A new monotypic genus, a species synonymy and nomenclatural corrections in the arid-adapted Canthonini (Scarabaeidae, Scarabaeinae) from the Succulent Karoo Biome of south-western Africa

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Abstract

Although it has been demonstrated that the tribe Canthonini (Scarabaeidae: Scarabaeinae) is polyphyletic, those canthonine genera occurring in arid south-western Africa apparently form a monophyletic group. In this paper we add one new monotypic genus, *Drogo stalsi* gen. *et*. sp. n. to this group, and synonymize another member, *Byrrhidium namaquense* Scholtz and Howden, 1987 syn. n. with *Byrrhidium ovale* Harold, 1869. We correct the spelling of two species names that were not in agreement with the gender rule. A phylogenetic analysis based on morphology supports the erection of *Drogo* gen. n. An updated key to the genera and species of the *Byrrhidium* group is presented.

Key words: new genus, new species, synonymy, mandatory spelling changes, Richtersveld, Namaqualand, key, South Africa, Namibia, *Byrrhidium* group

Introduction

Although the scarabaeine dung beetle tribe Canthonini is clearly polyphyletic (Philips *et al*. 2004; Monaghan *et al*. 2008), it appears that the flightless canthonines of the *Byrrhidium* Harold group are monophyletic (Sole and Scholtz 2010). This group occurs in the arid Succulent Karoo and Nama Karoo Biomes of south-western Africa and is currently represented by *Byrrhidium*, *Namakwanus* Scholtz and Howden, *Dicranocara* Frolov and Scholtz and, probably, *Versicorpus* Deschodt, Davis and Scholtz. All of the group representatives seem to be well adapted to the aridity of their habitat, have localized distributions (Frolov and Scholtz 2003, Deschodt *et al*. 2007, Deschodt *et al*. 2011), and most are strictly associated with rock hyrax (*Procavia capensis* (Pallas, 1766)) dung middens (Frolov and Scholtz 2003, Deschodt *et al*. 2007, Deschodt *et al*. 2011). The only probable

exception is the most widespread species, *Byrrhidium ovale* Harold, 1869, which has been recorded at a small distance from hyrax colonies.

Hyrax-associated species of the *Byrrhidium* group are found amongst boulders and in close proximity to their food source. Rock hyrax can be found wherever there are rocky formations that provide a hiding place from predators together with nearby food plant species (Skinner and Chimimba 2005). As suitable rock hyrax habitat is naturally disjunct, its combination with this harsh environment creates islands surrounded by barriers to emigration by the flightless dung beetles. These isolated islands serve as stable refugia where speciation may occur over time. It is thus not surprising to find a new undescribed species that is distinct enough to also accord it new generic status. It is described here as *Drogo stalsi* gen. *et*. sp. n.

The genus *Byrrhidium* Harold, 1869 currently consists of three hitherto valid species. These are: *Byrrhidium ovale*, *Byrrhidium convexum* Scholtz and Howden, 1987 and *Byrrhidium namaquense* Scholtz and Howden, 1987. All of the species are very similar in appearance and endemic to South Africa. Recently new material was collected and our understanding of the generic distribution became clearer. While reviewing this new information we have recognized that *Byrrhidium namaquense* is a synonym of *Byrrhidium ovale*.

Materials and Methods

Locality labels are reported verbatim with our comments in square brackets.

The color images of the habitus of the new genus were made using a Canon 500D camera body mounted with a Canon 65mm MPE 1–5x zoom lens and of the aedeagus using a Leica M165 C microscope and a Leica DMC 2900 digital camera. Image stacking was done using the Helicon remote and Helicon focus software packages. All other images were generated by the various museums curating the type specimens mentioned here, using their own imaging systems. Measurements of specimens were made using a Zeiss dissecting microscope fitted with a reticle.

Lineage II in Sole and Scholtz 2010 includes *Byrrhidium* and several other genera that are all exceedingly small-bodied thus making reliable measuring difficult. Therefore, *Epirinus convexus*, the larger-bodied, basal taxon on the sister lineage III, was selected as the outgroup.

All the measurements made for the character matrix were averaged out. These measurements were then plotted on an excel graph and visually separated into the distinct groupings used in the analyses.

List of characters used for the cladistic analysis

1. Relative species length (defined as pronotum length plus elytron length, appendix 2) (0) large (more than 10 mm) (1) big (between 8 and 10 mm) (2) medium (between 4 and 8 mm) (3) small (less than 4 mm)
2. Pronotum area vs. elytron area (0) large (group a on figure 5A) (1) medium (group b on figure 5A) (2) small (group c on figure 5A)
3. Pronotum length, from appendix 2 (0) shorter than 2.5 mm (1) longer than 3 mm
4. Pronotum length vs. pronotum width (0) group a on figure 5B (1) group b on figure 5B
5. Elytron length vs. elytron width (0) group a on figure 5C (1) group b on figure 5C (2) group c on figure 5C (3) group d on figure 5C (4) group e on figure 5C
6. Elytron length, from table 2 (0) longer than 6 mm (1) between 5 and 6 mm (2) between 3.5 and 5 mm (3) between 2.5 and 3.5 mm (4) shorter than 2.5 mm
7. Mesocoxae distance vs. meso-metacoxa distance (0) group a on figure 5D (1) group b on figure 5D (2) group c on figure 5D
8. Elytron width vs. pronotum width (0) group a on figure 5E (1) group b on figure 5E (2) group c on figure 5E (3) group d on figure 5E
9. Visual grouping of clypeal horn size relative to body size (0) big (1) medium (2) small
10. Front tibial teeth (0) two (1) three
11. Serrations on median area of outside fore tibia (0) close together with sharp points (1) long and flat
12. Clypeus with third small median tooth (0) absent (1) present
13. Clypeus (0) bidentate (1) quadridentate
14. Clypeogenal suture (0) straight (1) inward curving
15. Sexual dimorphism in clypeal horns (0) absent (1) present
16. Aedeagus apex in side view (0) acutely downward pointing (around 90° angle) (1) downward pointing (around 45° angle) (2) almost straight
17. Aedeagus apex in frontal view (0) sideways or outwards pointing (1) not sideways or outwards pointing
18. Side protrusions on aedeagus (0) absent (1) present
19. Aedeagus (0) without saw-like structures between parameres (1) with saw-like structures between parameres
20. Edge of aedeagus at outside apex (0) with notch (1) no notch
21. Mesometasternal suture (0) straight (1) forward curving (2) slightly backward curving
22. Mesometasternal suture (0) not well defined (1) clearly defined
23. Prosternal punctures (0) faint (1) clear (2) not punctate
24. Separation of punctures on prosternum (0) close together (1) further apart (2) not punctate
25. Puncture size on prosternum (0) small (1) large (2) not punctate
26. Mesosternal punctures (0) faint (1) clear
27. Separation of punctures on mesosternum (0) close together (1) further apart
28. Puncture size on mesosternum (0) small (1) large

29. Metasternal punctures (0) faint (1) clear
30. Separation of punctures on metasternum (0) close together (1) further apart
31. Sides of pronotum (0) almost parallel (1) clearly converging anteriorly

Morphological relationships between canthonine species of the arid southwest were determined by cladistic analysis using NONA in WinClada (Nixon 2002). We deactivated the four uninformative characters. We then performed Bootstrap analyses running 10000 replicates with number of search reps set at 1000 repeated five times. The resulting cladograms were then submitted to the commands "keep Best trees only (delete suboptimal)" and "Consensus (strict)". The averages for the bootstraps were calculated.

Institutions mentioned in this paper are:

MNHN, France, Paris, Muséum National d'Histoire Naturelle

SANC, South Africa, Pretoria, South African National Collection of Insects

SAMC, South Africa, Cape Town, Iziko South African Museum

MFNB, Germany, Berlin, Museum für Naturkunde

Systematic Entomology

Mandatory changes in spelling

Article 34 of the International Code of Zoological Nomenclature (ICZN 1999) deals with mandatory changes in spelling. According to article 34.2 (and also 31.2) that specifically deal with species-group names, the ending of a species name must agree in gender with the generic name.

Two species names cited in this paper are not in accordance with the abovementioned rules and must be changed.

The species name *Byrrhidium namaquensis* Scholtz and Howden, 1987 should thus change to *Byrrhidium namaquense* Scholtz and Howden, 1987 and *Versicorpus erongoensis* Deschodt, Davis and Scholtz, 2011 must change to *Versicorpus erongoense* Deschodt, Davis and Scholtz, 2011.

These new and correct spellings are followed throughout this paper.

New genus

Drogo Deschodt, Davis & Scholtz, gen. n. Figs. 1, 2 and 4

Type species: *Drogo stalsi* Deschodt, Davis & Scholtz, sp. n.

Head. Clypeus quadridentate, with two relatively well-developed slender forward-pointing teeth, and two outside teeth that are right angled at ends. One very small tooth on lower clypeal margin between dorsal teeth. Clypeogenal suture distinct and inward curving.

Pronotum. Convex.

Elytra. Convex. Striae visible.

Sterna. Meso- and metasternum fused, mesometasternal suture well defined, somewhat curved anteriorly.

Protibia. Two teeth at apical outside margin.

Pygidium. Surface shagreened with big shallow punctures.

Aedeagus. Symmetrical. Medial sclerotized plate serrated ventrally (Fig. 1B, C).

Diagnosis. *Drogo* clearly falls within the tribe Canthonini by being strongly convex, having no more than three protibial teeth, the lateral margin of elytra being entire and by having fore tarsi present. It falls within the *Byrrhidium* group as described above. This genus and *Byrrhidium* are the only genera in the group that have a quadridentate clypeus. However *Drogo* can be separated from *Byrrhidium* by having longer clypeal horns and the mesometasternal suture being well defined. The body shape of *Drogo* is also more rounded whereas it is slightly elongate in *Byrrhidium*. *Drogo* can be separated from *Namakwanus* by having two protibial teeth instead of three and having the clypeus quadridentate instead of bidentate as in *Namakwanus*. None of the other species in the *Byrrhidium* group has the saw-like serrations on the medial sclerotized plate of the aedeagus (note that the aedeagus of *Versicorpus* is unknown).

Etymology. The gender is masculine. The aedeagus of *Drogo* reminds us of a sword thus the name is from contemporary fantasy after a powerful warlord known for his swordsmanship.

New species

Drogo stalsi sp. n. Figs. 1, 2 and 4

Description: Holotype #m: Medium sized beetle. Measurements with head inflexed, 7.34 mm (long) ×5.60 mm (wide) ×4.21 mm (high).

Head. Clypeus quadridentate, with two well-developed teeth, area between inside teeth more or less straight. Outside teeth are right-angled. One very small tooth on lower clypeal margin

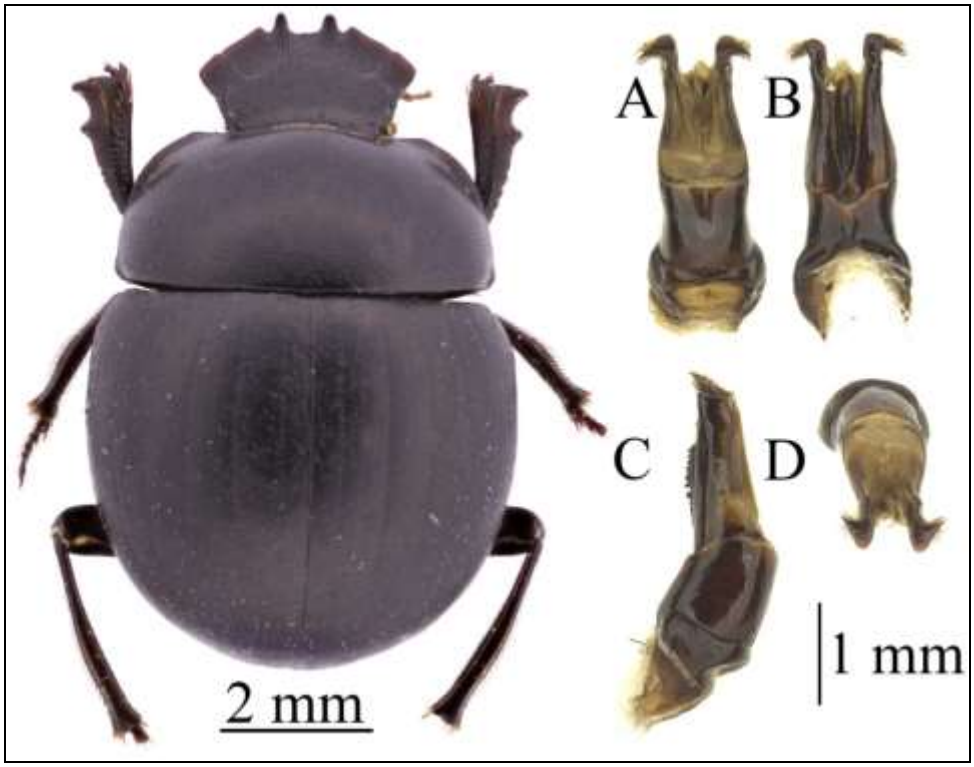

Figure 1. Habitus and aedeagus of *Drogo stalsi* gen. *et*. sp. n. Dorsal (A) ventral (B) left lateral (C) and (D) frontal views of aedeagus.

between dorsal teeth. Clypeogenal suture distinct and curving markedly inward. Clypeal surface clearly punctate.

Pronotum. Convex, small punctures completely covering pronotum, punctures separated by about one and a half lengths of their own diameter.

Elytra. Convex. Striae very shallow but visible, faintly punctate. Irregular and very faint punctures on interstriae.

Sterna. Prosternum with large shallow punctures. Meso- and metasternum fused, mesometasternal suture slightly curved anteriorly. Surface of mesosternum shagreened with clear, medium-sized shallow punctures. Surface of metasternum shagreened with a few very faint punctures.

Protibia. Inner margin more or less straight with no denticles. Line of punctures with associated tan setae along dorsal inside margin, deviating onto margin at apex, setae forming a small brush at apical tip. Tibial apex blunt with small spatulate outside-curving spur next to setal brush. Tarsi attached under spur close to inner margin of tibia. Setae on inner margins of tarsi short. Three very short thick and dark, spine-like setae on dorsoapical margin, parallel with apical margin. Two teeth at apical outer margin. First half of outer margin from joint serrated.

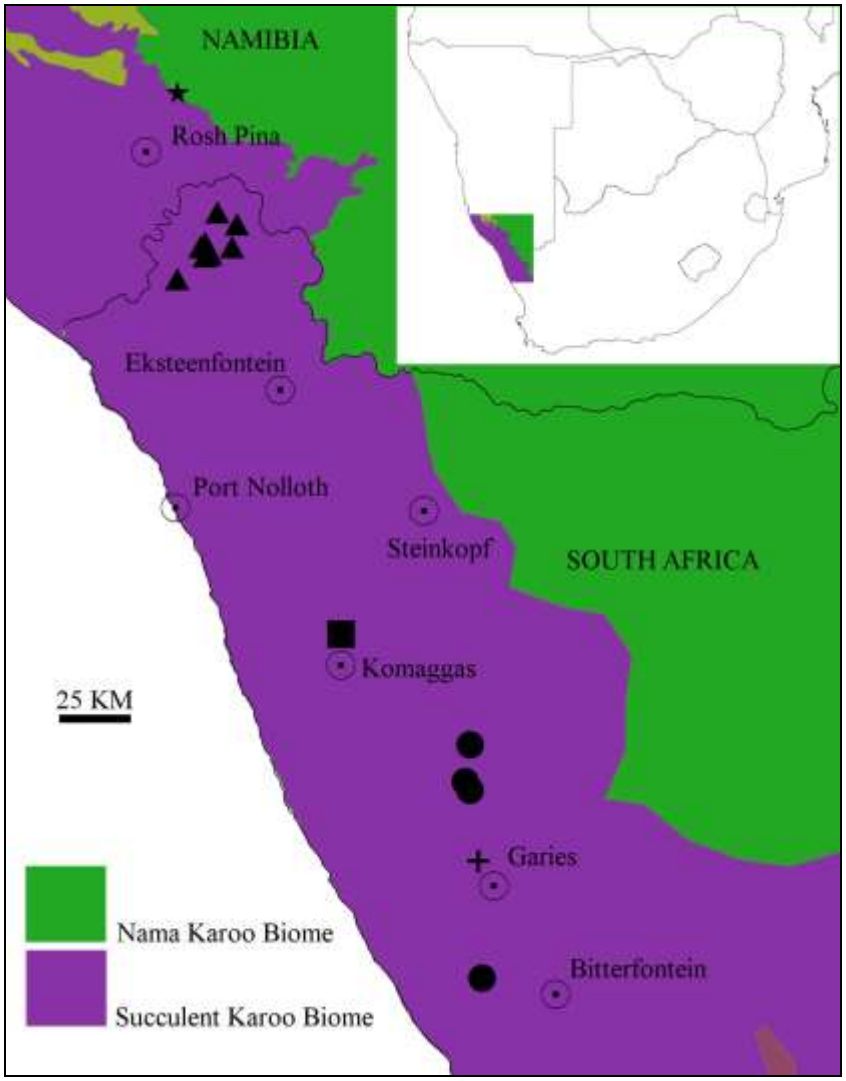

Figure 2. Map showing the type localities of *Drogo stalsi* gen. *et*. sp. n (★) and *Elassocanthon brevipes* Kolbe, 1908 (■) together with the type locality (G) and recent collecting localities (●) for *Byrrhidium namaquense* Scholtz and Howden, 1987 and *B. convexum* Scholtz and Howden, 1987 (▲).

Mesotibia. Outer margin sinuous with small and closely arranged serrations and with short tan setae all along edge. Inner margin relatively smooth except last fifth which is somewhat serrated. Setae short and sparse at regular intervals. Ventromedially and dorsomedially with a dense regular line of tan setae. Apically with two spurs. Tarsi with short tan setae, ending with two claws.

Metatibia. Angulate in cross section. with six rows of short tan setae that are densely spaced.

Pygidium. Surface shagreened with large shallow punctures.

Aedeagus. Symmetrical, see Figure 1.

Female. unknown.

Specimen examined, Holotype male: NAMIBIA, Zebrafontein, ca 30km, NNE of Rosh Pinah, 27˚45'S 16°53'E 2-6.iv.,2002 E.Holm & H.Gebhardt. (SANC).

Etymology. This species is named after Riaan Stals (SANC), who first identified it as new.

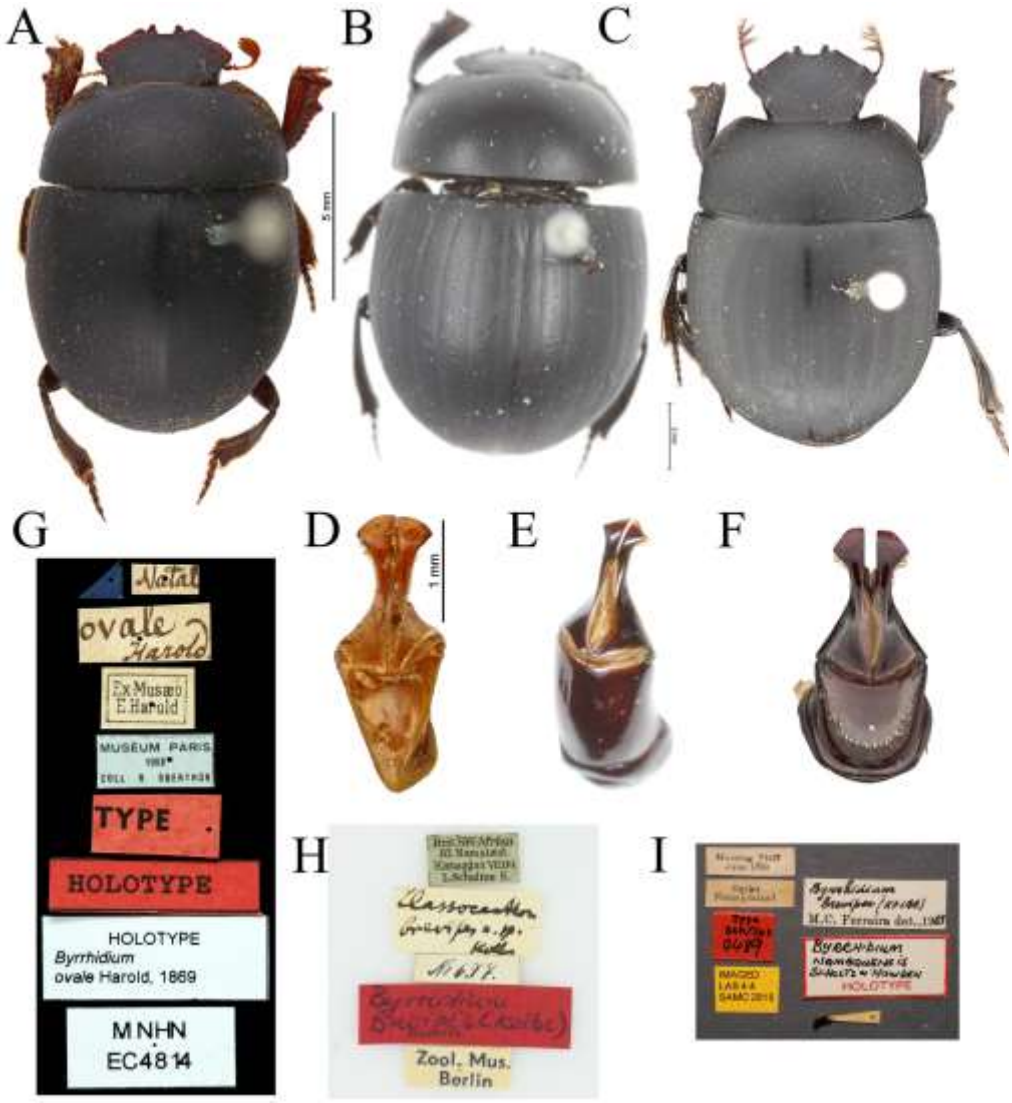

Figure 3. Habitus, aedeagus and specimen labels of the holotype specimens of *Byrrhidium ovale* Harold (A, D and G) *Elassocanthon brevipes* Kolbe (B, E and H) (no scale) and *Byrrhidium namaquense* Scholtz and Howden (C, F and I).

Discussion and support for generic status

Five trees with the same topology but with different bootstrap support were recovered in the analyses (Fig. 4). The bootstrapping for the constructed tree is not very well supported. This is probably due to the use of only morphological characters for a group of genera and species with the same general appearance that occupy similar niches in different locations in a very stable environment. Therefore, the classification of the presented tree needs to be supported by a molecular study.

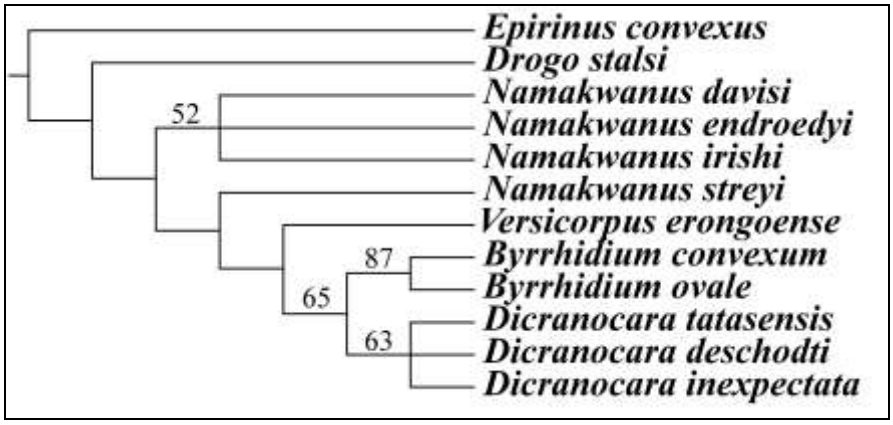

Figure 4. Strict consensus tree showing support for the currently recognized genera of the *Byrrhidium* group based on 31 morphological characters. Bootstrap percentages above nodes (percentages lower than 50% not shown) L=66, CI=68, RI=73.

Despite similarity in habitus between *Byrrhidium* and *Drogo*, the size differences, divergent characters of the aedeagi (Figs. 1, 3), and allopatry across the Orange River Valley suggest that they are sufficiently distant to be separated at generic level. Furthermore, erection of the new genus is supported by the topology of Figure 4 where the branches for *Namakwanus* lie between those for *Drogo* and *Byrrhidium*, suggesting separate histories of derivation.

Topology of Figure 4 may also go some way towards supporting the separation of *Namakwanus streyi* from other *Namakwanus* species at generic level. However the limited observed morphological differences and close similarities in geographical distribution suggest that a molecular study is required as additional support for such a decision.

New synonymy

Byrrhidium ovale Harold, 1869 Figure 3

Elassocanthon brevipes Kolbe, 1908
Byrrhidium namaquense Scholtz and Howden, 1987 **new synonym**

Harold (1869) described the genus *Byrrhidium* with *Byrrhidium ovale* Harold, 1869 as the only constituent species. The very doubtful type locality was cited as “Port. Natal” by Harold (1869) although the label reads only “Natal”. Kolbe (1908) later described a new genus and species, *Elassocanthon brevipes* Kolbe 1908 (see figure 3B, E and H) from Brit. S.W. Africa, Kl. Namaland, Kamaggas [=Komaggas S29.80° E17.50°], vii. [19]04, L. Schultze S. This locality is consistent with the travels of L. Schultze during August 1904 from Steinkopf to Port Nolloth [S29.26° E16.87°], Henkries [S28.97° E18.09°] and Ka[o]maggas (Schultze 1908). In 1938, Janssens noted that *Elassocanthon brevipes* Kolbe, 1908 is most likely a synonym of *Byrrhidium ovale*. However the two species were only formally synonymized by Scholtz and Howden (1987), who also added two new species to the genus, *Byrrhidium convexum* and *Byrrhidium namaquense*. However, following the reasoning in Table 1, where we compared images of the three type specimens, we are of the opinion that *Byrrhidium*

namaquense syn. n. is a junior synonym of *Byrrhidium ovale*. Consequently, we synonymize the two species.

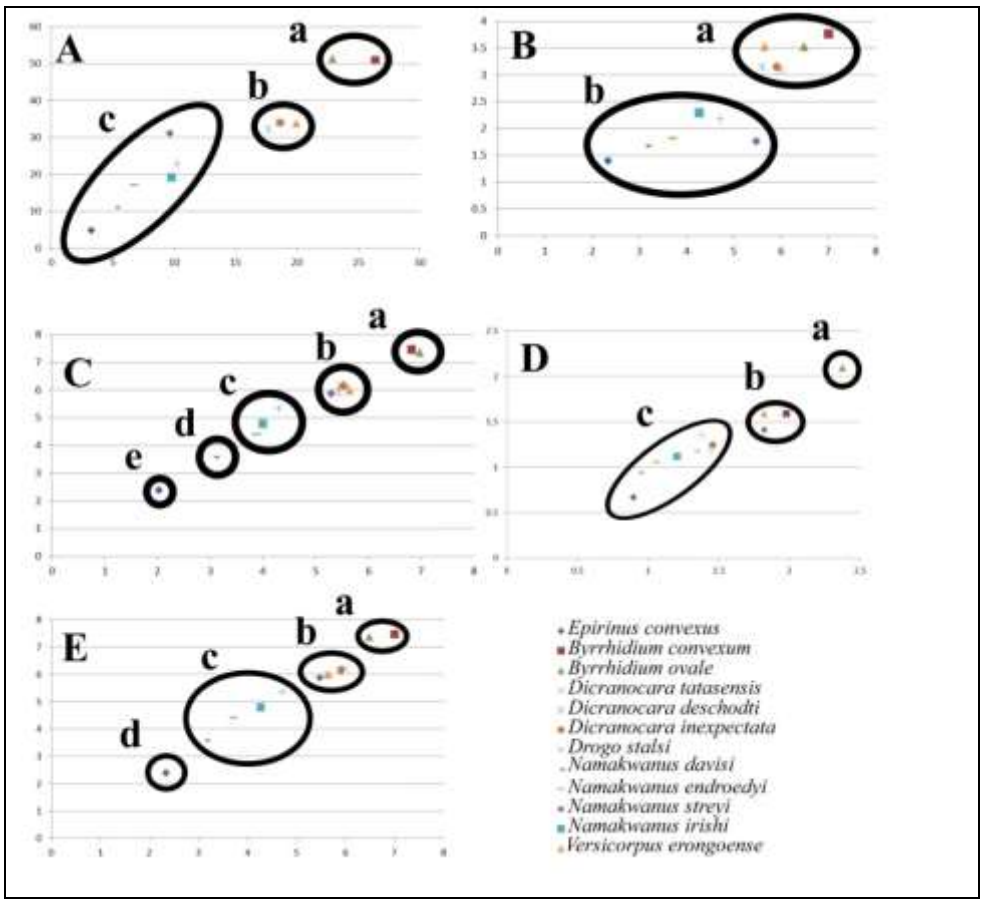

Figure 5. Graphs from measurements of characters: (A) pronotum area vs. elytron area, (B) pronotum length vs. pronotum width, (C) elytron length vs. elytron width, (D) mesocoxae distance vs. meso-metacoxa distance and (E) elytron width vs. pronotum width.

Key to the genera and species in the *Byrrhidium* group

Note: Some species can only reliably be separated by examination of the male genitalia. The females and fragmented body parts may thus not be identifiable. In those cases, identity may be obtained from geographical distribution, which is included in the key, and may suggest an identity.

1 Fore tibia with three external denticles … 2

– Fore tibia with two external denticles … 6

2 Habitus fairly elongate; Erongo Mountain ... *Versicorpus erongoense* Deschodt, Davis and Scholtz

– Habitus convex … *Namakwanus* Scholtz and Howden ... 3

3 Clypeal horns as long as, or longer than, distance between them; Windhoek and Gobabeb ... *N. irishi* Scholtz and Howden

– Clypeal horns shorter than distance between them … 4

4 Apices of aedeagus not curving outwards terminally, with rows of long setae; Remhoogte Mountains to the south of the Tsondab River canyon … *N. streyi* Frolov

– Apices of aedeagus curving outwards terminally, without rows of long setae ... 5

5 Tips of parameres with two notches in frontal view; Naukluft Mountains to the south of the Tsondab River canyon ... *N. endroedyi* Deschodt, Davis and Scholtz

– Tips of parameres without notches in frontal view; Hardap Dam ... *N. davisi* Deschodt and Scholtz

6 Clypeus clearly bidentate with clypeal horns long … *Dicranocara* Frolov and Scholtz … 7

– Clypeus quadridentate, with short medial clypeal horns … 9

7 Aedeagus with lateral clypeal horns on parameres that extend forward; punctures on pronotum fewer, faint and shallow; Richtersveld south of Orange River, in South Africa ... *D. tatasensis* Deschodt and Scholtz

– Aedeagus without lateral clypeal horns on parameres; punctures on pronotum numerous and obvious; Richtersveld north of Orange River, in Namibia … 8

8 Apex of parameres bulky; northern Richtersveld and Fish River Canyon ... *D. inexpectata* Deschodt and Scholtz

– Apex of parameres slender; southern Richtersveld: Boom River ... *D. deschodti* Frolov and Scholtz

9 Clypeal horns short, mesometasternal suture not well defined; south of Orange River *Byrrhidium* Harold … 10

– Clypeal horns medium length, mesometasternal suture well defined; north of Orange River ... *Drogo stalsi* gen. *et.* sp. n.

10 Aedeagus with side protrusions, fore tibia with outer teeth parallel; Richtersveld in South Africa ... *B. convexum* Scholtz and Howden

– Aedeagus plain with no side protrusions, fore tibia with outer teeth diverging; Namaqualand … *B. ovale* Harold

Table 1. Table showing the differences between *Elassocanthon brevipes* and *Byrrhidium namaquense* according to Scholtz and Howden 1987 with characters for *Byrrhidium ovale* included from images of the holotype.

	Byrrhidium ovale Type specimen not seen by Scholtz and Howden	***Elassocanthon brevipes*** Type specimen seen by Scholtz and Howden	***Byrrhidium namaquense*** Seen by Scholtz and Howden	**Our remarks made from images of types**
Fourth clypeal tooth	Absent	Present	Absent	Absent in all three images
Genal margin	Straight	Sinuate	Straight	More or less straight in all
Granules on the elytral interstriae	Absent	Present	Absent	Absent in all three images.
All elytral striae	Distinct	Distinct	Only some visible	Relatively distinct in all three images
Size of apical piece of each paramere	Slightly smaller than *Byrrhidium namaquense* type	Smaller [from fig. 15 in Scholtz and Howden 1987]	Larger [from fig. 17 in Scholtz and Howden 1987]	All aedeagi within normal species-group size variation
Locality	Natal [Erroneous]	Kl. Namaland, Ka[o]maggas	Garies Namaqualand	

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Appendix 1. Data matrix for all the species of the *Byrrhidium* group and one outgroup species, used in the cladistic analysis (description of characters is included in the text).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Epirinus convexus	3	2	0	0	4	4	2	3	2	1	0	0	0	0	0	2	1	0	0	1	2	1	2	2	2	1	0	1	1	0	0
Byrrhidium convexum	0	0	1	1	0	0	0	0	1	0	1	1	1	0	0	0	1	1	0	1	1	1	1	0	1	1	0	0	1	0	1
Byrrhidium ovale	0	0	1	1	0	0	1	0	1	0	1	1	1	0	0	1	1	0	0	1	0	0	1	0	1	1	0	0	1	0	1
Dicranocara tatasensis	1	1	1	1	1	1	2	1	0	0	1	0	0	0	1	0	1	1	0	1	1	1	0	1	0	1	1	1	0	1	0
Dicranocara deschodti	1	1	1	1	1	1	2	1	0	0	1	0	0	0	1	1	1	0	0	1	1	1	0	1	1	1	1	1	0	1	0
Dicranocara inexpectata	1	1	1	1	1	1	2	1	0	0	1	0	0	0	1	1	1	0	0	1	1	1	0	1	1	0	1	0	0	1	0
Drogo stalsi	2	2	0	0	2	2	2	2	1	0	1	1	1	1	?	2	1	0	1	1	1	1	1	0	1	1	1	0	0	1	1
Namakwanus davisi	2	2	0	0	3	3	2	2	1	1	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	1	1	0	1	1	0
Namakwanus endroedyi	2	2	0	0	2	2	2	2	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0
Namakwanus streyi	2	2	0	0	1	1	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	1	1	0	1	1	1	0	1	1	0
Namakwanus irishi	2	2	0	0	2	2	2	2	0	1	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	1	1	0	1	1	0
Versicorpus erongoense	1	1	1	1	1	1	1	1	1	1	0	1	0	1	?	?	?	?	0	1	1	1	1	0	0	1	1	0	1	0	0

Appendix 2. Average of all measurements made. The number of specimens measured is shown after each species name.

	Pronotum width	Pronotum length	Elytron length	Elytron width	Mesocoxae distance	Diagonal meso-to metacoxa distance	Pronotum area	Elytra area	pronotum length + elytron length
Epirinus convexus (5)	2.33	1.40	2.03	2.40	0.90	0.67	3.26	4.86	3.43
Byrrhidium convexum (2)	7.00	3.76	6.82	7.47	1.98	1.59	26.35	50.98	10.59
Byrrhidium ovale (5)	6.48	3.53	6.98	7.36	2.38	2.09	22.88	51.38	10.51
Dicranocara tatasensis (2)	6.00	3.09	5.47	6.21	1.38	1.35	18.53	33.95	8.56
Dicranocara deschodti (5)	5.60	3.15	5.44	5.94	1.45	1.20	17.66	32.29	8.59
Dicranocara inexpectata (5)	5.91	3.15	5.53	6.15	1.46	1.25	18.62	34.02	8.68
Drogo stalsi (1)	4.71	2.18	4.29	5.35	1.35	1.18	10.24	22.99	6.47
Namakwanus davisi (2)	3.15	1.68	3.09	3.59	0.94	0.94	5.28	11.08	4.76
Namakwanus endroedyi (1)	3.71	1.82	3.88	4.41	1.06	1.06	6.76	17.13	5.71
Namakwanus streyi (1)	5.47	1.76	5.29	5.88	1.82	1.41	9.65	31.14	7.06
Namakwanus irishi (2)	4.26	2.29	4.00	4.79	1.21	1.12	9.78	19.18	6.29
Versicorpus erongoense (1)	5.65	3.53	5.65	6.00	1.82	1.59	19.93	33.88	9.18