale pink to white, very small. Habitat moist, stony soil on rock sheets, seasonal pools. Hybridises with *R. thodiana*

Rhodohypoxis incompta. Localised at Sani Pass area at the KwaZulu-Natal-Lesotho border. Leaves triangular-filiform, subglabrous. Flowers pink. Habitat, wet, gravelly soil on rocks, edges of grass or sedge tussocks on sandstone rock sheets.

GROWING *RHODOHYPOXIS*

At least 12 varieties of *Rhodohypoxis* are available in the United Kingdom, Europe, the United States and Japan. Species in the trade include *R. baurii*, *R. milloides*, *R. deflexa* and *R. thodiana*, with *R. baurii* the most common. Varieties of *Rhodohypoxis* sell for $2.99–$6.75 in the States and £1.50 to £4.00 in the UK per 4 inch pot. As white, pink or red flower color (dependent on the age of the flower) in *R. baurii* var. *confecta* is displayed on a single plant (Fig. 7), this offers a brilliant mix in one pot. The perianth-segments are persistent following the reproductive phase of the flower and thus provides the desirable advantage of a long flowering period. Cultivated hybrids of *Rhodohypoxis baurii* and *Hypoxis parvula*, named X *Rhodoxis hybrida* B. Mathew (Mathew, 1998) are popular pot plants in the United Kingdom (B.L. Burtt, Royal Botanic Garden, Edinburgh , pers. com. 1999).

It is rather difficult to grow *Rhodohypoxis* in warm and humid conditions like those experienced in the coastal region of South Africa. Plants are adapted to seasonal rainfall and, once established, require no watering during the dry season. They are also frost and snow hardy and thus are well suited to northern hemisphere gardens. Vegetative propagation is easily achieved by division of the underground stolons that hold the plants together in a clump. Rhizomes are small and require shallow planting in well-drained loam soil. Seed germination is slow, requiring 30–60 days.

Rhodohypoxis plants are suitable as pot plants as well as for bedding in cool climates. Flowers of *Rhodohypoxis* provide good color in the landscape, especially beautiful when grown *en masse*.

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RHODOHYPOXIS (SINGH; PP. 162–168)

Fig. 1. *Rhodohypoxis baurii* var. *confecta* forming a colorful cluster on rocky precipices at Sentinel Peak, a scenic part of the Free State Drakensberg.

Fig. 2. *Hypoxis costata*, yellow flowers with perianth-segments free and stamens visible.

Fig. 5. *Rhodohypoxis baurii* var. *baurii*; deep red flowers dot the slopes of Jonkershoek, Eastern Cape Drakensberg.

Fig. 6. White flowers of *R. baurii* var. *platypetala* in KwaZulu-Natal Midlands.

Fig. 7. *Rhodohypoxis baurii* var. *confecta*, red, pink and white flowers on a single plant.

All photos by Y. Singh

Getting to Grips with *Hypoxis*

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HYPOXIS. *Cor.* 6-partita. *Stam.* breviora. *Germen* inferum (*corolla 6 parts, stamens short, ovary inferior*).

This unimposing description of a new genus by Carl Linnaeus in 1759 in *Species Plantarum* included three species and marked the beginning of what is now a rather complex group of some 90 species. *Hypoxis* is part of a small monocot family, the Hypoxidaceae (Star-flower family) and is distributed in the warmer regions of all continents except Europe. In sub-Saharan Africa, there are about 60 *Hypoxis* species, with 35 of these in southern Africa (namely South Africa, Lesotho, Namibia, Botswana and Swaziland). The greatest species richness and endemism occur in the eastern region of South Africa, that is to say in the KwaZulu-Natal and Eastern Cape Provinces. The occurrence of *Hypoxis* extends from coast to alpine parts of southern Africa, mainly in grasslands. A few species prefer partial shady conditions in open woodlands or forest cliffs. It is very rare to step out into grasslands in the summer-rainfall region of South Africa during the growing season and not encounter some or other species of *Hypoxis*.

Hypoxis plants are fairly easy to recognise in the field. They are geophytic, erect herbs with leaves usually hairy; flowers star-shaped, yellow (white in a few species), with perianth-segments and anthers free. It is however difficult to distinguish between species in the genus and the reasons for the difficulties are explained below. It is easier to begin to identify a *Hypoxis* plant by placing it into a species group. Eight species groups are recognised for southern African *Hypoxis*. This article provides the morphological characters of each of the groups.

Why is it difficult to identify *Hypoxis* species?

Hypoxis species are not clearly defined due to a lack of distinctive morphological characters. Species are represented by sets of morphological characters that often overlap. Furthermore, the changing growth forms of plants during the growing season are not well recorded and depending on the stage of development, a plant may not match its description. For instance, in *H. multiceps* and *H. interjecta* leaves are hysteranthous (flowers appear before leaves). The flower stalks appear similar in both species and pose problems for identification. With the onset of leaves, the appearance of the plants is altered and at this stage separation of species is possible on differences in leaf characters.

The phenomena of hybridisation, polyploidy and apomixis cause frequent morphological variation in *Hypoxis* and it is this interspecific variation that adds to the difficulty of identifying species. **Hybridisation** between some species in *Hypoxis* causes practical taxonomic problems, because morphological characters in the hybrids become obscure, and characters in these plants cannot be matched with those of either parent. For example, it is impossible to recognise natural hybrids between the distinct species *H. rigidula* and *H. obtusa* without an understanding of the populations of these plants in the wild.

Hypoxis has a diploid chromosome count of 2n=14 and a base chromosome number of x=7. **Polyploidy** causes the chromosome set to replicate one to several times and this is responsible for variation in chromosome numbers within a species. In *Hypoxis*, polyploidy has produced chromosome counts of 2n= 28, 42, 56, 70 within various species. These plants are referred to as tetraploids, hexaploids, octoploids and decaploids (divided by x=7) respectively. In diploid plants the taxa are morphologically distinct. At higher ploidy levels, morphological differences between taxa become unclear and distinct taxa cannot be recognised, thereby creating problems for identification. Polyploids often possess attributes that allow them to adapt to new ecological niches. The range of variation at different ploidy levels is not well understood in *Hypoxis*.

Apoximis is the production of viable seeds without the transfer of pollen i.e. 'seeds without sex'. The embryo is formed by maternal tissue only and the offspring is genetically identical to its maternal parent. Since pollen viability is high in *Hypoxis*, the occurrence of apomixis in the genus cannot be correlated with a reduction in pollen viability (Zimudzi, 1994). This makes *Hypoxis* a facultative apomict, i.e. apomictic and also sexual. Zimudzi (1994) determined that all apomictic species of *Hypoxis* are polyploids. It still needs to be established whether all apomictic *Hypoxis* originate from hybridisation. The varying morphotypes in *Hypoxis*

H. argentea
Scan of herbarium sheet

GROUP 6

Plants solitary

Leaves few, erect, linear to linear-lanceolate, outer ones curved, moderately firm in texture, usually < 6mm (-10mm) wide.

Flowers yellow, stigma pyramidal.

H. argentea
H. parvifolia
H. kraussiana
H. flanaganii
H. uniflorata
H. obconica
H. gerrardii
H. dinteri
H. patula
H. neliana
H. floccosa

H. parvula

GROUP 7

Plants solitary or in clumps

Leaves few to many, erect to semi-erect, thin, almost membranous in texture, narrow or wide, up to 20mm wide.

Flowers yellow or white, stigma pyramidal or spherical.

H. angustifolia
H. membranacea
H. limicola
H. parvula

H. filiformis

GROUP 8

Plants solitary

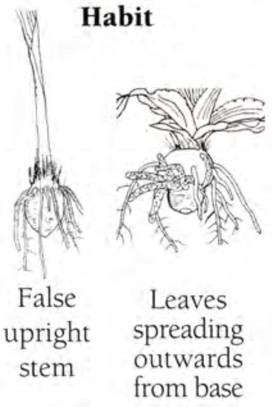
Leaves rigid, thread-like, <3mm wide, margins curving inwards.

Flowers yellow, stigma pyramidal.

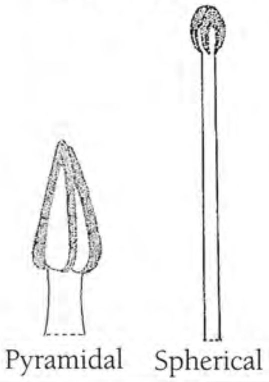
H. filiformis
H. tetramera

Key Characters Illustrated

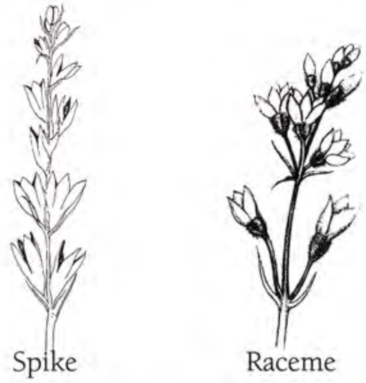
Habit

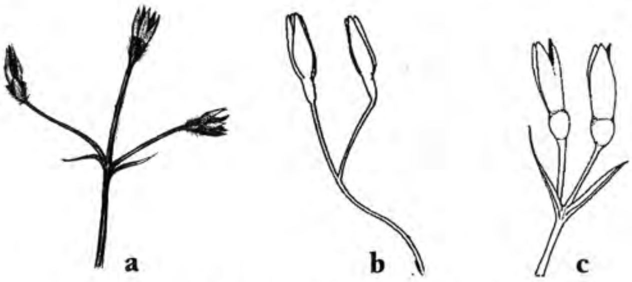


Stigma types



Apical part of flowering stalk





Corymb types **a** & **b** - long slender pedicels
c - stout pedicels

Illustrations

Growth form line illustrations are by Angela Beaumont. The illustration of the raceme was extracted from Nordal *et al* (1985); those of corymb types a & b and stigma types are from Wood (1976).

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Species groups illustrated, described further and members listed

H. colchicifolia

GROUP 1a

Leaves widening above false stem into the shape of a funnel, broadly lanceolate, stiff in texture, strongly ribbed, broad, 20-50mm wide.

Leaf lamina hairless to sparsely hairy.

H. colchicifolia
H. galpinii

H. rigidula

GROUP 1b

Leaves spreading outwards and recurving above false stem, linear, moderately firm in texture, only veins along margins prominent, narrow, <20mm wide.

Leaf lamina sparsely to densely hairy.

H. cordata
H. oblonga
H. rigidula

H. acuminate
Scan of herbarium sheet

GROUP 2

Leaves spread outwards and upwards loosely from base, false stem not obvious, erect to semi-erect, moderately firm in texture, narrow, 300-400mm long, <13mm wide.

Leaf lamina hairless to densely hairy.

H. acuminata
H. exaltata
H. ludwigii
H. longifolia

H. obtusa

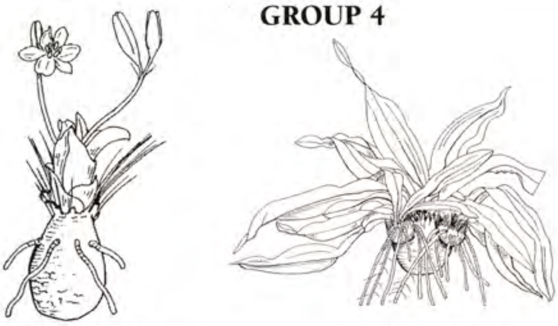
GROUP 3

Leaves tightly stacked in 3 ranks, broad, usually >20mm wide.

Flowering stalk a raceme.

H. hemerocallidea
H. obtusa

GROUP 4



early season

late season

H. multiceps

Leaves stiff, oblong-lanceolate, erect to semi-erect, broad, >25mm wide.

Flowering stalk thick and stiff, with 1-5 flowers on stout pedicels.

H. costata
H. interjecta
H. multiceps

H. setosa

GROUP 5a

Leaves loosely stacked in 2-3 ranks, moderately firm, linear to lanceolate, recurving, narrow, 8-20mm wide.

Flowering stalk pliable with 1-7 flowers on long slender pedicels.

H. setosa
H. sobolifera
H. villosa

H. stellipilis

GROUP 5b

Leaves lanceolate, tightly stacked in 3 ranks, dark green and hairless on upper surface, hairs forming felt-like white coating on lower surface; narrow, 10-20mm wide.

Flowering stalk long, pliable with 2-6 flowers on long slender pedicels, all pedicels arise at same point.

H. stellipilis

may be attributed to the occurrence of hybridisation, polyploidy and apomixis, and their interrelatedness drives the evolution of new entities, keeping the genus in a state of flux.

The 35 southern African species are classified into 8 broad groups based on morphological characters. A key to species groups using the readily observable characters of growth form, leaf texture, type of flowering stalk, number of flowers and stigma type is provided below. The key includes characters that may overlap between groups. It is therefore necessary to use the combination of characters to separate species groups. Diagnostic characters for each group appear in bold type. In addition, the growth form of a representative species is illustrated for each group and additional diagnostic characters emphasised alongside the illustration. Lastly, diagnostic characters used in the key to species groups are illustrated to explain the terminology used.

Species groups: summary of key features

Plants solitary; **40-60cm** tall; leaves clasping at the base to form a **false upright stem**, stiff to moderately firm in texture, hairless to densely hairy, flowering stalk long, firm, with 6-20 flowers on short pedicels (**raceme or spike**); flowers yellow, **>20mm** in diameter when open.	**Group 1**
Plants solitary or clump forming; **30-40cm** tall; leaves erect, spreading outwards and upwards, not forming a false stem but **loosely spreading from base**, rigid to moderately firm in texture, hairless to densely hairy; flowering stalk long, pliable, with 2-4 flowers on long slender pedicels (**corymb**); flowers yellow, **>20mm** in diameter when open.	**Group 2**
Plants solitary; **20-50cm** tall; leaves spreading outwards and upwards, not forming a false stem, **noticeably stacked tightly in 3 ranks**, stiff to moderately firm in texture, hairless to densely hairy; flowering stalk long, firm, with 8-15 flowers on short pedicels (**raceme**); flowers yellow, **>20mm** in diameter when open.	**Group 3**
Plants solitary or clump forming; **10-20cm** tall, **squat appearance**, leaves spreading outwards and upwards, not forming a false stem but **loosely spreading from base**, stiff to moderately firm in texture, hairless to densely hairy; flowering stalk long and thick with 2 (-4) flowers on **stout** pedicels (**corymb**); flowers yellow, **15-25mm** in diameter when open.	**Group 4**
Plants solitary or clump forming; **12-30cm** tall, leaves spreading outwards and upwards, not forming a false stem but **stacked either tightly or loosely in 2-3 ranks**, moderately firm in texture, sparsely to densely hairy; flowering stalk long and slender with 2-7 flowers on long and slender pedicels (**corymb**); flowers yellow, **15-25mm** in diameter when open.	**Group 5**
Plants solitary; **usually <15cm** tall; leaves spreading outwards and upwards, neither forming false stem nor neatly stacked in ranks, erect, moderately firm in texture, sparsely to densely hairy; flowering stalk long and slender with 1-3 (-5) flowers on long and slender pedicels (**corymb**); flowers yellow, **<15mm** in diameter when open.	**Group 6**
Plants solitary or clump forming; **usually <15cm** tall; **soft appearance**, leaves spreading outwards and upwards, neither forming false stem nor neatly stacked in ranks, erect to semi-erect, **membranous** in texture, sparsely hairy; flowering stalk long and slender with 1-3 flowers on long and slender pedicels (**corymb**); flowers yellow or white, **<15mm** in diameter when open.	**Group 7**
Plants solitary; usually **<15cm** tall; leaves spreading outwards and upwards, not forming false stem, erect, **rigid in texture, thread-like**, very sparsely hairy; flowering stalk long and slender with 1-3 (-4) flowers on long and slender pedicels (**corymb**); flowers yellow, **<15mm** in diameter when open.	**Group 8**

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SUMMARY

Systematics of *Hypoxis* (Hypoxidaceae) in southern Africa

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Hypoxis is a genus of about 70 species found in the warmer parts of all continents except Europe. About 50 species occur in Africa, with the core diversity in the eastern region of South Africa. It is difficult to draw up a practical key to species due to the high level of polymorphism in the genus caused by hybridization and apomixis that give rise to polyploids. The forms derived through these genetic mechanisms end up with characters that do correspond with the parent species, and this affects species limits. Further, the appearance of plants changes when the leaves develop. This work presents a systematic account of *Hypoxis* in the Flora of southern Africa region (South Africa, Swaziland, Lesotho, Namibia and Botswana). It focuses on providing a revision of the genus based on morphological data accumulated from extensive field and herbarium studies. Growth form, leaf shape, distribution and type of hairs on leaves, inflorescence type, flower colour and ratio of floral dimensions were found to be important diagnostic characters for the genus. By applying these characters, 28 species and 5 varieties are recognised in southern Africa, all with yellow flowers except for two species and one variety in which the flower colour is white. The revision includes notes on diagnostic characters and relationships, distribution and ecology, etymology and common English, Afrikaans, Zulu and Xhosa names, for each taxon. In being data deficient, eight species remain unresolved.

Also, in this work, leaf anatomy, seed micromorphology and preliminary phytochemistry of *Hypoxis* were investigated and data from these disciplines were used to augment the species relationships inferred from morphology. Further, an assessment of the phytogeography of the genus is presented. Within southern Africa, three species occur in Namibia and two species in Botswana. The rest of the species are concentrated in South Africa, Swaziland and Lesotho and species richness is greatest in grasslands of the summer rainfall region. Species have either a wide or narrow range of distribution. Distribution ranges are integrated into the key especially for species with very a narrow range, to assist with identification.

A few members of the southern African *Hypoxis* are of economic importance. One species in particular, *H. hemerocallidea* (earlier name *H. rooperi*) commonly known as the ‘African potato’ has become a popular medicinal plant in South Africa. The rhizomes of the species are a rich source of hypoxoside, a phenolic glycoside that hydrolyses to form its aglycone called rooperol which has been shown to be active in destroying some cancer cells. *H. hemerocallidea* is also the plant from which the properties of sterols and sterolins were correlated with enhancing the human immune system. The genus therefore has potential for treating patients with auto-immune diseases such as rheumatoid arthritis, cancer and possibly HIV and AIDS.

The main output of this study is the taxonomic treatment that enables users to determine accurate names of species, their relationships and distribution in the Flora of southern Africa region. It should be useful to botanists, pharmacologists, chemists and horticulturalists.

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Curriculum Vitae

The degree PhD Yashica Singh

Yashica Singh completed her undergraduate and honours degrees at the University of Durban-Westville (now University of KwaZulu-Natal), and a higher degree in Education through the University of South Africa. She holds an MSc from the University of Pretoria, in which she examined the taxonomy of the economically important, South African endemic genus *Zantedeschia* (Araceae). Yashica is the Curator of the SANBI KwaZulu-Natal Herbarium in Durban. Over the past 14 years her contribution to plant systematics was focussed on the families Araceae and Hypoxidaceae in the Flora of southern Africa region. She has undertaken extensive field studies on *Zantedechia* and *Hypoxis* throughout South Africa, and is the author or co-author of several scientific and popular publications. She is co-editor of the book, 'Rebirth of Science in Africa: a shared vision for life and environmental sciences'. Yashica served as the secretary of the local Committee for the South African Association of Botanists, and as a member on the South African National Committee of the International Union of Biological Sciences.

In her thesis, **Systematics of *Hypoxis* (Hypoxidaceae) in southern Africa**, the promovenda re-evaluated the classification of *Hypoxis*, a group of flowering plants mainly confined to grassland. Commonly known as African potatoes or yellow stars, some members are of considerable importance in traditional medicine. Twenty eight species have been identified, making southern Africa the most species rich region for the genus world-wide. Seed micromorphology is shown to be particularly useful for classification purposes. The identities of several previously poorly understood taxa have been clarified, resulting in a considerable improvement of the classification of the group.

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