

Bothalia

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A taxonomic revision of the genus *Merciera* (Campanulaceae)

C.N. CUPIDO*

Keywords: Campanulaceae, *Merciera* A.DC., South Africa, taxonomy, Western Cape

ABSTRACT

A taxonomic account of Western Cape endemic genus *Merciera* A.DC. is presented. Six species, supported by recent phenetic studies, are recognized. *M. brevifolia* A.DC., *M. eckloniana* H.Buek, *M. leptoloba* A.DC. and *M. tenuifolia* (L.f.) A.DC. are retained as species. *M. azurea* Schltr. is returned to species status and *M. tetraloba* C.N.Cupido was recently described. Each species is described and illustrated. A key to the species, and distribution maps are provided.

INTRODUCTION

Merciera A.DC. is a poorly known genus of small shrubs confined to Western Cape, South Africa. The genus is classified in the Campanulaceae subfamily Campanuloideae. This subfamily, often treated as a separate family, comprises between 35 to 55 genera and 600 species (Cosner *et al.* 2004). In the southern hemisphere only South Africa shows great diversity with 10 genera. Eight genera are endemic to South Africa and of these five are endemic to the Cape Floristic Region (CFR) (Goldblatt 1978). Taxonomically, genera are separated on account of capsule structure, particularly the mode of dehiscence. *Merciera* is unique amongst the South African genera in that its capsule is indehiscent. In addition to the unique capsule, the genus is characterized by salverform, tetramerous or pentamerous, blue-violet or white flowers and four basal ovules.

Species limits of *Merciera* were re-assessed in Cupido (2003), employing phenetic methods. The results of the phenetic studies support the recognition of six species. A taxonomic account of *Merciera* based on the phenetic studies is presented here.

MATERIAL AND METHODS

Sampling methods, preparation and examination of study material used are set out in Cupido (2003). In addition to specimens from SAM, BOL, and NBG cited in Cupido (2003), material from PRE, K and MO (acronyms as in Holmgren *et al.* 1990) were also examined for this revision.

Species concept

Taxonomists are frequently criticized for not being explicit about the criteria used in species delimitation. No universal species concept exists (Davis & Goldman 1993) and it therefore depends on the individual taxonomist to define species level taxa (Cupido 2003). In this study, the criterion of overall similarity that is based on observed patterns of character variation is employed. This criterion has been formulated into the phenetic species concept. The phenetic species concept considers discrete clusters

in character hyperspace as species. Phenetic clusters are recognized by the possession of a particular minimum number of characters in common. Six phenetic clusters were revealed by phenetic analysis (Cupido 2003). Each of these clusters is considered a species.

TAXONOMIC HISTORY

De Candolle (1830) established the genus *Merciera* to accommodate three species of Campanulaceae from the Cape characterized by having four basal ovules in unilocular or incompletely two-locular ovaries, and indehiscent capsules. One of these species, *M. tenuifolia* (L.f.) A.DC. had previously been placed in either *Trachelium* L. or *Roella* L., the other species were newly described. The genus was named in honour of botanist Phillip Mercier who wrote a monograph on the family Polemoniaceae. Initially De Candolle described the genus as '*incertae sedis*' because of the unusual structure of the ovary, but later classified it in the monogeneric tribe Merciereae (De Candolle 1839). Buek (1837) added two more species, but one of these, *M. heteromorpha*, was erroneously placed in the genus, belonging in the Rubiaceae instead (Sonder 1865). Species described by Buek (1837) appear to have been overlooked by De Candolle (1839). Sonder (1865) reduced the genus to two species, *M. brevifolia* A.DC. and *M. tenuifolia*, which were divided into two and four varieties respectively. More than three decades later, Schlechter (1898) described a species, *M. azurea* Schltr. from Sir Lowry's Pass. In the last comprehensive treatment of *Merciera*, Adamson (1954) recognized five species, one of which, *M. tenuifolia*, was divided into two varieties. In a remarkable coincidence, Adamson, like Buek before him, described a species, *M. vaginata* Adamson, which also belongs in the Rubiaceae (Adamson 1955). Since Adamson's treatment, Cupido (2002) added one more species from localities west of the Hottentots Holland Mountains in the Western Cape. In the present paper, six species are recognized in total, comprising De Candolle's (1830) original three, and one each described by Buek (1837), Schlechter (1898) and Cupido (2002). None of the species are divided into varieties.

Nomenclatural notes

Phillips (1951) cited *Merciera leptoloba* A.DC. as the type species of *Merciera*, in effect, an act of lectotypification. However, according to Stafleu & Cowan (1983), Pfeiffer (1874) frequently indicated type species for

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generic names, which constitute in numerous instances, the first selection of a lectotype. For the genus *Merciera*, Pfeiffer (1874) cited only *Trachelium tenuifolium*, the basionym of *M. tenuifolia* (L.f.) A.DC. Single species are mentioned only when they serve as a type of new genera or sections, as was done with *Merciera*. Article 9.17 of the Code (Greuter *et al.* 2000) is applied here. It states that the author who first designated a lectotype or a neotype must be followed. The species designated by Pfeiffer should therefore be regarded as the lectotype of *Merciera*.

The author citations of *Merciera* species described by Buek in the *Enumeratio* (Ecklon & Zeyher 1837) were given as H.Buek ex Eckl. & Zeyh. by Welman & Cupido (2003), because the specific epithets are interpreted as manuscript names. Nordenstam (2003) came to a different conclusion after studying Buek's taxonomic contributions to South African Campanulaceae, particularly the typification of species described by Buek. He found that the published descriptions attributed to the Buek MS and the wording of the handwritten descriptions found on the specimens in Stockholm (S), agree completely with that of Buek. Buek is therefore 'the author of the Campanulaceae in the *Enumeratio* (Ecklon & Zeyher 1837) and names published therein must be attributed to H.Buek alone (or H.Buek in Eckl. & Zeyh., if a bibliographical citation is involved; cf. Art. 46 Note 1 of the ICBN, Greuter *et al.* 2000)' (Nordenstam 2003). This conclusion is followed here.

MORPHOLOGICAL CHARACTERS

Habit

All species are resprouting, dwarf shrubs with branched stems. Stems are decumbent to suberect, occasionally with groups of branches at the end of a year's growth. The resprouting habit of *Merciera* is an adaptation to survive fires, and the genus is confined to the fire-prone fynbos vegetation of the Cape Region. Vegetatively, *Merciera* species resemble species of *Roella*, particularly of the series *Ciliatae*.

Leaves

The leaves are alternate, linear and sessile, often appearing dead due to the brown colour. The margins are entire, and usually ciliate. The abaxial surface is hairy in all species, except in *Merciera tetraloba* C.N.Cupido.

Leaves are variable in size and insertion along the stem. In *Merciera leptoloba* the leaves become smaller towards the top of the stem. In *M. tenuifolia* and *M. azurea* the leaves are subequal and crowded, but in *M. eckloniana* H.Buek, they are widely spaced.

Clusters of smaller green leaves are always present in the axils of leaves in all species except *Merciera azurea*, in which they are seldom present. These leaf clusters are in fact highly reduced short shoots developed in the axils of long shoot leaves.

Inflorescence

In an account on the inflorescence morphology of the Campanulaceae, Philipson (1953) described the inflores-

cence of *Merciera* as intercalary. The flowers are solitary in the axils of foliage leaves and after producing a zone of flowers, the axis continues to grow vegetatively. This arrangement is particularly marked in *M. leptoloba*.

Careful examination of the inflorescence reveals that there are in fact three flowers per axil. Only the terminal one develops however, and the two lateral flowers remain rudimentary on highly reduced lateral branches with bract-like leaves. The terminal flower lacks a bract-like leaf. The reduction of the lateral branches gives the flowers an axillary appearance. This basic structure is repeated in the entire flowering zone, forming a spike-like synflorescence towards the end of the main branches. The order of flowering is acropetal.

Flowers

Phenotypic plasticity is common in the Campanulaceae (Eddie & Ingrouille 1999) and *Merciera* is no exception to the rule. Numbers of floral parts are sometimes variable in the same species. Additional floral parts tend to develop, and flowers that are normally pentamerous, may become hexamerous. Both flower types are usually present on the same plant.

Calyx

The calyx is 4- or more commonly 5-lobed. Hairs are often present on the hyaline tips, but only on the margins in *Merciera tetraloba*. The lobes are fused at the base to form a short tube.

Corolla

The corolla is actinomorphic with a conspicuous tube and 4 or 5 spreading lobes. The corolla colour is white or blue to violet, and occasionally white-flowered species have purple tips to the corolla lobes. Tube length and flower colour is correlated, dividing the genus into two groups. White-flowered species have tube lengths less than 7 mm, whereas blue to violet-flowered species have tube lengths exceeding 7 mm.

Androecium

Stamens are 4 or 5, free, inserted at the base of the corolla tube and included in the corolla. The filaments are flattened, wider and pilose about the middle becoming narrower towards the apex. Anthers are linear and basifixed.

Gynoecium

The inferior ovary is surrounded by a hispid hypanthium. In accordance with the trichome terminology of Payne (1978), four trichome types are found on the hypanthium: filiform, clavate, uncinata or circinate (Figure 1A–D). The locule number has been described as 1- or incompletely 2-locular (De Candolle 1830). However, careful dissecting of the ovary reveals a complete but delicate septum, dividing the ovary into 2 locules. Each locule contains 2 basal ovules. The style is filiform, exserted, glabrous and inserted in a convex disc. The style is shortly divided, with the number of stigmatic lobes corresponding to the number of locules in the ovary.

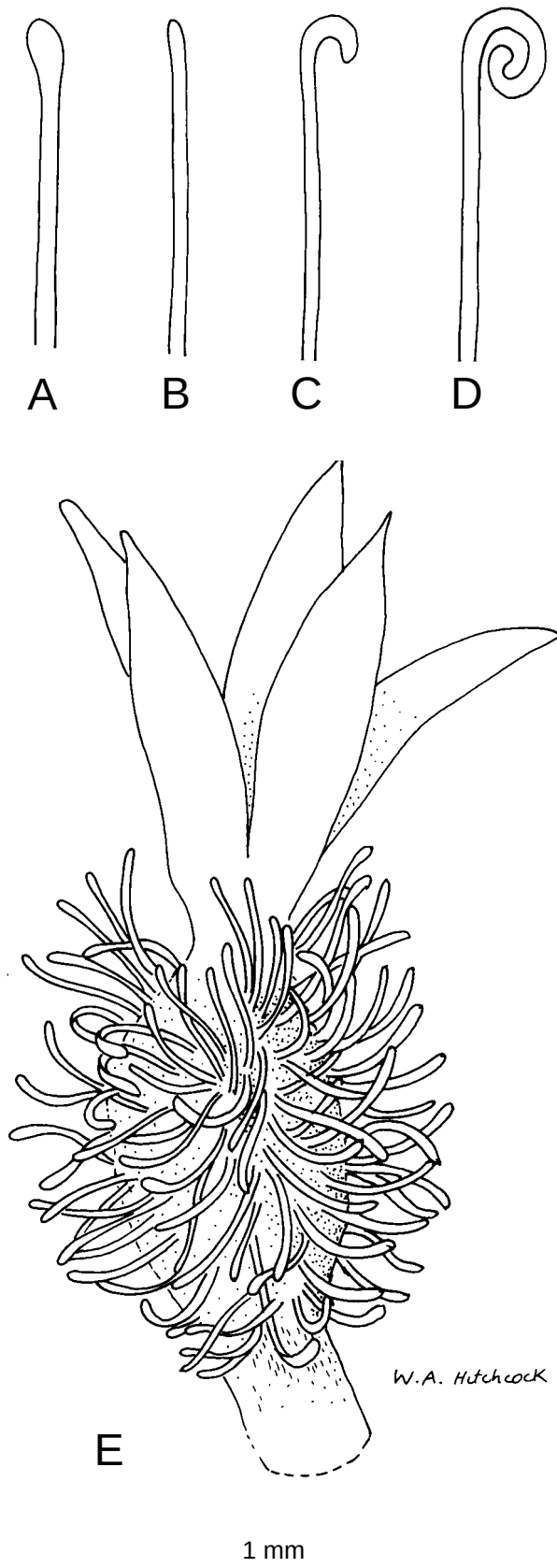


FIGURE 1.— *Merciera*. A–D, trichome types: A, clavate; B, filiform; C, uncinat; D, circinate. E, capsule. Scale bar: 1 mm. Artist: W.A. Hitchcock.

Fruits and seeds

Merciera has indehiscent, hispid capsules, crowned with a persistent calyx (Figure 1E). Only 1 ovule develops into a seed, which occupies the entire capsule cavity. Seeds are elliptic to ovate, pale brown with a darker hilum.

TAXONOMIC TREATMENT

***Merciera* A.DC.**, Monographie des Campanulées: 369 (1830); H.Buek: 372 (1837); Sond.: 530 (1865); Adamson: 157 (1954). Type species: *M. tenuifolia* (L.f.) A.DC. [*Trachelium tenuifolium* L.f.: 143 (1782)]. (lecto-type, designated by Pfeiffer 1874).

Subshrubs; branches hispidulous to hispid. *Stems* decumbent or suberect, branched. *Leaves* alternate, sessile, linear, subulate, entire, scattered or crowded, ascending or spreading, glabrous or hairy abaxially, margins $\pm$ ciliate, axillary clusters of smaller, glabrous leaves often present. *Inflorescence* 3-flowered, with 1 terminal, and 2 rudimentary flowers lateral, on highly reduced lateral branches with bract-like leaves, aggregated into spike-like synflorescences towards ends of main branches. *Flowers* sessile, axillary, actinomorphic; bract-like leaves 2, succulent, subtending each rudimentary flower, absent in terminal flower; hypanthium obconical, hispid with clavate, filiform, uncinat or circinate trichomes; calyx 4- or 5-lobed, often fused at base to form short tube, glabrous or hairy on hyaline tips and margins; corolla narrowly tubular or funnel-shaped, white, occasionally with purple tips, or violet-blue, or very rarely pale blue, lobes 4 or 5, ovate or linear-lanceolate, occasionally unequal, glabrous, or hairy on back. *Stamens* 4 or 5, free, inserted at base of corolla tube; filaments flattened, wider and pilose $\pm$ in middle, narrower towards apex; anthers linear, basifixed. *Ovary* inferior, 2-locular, containing 4 erect basal ovules; style filiform, bifid, exserted, glabrous, swollen at base; stigmas glabrescent, bluish purple. *Fruit* a hispid capsule, crowned with persistent calyx, 1-seeded, indehiscent. *Seed* elliptic to ovate.

The six species are endemic to the southwestern parts of the CFR and grow in open, sandy, clayey or rocky soil, often in disturbed habitats. Fire is important in the growth and survival of the genus. After fire, the plants resprout from the base and a period of four to six years of vigorous vegetative growth and flowering follows. After six years, the plants become moribund and start disappearing when the veld remains unburnt for very long periods.

1. ***Merciera tenuifolia* (L.f.) A.DC.**, Monographie des Campanulées: 370 (1830); Sond.: 596 (1865); Adamson: 159 (1954). *Trachelium tenuifolium* L.f.: 143 (1782); Thunb.: 38 (1800). *Roella tenuifolia* (L.f.) Thunb.: 174 (1823). Type: South Africa, without precise locality, *Thunberg* 4774 (UPS-THUNB, lecto., here designated, NBG, microfiche!).

M. tenuifolia (L.f.) A.DC. var. *candolleana* Sond.: 596 (1865). Type: South Africa, Western Cape, Houwhoek Mountains, *Ecklon & Zeyher* 2417 (SAM!).

M. tenuifolia (L.f.) A.DC. var. *thunbergiana* Sond.: 596 (1865). Type: South Africa, without precise locality, *Thunberg* 4773 (UPS-THUNB, holo.).

Key to species

- 1a Flowers pentamerous, blue, violet or purple, rarely white; corolla tube more than 7 mm long:
 - 2a Plants slender (stem equal to or less than 1 mm thick); leaves scattered; corolla lobes glabrous adaxially; distributed from Groenlandberg (Grabouw, 3419AA) northwards to Tulbagh (3319AC) 3. *M. eckloniana*
 - 2b Plants stout (stem more than 1 mm thick); leaves crowded; corolla lobes hairy adaxially; distributed south of Groenlandberg (Grabouw, 3419AA):
 - 3a Stems suberect; leaves ascending, abaxial surface hairy, axillary clusters of smaller leaves always present; corolla tube 11–26 mm long, five times as long as lobes 1. *M. tenuifolia*
 - 3b Stems decumbent; leaves spreading, abaxial surface glabrescent, axillary clusters of smaller leaves occasionally present on lower parts of stem; corolla tube 7–14 mm long, less than three times as long as lobes 2. *M. azurea*
- 1b Flowers tetramerous or pentamerous, white, occasionally with purple tips; corolla tube less than 7 mm long:
 - 4a Flowers tetramerous; margins of calyx lobes ciliate; hypanthium trichomes uncinata to circinate; plants growing in clayey soil; distributed west of Hottentots Holland Mountains 6. *M. tetraloba*
 - 4b Flowers pentamerous; margins of calyx lobes glabrous; hypanthium trichomes clavate or filiform; plants growing in sandy or stony soil; distributed southeast of Hottentots Holland Mountains:
 - 5a Plants decumbent, stout; lower leaves more than 8 mm long, crowded; corolla lobes, linear-lanceolate; 2–6 mm long, almost as long as tube; hypanthium trichomes clavate 4. *M. leptoloba*
 - 5b Plants suberect, slender; lower leaves less than 8 mm long, scattered; corolla lobes ovate, 2–3 mm long, up to half as long as tube; hypanthium trichomes filiform 5. *M. brevifolia*

Stems suberect, sparsely or profusely branched, occasionally with group of branches at end of each season's growth. *Leaves* crowded, ascending, hairy on abaxial surface, axillary cluster of smaller leaves occasionally present; bract-like leaves 4–10 mm long. *Flowers* violet-blue, rarely white; hypanthium 1–3 mm long, hispid with clavate trichomes; calyx lobes 5, 0.8–1 mm long, hairs on hyaline tips; corolla tube narrow, 10.0–25.5 mm long; lobes 5, ovate, 2.5–4.0 mm long, hairy on back. *Stamens* 5; filaments 7–21 mm long. *Style* 13.0–30.5 mm long. *Flowering time*: December to January. Figure 2.

Distribution and habitat: the distribution of *Merciera tenuifolia* (Figure 3) is limited to Bot River, Houwhoek and Kogelberg where it is found on stony soil at altitudes ranging between 110 and 600 m.

The locality of the specimen MacOwan 3103 (SAM) collected at Tulbagh Nuwekloof is suspect. It has the same locality, collecting date and number as a specimen of *M. azurea*. No recent collections of *M. tenuifolia* have been made in the Tulbagh area.

Conservation status: Vulnerable D2 (World Conservation Union [IUCN] 2001).

2. *Merciera azurea* Schltr. in Botanische Jahrbücher 24: 447 (1898). *M. tenuifolia* (L.f.) A.DC. var. *azurea* (Schltr.) Adamson: 160 (1954). Type: South Africa, Western Cape, Sir Lowry's Pass, Schlechter 7263 (B, holo.; MO, SAM, iso.).

Stems decumbent, stout, occasionally with group of branches at end of each season's growth. *Leaves* crowded, spreading, glabrous or hairy on abaxial surface, axillary cluster of smaller leaves occasionally present; bract-like leaves 4.0–9.5 mm long. *Flowers* violet-blue, rarely white; hypanthium 1.5–2.7 mm long, hispid with clavate or filiform trichomes; calyx lobes 5, 1.0–1.9 mm long, hairy on hyaline tips; corolla tube wide, 7–14 mm long; lobes 5, ovate, 3.0–5.5 mm long, glabrous or hairy on back. *Stamens* 5; filaments 7–11 mm long. *Style* 12.0–19.5 mm long. *Flowering time*: November to February. Figure 4.

Distribution and habitat: *Merciera azurea* ranges from Sir Lowry's Pass to Bredasdorp (Figure 5) and occurs on

sandy or stony soil at altitudes ranging between 100 and 650 m.

The locality of the specimen MacOwan 3103b (SAM) collected at Tulbagh Nuwekloof is suspect. It has the same locality, collecting date and number as a specimen of *Merciera tenuifolia*. No recent collections of *M. azurea* have been made in the Tulbagh area.

During 1896 MacOwan made several collecting trips to Tulbagh, Caledon, Houwhoek and the Hottentots Holland Mountains (Gunn & Codd 1981) and it could have happened that specimens from the different localities were unknowingly mixed up resulting in incorrect locality information.

Conservation status: Vulnerable D2 (World Conservation Union [IUCN] 2001).

3. *Merciera eckloniana* H.Buek in Eckl. & Zeyh., Enumeratio plantarum Africae Australis extratropicae: 387 (1837); Adamson: 160 (1954). *M. tenuifolia* (L.f.) A.DC. var. *eckloniana* (H.Buek) Sond.: 596 (1865). Type: South Africa, inter rupes (altit. IV) montium supra 'Waterfall' in valle 'Tulbagh' (Worcester), December, Ecklon & Zeyher 2420 (S, holo.; SAM, iso.).

Stems semi-erect, slender, occasionally with group of branches at end of each season's growth. *Leaves* scattered, spreading, glabrous, or hairy on abaxial surface, axillary cluster of smaller leaves occasionally present; bract-like leaves 2–6 mm long. *Flowers* violet-blue, rarely white; hypanthium 1.0–2.8 mm long; hispid with filiform trichomes; calyx lobes 5, less than 1 mm long, hairs on hyaline tips; corolla tube narrow, 7.5–16.0 mm long, lobes 5, ovate, 1.5–3.5 mm long, glabrous on back. *Stamens* 5; filaments 5.5–10.0 mm long. *Style* 8.5–17.5 mm long. *Flowering time*: October to February. Figure 6.

Distribution and habitat: this species is distributed from the Groenlandberg northwards to Tulbagh (Figure 5). It is found on sandy or stony soil at altitudes ranging from 450 to 1 500 m.

Conservation status: Vulnerable D1 (World Conservation Union [IUCN] 2001).

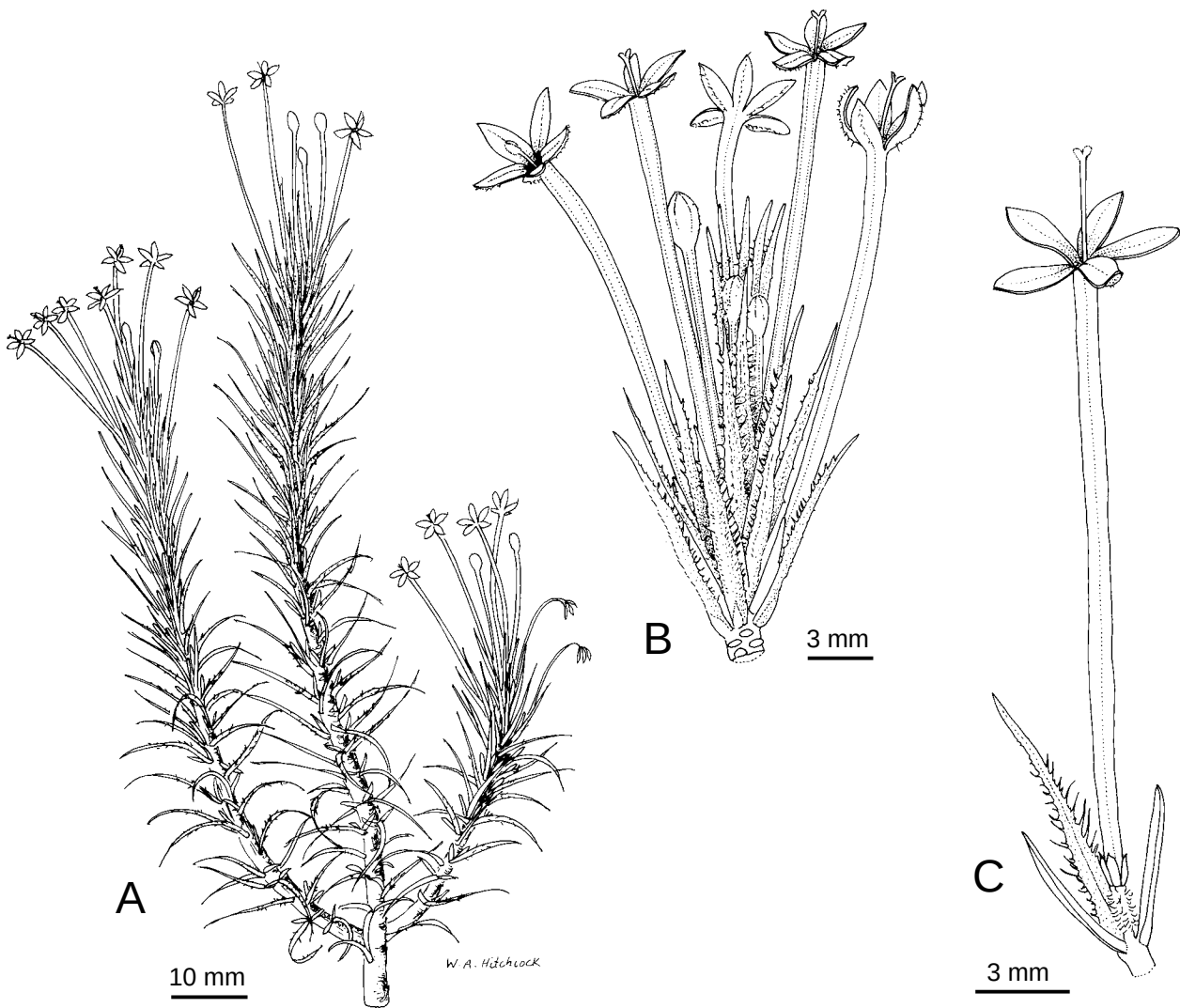


FIGURE 2.—*Merciera tenuifolia*, Cupido 289. A, portion of plant; B, flowering branch; C, flower with prophylls. Scale bars: A, 10 mm; B, C, 3 mm. Artist: W.A. Hitchcock.

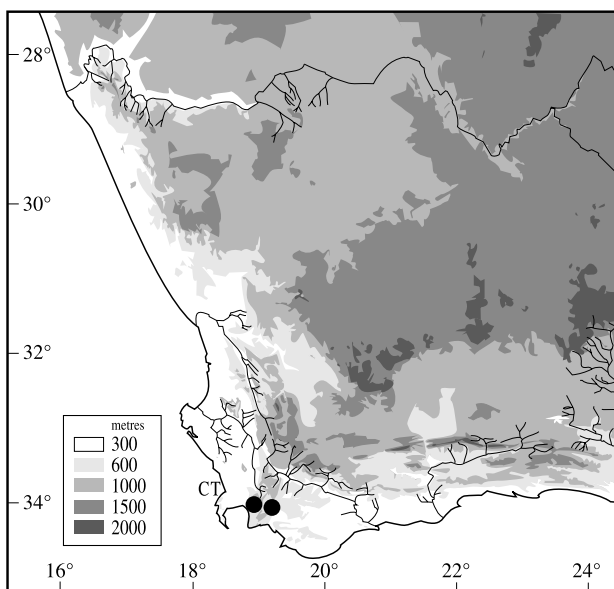


FIGURE 3.—Known distribution of *Merciera tenuifolia*.

4. *Merciera leptoloba* A.DC., Monographie des Campanulées: 371 (1830); H.Buek in Eckl. & Zeyh.: 387 (1837); Adamson: 162 (1954). *M. brevifolia* A.DC. var. *leptoloba* (A.DC.) Sond.: 596 (1865). Type: South Africa, Cape of Good Hope (Caput Bonae Spei), Hooker s.n. (K, holo.).

Stems decumbent with groups of branches at end of each season's growth. *Leaves* scattered to crowded, lower leaves more than 8 mm long, glabrous to hairy on abaxial surface, with axillary cluster of smaller leaves; bract-like leaves 2–8 mm long. *Flowers* white; hypanthium 1–3 mm long; trichomes clavate; calyx lobes 5, 0.7–1.8 mm long, hairy on hyaline tips, rarely on back; corolla tube 3.0–5.5 mm long, occasionally shorter than lobes; lobes 5, linear, 2–6 mm long, glabrous on back. *Stamens* 5; filaments 3–5 mm long. *Style* 4–12 mm long. *Flowering time*: November to March. Figure 7.

Distribution and habitat: *Merciera leptoloba* is a common species of the Cape southeast coast, from Kogelberg to Bredasdorp (Figure 8). This species is found on sandy or stony flats and hills at altitudes ranging between sea level and 400 m.

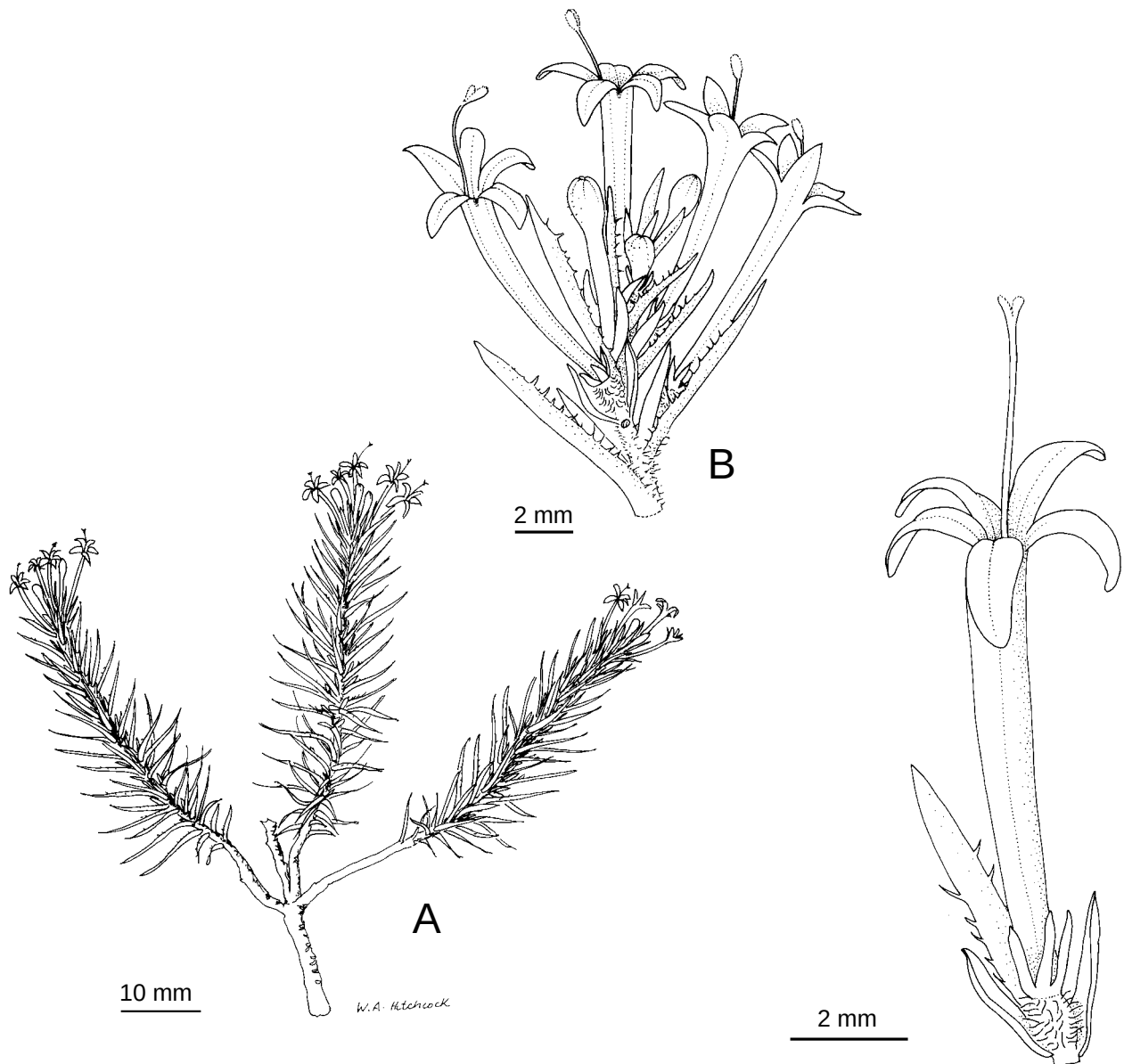


FIGURE 4.—*Merciera azurea*, Cupido 68. A, portion of plant; B, flowering branch; C, flower with prophylls. Scale bars: A, 10 mm; B, C, 2 mm. Artist: W.A. Hitchcock.

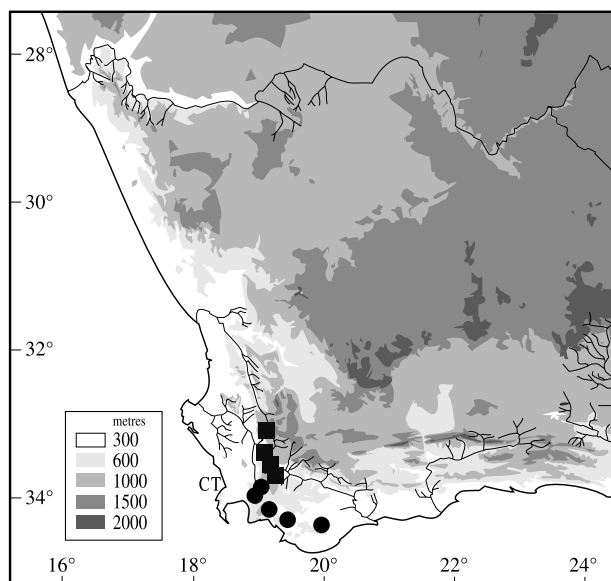


FIGURE 5.—Known distribution of *Merciera azurea*, ●; *M. eckloniana*, ■.

Conservation status: Vulnerable D1 D2 (World Conservation Union [IUCN] 2001).

5. *Merciera brevifolia* A.DC., Monographie des Campanulées: 371 (1830); H.Buek in Eckl. & Zeyh.: 387 (1837); Adamson: 161 (1954). Type: South Africa, without precise locality, *Masson s.n.* (BM, holo. –NBG, photo.!).

Stems semi-erect, slender with groups of branches at end of each season's growth. *Leaves* scattered to crowded, less than 8 mm long, glabrous to hairy on abaxial surface, with axillary cluster of smaller leaves; bract-like leaves 2–4 mm long. *Flowers* white; hypanthium 0.8–1.6 mm long; trichomes filiform; calyx lobes 5, 0.5–1.0 mm long, hairy on hyaline tips, rarely on back; corolla tube 3–6 mm long; lobes 5, ovate, 1.5–3.0 mm long, glabrous on back. *Stamens* 5; filaments 2–4 mm long. *Style* 4.0–8.5 mm long. *Flowering time:* November to February. Figure 9.

Distribution: *Merciera brevifolia* is a montane species occurring on the Babylons Tower, and on the Bot

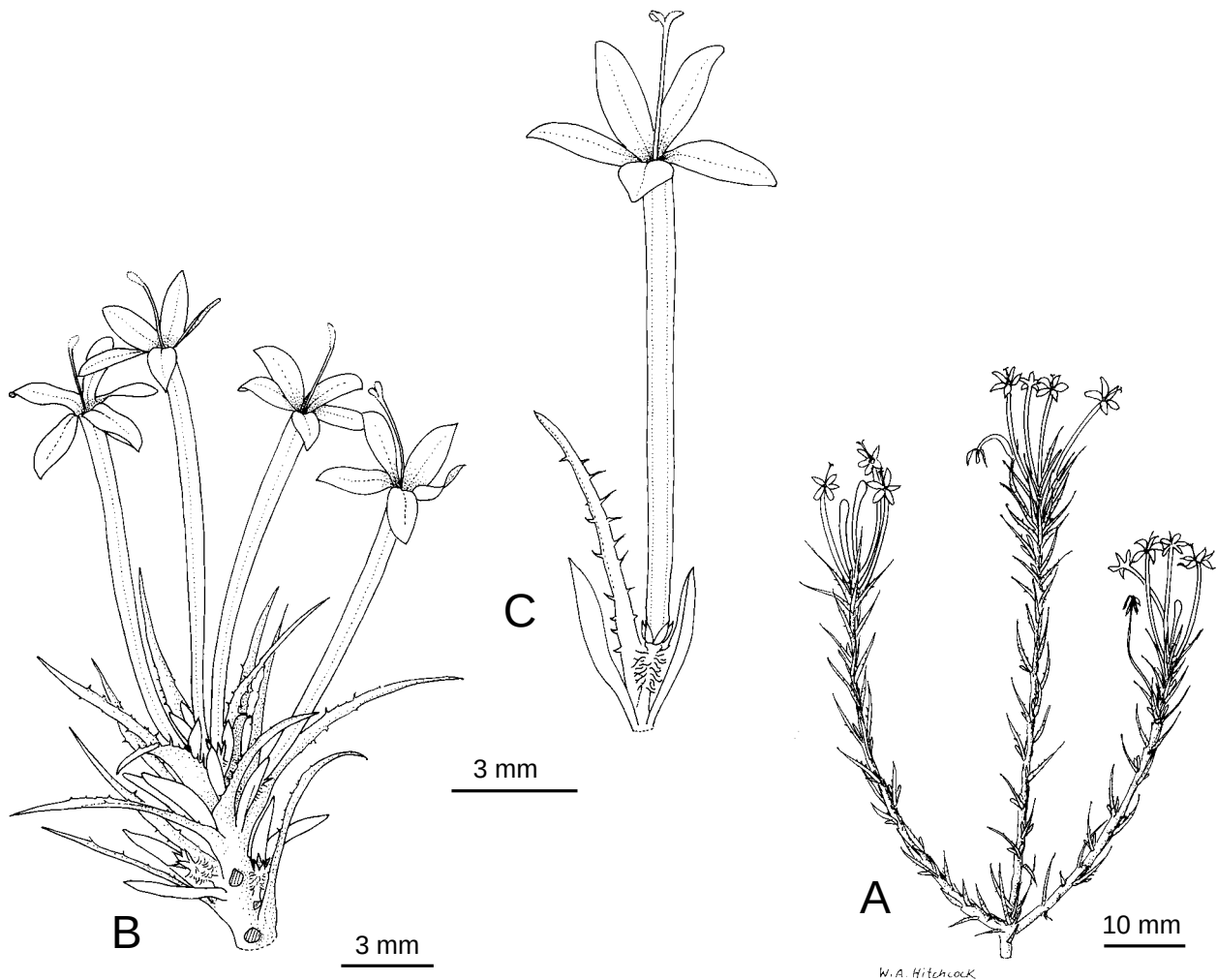


FIGURE 6.—*Merciera eckloniana*, Cupido 71. A, portion of plant; B, flowering branch; C, flower with prophylls. Scale bars: A, 10 mm; B, C, 3 mm. Artist: W.A. Hitchcock.

River, Houwhoek, Shaw's Mountains and the Caledon Swartberg (Figure 10).

On the Houwhoek Mountains where this species occurs in sympatry with *Merciera leptoloba*, possible hybrids between the two species are formed.

Conservation status: Vulnerable D2 (World Conservation Union [IUCN] 2001).

6. *Merciera tetraloba* C.N. Cupido in *Bothalia* 31: 74 (2002). Type: Western Cape, Strand, Harmony Flats, Tortoise Nature Reserve, off Disa Road, 17 January 2000, C.N. Cupido 77 (NBG, ho lo.; BM!, K!, MO!, NY!, PRE!, iso.).

Stems decumbent or suberect, slender, occasionally with groups of branches at end of each season's growth. **Leaves** scattered, ascending, the older spreading, glabrous on abaxial surface, margins ciliate; axillary cluster of smaller leaves present; bract-like leaves, 1–4 mm long. **Flowers** tetramerous, white, occasionally with purple tips, or very rarely pale blue; hypanthium 1–2 mm long, hispid with uncinatate or circinate trichomes; calyx lobes 4, 0.6–1.2 mm long, often hairy on hyaline tips and margins; corolla tube 4–6 mm long; lobes 4, ovate, 2–3 mm long, glabrous or hairy on back. **Stamens** 4; filaments 3.0–4.5 mm long. **Style** 6–10 mm long. **Flowering time:**

November to January. Figure 11.

Distribution and habitat: this species is found in Faure, Gordon's Bay, Sir Lowry's Pass, Somerset West, Strand, Dal Josaphat, Du Toitskloof, Stellenbosch, Hermon and Malmesbury on flats and lower mountain slopes at altitudes between 30 and 350 m (Figure 10). It grows in open clayey soil, often in disturbed habitats.

When originally described, this species was thought to be restricted to Faure, Gordon's Bay, Sir Lowry's Pass, Somerset West, Strand, Dal Josaphat, Du Toitskloof, and Stellenbosch. Subsequently, the author came across a specimen collected by Elsie Esterhuysen (*Esterhuysen* 34802, BOL) at Michiel Heyns Kraal near Malmesbury in 1977 and misidentified as *Lightfootia*. Attempts to verify this collection in the field have so far been unsuccessful. John Manning recorded another new locality for this species (*Manning* 2941, NBG) at Hermon on the Farm Bosplaas in 2005.

Conservation status: Endangered B1 a (i, ii) b (iii) 2 (i, ii) b (iii) D (World Conservation Union [IUCN] 2001).

Large areas of the habitat of this species in the Helderberg and Stellenbosch areas have been destroyed because lower mountain slopes and lowland areas are sought after for urban development. On the Harmony

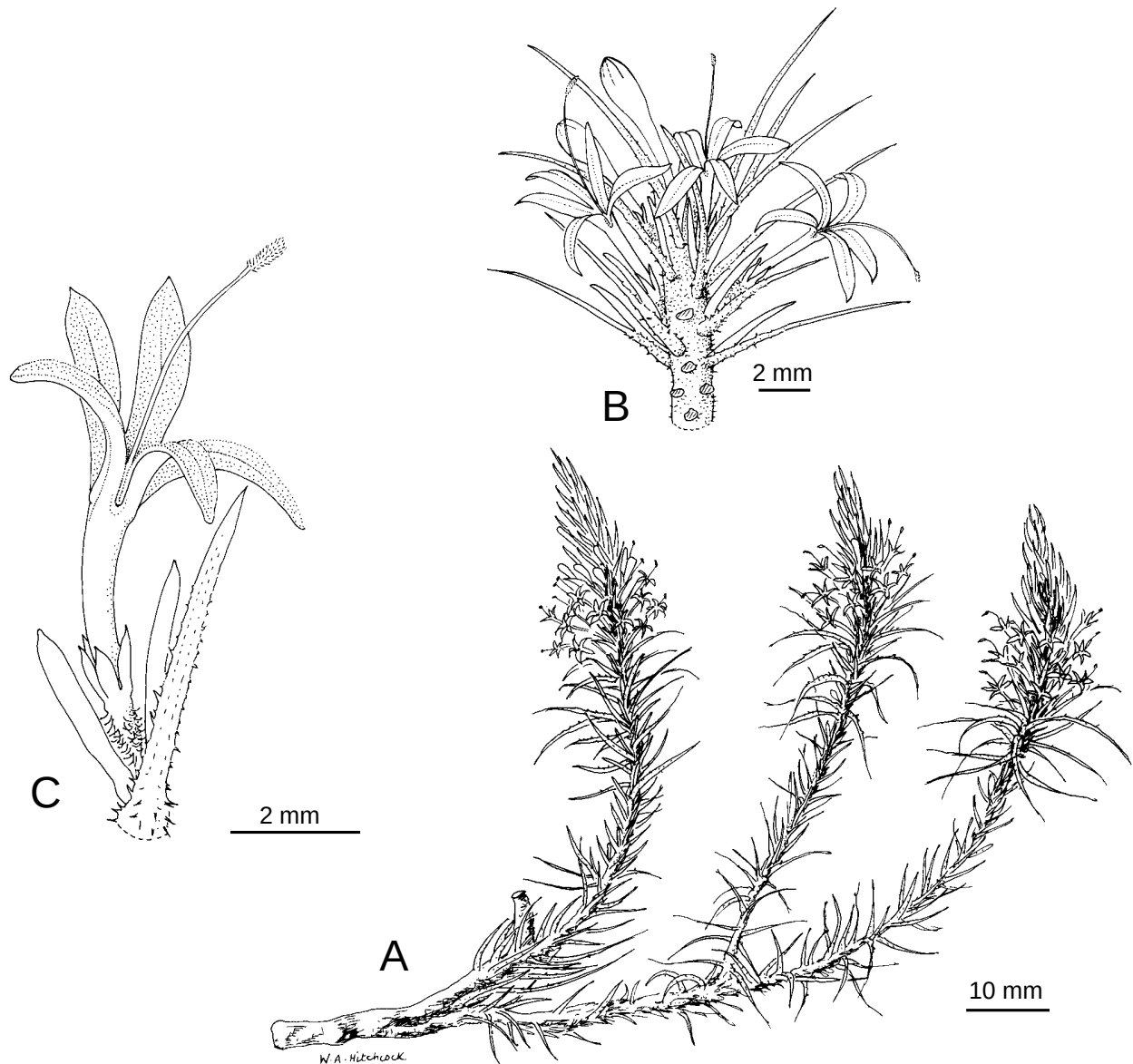


FIGURE 7.—*Merciera leptoloba*, Cupido 66. A, portion of plant; B, flowering branch; C, flower with prophylls. Scale bars: A, 10 mm; B, C, 2 mm. Artist: W.A. Hitchcock.

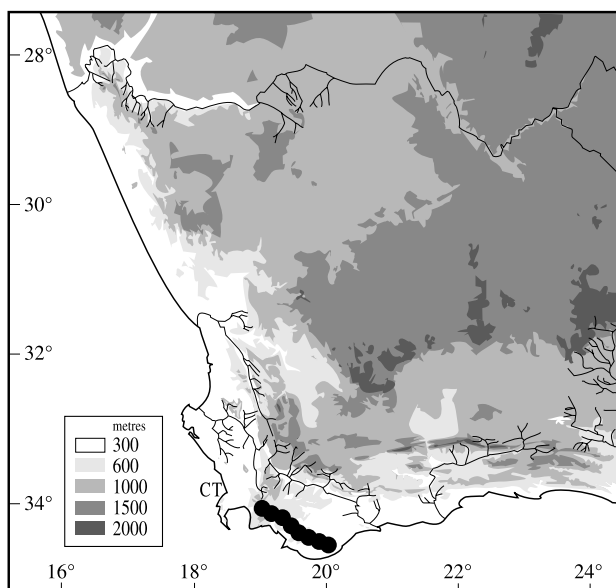


FIGURE 8.—Known distribution of *Merciera leptoloba*.

Flats in Strand, the few existing populations are under serious threat of extinction.

Excluded species

Merciera heteromorpha H.Buek = *Carpacoe heteromorpha* (H.Buek) Bolus

When Buek (1837) described the species, he noted that it most likely constituted a distinct genus. Sonder (1865) considered it a member of Rubiaceae, but did not treat it taxonomically. A few decades after Sonder, Bolus (1896) transferred the species to the genus *Carpacoe* in the Rubiaceae, where it is currently classified.

Merciera vaginata Adamson = *Carpacoe heteromorpha* (H.Buek) Bolus (*Merciera heteromorpha* H.Buek)

Adamson erroneously thought that *Stokoe* s.n. (SAM) from the Somerset Sneeuwkop represented a new species of *Merciera* and consequently described it as such. After it had been brought to his attention that the plant described as *M. vaginata* appeared to be the same as

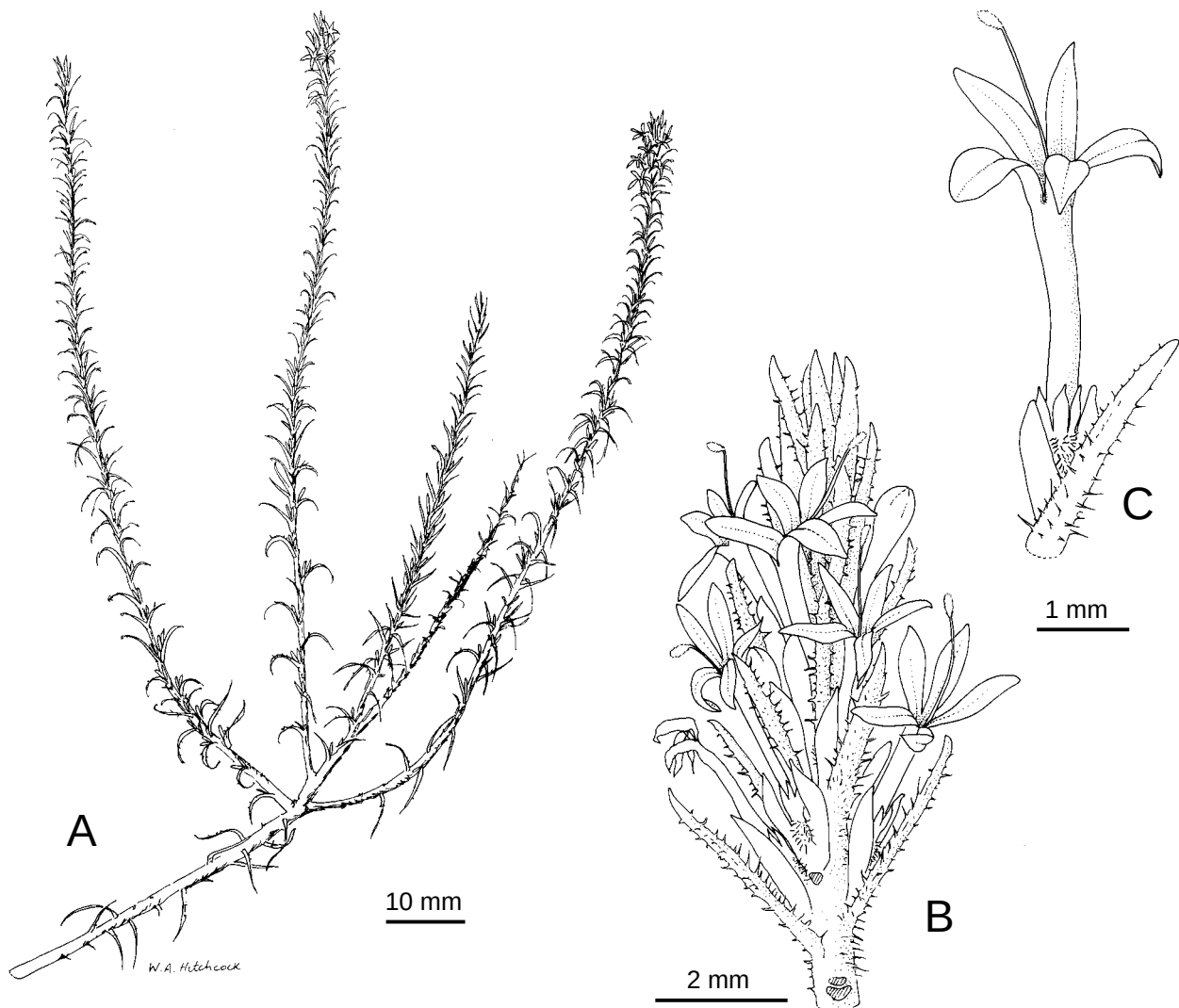


FIGURE 9.—*Merciera brevifolia*, Cupido 235. A, portion of plant; B, flowering branch; C, flower with prophylls. Scale bars: A, 10 mm; B, 2 mm; C, 1 mm. Artist: W.A. Hitchcock.

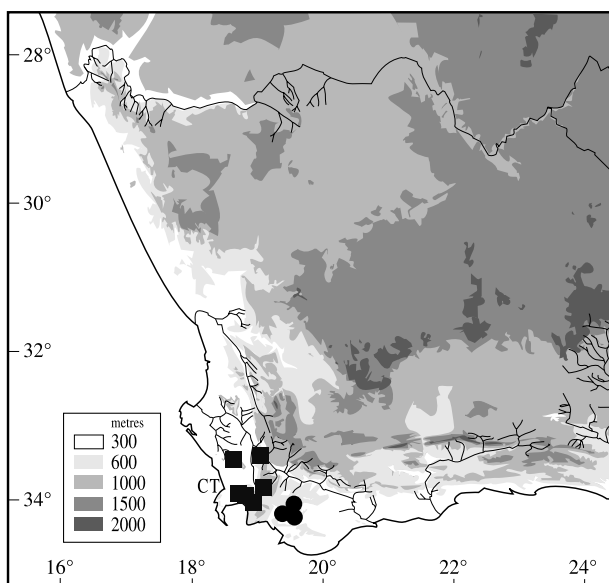


FIGURE 10.—Known distribution of *Merciera brevifolia*, ●; *M. tetraloba*, ■.

certain specimens in the herbarium of the South African Museum, he re-examined the specimen. He conceded that the plant was the same as Zeyher 2421, the type of *M. heteromorpha* (Adamson 1955) and is therefore correctly referred to *Carpacoe heteromorpha*.

Merciera muraltioides Schltr.

Specimens collected by R. Schlechter (Schlechter 7372, BOL, MO, SAM) from Houwhoek appear under the manuscript name *Merciera muraltioides* Schltr. sp. nov. This name was never published and is therefore not valid. The inclusion of these specimens in *M. brevifolia* A.DC. by Adamson (1954) is supported by the phenetic studies of Cupido (2003) and accordingly upheld in this paper.

SPECIMENS EXAMINED

Adamson 4095 (4) PRE; 4098 (1) BOL; 4773, 4774, 4898 (4) BOL; 4780 (4) K; 4781 (4) SAM; 4895 (6) BOL; 4904 (2) SAM.

Barker 286 (3) NBG; 7776 (4) NBG; 8802 (5) NBG; 8865 (6) NBG. Barker (Belle) s.n. (2) MO. Barnard 40469 (2) SAM. Bayer SA01108

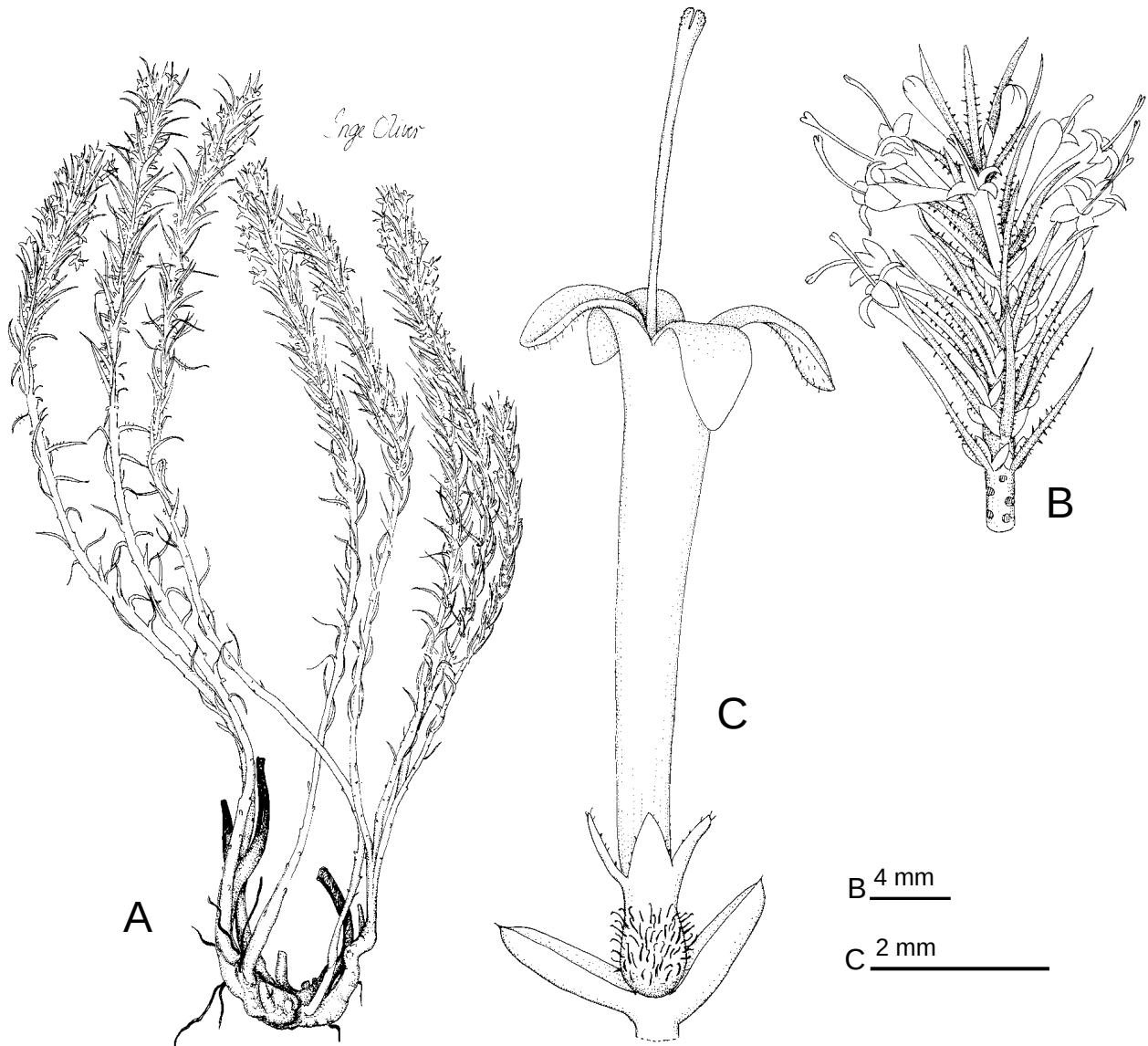


FIGURE 11.—*Merciera tetraloba*, Cupido 77. A, portion of plant, life size; B, flowering branch; C, flower with prophylls. Scale bars: B, 4 mm; C, 2 mm. Artist: Inge Oliver.

(2) MO. Bayliss 4089 (6) NBG, MO. Bolus 634 (2) SAM; 4679, 5105 (5) BOL; 6948 (1) NBG; 7402 (5) BOL; BOL98256 (6) BOL. Bond 1684 (3) NBG. Boucher 167, 1781 (2) NBG; 932, 1769 (4) NBG; 3447 (6) NBG, PRE; 5279 (1) NBG. Brennan 14048 (4) NBG, MO, K. Burger 2859 (4) NBG. Burman 1079 (2) BOL; 1255 (4) BOL.

Compton 6116, 10223, 14225, 18951, 19016, 23238 (4) NBG; 10372 (6) NBG; 10603 (5) NBG; 14234, 16835 (2) NBG; 16832 (1) NBG; 21897 (3) NBG. Cupido 66, 69, 72 (4) NBG; 67, 71 (3) NBG; 68, 70, 73 (2) NBG; 75, 77, 117 (6) NBG.

De Vos 475 (4) NBG; 1161 (2) NBG. Drège SAM17297 (6) SAM.

Ecklon & Zeyher s.n. (5) SAM; 2417 (1) SAM; 3154 (5) NBG. Esterhuysen 4229, 10007 (2) BOL; 4954 (4) NBG; 11424, 14361 (3) BOL; 19594, 33722 (4) BOL.

Forsyth 394 (4) NBG.

Galpin 11316 (4) PRE, K. Goldblatt 5381 (4) PRE, K; 7623, 11262 (3) MO. Gill s.n. (1) BOL. Gillet s.n. (5) NBG; 670 (3) NBG. Guthrie s.n. (4) NBG; 2275 (1) NBG; 2792 (6) NBG.

Hafström & Acocks 2006 (5) PRE. Haynes 1543 (1) NBG.

Jordaan s.n. (6) NBG; 832, 18402 (2) NBG.

Kensit 13469 (4) BOL, MO. Kruger 90 (2) NBG; 91 (4) NBG.

Leighton 906 (2) BOL; 2465, 2587 (4) BOL. Le Maitre 177 (1) NBG. Levyns 4046 (4) BOL; 5372 (2) MO, BOL; 11265 (4) BOL, PRE. Lewis 3194 (4) SAM; 3532 (5) SAM. Liede 16447 (4) MO.

MacOwan 3103 (1) SAM; 3103b (2) SAM. Manning 2941 (6) NBG. Markotter 8639 (6) NBG. Martin s.n. (2) NBG. McDonald 603, 1735 (3) NBG.

Nilsson 120 (4) PRE.

Oliver & Oliver 11866 (6) NBG. Orchard 341 (4) NBG, MO; 358, 524 (2) NBG, MO.

Pappe s.n. (4) K. Parker 3455 (6) K, MO; 3550 (6) NBG, MO, K; s.n. (6) MO. Pillans 6749 (3) BOL. Potts 5054 (4) SAM.

Rourke 998 (1) NBG. Rycroft 3149 (4) NBG.

Salter 5136 (3) BOL, K. Schlechter 7211 (6) PRE, MO, K; 7263 (2) MO, SAM; 7370 (1) MO; 7372 (5) BOL, MO, PRE; SAM, 9228 (3) MO. Steiner 2445 (2) NBG. Stokoe 8653, 9113, 69735, 358443 (1) BOL; 58444 (4) SAM; 58445, 64365, 67099 (3) SAM; 64366, 65581 (2) SAM.

Taylor 3016, 3877 (3) NBG; 3793 (4) NBG; 4401, 10251 (2) NBG;

9557 (4) K, NBG, PRE. *Thompson* 2303 (3) NBG; 3872 (4) NBG. *Tyson* 899 (6) SAM.

Van der Merwe 1787 (2) NBG. *Van der Schijff* 7437 (2) MO; 7457 (4) MO. *Van Jaarsveld & Bean* 6411 (3) NBG. *Viviers* 81 (2) NBG; 775 (3) NBG.

Walters 51, 1048 (4) NBG. *Williams* 65 (4) MO, K; 2937 (2) NBG; 2949 (4) NBG, PRE; 3389 (4) NBG.

Zeyher 3152 (1) NBG; 3154 (5) BOL.

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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.Burt 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; R  , R  union; 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, R , 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 S lch: 115 (1960), nom. nud.

sericea Baker: 111 (1878b)

sericea Baker var. *dregei* Baker: 112 (1878b), pro parte quoad specim. *Dr ge* 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)

m nzn rii Nel: 307 (1914)

sericea Baker var. *dregei* Baker: 112 (1878b), pro parte quoad specim. *Cooper* 1811 (TCD)

fischeri Pax: 143 (1893); Cam, Zam

flanagani 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. & Av -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. & Av -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

malaissii 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
schimperii 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
uniflora 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 Lall. 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)

* MS., manuscript.

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors

Taxon	Accepted or suggested name	Reference or comment
<i>abyssinica</i> Hochst.	H. villosa L.f.	Richard: 314 (1851); Baker: 113 (1878b); Cufodontis: 1580 (1972).
	<i>H. villosa</i> complex	Nordal: 86 (1997).
<i>acida</i> (Nel) Geerinck	Spiloxene acida (Nel) Garside	Garside: 268 (1936); Snijman: 110 (2000).
<i>aculeata</i> Nel as <i>aculeolata</i>	<i>H. obtusa</i> Burch. complex	Nordal et al. 28 (1985).
	* <i>H. aculeata</i> Nel	
<i>acuminata</i> Eckl. (1827), nom. nud.	<i>H. stellata</i> L. var. <i>linearis</i> (Andrews) Baker = Spiloxene capensis (L.) Garside	Baker: 178 (1896); Nordenstam: 294 (1972).
<i>acuminata</i> sensu Norl., quoad specim. 4833	H. rigidula Baker	Nordal & Zimudzi: 12 (2001).
<i>aemulans</i> (Nel) Geerinck	Spiloxene aemulans (Nel) Garside	Garside: 269 (1936); Snijman: 110 (2000).
<i>affinis</i> Schult.f.	<i>H. alba</i> 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
<i>alba</i> (Thunb.) L.f.	Spiloxene alba (Thunb.) Fourc.	Garside: 268 (1936).
<i>alba</i> L.f.	<i>Spiloxene alba</i> (L.f.) Fourc. = Spiloxene alba (Thunb.) Fourc.	Fourcade: 76 (1934).
<i>alba</i> L.f. var. γ Thunb.	<i>H. alba</i> L.f. var. <i>burkei</i> Baker = Spiloxene alba (Thunb.) Fourc.	Baker: 102 (1878b)
<i>alba</i> sensu Lodd.	<i>H. alba</i> var. <i>gracilis</i> Baker = Spiloxene alba (Thunb.) Fourc..	Baker: 102 (1878b)
<i>alpina</i> R.E.Fr.	H. kilimanjarica Baker	Nordal et al.: 26 (1985).
<i>andrewsii</i> Baker	H. kilimanjarica Baker subsp. kilimanjarica	Lebrun & Stork: 106 (1995).
<i>angolensis</i> Baker	<i>Janthe andrewsii</i> (Baker) Nel = Spiloxene	Nel: 337 Index (1914).
<i>angustifolia</i> auct. non Lam., quoad. specim. <i>Noirfalise</i> 287	* <i>H. obtusa</i> Burch. ex Ker Gawl.	Nordal & Zimudzi: 13 (2001).
<i>angustifolia</i> Lam. var. <i>cernua</i> Nel, ined. name applied to specim. <i>Rehmann</i> 7238 (Z), nom. nud.	Curculigo pilosa (Schum. & Thonn.) subsp. minor (Guinea E.) Wiland	Wiland: 16 (1997a).
<i>apiculata</i> Nel	<i>H. sp.</i>	Singh in prep.
	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
	<i>H. villosa</i> complex	Nordal: 86 (1997).
	H. urceolata Nel	Wiland-Szymańska: 345 (2001).
<i>aquatica</i> L.f.	Spiloxene aquatica (L.f.) Fourc.	Fourcade: 76 (1934); Garside 268 (1936); Snijman: 109 (2000).
<i>araneosa</i> Nel	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
	* <i>H. araneosa</i> Nel	
<i>arenosa</i> Nel	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
	* <i>H. arenosa</i> Nel	
<i>arnottii</i> Baker	H. rigidula Baker var. pilosissima Baker	Nel: 331 (1914). Nel cited type of <i>H. arnottii</i> as <i>H. rigidula</i> var. <i>pilosissima</i> ; Singh in prep.
<i>aurea</i> Eckl. (1827), nom. nud.	Spiloxene capensis (L.) Garside	Nordenstam: 294 (1972).
<i>baguirmiensis</i> A.Chev.	<i>H. angustifolia</i> Lam. = Curculigo baguirmiensis (A.Chev.) A.Chev.	Lebrun & Stork 3: 106 (1995); Chevalier: 305 (1913).
<i>baurii</i> Baker	Rhodohypoxis baurii (Baker) Nel	Nel: 300 (1914).
<i>bequaertii</i> De Wild.	<i>H. subspicata</i> Pax	Lebrun & Stork: 106 (1995).
	H. urceolata Nel	Troupin: 277 (1971); Wiland-Szymańska: 345 (2001).
<i>beyrichii</i> Nel	<i>H. villosa</i> L.f.	Zimudzi: 17 (1996).
	* <i>H. rigidula</i> Baker	Singh in prep. Insufficiently known, known only from type having inadequate material.
<i>biflora</i> Baker non De Wild.	H. angustifolia Lam.	Baker: 111 (1878b).
<i>biflora</i> De Wild., nom. illeg.	<i>H. dregei</i> var. <i>biflora</i> (De Wild.) Nel	De Wildeman: 8 (1914).
	H. malosana Baker	Nordal et al.: 27 (1985); Lebrun & Stork: 106 (1995); Wiland-Szymańska: 329 (2001).
	<i>H. filiformis</i> Baker	Nordal & Zimudzi: 10 (2001).
<i>boranensis</i> Cufod.	<i>H. villosa</i> complex	Nordal: 86 (1997).
	* <i>H. villosa</i> L.f.	
<i>bowriana</i> Baker, ined. name applied to specim. <i>Bowie s.n.</i> (BM), nom. nud.	H. villosa L.f.	Singh in prep.
<i>brevifolia</i> Baker	<i>H. membranacea</i> Baker	Nel: 338 (1914).
	H. parvula Baker var. parvula	Burt: 190 (1988).
<i>caerulescens</i> DC.	<i>H. stellata</i> (Thunb.) L.f. var. <i>elegans</i> (Andrews) Baker = * <i>Spiloxene capensis</i> (L.) Garside	Baker: 101 (1878b).
<i>caespitosa</i> Baker	H. filiformis Baker	Nel: 305 (1914).
<i>camerooniana</i> Baker	<i>H. angustifolia</i> Lam.	Cufodontis: 1577 (1971).
<i>campanulata</i> Nel	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
	* <i>H. campanulata</i> Nel	
<i>canaliculata</i> sensu Brenan quoad <i>Brass</i> 17598	H. nyasica Baker	Nordal & Zimudzi: 16 (2001).
<i>canescens</i> Fisch.	<i>H. villosa</i> L.f. var. <i>canescens</i> (Fisch.) Baker	Baker: 114 (1878b).
	H. sobolifera Jacq. var. sobolifera (Jacq.) Nel	Nel: 339 (1914).
<i>completa</i> Nel, ined. name applied to specim. <i>Allen</i> 30 (B), nom. nud.	<i>H. orbiculata</i> Nel = H. polystachya Welw. ex Baker	Nel struck off <i>H. completa</i> and replaced it by <i>H. orbiculata</i> on specim. <i>Allen</i> 30 (B).
	<i>H. completa</i> Nel	De Wildeman: 8 (1914); 34 (1921a).
<i>cordata</i> Nel	<i>H. rigidula</i> Baker var. <i>hemerocallidea</i> (Fisch., C.A. Mey. & Avè-Lall.) Heideman	Heideman: 892 (1983).
	H. rigidula Baker var. rigidula	Singh in prep.
<i>costata</i> sensu Norl.	H. galpinii Baker	Nordal & Zimudzi: 11 (2001).
<i>crassifolia</i> Pappe in Baker	<i>H. alba</i> L.f. = Spiloxene alba (Thunb.) Fourc.	Baker: 102 (1878b).
<i>crispa</i> Nel	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
	H. urceolata Nel	Wiland-Szymańska: 345 (2001).
<i>cryptophylla</i> Nel	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
	* <i>H. cryptophylla</i> Nel	
<i>curculigoides</i> Bolus	Spiloxene curculigoides (Bolus) Garside	Garside: 269 (1936); Snijman: 110 (2000).
<i>cuspidata</i> (Nel) Geerinck	* <i>Spiloxene ovata</i> (L.f.) Garside	Snijman: 110 (2000).
<i>declinata</i> (Nel) Geerinck	* <i>Spiloxene curculigoides</i> (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
<i>decumbens</i> β & γ Thunb. ex Baker non L.	<i>H. villosa</i> var. <i>canescens</i> (Fisch.) Baker H. sobolifera Jacq. var. sobolifera (Jacq.) Nel	Baker: 114 (1878b). Singh in prep.
<i>decumbens</i> Lam.	H. villosa L.f.	Schult.f. in Schultes & Schultes: 765 (1830).
<i>demissa</i> Nel	<i>H. obtusa</i> Burch. complex * <i>H. demissa</i> Nel	Nordal et al.: 28 (1985).
<i>dielsiana</i> (Nel) Geerinck	Spiloxene dielsiana (Nel) Garside	Garside: 268 (1936); Snijman: 110 (2000).
<i>dinteri</i> Nel	<i>H. villosa</i> L.f. H. argentea Harv. ex Baker var. sericea Baker	Zimudzi: 17 (1996). Singh in prep.
<i>distachya</i> Nel	H. colchicifolia Baker	Singh in prep.
<i>djalonsensis</i> Hutch.	H. angustifolia Lam.	Hepper: 172 (1968); Nordal & Iversen: 34 (1987).
<i>dregei</i> (Baker) Nel	H. filiformis Baker	Zimudzi: 15 (1996); Nordal & Zimudzi: 10 (2001).
<i>dregei</i> (Baker) Nel var. <i>biflora</i> (De Wild.) Nel, nom. illeg.	<i>H. malosana</i> Baker H. filiformis Baker	Nordal et al.: 27 (1985); Lebrun & Stork: 106 (1995). Nordal & Zimudzi: 10 (2001).
<i>dubia</i> Schult.f.	<i>H. alba</i> L.f. = Spiloxene alba (L.f.) Fourc.	Baker: 102 (1878b).
<i>eckloniana</i> Schult.f.		Insufficiently known.
<i>ecklonii</i> Baker as <i>eckloni</i>	H. floccosa Baker	Singh in prep.
<i>elata</i> Hook.f. non Schult.f., nom. illeg.	H. hemerocallidea Fisch. & C.A. Mey. & Avè-Lall.	Baker: 119 (1878b).
<i>elata</i> Schult.f. non Hook.f.	<i>H. stellata</i> L. var. <i>albiflora</i> Baker = Spiloxene	Baker: 101 (1878b).
<i>elegans</i> Andrews	<i>H. stellata</i> L. var. <i>elegans</i> (Andrews) Baker = * <i>Spiloxene capensis</i> (L.) Garside	Baker: 101 (1878b); Garside: 269 (1936).
<i>elliptica</i> Nel	H. rigidula Baker H. rigidula Baker var. rigidula	Zimudzi: 16 (1996); Nordal & Zimudzi: 12 (2001). Singh in prep.
<i>engleriana</i> Nel	<i>H. villosa</i> L.f. H. nyasica Baker	Zimudzi: 17 (1996). Nordal & Zimudzi: 16 (2001).
<i>engleriana</i> Nel var. <i>scottii</i> Nel	H. nyasica Baker	Nordal & Zimudzi: 16 (2001).
<i>esculenta</i> De Wild.	<i>H. subspicata</i> Pax H. goetzei Harms	De Wildeman: 34 (1921a); Nordal et al.: 25 (1985); Lebrun & Stork: 106 (1995). Zimudzi: 14 (1996); Nordal & Zimudzi: 8 (2001); Wiland-Szymańska: 319 (2001).
<i>filifolia</i> Eckl. (1827), nom. nud.	Spiloxene sp.	Nordenstam: 294 (1972).
<i>filifolia</i> Nob., ined. name applied to specim. <i>Mund & Maire s.n.</i> (B) by Nel, nom. nud.	H. longifolia Baker ex Hook.f.	Singh in prep.
<i>fischeri</i> Pax	<i>H. obtusa</i> Burch. complex H. fischeri Pax	Nordal et al.: 28 (1985). Nordal & Iversen: 40 (1987).
<i>flaccida</i> (Nel) Geerinck	Spiloxene flaccida (Nel) Garside	Garside: 269 (1936); Snijman: 109 (2000).
<i>flavescens</i> Eckl. (1827), nom. nud.	Spiloxene capensis (L.) Garside	Nordenstam: 294 (1972).
<i>flavopetala</i> Eckl. (1827), nom. nud.	Spiloxene capensis (L.) Garside	Nordenstam: 294 (1972).
<i>geniculata</i> Eckl. (1827), nom. nud.	<i>H. stellata</i> L. var. <i>linearis</i> (Andrews) Baker = Spiloxene capensis (L.) Garside	Baker: 178 (1896); Nordenstam: 294 (1972).
<i>gilgiana</i> Nel	H. colchicifolia Baker	Singh in prep.
<i>gracilipes</i> Schltr.	* <i>Spiloxene ovata</i> (L.f.) Garside	Snijman: 109 (2000).
<i>gregoriana</i> Rendle	<i>H. obtusa</i> Burch. complex * <i>H. gregoriana</i> Rendle	Nordal et al.: 28 (1985).
<i>hemerocallidea</i> Fisch., C.A.Mey. & Avè-Lall.	<i>H. rigidula</i> Baker var. <i>hemerocallidea</i> (Fisch., C.A. Mey. & Avè-Lall.) Heideman	Heideman: 892 (1983).
<i>hockii</i> De Wild.	<i>H. subspicata</i> Pax H. hockii De Wild.	Lebrun & Stork: 106 (1995). Wiland: 321 (2001).
<i>incisa</i> Nel	H. kilimanjarica Baker H. kilimanjarica Baker subsp. kilimanjarica	Nordal et al.: 26 (1985); Wiland-Szymańska: 324 (2001). Lebrun & Stork: 106 (1995).
<i>infausta</i> Nel	<i>H. obtusa</i> Burch. complex * <i>H. infausta</i> Nel	Nordal et al.: 28 (1985).
<i>ingrata</i> Nel	<i>H. obtusa</i> Burch. complex H. nyasica Baker	Nordal et al.: 28 (1985). Nordal & Zimudzi: 16 (2001).
<i>iridifolia</i> Baker	<i>H. villosa</i> L.f. H. obtusa Burch. ex Ker Gawl.	Zimudzi: 17 (1996). Nordal & Zimudzi: 13 (2001).
<i>jacquinii</i> Baker as <i>jacquini</i>	* <i>H. villosa</i> L.f.	Insufficiently known; Singh in prep.
<i>junceae</i> Eckl. (1827), nom. nud.	<i>H. stellata</i> L. var. <i>linearis</i> (Andrews) Baker = Spiloxene capensis (L.) Garside	Baker: 101 (1878b); Nordenstam: 294 (1972).
<i>junodii</i> Baker as <i>junodi</i>	<i>H. dregei</i> Baker H. gerrardii Baker	Nel: 338 (1914); Bews: 64 (1921). Burt: 188 (1988).
<i>katangensis</i> Nel ex De Wild.	<i>H. subspicata</i> Pax <i>H. polystachya</i> Welw. ex Baker H. hockii De Wild. var. katangensis (Nel ex De Wild.) Wiland	Lebrun & Stork: 106 (1995). Nordal & Zimudzi: 14 (2001). Wiland-Szymanska: 324 (2001).
<i>krebsii</i> Fisch.	<i>H. villosa</i> L.f. var. <i>sobolifera</i> Jacq. = H. sobolifera Jacq. var. sobolifera (Jacq.) Nel	Baker: 114 (1878b); Cufodontis: 1580 (1972).
<i>laikipiensis</i> Rendle	<i>H. obtusa</i> Burch. complex. * <i>H. laikipiensis</i> 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
<i>lanata</i> Eckl. ex Baker	H. stellipilis Ker Gawl.	Baker: 118 (1878b); 187 (1896).
<i>lanceolata</i> Nel	<i>H. recurva</i> Hook.f. H. camerooniana Baker	Hepper: 172 (1968). Nordal & Iversen: 38 (1987).
<i>latifolia</i> Hook.	H. colchicifolia Baker	Burt: 201 (1986).
<i>lata</i> Nel	H. angustifolia Lam. var. angustifolia	Singh in prep.
<i>laxa</i> Eckl.(1827), nom. nud.	<i>H. stellata</i> L. var. <i>linearis</i> (Andrews) Baker = Spiloxene capensis (L.) Garside	Baker: 178 (1896); Nordenstam: 294 (1972).
<i>ledermannii</i> Nel	<i>H. recurva</i> Hook.f. H. camerooniana Baker	Hepper: 172 (1968). Nordal & Iversen: 37 (1987).
<i>leucotricha</i> Fritsch (1901)		Insufficiently known.
<i>limicola</i> B.L.Burt	H. parvula Baker var. parvula	Singh in prep.
<i>linearis</i> Andrews	<i>H. serrata</i> (Thunb.) L.f. <i>Spiloxene stellata</i> (Thunb.) L.f. var. <i>linearis</i> (Andrews) Baker <i>Spiloxene linearis</i> (Andr.) Garside Spiloxene serrata (Thunb.) Garside var. serrata	Ker Gawler: t. 917 (1806). Baker: 101 (1878b). Garside: 268 (1936). Snijman: 110 (2000).
<i>longifolia</i> Baker, based on specim. <i>Junod 1445</i> (Z), nom. illeg..	<i>H. cordata</i> Nel	Nel: 331 (1914)
	H. rigidula Baker var. rigidula	Singh in prep.
<i>longifolia</i> Dinter ex Sölch, nom. nud.	H. rigidula Baker	Merxmüller: 2 (1969).
<i>longifolia</i> Eckl. (1827), nom. nud.	Spiloxene capensis (L.) Garside	Nordenstam: 294 (1972).
<i>longifolia</i> Baker ex Hook.f. var. <i>thunbergii</i> Baker	H. longifolia Baker ex Hook.f.	Singh in prep.
<i>longipes</i> Baker	* <i>H. obtusa</i> Burch. ex Ker Gawl.	Insufficiently known.
<i>ludwigii</i> sensu Nel (is the same as ludwigii Baker)	<i>H. obtusa</i> Burch. ex Ker Gawl. H. ludwigii Baker	Nordal & Zimudzi: 13 (2001). Singh in prep.
<i>luzulaefolia</i> DC.	<i>Curculigo plicata</i> Dryand. Curculigo scorzonrifolia (Lam.) Baker	Baker: 122 (1878b). Hilliard & Burt: 307 (1973).
<i>luzulaefolia</i> Eckl. (1827), nom. nud.	<i>H. serrata</i> L. = Spiloxene serrata (Thunb.) Garside	Baker: 103 (1878b); Nordenstam: 294 (1972).
<i>luzulifolia</i> DC.	Curculigo scorzonrifolia (Lam.) Baker	Hilliard & Burt: 307 (1973).
<i>luzuloides</i> 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).
<i>macrocarpa</i> E.M.Holt & Staubo	H. cuanensis Welw. ex Baker <i>H. schimperii</i> Baker	Zimudzi: 15 (1996). Nordal & Zimudzi: 7 (2001); Nordal: 89 (1997).
<i>malosana</i> Baker	<i>H. dregei</i> Baker <i>H. filiformis</i> Baker	Nel: 339 (1914). Zimudzi: 15 (1996); Nordal & Zimudzi: 10 (2001).
	H. malosana Baker	Wiland-Szymańska: 309 (2001).
<i>matengensis</i> G.M.Schulze	<i>H. obtusa</i> Burch. complex * <i>H. matengensis</i> G.M.Schulze	Nordal et al.: 28 (1985).
<i>maximiliani</i> Schltr.	* <i>Spiloxene umbraticola</i> (Schltr.) Garside	Snijman: 109 (2000).
<i>membranacea</i> auct. non Baker	<i>H. limicola</i> B.L.Burt = H. parvula Baker var. parvula	Burt: 188 (1988); Singh in prep.
<i>microsperma</i> Lallum.	<i>H. villosa</i> L.f. var. <i>pannosa</i> (Baker) Baker H. villosa L.f.	Baker: 184 (1896). Singh in prep.
<i>millioides</i> Baker	<i>Rhodohypoxis baurii</i> (Baker) Nel var. <i>millioides</i> (Baker) Nel Rhodohypoxis millioides (Baker) Hilliard & B.L. Burt	Nel: 300 (1914). Hilliard & Burt: 59 (1978).
<i>minor</i> Eckl. (1827), nom. nud.	<i>H. alba</i> L.f. var. <i>gracilis</i> Baker = Spiloxene alba (Thunb.) Fourc.	Baker: 176 (1896).
<i>minuta</i> (L.) L.f.	Spiloxene minuta (L.) Fourc.	Fourcade: 76 (1934); Garside: 269 (1936); Snijman: 109 (2000).
<i>mollis</i> Baker		Insufficiently known.
<i>monophylla</i> Schltr. ex Baker	Spiloxene monophylla (Schltr.) Garside	Garside: 269 (1936); Snijman: 110 (2000).
<i>multiceps</i> sensu Zimudzi non Buchinger ex Baker	H. bampsiana Wiland	Nordal & Zimudzi: 8 (2001).
<i>multiflora</i> Nel	<i>H. obtusa</i> Burch. complex ? <i>H. fischeri</i> Pax H. polystachya Welw. ex Baker	Nordal et al.: 28 (1985). Lebrun & Stork: 106 (1995). Nordal & Zimudzi: 14 (2001).
<i>münznerii</i> Nel as <i>münzneri</i> , <i>muenzneri</i>	<i>H. malosana</i> Baker	Nordal et al.: 27 (1985); Lebrun & Stork: 106 (1995).
<i>münznerii</i> Nel as <i>münzneri</i> , <i>muenzneri</i>	H. filiformis Baker	Zimudzi: 17 (1996); Nordal & Zimudzi: 10 (2001).
<i>nana</i> E.Mey. in herb. Drège, nom. nud.	<i>Pauridia hypoxidoides</i> Harv. = P. minuta (L.f.) T.Durand & Schinz	Baker: 126 (1878b); Thompson: 621 (1979).
<i>natalensis</i> Klotzsch	* <i>H. colchicifolia</i> Baker	Insufficiently known.
<i>neghellensis</i> Cufod.	<i>H. villosa</i> complex	Nordal: 87 (1997).
<i>neocanaliculata</i> Geerinck	Spiloxene canaliculata Garside	Snijman: 110 (2000).
<i>nigricans</i> Conrath	* <i>H. obtusa</i> 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
<i>nitida</i> I. Verd.	<i>H. obtusa</i> Burch. ex Ker Gawl. var. <i>nitida</i> (I. Verd.) Heideman <i>H. iridifolia</i> Baker <i>H. villosa</i> L.f. H. obtusa Burch. ex Ker Gawl.	Heideman: 892 (1983). Burt: 204 (1986). Zimudzi: 17 (1996). Nordal & Zimudzi: 14 (2001).
<i>nyasica</i> Baker as <i>nyassica</i>	<i>H. villosa</i> L.f. H. nyasica Baker	Zimudzi: 17 (1996). Nordal & Zimudzi: 16 (2001).
<i>obconica</i> Nel	H. hemerocallidea Fisch., C.A.Mey. & Avé-Lall.	Singh in prep.
<i>obliqua</i> Andrews non Jacq.	<i>H. andrewsii</i> Baker = * <i>Spiloxene</i>	Baker: 104 (1878b).
<i>obliqua</i> Eckl. & Zeyh. non Jacq.	<i>H. alba</i> L.f. = Spiloxene alba (L.f.) Fourc.	Baker: 102 (1878b).
<i>obliqua</i> Jacq. non Andrews	<i>H. villosa</i> L.f. var. <i>obliqua</i> Jacq. H. obliqua Jacq.	Baker: 114 (1878b); Singh in prep.
<i>obliqua</i> Jacq. var. <i>woodii</i> (Baker) Nel	H. angustifolia Lam. var. buchananii Baker	Wood: 88 (1976); Singh in prep.
<i>oblonga</i> Nel	H. rigidula Baker	Zimudzi: 16 (1996); Singh in prep.
<i>obtusa</i> auct. non Burch. ex Ker Gawl.	partly H. rigidula Baker and partly H. polystachya Welw. ex Baker	Nordal & Zimudzi: 12, 14 (2001).
<i>obtusa</i> Burch. MS.	<i>H. villosa</i> L.f. var. <i>obtusa</i> (Burch.) T. Durand & Schinz <i>H. iridifolia</i> Baker = H. obtusa Burch. ex Ker Gawl.	Durand & Schinz: 236 (1895). Burt: 204 (1986); Lebrun & Stork: 106 (1995).
<i>obtusa</i> Burch. ex Ker Gawl.	<i>H. obtusa</i> Burch. complex <i>H. villosa</i> L.f. <i>H. villosa</i> complex H. obtusa Burch. ex Ker Gawl.	Nordal et al.: 28 (1985). Zimudzi: 17 (1996). Nordal: 86 (1997). Singh in prep.
<i>obtusa</i> Burch. ex Ker Gawl. var. <i>chrysotricha</i> Nel	H. obtusa Burch. ex Ker Gawl.	Singh in prep.
<i>obtusa</i> Burch. var. <i>nitida</i> (I. Verd.) Heideman	H. obtusa Burch. ex Ker Gawl.	Singh in prep.
<i>obtusa</i> Burch. var. <i>obtusa</i>	H. obtusa Burch. ex Ker Gawl.	Singh in prep.
<i>obtusa</i> complex sensu Nordal et al. (1985)	<i>H. obtusa</i> Burch. ex Ker Gawl.	Nordal & Zimudzi: 14 (2001).
<i>oligophylla</i> Baker		Insufficiently known.
<i>oligotricha</i> Baker	H. colchicifolia Baker	Burt: 202 (1986)
<i>olivacea</i> Engl., nom. nud.		Insufficiently known.
<i>orbiculata</i> Nel	<i>H. subspicata</i> Pax <i>H. villosa</i> L.f. H. polystachya Welw. ex Baker	Lebrun & Stork: 106 (1995). Zimudzi: 17 (1996). Nordal & Zimudzi: 14 (2001).
<i>ovata</i> L.f.	Spiloxene ovata (L.f.) Garside	Garside: 268 (1936); Snijman: 110 (2000).
<i>pannosa</i> Baker	H. sobolifera L.f. var. pannosa (Baker) Baker	Baker: 114 (1878b).
<i>parviflora</i> Dinter ex Sölch, nom. nud.	<i>H. dinteri</i> Nel H. argentea Harv. ex Baker var. sericea Baker	Merxmüller: 2 (1969). Singh in prep.
<i>patula</i> Nel	H. hemerocallidea Fisch., C.A.Mey. & Avé-Lall.	Singh in prep.
<i>pavonina</i> Salisb.	<i>H. stellata</i> L. var. <i>elegans</i> (Andrews) Baker = * <i>Spiloxene capensis</i> (L.) Garside	Baker: 101 (1878b)
<i>pedicellata</i> Nel ex De Wild.	<i>H. subspicata</i> Pax <i>H. villosa</i> L.f. <i>H. polystachya</i> Welw. ex Baker H. hockii De Wild.	Lebrun & Stork: 106 (1995). Zimudzi: 17 (1996). Nordal & Zimudzi: 14 (2001). Wiland-Szymańska: 320 (2001).
<i>petitiana</i> A. Rich.	H. villosa L.f. <i>H. villosa</i> complex	Baker: 113 (1878b). Nordal: 86 (1997).
<i>petitiana</i> A. Rich. forma <i>petitiana</i>	<i>H. villosa</i> complex * <i>H. villosa</i> L.f.	Nordal: 86 (1997).
<i>petrosa</i> Nel	H. camerooniana Baker	Nordal & Iversen: 37 (1987).
<i>phoenica</i> Nel, ined. name applied to specim. Wood 184 (K), nom. nud.	H. hemerocallidea Fisch., C.A.Mey. & Avé-Lall.	Singh in prep.
<i>platypetala</i> Baker	Rhodohypoxis baurii (Baker) Nel var. platypetala (Baker) Nel	Nel: 300 (1914).
<i>plicata</i> (Thunb.) L.f.	<i>Curculigo plicata</i> (Thunb.) Dryand. Empodium plicatum (Thunb.) Garside	Baker: 122 (1878b). Hilliard & Burt: 313 (1973).
<i>plicata</i> Jacq. non (Thunb.) L.f.	<i>Curculigo veratrifolia</i> Baker Empodium veratrifolium (Willd.) Thompson	Baker: 123 (1878b). Thompson: 163 (1972).
<i>pretoriensis</i> Goossens, ined. description attached to specim. Goossens 91 (K), nom. nud.	H. interjecta Nel	Heideman: 87 (1979); Singh in prep.
<i>probata</i> Nel	<i>H. obtusa</i> Burch. complex H. nyasica Baker	Nordal et al.: 28 (1985). Nordal & Zimudzi: 16 (2001).
<i>protusa</i> Nel	<i>H. obtusa</i> Burch. complex * <i>H. protrusa</i> Nel	Nordal et al.: 28 (1985).
<i>pumila</i> Lam.	<i>H. minuta</i> (L.) L.f. = Spiloxene minuta (L.) Fourc.	Baker: 101 (1878b); Snijman: 109 (2000).
<i>pungwensis</i> Norl	<i>H. villosa</i> L.f. H. galpinii Baker	Zimudzi: 17 (1996). Nordal & Zimudzi: 11 (2001).
<i>recurva</i> Hook.f.	<i>H. villosa</i> L.f. var. <i>recurva</i> (Hook. f.) Baker H. camerooniana Baker	Baker: 114 (1878b). Nordal & Iversen: 37 (1987).
<i>retracta</i> Nel	<i>H. obtusa</i> Burch. complex H. nyasica Baker	Nordal et al.: 28 (1985). Nordal & Zimudzi: 16 (2001).
<i>rigidula</i> Baker var. <i>hemerocallidea</i> (Fisch., C.A.Mey. & Avé-Lall.) Heideman based on Junod 1445 (Z)	H. rigidula Baker var. rigidula	Singh in prep.

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Taxon	Accepted or suggested name	Reference or comment
<i>rigidula</i> Baker var. <i>hemerocallidea</i> (Fisch., C.A.Mey. & Avé-Lall.) Heideman based on <i>Cooper</i> 3242 (BM)	H. hemerocallidea Fisch., C.A.Mey. & Avé-Lall.	Singh in prep.
<i>rigidula</i> Baker var. <i>pilosissima</i> Baker	<i>H. rigidula</i> Baker H. rigidula Baker var. pilosissima Baker	Zimudzi: 16 (1996). Singh in prep.
<i>robusta</i> Nel	<i>H. subspicata</i> Pax H. robusta Nel	Lebrun & Stork: 106 (1995). Wiland-Szymańska: 337 (2001).
<i>rooperii</i> T.Moore as <i>rooperi</i>	H. hemerocallidea Fisch., C.A.Mey. & Avé-Lall.	Burt: 202 (1986); Nordal & Zimudzi: 12 (2001).
<i>rooperii</i> T.Moore var. <i>forbesii</i> Baker	H. hemerocallidea Fisch., C.A.Mey. & Avé-Lall.	Burt: 204 (1986); Singh in prep.
<i>rubella</i> Baker	Rhodohypoxis rubella (Baker) Nel	Nel: 300 (1914).
<i>rubiginosa</i> Nel	H. goetzei Harms	Nordal et al.: 25 (1985); Lebrun & Stork: 106 (1995); Zimudzi: 14 (1996); Nordal & Zimudzi: 8 (2001); Wiland-Szymańska: 319 (2001).
<i>scabra</i> Lodd.	<i>H. villosa</i> L.f. var. <i>scabra</i> (Lodd.) Baker H. villosa L.f.	Baker: 114 (1878b). Singh in prep.
<i>schlechteri</i> Bolus	Spiloxene schlechteri (Bolus) Garside	Garside: 269 (1936); Snijman: 110 (2000).
<i>schnitzleinia</i> Hochst.	Xerophyta Xerophyta schnitzleini (Hochst.) Baker	Baker: 126 (1878b). Cufodontis: 1580 (1972).
<i>schweinfurthiana</i> Nel	<i>H. villosa</i> L.f. var. <i>sobolifera</i> (Jacq.) Baker <i>H. villosa</i> complex H. sobolifera Jacq. var. sobolifera (Jacq.) Nel	Cufodontis: 1580 (1972). Nordal: 86 (1997). Nel: 339 (1914).
<i>scullyi</i> Baker	Spiloxene scullyi (Baker) Garside	Garside: 268 (1936); Snijman: 110 (2000).
<i>sericea</i> Baker	H. argentea Baker var. sericea Baker	Baker: 182 (1896).
<i>sericea</i> Baker var. <i>dregei</i> Baker, pro parte quoad specim. <i>Cooper</i> 1811 (TCD).	<i>H. argentea</i> Baker var. <i>sericea</i> Baker <i>H. dregei</i> (Baker) Nel H. filiformis Baker	Baker: 182 (1896). Burt: 188 (1988). Nordal & Zimudzi: 10 (2001).
<i>sericea</i> Baker var. <i>dregei</i> Baker, pro parte quoad specim. <i>Drège</i> 8525 (K)	H. argentea Baker var. sericea Baker	Baker: 182 (1896).
<i>sericea</i> Baker var. <i>flaccida</i> Baker	<i>H. argentea</i> Baker var. <i>flaccida</i> Baker H. argentea Baker var. sericea Baker	Baker: 182 (1896). Wood: 80 (1976); Singh in prep.
<i>serrata</i> (Thunb.) L.f.	Spiloxene serrata (Thunb.) Garside	Garside: 268 (1936); Snijman: 110 (2000).
<i>serrata</i> (Thunb.) L.f. var. β Ker Gawl.	<i>H. stellata</i> (Thunb.) L.f. var. <i>linearis</i> (Andrews) Baker = Spiloxene linearis (Andr.) Garside	Baker: 101 (1878b); Garside: 268 (1936).
<i>setosa</i> Baker	H. zeyheri Baker	Singh in prep.
<i>simensis</i> Hochst.	H. villosa L.f.	Richard: 314 (1851); Baker: 113 (1878b); Cufodontis: 1580 (1972). Nordal: 86 (1997).
<i>sobolifera</i> Jacq.	<i>H. villosa</i> complex <i>H. villosa</i> L.f. var. <i>sobolifera</i> (Jacq.) Baker <i>H. villosa</i> complex H. sobolifera Jacq.	Baker: 114 (1878b); Cufodontis: 1580 (1972). Baker: 6: 184 (1896); Nordal: 86 (1997). Singh in prep.
<i>sobolifera</i> Jacq. var. <i>accedens</i> Nel	H. sobolifera Jacq. var. sobolifera (Jacq.) Nel	Wood: 97 (1976); Singh in prep.
<i>spathacea</i> Eckl. (1827), nom. nud.		Nordenstam: 294 (1972); insufficiently known.
sp. A Guillardmod (1971), based on specim. <i>Compton</i> 21365		Insufficiently known.
sp. A of Nordal et al. (1985), pro parte quoad <i>Bullock</i> 2045	H. bampsiana Wiland	Nordal & Zimudzi: 8 (2001).
sp. A of Nordal et al. (1985), pro parte quoad <i>Davies</i> 742	H. subspicata Pax	Nordal & Zimudzi: 7 (2001).
<i>stellata</i> (Thunb.) L.f.	<i>Spiloxene stellata</i> (L.f.) Salisb. = * <i>S. capensis</i> (L.) Garside	Fourcade: 76 (1934); Garside: 267 (1936).
<i>stellata</i> (Thunb.) L.f. var. α Thunb.	<i>H. stellata</i> (Thunb.) L.f. var. <i>albiflora</i> Baker = * <i>S. capensis</i> (L.) Garside	Baker: 101 (1878b).
<i>stellata</i> (Thunb.) L.f. var. β Thunb.	<i>H. stellata</i> (Thunb.) L.f. var. <i>linearis</i> (Andrews) Baker = Spiloxene linearis (Andrews) Garside	Baker: 101 (1878b); Garside: 268 (1936).
<i>stellata</i> L.f. var. ? <i>elegans</i> (Andrews) Baker	<i>H. stellata</i> L.f. var. <i>elegans</i> (Andrews) Baker = * <i>Spiloxene capensis</i> (L.) Garside	Garside: 269 (1936).
<i>stellata</i> L.f. var. <i>gawleri</i> Baker	* <i>Spiloxene capensis</i> (L.) Garside	Garside: 269 (1936).
<i>stricta</i> Nel	H. galpinii Baker	Zimudzi: 16 (1996); Nordal & Zimudzi: 11 (2001).
<i>suffructicosa</i> Nel	<i>H. recurva</i> Hook.f. * <i>H. suffructicosa</i> Nel	Hepper: 172 (1968).
<i>tabularis</i> Eckl. (1827), nom. nud.	<i>H. stellata</i> L. var. <i>linearis</i> Andrews = Spiloxene schlechteri (Bolus) Garside	Baker: 101 (1878b), 176 (1896); Nordenstam: 294 (1972).
<i>tenuifolia</i> Eckl. (1827), nom. nud.	Spiloxene capensis (L.) Garside	Nordenstam: 294 (1972).
<i>textilis</i> Nel	<i>H. villosa</i> complex * H. villosa L.f.	Nordal: 87 (1997).
<i>thorbeckei</i> Nel	<i>H. recurva</i> Hook.f. H. camerooniana Baker	Hepper: 172 (1968). Nordal & Iversen: 38 (1987).
<i>tomentosa</i> Lam.	H. villosa L.f.	Baker: 113 (1878b); Cufontontis: 1580 (1972).

TABLE 1.—Synonyms in *Hypoxis* and reference to new combinations by various authors (cont.)

Taxon	Accepted or suggested name	Reference or comment
<i>triandra</i> Pappe, MS.	<i>Pauridia hypoxidoides</i> Harv. = Pauridia minuta (L.f.) T.Durand & Schinz	Baker: 126 (1878b); Thompson: 621 (1979).
<i>tridentata</i> DC.	<i>H. stellata</i> (Thunb.) L.f. var. <i>elegans</i> (Andrews) Baker = Spiloxene	Baker: 101 (1878b).
<i>triflora</i> Harv., MS.	<i>H. minuta</i> L.f. = Spiloxene minuta (L.) Fourc.	Baker: 102 (1878b).
<i>trifurcillata</i> (Nel) Geerinck	Spiloxene trifurcillata (Nel) Fourc.	Fourcade: 76 (1934); Snijman: 109 (2000).
<i>tristycha</i> Cufod.	<i>H. villosa</i> complex * <i>H. villosa</i> L.f.	Nordal: 87 (1997).
<i>truncata</i> Thunb. ex Schult.	<i>Pauridia hypoxidoides</i> Harv. as <i>hypoxidoides</i> = Pauridia minuta (L.f.) T.Durand & Schinz	Baker: 126 (1878); Thompson: 621 (1979).
<i>turbinata</i> Nel	<i>H. villosa</i> L.f. H. goetzei Harms	Zimudzi: 17 (1996). Nordal & Zimudzi: 8 (2001).
<i>tysonii</i> Schönland ex Bruce-Miller, ined. name applied to specim. <i>Tyson s.n.</i> May 1916 (PRE), nom. nud.	H. villosa L.f.	Singh in prep.
<i>umbraticola</i> Schltr.	Spiloxene umbraticola (Schltr.) Garside	Garside: 269 (1936); Snijman: 109 (2000).
<i>urceolata</i> auct. non Nel	H. suffruticosa Nel	Nordal & Iversen: 37 (1987); Lebrun & Stork: 106 (1995).
<i>urceolata</i> Nel	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
<i>veratrifolium</i> Willd.	<i>Curculigo veratrifolia</i> (Willd.) Baker = Empodium veratrifolium (Willd.) Thompson	Baker: 123 (1878b); Thompson: 163 (1972).
<i>villosa</i> auct. non L.f.	H. schimperii Baker	Cufodontis: 1578 (1971).
<i>villosa</i> auct. non L.f. 'var. <i>foliis recurvis</i> ' Hook.f.	<i>H. recurva</i> Hook.f. H. camerooniana Baker	Hepper: 172 (1968). Nordal & Iversen: 38 (1987).
<i>villosa</i> complex	partly H. polystachya Welw. ex Baker and partly H. rigidula Baker	Nordal & Zimudzi: 14 (2001).
<i>villosa</i> Jacq. non Thunb., non L.f.	<i>H. jacquini</i> Baker as <i>Jacquini</i> * <i>H. villosa</i> L.f.	Baker: 112 (1878b). Insufficiently known.
<i>villosa</i> L.f. var. δ Thunb. ex Baker	<i>H. longifolia</i> Baker ex Hook.f. var. <i>thunbergii</i> Baker H. longifolia Baker ex Hook.f.	Baker: 116 (1878b). Singh in prep.
<i>villosa</i> L.f. var. <i>canescens</i> (Fisch.) Baker	H. sobolifera Jacq. var. <i>sobolifera</i> (Jacq.) Nel	Singh in prep.
<i>villosa</i> L.f. var. <i>fimbriata</i> Nel	H. villosa L.f.	Singh in prep.
<i>villosa</i> L.f. var. <i>obliqua</i> (Jacq.) Baker	H. obliqua Jacq.	Singh in prep.
<i>villosa</i> L.f. var. <i>obtusa</i> (Burch. ex Ker Gawl.) T.Durand & Schinz	H. obtusa Burch. ex Ker Gawl.	Cufodontis: 1578 (1971); Singh in prep.
<i>villosa</i> L.f. var. <i>pannosa</i> (Baker) Nel	H. sobolifera Jacq. var. <i>pannosa</i> (Baker) Nel	Nel: 309 (1914).
<i>villosa</i> L.f. var. <i>recurva</i> (Hook.f.) Baker	<i>H. recurva</i> Hook.f. H. camerooniana Baker	Nel: 325 (1914). Nordal & Iversen: 38 (1987).
<i>villosa</i> L.f. var. <i>scabra</i> (Lodd.) Baker	H. villosa L.f.	Singh in prep.
<i>villosa</i> L.f. var. <i>schweinfurthii</i> Harms	<i>H. villosa</i> L.f. var. <i>sobolifera</i> = H. sobolifera Jacq. var. <i>sobolifera</i> (Jacq.) Nel	Cufodontis: 1580 (1972); Nel: 309 (1914).
<i>villosa</i> L.f. var. <i>sobolifera</i> (Jacq.) Baker	<i>H. villosa</i> complex H. sobolifera Jacq. var. <i>sobolifera</i> (Jacq.) Nel	Nordal: 86 (1997). Nel: 309 (1914).
<i>villosa</i> sensu Baker (1898), partly not of L.f.	<i>H. recurva</i> Hook.f.	Hepper: 172 (1968)
<i>villosa</i> sensu Eyles, quoad specim. Gibbs 192	H. obtusa Burch. ex Ker Gawl.	Nordal & Zimudzi: 13 (2001).
<i>villosa</i> sensu Zimudzi	H. obtusa Burch. ex Ker Gawl. H. nyasica Baker	Nordal & Zimudzi: 14 (2001). Nordal & Zimudzi: 16 (2001).
<i>volkensii</i> Harms ex Engl., nom. nud.	H. villosa L.f.	Cufodontis: 1579 (1972).
<i>volkmanniae</i> Dinter	H. rigidula Baker <i>H. villosa</i> L.f.	Sölch: 2 (1960). Zimudzi: 17 (1996).
<i>woodii</i> Baker	<i>H. obliqua</i> Jacq. var. <i>woodii</i> (Baker) Nel H. angustifolia Lam. var. <i>buchananii</i> Baker	Nel: 309 (1914). Wood: 88 (1976); Singh in prep.
<i>zernyi</i> G.M. Schulze	<i>H. obtusa</i> Burch. complex	Nordal et al.: 28 (1985).
<i>zuluensis</i> S.E.Wood, ined. name applied to specim. Gerstner 4936 (PRE)	<i>H. zululandensis</i> S.E.Wood = H. longifolia Baker ex Hook.f.	Singh in prep.
<i>zululandensis</i> S.E.Wood, ined. MS., nom. nud.	H. longifolia Baker ex Hook.f.	Singh in prep.

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Sesotho names for exotic and indigenous edible plants in southern Africa

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Keywords: edible plants, exotic plants, indigenous plants, Sesotho, southern Africa

ABSTRACT

A comprehensive checklist of Sesotho names of both indigenous and exotic food plants is presented, based on a literature survey and the first author's experience. The list includes the scientific names, English common names and parts of the plant that are used. Where possible, the origin or meaning of the Sesotho names is given. Exotic edible plants for which the English common names are in general use have been excluded. The list includes 164 indigenous and 39 names of exotic species.

INTRODUCTION

The aim of this paper is to compile, for the first time, a comprehensive checklist of Sesotho names of both indigenous and exotic edible plants. With diminishing vocabulary of many languages (Sesotho included), it has become necessary to preserve and update these names so that they are not lost. We believe such a list would be of value to translators and compilers of dictionaries.

The extensive use of wild plants as food in southern Africa has been well documented in a number of publications including the books of Fox & Norwood Young (1982), Peters *et al.* (1992), and Van Wyk & Gericke (2000). Lists of common names of plants in vernacular languages have also been written. For example, a comprehensive list of Setswana common names of plants by Cole (1995) is available. A list of some Zulu names has also been published (Ngwenya *et al.* 2003). Phillips (1917) and Jacot Guillarmod (1971) published Sesotho names of indigenous plants. Smith (1966) also included some Sesotho names. However, the lists are not comprehensive and do not include Sesotho names for exotic food plants.

Many of the scientific names used in these publications are now outdated and it has become necessary to update them. Furthermore, the list of Phillips (1917) is only applicable to the Leribe Plateau region in Lesotho. While Jacot Guillarmod's (1971) work is much more comprehensive, it did not include the meanings of the Sesotho names. This checklist has been compiled based on plants used by Sesotho-speaking people in southern Africa, who live mainly in Lesotho and in the Free State, South Africa.

MATERIALS AND METHODS

The checklist was compiled using the available literature and the first author's own experiences while growing up in a rural area (Ha Thuube, Qacha's Nek District) in Lesotho. Authorities for scientific names are given in

Appendix 1 and are not repeated elsewhere in the text. The nomenclature follows that of Germishuizen & Meyer (2003).

The list is arranged alphabetically according to family and genus starting with the monocots. Where possible, English common names and the origin or meaning of the Sesotho names are presented. The edible parts of the plants have also been included in the list. Many exotic plants including fruits (e.g. banana, kiwi, mango, among others), nuts (e.g. almonds, cashews, macadamias, among others), spices and herbs (e.g. coriander, oregano, parsley, and others) do not have Sesotho names and are therefore excluded.

DISCUSSION

Sesotho names of 164 indigenous and 39 exotic plant species of edible plants are given in Appendix 1.

Some Sesotho names of plants are expressed in short sentences to indicate either the habit of the plant (e.g. its appearance, striking features or size), habitat, or its use (mostly for medicinal purposes). Many exotic plants also have Sesotho names, although these names have been taken directly from either English or Afrikaans. For example, the Sesotho name *tamati* for tomato (*Lycopersicon esculentum*) has been taken directly from the Afrikaans word *tamatie*. To highlight the typical derivation of names, some examples of plant names are given below (for full meanings see Appendix 1).

Names based on characteristics of the plant

Diospyros austro-africana: *Ntlo-ea-lekhoaba*—the house of a crow, with reference to its flower shape.

Empodium plicatum: *Leihlo-la-khomo*—eye of the cow, so named because its flower resembles an eye of a cow.

Sisymbrium capense: *Tlhako-ea-khomo*—hoof of the cow, the shape of the leaves resembles a hoof of a cow.

Watsonia densiflora (and other members of Iridaceae): *Khahla*—the flower which pleases, this is because the flowers of these plants look pretty.

Tragopogon porrifolius: *Moetse-oa-pere*—mane of a horse, in reference to the thin, elongated leaves.

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Names based on the size of the plant

Gladiolus dalenii: *Khahla-e-kholo*—the big plant/flower which pleases.

Hesperantha baurii: *Khahla-e-nyenyane*—the small plant/flower which pleases.

Hypoxis argentea: *Leihlo-la-khomo-le-lehlo*—the big eye of the cow.

Mentha aquatica: *Koena-e-nyenyane*—the small crocodile.

Names based on the habitat of the plant

Eulophia hians: *Mametsana-a-manyenyane*—mother of little water, because the plants are found in wet places.

Gladiolus cruentus: *Khahla-ea-loti*—the mountain plant which pleases, so called because the plants usually grow in mountainous areas.

Oxalis corniculata: *Bolila-ba-thaba*—the sour plant of the mountain; these plants are more frequent at higher altitudes.

Names based on the taste of the plant

Epilobium hirsutum: *Letsoai-la-balisana*—salt of the shepherds, so called because the leaves taste salty.

Nasturtium officinale: *Liababa*—they are bitter, due to the bitter leaves.

Oxalis species: *Bolila*—the sour plant, because the leaves are extremely sour.

The replacement of indigenous food plants with seemingly more attractive exotic ones is just one aspect of a broader pattern of aculturization that affects many aspects of Sesotho culture. The impoverishment of Sesotho plant nomenclature is very evident in rural areas

where only the elderly still know and use the traditional names of plants.

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APPENDIX 1.—List of edible plants; their common names (Sesotho and English); the parts that are used for food; and references

Taxon	Sesotho name	Origin or meaning	English name	Parts used	Reference
Monocotyledons					
Alliaceae					
* <i>Allium cepa</i> L.	<i>Eiee/ Hanyanese</i>	from the Afrikaans word <i>ui</i>	onion	bulb	5, 6
<i>Tulbaghia acutiloba</i> Harv.	<i>Motsuntsunyane</i>	unknown		young plants	1–4
<i>alliacea</i> L.f.	<i>Moelela</i>	unknown	wild garlic	leaves	1–4, 6
<i>leucantha</i> Baker	<i>Sefotha-fotha</i>	unknown		young plants	2, 4
Amarylidaeae					
<i>Cyrtanthus stenanthus</i> Baker	<i>Lepontoane</i>	unknown	golden star	bulb	2, 4
Anthericaceae					
<i>Chlorophytum fasciculatum</i> (Baker) Kativu	<i>Lehaohao</i>	unknown		roots	1, 2
Araceae					
<i>Zantedeschia aethiopica</i> (L.) Spreng.	<i>Mothebe</i>	unknown	arum lily	leaves, stems	2–4, 6, 7
<i>albomaculata</i> (Hook.) Baill. subsp. <i>albomaculata</i>	<i>Mohalalito</i>	unknown	spotted-leaf arum	leaves	2–4, 6
Asparagaceae					
<i>Asparagus africanus</i> Lam.	<i>Lerara-tau/</i>	one who watches (<i>lelala/ lerara</i>)	asparagus	young shoots	1–4, 6
<i>setaceus</i> (Kunth) Oberm.	<i>Lelala-tau</i> <i>Lehonyeli</i>	the lion (<i>tau</i>) unknown (general name for species of <i>Asparagus</i>)	feathery asparagus	young shoots	3, 6

* exotic taxa; 1, Phillips (1917); 2, Jacot Guillarmod (1971); 3, Fox & Norwood Young (1982); 4, Peters *et al.* (1992); 5, Masefield *et al.* (1969); 6, Van Wyk & Gericke (2000); 7, Jacot Guillarmod (1966). Author abbreviations according to Brummitt & Powell 1992.

APPENDIX 1.—List of edible plants; their common names (Sesotho and English); the parts that are used for food; and references (cont.)

Taxon	Sesotho name	Origin or meaning	English name	Parts used	Reference
Asphodelaceae					
<i>Kniphofia</i> spp.	<i>Leloele</i>	unknown	red-hot poker	flower; nectar	1–4, 7
Cyperaceae					
<i>Cyperus</i>					
<i>esculentus</i> L.	<i>Monakalali</i>	unknown		bulb	1–4, 6
<i>usitatus</i> Burch.	<i>Monakalaki</i>	same as above	Indian grass	bulb	1–4, 6, 7
Hyacinthaceae					
<i>Albucca maxima</i> Burm.f.	<i>Mototse</i>	unknown	soldier in the box	bulb	1, 3, 4
<i>Dipcadi</i>					
<i>marlothii</i> Engl.	<i>Morotoana</i>	the small urine (from <i>moroto</i> which means urine)		bulb	2–4
<i>viride</i> (L.) Moench	<i>Morotoana-phokoana</i>	the small urine of the young male goat (<i>phokoana</i>)	green bells	bulb	1–4, 7
<i>Empodium plicatum</i> (Thunb.) Garside	<i>Leihlo-la-khomo</i>	the eye (<i>leihlo</i>) of the cow (<i>khomo</i>)	ifafa lily	bulb	2–4
<i>Ornithogallum tenuifolium</i>	<i>Moretele-o-monyenyane</i>	the small (<i>monyenyane</i>) one which causes the body to become itchy and reddish (from the word <i>retela</i>)	wild onion	bulb	1, 3
F.Delaroche subsp. <i>tenuifolium</i>					
Hypoxidaceae					
<i>Hypoxis argentea</i> Harv. ex Baker	<i>Leihlo-la-khomo-le-leholo</i>	the large (<i>leholo</i>) eye (<i>leihlo</i>) of the cow (<i>khomo</i>)	small yellow star	rootstock	1–4
Iridaceae					
<i>Gladiolus</i>					
<i>cruentus</i> T.Moore	<i>Khahla-ea-loti</i>	the mountain (<i>loti</i>) flower which pleases (<i>khahla</i>)		flowers	2–4, 7
<i>dalenii</i> Van Geel	<i>Khahla-e-kholo</i>	the big (<i>kholo</i>) flower which pleases		flowers	3, 4
<i>ecklonii</i> Lehm.	<i>Khahla</i>	the flower which pleases		flowers	1–4, 7
<i>Hesperantha baurii</i> Baker	<i>Khahla-e-nyenyane</i>	the small (<i>nyenyane</i>) flower which pleases (<i>khahla</i>)		bulbs	1–4
<i>Moraea</i>					
<i>simulans</i> Baker	<i>Teele</i>	unknown		corms	2, 4
<i>stricta</i> Baker	<i>Qekoe</i>	unknown		corms	2, 4
<i>Watsonia densiflora</i> Baker	<i>Khahla</i>	the flower which pleases	Natal watsonia	corms	1, 2, 4, 7
Orchidaceae					
<i>Eulophia hians</i> Spreng. var. <i>nutans</i> (Sond.) S.Thomas	<i>'Mametsana-a-man-nyenyane</i>	the small (<i>nyenyane</i>) mother (<i>'Ma</i>) of little water (<i>metsana</i> from <i>metsi</i> which means water)		tubers	1–3
<i>Neobolusia tysonii</i> (Bolos) Schltr.	same as above	the small (<i>nyenyane</i>) mother (<i>'Ma</i>) of little water (<i>metsana</i> from <i>metsi</i> which means water)		tubers	1, 2
Poaceae					
<i>Eleusine coracana</i> (L.) Gaerth. subsp. <i>africana</i> (Kenn.-O'Byrne) Hilu & de Wet	<i>Moseli</i>	the one who searches for food (from verb <i>ho sela</i> which means to look for food)	African finger millet	grain	2–7
<i>Eragrostis</i>					
<i>chloromelas</i> Steud.	<i>Seritšoana</i>	unknown		grain	1–3, 6
<i>cilianensis</i> (All.) Vignolo ex Janch.	<i>Moseeka</i>	unknown		grain	2, 4, 6
<i>curvula</i> (Schr.) Nees	<i>Moseeka</i>	unknown	weeping lovegrass	grain	1–5
<i>planiculmis</i> Nees	<i>Tšane/ Mofethe</i>	unknown		grain	2–4
<i>Hermathria altissima</i> (Poir.) Stapf & C.E.Hubb.	<i>Marotlo-a-mafubelu</i>	unknown	quick grass	rhizome	3, 4, 7
<i>Imperata cylindrica</i> (L.) Raeusch.	<i>Mohlaba-lerumo</i>	the one who pierces (<i>hlaba</i>) with an assegai (<i>lerumo</i>)	bedding grass	rhizome	1–4, 7
<i>Miscanthus capensis</i> (Nees) Anders-son	<i>Mothala</i>	unknown		rhizome	2, 4, 7
* <i>Oryza sativa</i> L.	<i>Raese</i>	from the word rice	rice	grain	3, 5, 6
<i>Pennisetum glaucum</i> (L.) R.Br.	<i>Nyalothi</i>	unknown	pearl millet	grain	1, 2, 4, 6
<i>Phragmites australis</i> (Cav.) Steud.	<i>Lehlaka</i>	unknown (general name for all reeds)	common reed	rhizome	1, 3, 4, 6
<i>Saccharum officinarum</i> L.	<i>Tsoekere</i> (refers to sugar)	from the Afrikaans word <i>suiker</i>	sugar cane	stem	3, 6
<i>Setaria italica</i> (L.) P.Beauv.	<i>Joang-ba-lipere</i>	the grass (<i>joang</i>) for the horses (<i>lipere</i>)	foxtail millet	grain	2, 4, 6
<i>Sorghum bicolor</i> (L.) Moench	<i>Mabele</i>	unknown (any sorghum-like grain)	sorghum	grain	2–6
<i>Sporobolus fimbriatus</i> (Trin.) Nees	<i>Matolo-a-maholo</i>	the big (<i>maholo</i> from the adjective <i>kholo</i>) knots on the stems (<i>matolo</i>)		grain	1–4
<i>Triticum</i>					
<i>aestivum</i> L.	<i>Kooro</i>	from the Afrikaans word <i>koring</i>	bread wheat	grain	4–6
<i>durum</i> Desf.	<i>Kooro</i>	from the Afrikaans word <i>koring</i>	durum wheat	grain	4, 5
<i>Zea mays</i> L.	<i>Poone</i>	unknown	maize	grain	2, 3, 5, 6

* exotic taxa; 1, Phillips (1917); 2, Jacot Guillarmod (1971); 3, Fox & Norwood Young (1982); 4, Peters *et al.* (1992); 5, Masefield *et al.* (1969); 6, Van Wyk & Gericke (2000); 7, Jacot Guillarmod (1966). Author abbreviations according to Brummitt & Powell 1992.

APPENDIX 1.—List of edible plants; their common names (Sesotho and English); the parts that are used for food; and references (cont.)

Taxon	Sesotho name	Origin or meaning	English name	Parts used	Reference
Dicotyledons					
Amaranthaceae					
<i>Amaranthus deflexus</i> L.	<i>Theepe</i>	unknown		young shoots	4, 6
* <i>hybridus</i> L.	<i>Theepe</i>	unknown	pigweed/ red amaranth	young shoots	1–3, 6, 7
<i>thunbergii</i> Moq.	<i>Theepe-ea-bokone</i>	unknown	Cape pigweed	young shoots	1–4, 6, 7
Anacardiaceae					
<i>Rhus dentata</i> Thunb.	<i>Mabelebele</i>	much grain (derived from <i>mabele</i>)	nana berry	fruits	1–4, 7
<i>discolor</i> E.Mey. ex Sond.	<i>Mohlohloane</i>	thick part or swelling in a root		fruits	2, 4
<i>petheri</i> Zahlbr.	<i>Mabelebele</i>	much grain (derived from <i>mabele</i>)		fruits	1, 2, 4
Apiaceae					
<i>Centella asiatica</i> (L.) Urb.	<i>Bolila-ba-linku</i>	the sour (<i>bolila</i>) plant of the sheep (<i>linku</i>)	marsh pepperwort	leaves	3
* <i>Daucus carota</i> L.	<i>Sehoete</i>	unknown (any carrot-like root)	carrot	roots	5
<i>Peucedanum magalismontanum</i> Sond.	<i>Sepaile</i>	unknown	wild parsley	leaves	1–4, 6
<i>Pimpinella caffra</i> (Eckl. & Zeyh.) D.Dietr.	<i>Mohopu</i>	unknown		leaves	1–3
Apocynaceae					
<i>Ancylotrys capensis</i> (Oliv.) Pichon	<i>Marapa</i>	unknown	wild apricot/ wild peach	fruits	
<i>Asclepias aurea</i> (Schltr.) Schltr.	<i>Mohlatsisa</i>	one who causes vomit (from the verb <i>ho hlatsa</i> which means to vomit)		rootstock	1, 2, 4
<i>gibba</i> (E.Mey.) Schltr.	<i>Montsoko</i>	unknown		rootstock	1–4
<i>humilis</i> (E.Mey.) Schltr.	<i>Sehoete</i>	unknown (any carrot-like root)		rootstock	1, 2, 4
<i>multicaulis</i> (E.Mey.) Schltr.	<i>Mankiling</i>	unknown	milk bush	leaves, stems, flowers, roots	1–4, 7
<i>Aspidoglossum araneiferum</i> (Schltr.) Kupicha	<i>Ntlhokoe</i>	the slender one (likened to the thin stem of a grass, called <i>lehlokoa</i>)		tubers	3
<i>gracile</i> (E.Mey.) Kupicha	<i>Sehoete</i>	unknown		roots	2, 3
<i>interruptum</i> (E.Mey.) Bullock	<i>Morema-phofu</i>	the one who breaks (<i>rema</i>) a wild animal (<i>phofu</i>)		roots	1–3
<i>lamellatum</i> (Schltr.) Kupicha	<i>Sehoete-moru</i>	unknown		roots	1–3
<i>Brachystelma circinatum</i> E.Mey.	<i>Bohobe-ba-setsomi</i>	the bread (<i>bohobe</i>) of the hunter (<i>setsomi</i>)		tubers	1, 3
<i>foetidum</i> Schltr.	<i>Seru</i>	unknown		tubers	3
<i>Cynanchum virens</i> (E.Mey.) D.Dietr.	<i>Morara-oa-moru</i>	the creeper (<i>morara</i>) of the forest/ woods (<i>moru</i>)		leaves, roots	1, 2
<i>Gomphocarpus fruticosus</i> (L.) Aiton f.	<i>Lebejana/ Moethimolo</i>	the milky one (referring to the milky substance protruding from the un-ripe fruit)/ the one who causes sneezing (from the verb <i>ho thimola</i>)	wild cotton/ milkweed	rootstock	2, 4
<i>Miraglossum pulchellum</i> (Schltr.) Kupicha	<i>Sehoete-mpulutsana</i>	the greyish (<i>pulutsana</i>) carrot-like root (<i>sehoete</i>)		roots	1, 3
<i>Pachycarpus rigidus</i> E.Mey.	<i>Phomametsu</i>	the one who escapes (<i>phoma</i>) the arrows (<i>metsu</i>)		young plants	1–3
<i>vexillaris</i> E.Mey.	<i>Leshokhoa</i>	unknown		leaves	2, 4
<i>Parapodium costatum</i> E.Mey.	<i>Sehamelapoli</i>	the one who milks for (from the verb <i>hama</i> which means to milk; <i>hamela</i> means to milk for) the goat (<i>poli</i>)		leaves	1–4
<i>Periglossum angustifolium</i> Decne.	<i>Sehoete-mohlaka</i>	carrot-like root of the marsh (carrot)		rootstock	1, 2
<i>Riocrexia torulosa</i> Decne.	<i>Morarana-oa-moru</i>	the small creeper (<i>morarana</i>) of the forest/ woods (<i>moru</i>)		leaves	1–4, 7
<i>Sarcostemma viminalis</i> (L.) R.Br.	<i>Mabele-a-lilomo</i>	the grain (<i>mabele</i>) of the cliffs (<i>lilomo</i>)	caustic bush	stem and young fruits	1–4
<i>Schizoglossum atropurpureum</i> E.Mey.	<i>Sehoete-moru</i>	carrot of the forest/ woods (<i>moru</i>)		roots	1–4
<i>linifolium</i> Schltr.	<i>Sehoete-ntlhokoe</i>	the slender (<i>ntlhokoe</i> , likened to the thin stem of a grass) carrot (<i>sehoete</i>)		roots	1, 3
<i>Xysmalobium undulatum</i> (L.) Aiton f.	<i>Leshokhoa</i>	unknown	milk bush	leaves	1–4, 6

* exotic taxa; 1, Phillips (1917); 2, Jacot Guillarmod (1971); 3, Fox & Norwood Young (1982); 4, Peters *et al.* (1992); 5, Masefield *et al.* (1969); 6, Van Wyk & Gericke (2000); 7, Jacot Guillarmod (1966). Author abbreviations according to Brummitt & Powell 1992.

APPENDIX 1.—List of edible plants; their common names (Sesotho and English); the parts that are used for food; and references (cont.)

Taxon	Sesotho name	Origin or meaning	English name	Parts used	Reference
Asteraceae					
<i>Athrixia angustissima</i> DC.	<i>Phefshoana-e-nyenyane</i>	the small wind (from the word <i>phefo</i> which means wind)		leaves	1–3
<i>elata</i> Sond.	<i>Phefshoana-ea-basiea</i>	the small wind (see above) of the <i>Basiea</i> (one of the Basotho clans)	daisy tea	leaves	1–3, 7
<i>phylicoides</i> DC.	<i>Sephomolo</i>	one who rests or relaxes (from the verb <i>phomola</i>)	bush tea	leaves	3, 6
<i>Berkheya discolor</i> (DC.) O.Hoffm. & Muschl.	<i>Sehlohlo-se-seholo</i>	unknown [the big (<i>seholo</i>) <i>Sehlohlo</i>]		young plants	2–4
<i>Dicoma anomala</i> Sond.	<i>Hloenya</i>	to blush or change colour		leaves	1–3
<i>Gazania krebsiana</i> Less.	<i>Tsikitlana</i>	to become stiff (as a result of the twining of the leaves; the leaves are twined together to make a traditional skirt for girls known as <i>thethana</i>)		leaves	2, 4
<i>*Helianthus annuus</i> L.	<i>Sonobolomo</i>	from the Afrikaans word <i>sonneblom</i>	sunflower	seeds	5, 6
<i>Helichrysum nudifolium</i> (L.) Less.	<i>Papetloana</i>	the flat, spreading one	Zulu tea	leaves	2–4
<i>platypterum</i> DC.	<i>Leshoetla</i>	soft, spongy part of a bone		crushed roots	1, 2, 4
<i>Metalasia muricata</i> (L.) D.Don.	<i>Sehalahala-se-seputsoa</i>	unknown [the grey <i>Erica</i> (all <i>ericas</i> or <i>Erica</i> -like plants are known as <i>sehalahala</i>)]		leaves, twigs	2, 4, 6, 7
<i>Sonchus dregeanus</i> DC.	<i>Leharasoana</i>	the ragged one		leaves	1, 3, 4
<i>integrifolius</i> Harv.	<i>Sethokonyane-se-seholo</i>	unknown [the big (<i>seholo</i>) <i>Sethokonyane</i>]		leaves	1, 3, 4
<i>nanus</i> Sond. ex Harv.	<i>Sentlokojane</i>	unknown	ground thistle	leaves	1, 3, 4
<i>*oleraceus</i> L.	<i>Leshoabe</i>	unknown	milk thistle	leaves	1, 3
<i>Tolpis capensis</i> (L.) Sch.Bip.	<i>Fukuthoane</i>	unknown		young plants	3, 4
<i>Tragopogon porrifolius</i> L.	<i>Moetse-oa-pere</i>	the mane (<i>moetse</i>) of a horse (<i>pere</i>)	salsify	young plants	3, 7
Boraginaceae					
<i>Anchusa capensis</i> Thunb.	<i>Petlekheme</i>	unknown	forget-me-not	young plants	1–4
<i>Lithospermum cinereum</i> A.DC.	<i>Lefisoana</i>	small clay pot		young plants	1, 2, 4
Brassicaceae					
<i>*Brassica napus</i> L.	<i>Rapa</i>	from the Afrikaans word <i>raap</i>	rape	leaves	5
<i>*oleracea</i> L.	<i>Kh'abeche</i>	from cabbage	cabbage	leaves	5
<i>*rapa</i> L.	<i>Rapa</i>	same as above	turnip	leaves, roots	3, 5
<i>Lepidium capense</i> Thunb.	<i>Sebitsa</i>	it calls (from the verb <i>bitsa</i> which means to call)	pepper cress	leaves	1, 2, 6
<i>myriocarpum</i> Sond.	<i>Lerotho</i>	dimness	pepper cress	leaves	1–4, 6
<i>schinzii</i> Thell.	<i>Sebitsa</i>	it calls	birdseed	leaves	1–4, 6
<i>*Nasturtium officinale</i> R.Br.	<i>Liababa/ Mohata-metsi</i>	they are bitter (from the verb <i>baba</i> which means bitter)/ one who tramples (<i>hata</i>) on the water (<i>metsi</i>)	watercress	young plants	1–3, 7
<i>*Raphanus sativus</i> L.	<i>Sepaile</i>	unknown	radish	leaves, roots	3, 5
<i>*nudiuscula</i> Thell.	<i>Papasane</i>	unknown		young plants	
<i>Sisymbrium capense</i> Thunb.	<i>Tlhako-ea-khomo</i>	hoof (thlako) of a cow (<i>khomo</i>)	Cape mustard	young plants	1, 2, 4, 6
<i>thellungii</i> O.E.Schulz	<i>Sepatlapatla</i>	the flat one	wild mustard	leaves	1, 2, 4
<i>turczaninowii</i> Sond.	<i>Sentlokojane</i>	unknown	wild mustard	basal leaves	1, 2, 4
<i>*Turritis glabra</i> L.	<i>Lefisoana</i>	small clay pot			2, 4
Bromeliaceae					
<i>*Ananas comosus</i> (L.) Merr.	<i>Paeneapole</i>	from the word pineapple	pineapple	fruit	5
Buddlejaceae					
<i>Buddleja salviifolia</i> (L.) Lam.	<i>Lelothoane</i>	unknown	sage wood	leaves	1–3
Cactaceae					
<i>*Opuntia ficus-indica</i> (L.) Mill.	<i>Terefeie</i>	from the Afrikaans word <i>turksvy</i>	prickly pear	fruits	6
Campanulaceae					
<i>Wahlenbergia androsacea</i> A.DC.	<i>Tenane</i>	get tired of (from the verb <i>ho tena</i>)	harebell	young plants	1–4, 7
<i>denudata</i> A.DC.	<i>Tenane</i>	get tired of (from the verb <i>ho tena</i>)		young plants	1
<i>krebsii</i> Cham. subsp. <i>krebsii</i>	<i>Tenane</i>	get tired of (from the verb <i>ho tena</i>)		young plants	1, 2
<i>undulata</i> (L.f.) A.DC.	<i>Tenane</i>	get tired of (from the verb <i>ho tena</i>)	giant bell flower	young plants	1–3

* exotic taxa; 1, Phillips (1917); 2, Jacot Guillarmod (1971); 3, Fox & Norwood Young (1982); 4, Peters *et al.* (1992); 5, Masefield *et al.* (1969); 6, Van Wyk & Gericke (2000); 7, Jacot Guillarmod (1966). Author abbreviations according to Brummitt & Powell 1992.

APPENDIX 1.—List of edible plants; their common names (Sesotho and English); the parts that are used for food; and references (cont.)

Taxon	Sesotho name	Origin or meaning	English name	Parts used	Reference
Capparaceae					
<i>Boscia</i>					
<i>albitrunca</i> (Burch.) Gilg & Gilg-Ben	<i>Mopipi</i>	unknown	emigrant's tea/ caper bush	roots, fruits	3, 4
<i>foetida</i> Schinz. subsp. <i>rehmanniana</i> (Pestal) Toelken	<i>Mphephi</i>	unknown	old woman's bush	roots	3, 4
Caryophyllaceae					
<i>Cerastium capense</i> Sond.	<i>Mollo-oa-nku/</i> <i>qoqobala</i>	the bleating (from the verb <i>lla</i> which means cry) of a sheep (<i>nku</i>)		young plants	1, 2, 4, 7
<i>Pollichia campestris</i> Aiton	<i>Monokotšoi-oi-</i> <i>makhoaba</i>	the bramble (<i>Monokotšoi</i>) of the crows (<i>makhoaba</i>)	waxberry	fruits	1–3, 7
Chenopodiaceae					
* <i>Beta vulgaris</i> L.	<i>Biti</i>	from the word beet	beetroot	leaves, roots	5
* <i>Chenopodium album</i> L.	<i>Seruo</i>	unknown	goosefoot	young plants	1–4, 6, 7
* <i>Spinacea oleracea</i> L.	<i>Sepinichi</i>	from the word spinach	spinach	leaves	5
Convolvulaceae					
<i>Ipomoea</i>					
* <i>batatas</i> (L.) Lam.	<i>Patata</i>	from the Afrikaans word <i>patat</i>	sweet potato	tubers	3, 5, 6
<i>bolusiana</i> Schinz	<i>Seakhoe</i>	unknown	wild potato	rootstock	2, 4
<i>crassipes</i> Hook.	<i>Maime</i>	the heavy one (from the adjective <i>boima</i>)	wild potato	roots	1–4, 7
<i>oblongata</i> E. Mey. ex Choisy	<i>Mothokho</i>	traditional medicine	wild potato	roots	1, 3
<i>simplex</i> Thunb.	<i>Seakhoe</i>	unknown	wild potato	roots	1, 3
Cucurbitaceae					
<i>Citrullus</i>					
<i>lanatus</i> (Thunb.) Matsum. & Nakai (wild form)	<i>Tjoto</i>	unknown	bitter melon/ tsama melon	young leaves	1–4, 6
* <i>lanatus</i> (Thunb.) Matsum. & Nakai (cultivated form)	<i>Lehapu</i>	unknown	watermelon	fruits	2–4
<i>Coccinia sessilifolia</i> (Sond.) Cogn.	<i>Borobahlolo</i>	the one who breaks (from the verb <i>roba</i> which means break) the rock-rabbit (<i>hlolo</i>)		fruits, leaves	3, 4, 6
<i>Cucumis myriocarpus</i> Naudin	<i>Monyaku</i>	unknown	bitter apple	leaves	1–4
* <i>Curcubita pepo</i> L.	<i>Mokopu</i>	unknown	pumpkin	fruits and young leaves	3–6
<i>Langenaria siceraria</i> (Molina) Standl.	<i>Sehoana</i>	unknown	bottle guard	fruits, leaves	3, 4
<i>Momordica balsamina</i> L.	<i>Moholu</i>	stomach	African cucumber	leaves	3, 4, 6
Ebenaceae					
<i>Diospyros austro-africana</i> De Winter	<i>Ntlo-ea-lekhoaba</i>	the house (<i>ntlo</i>) of the crow (<i>lekhoaba</i>)		fruits	2, 4
<i>Euclea crispa</i> (Thunb.) Gürke	<i>Mohlakola</i>	the one who wipes (from the verb <i>hlakola</i> which means to wipe)	bush guarri	fruits	1–4
Euphorbiaceae					
<i>Euphorbia</i>					
<i>clavarioides</i> Boiss.	<i>Sehlooko</i>	unknown	lion spoor	stems	2–4, 7
<i>striata</i> Thunb.	<i>Mohlatsisa</i>	the one who causes vomit (from the verb <i>hlatsa</i> which means to vomit)	milk weed	roots	1–4, 7
Fabaceae					
* <i>Arachis hypogea</i> L.	<i>Makotomane</i>	unknown	ground nuts/ peanuts	seeds	3, 5
<i>Argyrobolium tuberosum</i> Eckl. & Zeyh.	<i>Tsoetla-e-nyenyane</i>	unknown [the small (<i>nyane</i>) <i>tsoetla</i>]		roots	1–4, 7
<i>Dolichos angustifolius</i> Eckl. & Zeyh.	<i>Tsoetla</i>	unknown		roots	2–4, 7
<i>Elephantorrhiza elephantina</i> (Burch.) Skeels	<i>Mositsane</i>	unknown	elephant's root	seeds	1–4, 6, 7
* <i>Gleditsia triacanthos</i> L.	<i>Leoka</i>	unknown	honey locust	fruits, seeds	3, 7
* <i>Lens esculenta</i> L.	<i>Lensisi</i>	from the Afrikaans word <i>lensie</i>	lentils	seeds	5
* <i>Pisum sativum</i> L.	<i>Lierekisi</i>	from the Afrikaans word <i>ertjie</i>	garden peas	seeds	5
* <i>Phaseolus vulgaris</i> L.	<i>Linaoa</i>	unknown [any bean-like seed is referred to as <i>naoa</i> (plural <i>linaoa</i>)]	kidney beans	seeds	3, 5
<i>Rhynchosia</i>					
<i>hirsuta</i> Eckl. & Zeyh.	<i>Monya-talane</i>	the one who defecates (<i>monya</i>) unripe grain (<i>talane</i>)		roots	1, 2, 4
<i>totta</i> (Thunb.) DC.	<i>Sebalibetloa</i>	unknown		roots	1–4
<i>Trifolium</i>					
<i>africanum</i> Ser. var. <i>africanum</i>	<i>Moqopolla-thupa</i>	unknown	Cape clover/red	inflorescences	1–4

* exotic taxa; 1, Phillips (1917); 2, Jacot Guillarmod (1971); 3, Fox & Norwood Young (1982); 4, Peters *et al.* (1992); 5, Masefield *et al.* (1969); 6, Van Wyk & Gericke (2000); 7, Jacot Guillarmod (1966). Author abbreviations according to Brummitt & Powell 1992.

APPENDIX 1.—List of edible plants; their common names (Sesotho and English); the parts that are used for food; and references (cont.)

Taxon	Sesotho name	Origin or meaning	English name	Parts used	Reference
Fabaceae (cont.)					
<i>Trifolium burchellianum</i> Ser.	<i>Moroko</i>	unknown	African clover	inflorescences	1, 2, 4
* <i>Vicia faba</i> L.	<i>Linaoa</i>	See <i>P. vulgaris</i> above	wild clover broad beans	seeds	3, 5
Geraniaceae					
<i>Geranium incanum</i> Burm.f.	<i>Ngope setšoha</i>	an idiom meaning something that rarely happens	carpet geranium	leaves	1–3, 7
<i>multisectum</i> N.E.Br.	<i>Bolila-ba-likhomo</i>	the sour (<i>bolila</i>) one of the cows (<i>likhomo</i>)		leaves	2, 4
<i>Pelargonium bowkeri</i> Harv.	<i>Khoara</i>	derived from <i>lekhoara</i> (a stony ridge; the plant grows near rocks)		leaves	1–4
Gunneraceae					
<i>Gunnera perpensa</i> L.	<i>Qobo</i>	favourite of the chief	river pumpkin	stems and flower stalks	1–4, 7
Lamiaceae					
<i>Mentha aquatica</i> L.	<i>Koena-e-nyenyane</i>	a small (<i>nyenyane</i>) crocodile (<i>koena</i>)	wild mint	leaves	1–4
<i>longifolia</i> (L.) Huds.	<i>Koena</i>	a crocodile (<i>koena</i>)	wild mint	leaves	1–4
Lobeliaceae					
<i>Cyphia elata</i> Harv.	<i>Lenkoto</i>	unknown		roots	1–4
<i>Lobelia erinus</i> L.	<i>Moroho-oa-likonyana</i>	the vegetables (<i>moroho</i>) of the lambs (<i>likonyana</i>)	wild lobelia	young plants	1, 2, 4
<i>preslii</i> A.DC.	<i>Mahlo-a-konyana</i>	the eyes (<i>mahlo</i>) of the lamb (<i>konyana</i>)		young plants	1, 2, 4
<i>Monopsis decipiens</i> (Sond.) Thulin	<i>Malana-a-konyana</i>	the small intestines (<i>malana</i>) of the lamb (<i>konyana</i>)	butterfly lobelia	young plants	1, 2, 4
Myricaceae					
<i>Morella serrata</i> (Lam.) Killick	<i>Monna-e-motšo</i>	the black (<i>motšo</i>) man (<i>monna</i>)	lance-leaf wax berry	fruits	3, 4
Myrtaceae					
* <i>Psidium guajava</i> L.	<i>Koafa</i>	from guava	guava	fruits	5
Onagraceae					
<i>Epilobium hirsutum</i> L.	<i>Letsoai-la-balisana</i>	salt (<i>letsoai</i>) of the shepherds (<i>balisana</i>)		leaves	1, 3, 4, 7
Oxalidaceae					
<i>Oxalis corniculata</i> L.	<i>Bolila-ba-thaba/bolila-ba-litšoene</i>	the sour plant (<i>bolila</i>) of the mountain (<i>thaba</i>)/ the sour plant of the monkeys (<i>litšoene</i>)		whole plant	1–4
<i>semiloba</i> Sond.	<i>Bolila</i>	the sour plant	sorrel	leaves, roots	2–4
<i>setosa</i> E.Mey. ex Sond.	<i>Bolila</i>	same as above	sorrel	leaves	1, 3
Papaveraceae					
<i>Papaver aculeatum</i> Thunb.	<i>Sehlohlo</i>	the one who causes anger	wild poppy	young plants	1–4
Plantaginaceae					
<i>Plantago major</i> L.	<i>Bolila-ba-lipoli</i>	the sour (<i>bolila</i>) plant of the goats (<i>lipoli</i>)	broadleaf plantain	leaves, roots	2, 3
Polygonaceae					
<i>Rumex sagittatus</i> Thunb.	<i>Bolila-bo-boholo</i>	the big (<i>boholo</i>) sour (<i>bolila</i>) plant	climbing sorrel	leaves	1–4
<i>woodii</i> N.E.Br.	<i>Bolila-ba-likhomo</i>	the sour (<i>bolila</i>) plant for the cows (<i>likhomo</i>)		leaves	1–4
Portulacaceae					
* <i>Portulaca oleracea</i> L.	<i>Selèlè</i>	slippery	common purselane	leaves, stems	2–4, 7
<i>Talinum cafrum</i> (Thunb.) Eckl. & Zeyh.	<i>Khutsana</i>	an orphan		leaves	2–4, 6
Ranunculaceae					
<i>Thalictrum minus</i> L.	<i>Lefokotsane</i>	the small feeble one		young plants	1, 2, 4, 7

* exotic taxa; 1, Phillips (1917); 2, Jacot Guillarmod (1971); 3, Fox & Norwood Young (1982); 4, Peters *et al.* (1992); 5, Masefield *et al.* (1969); 6, Van Wyk & Gericke (2000); 7, Jacot Guillarmod (1966). Author abbreviations according to Brummitt & Powell 1992.

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Taxon	Sesotho name	Origin or meaning	English name	Parts used	Reference
Rhamnaceae					
<i>Ziziphus mucronata</i> Willd.	<i>Mokhalo</i>	unknown	buffalo thorn	fruits	3, 4, 6
Rosaceae					
* <i>Malus domestica</i> Borkh.	<i>Apole</i>	from apple	apple	fruits	5
* <i>Prunus armeniaca</i> L.	<i>'Mabolilana</i>	the sour fruit	apricot	fruits	5
* <i>Persica</i> (L.) Batsch.	<i>Perekisi</i>	from the Afrikaans word <i>perske</i>	peach	fruits	5
* <i>Pyrus communis</i> L.	<i>Pere</i>	from the Afrikaans word <i>peer</i>	pear	fruits	5
* <i>Rosa rubiginosa</i> L.	<i>Khunoane</i>	unknown		fruits	7
<i>Rubus</i>					
<i>idaeus</i> L.	<i>Monokotsoai</i>	bramble	raspberry	fruits	5
<i>ludwigii</i> Eckl. & Zeyh.	<i>Monokotsoai-oo-balisana/ basali</i>	the bramble of the shepherds (<i>balisana</i>) or of the women (<i>basali</i>)	wild bramble	fruits	1–4
<i>rigidus</i> Sm.	<i>Monokotsoai-oo-banna</i>	the bramble of the men (<i>banna</i>)	bramble	fruits	1–4
Rutaceae					
* <i>Citrus</i>					
* <i>limon</i> (L.) Burm.f.	<i>Surulamunu/Surul amuni</i>	from the Afrikaans word <i>suurlemoen</i>	lemon	fruits	5
* <i>sinensis</i> Osbeck	<i>Lamunu/ Lamuni</i>	from the Afrikaans word <i>lemoen</i>	sweet orange	fruits	5
Scrophulariaceae					
<i>Diascia</i> spp.	<i>Bolao-ba-litoeba</i>	the love philtre (<i>bolao</i>) of the mice (<i>litoeba</i>)		young plants	1, 2, 4
<i>Halleria lucida</i> L.	<i>Lebetsa</i>	the one who throws at (from the verb <i>ho betsa</i> which means to throw at)	white olive	fruits	1–4, 7
<i>Nemesia</i>					
<i>albiflora</i> N.E.Br.	<i>Malana-a-konyana</i>	the small intestines (<i>malana</i>) of the lamb (<i>konyana</i>)		young plants	1, 2
<i>caerulea</i> Hiern	<i>Malana-a-konyana</i>	the small intestines (<i>malana</i>) of the lamb (<i>konyana</i>)		young plants	2
<i>fruticans</i> (Thunb.) Benth.	<i>Malana-a-konyana</i>	the small intestines (<i>malana</i>) of the lamb (<i>konyana</i>)	wild nemesia	young plants	1–3
<i>floribunda</i> Lehm.	<i>Malana-a-konyana</i>	the small intestines (<i>malana</i>) of the lamb (<i>konyana</i>)		young plants	1, 2
<i>pubescens</i> Benth.	<i>Malana-a-konyana</i>	the small intestines (<i>malana</i>) of the lamb (<i>konyana</i>)		young pants	1, 2
<i>rupicola</i> Hilliard	<i>Malana-a-konyana</i>	the small intestines (<i>malana</i>) of the lamb (<i>konyana</i>)		young plants	1, 2
<i>Zaluzianskya peduncularis</i> (Benth.) Walp.	<i>Lemèmèè</i>	unknown		young plants	1–3
Solanaceae					
* <i>Lycopersicon esculentum</i> Mill.	<i>Tamati</i>	from the Afrikaans word <i>tamatie</i>	tomato	fruits, seeds	5
* <i>Physalis viscosa</i> L.	<i>Mokusebere</i>	from the word gooseberry	gooseberry	fruits	2, 3, 7
<i>Solanum</i>					
* <i>nigrum</i> L.	<i>Seshoa-bohloko</i>	the one who dies (<i>shoa</i>) painfully (<i>bohloko</i>)	black nightshade	fruits and young plants	1–4, 7
<i>retroflexum</i> Dunal	<i>Seshoa-bohloko</i>	same as above	nightshade	fruits, leaves	3, 4
* <i>tuberosum</i> L.	<i>Tapole</i>	from the Afrikaans word <i>aartappel</i>	irish potato	tubers	2, 5, 6
Urticaceae					
<i>Urtica</i>					
* <i>dioica</i> L.	<i>Bobatsi</i>	unknown	small nettle	young leaves	1–3
<i>lobulata</i> Blume	<i>Bobatsi</i>	unknown		young leaves	1
Verbenaceae					
<i>Lantana rugosa</i> Thunb.	<i>Joala-ba-linonyana</i>	alcohol (<i>joala</i>) of the birds (<i>linonyana</i>)	chameleon's berry	fruits	2–4
Vitaceae					
<i>Rhoicissus</i>					
<i>tomentosa</i> (Lam.) Wild & R.B.Drumm.	<i>Moaparo</i>	unknown	bush grape	fruits	3, 4, 6
<i>tridentata</i> (L.f.) Wild & R.B.Drumm.	<i>Morara</i>	the one who creeps	bushman's grape	fruits	2–4, 6, 7
* <i>Vitis vinifera</i> L.	<i>Morara</i>	same as above	grape	fruits	5
Zygophyllaceae					
<i>Tribulus terrestris</i> L.	<i>Tšehlo</i>	unknown		leaves	2, 7

* exotic taxa; 1, Phillips (1917); 2, Jacot Guillarmod (1971); 3, Fox & Norwood Young (1982); 4, Peters *et al.* (1992); 5, Masefield *et al.* (1969); 6, Van Wyk & Gericke (2000); 7, Jacot Guillarmod (1966). Author abbreviations according to Brummitt & Powell 1992.

Two new species of *Erica* (Ericaceae) from the Langeberg, Western Cape, South Africa

R.C. TURNER* and E.G.H. OLIVER*

Keywords: *Erica* L., Langeberg, new species, South Africa, taxonomy, Western Cape

ABSTRACT

Two new species of the genus *Erica* L. from the north-facing slopes of the Langeberg are described—*E. turneri*, known only from the type locality on Zuurbraak Mountain and *E. euryphylla*, occurring on the same mountain slope, as well as on the middle north-facing slopes of Hermitage Peak near Misty Point in the Marloth Nature Reserve above Swellendam.

INTRODUCTION

The two species described in this paper are placed in section §*Ceramia* in which there are many species associated with damp, shaded or wet habitats. Most are soft, low shrublets, either erect and compact or diffuse and sprawling, with long, delicate main branches and often with open-backed leaves (Oliver & Oliver 2002). Both new species possess recaulescent bracts and bracteoles and have broad, flat leaves with distinctly thinned midribs towards the apices, allying them morphologically with *E. oxycoccifolia* and *E. cordata* respectively, rather than with the *E. planifolia* group, in which the bract is not recaulescent and is leaf-like and the leaves have apically thickened midribs.

Erica turneri E.G.H.Oliv., sp. nov., foliis 3-natis, ramis foliis bractea bracteolisque pilis glandulosis simplicibusque, bractea recaulescenti, corolla $\pm 3\text{--}4 \times 2.5\text{--}3.5$ mm pilis brevibus simplicibus, ovario pilis sparsis. Figura 1.

TYPE.—Western Cape, 3320 (Montagu): Langeberg Range, Zuurbraak Mountain west of Tradouw Pass, north-facing slopes above Farm Sandrift, 774 m, (–DC), 30 August 2003, Turner 792 (NBG, holo.; BOL, K, iso.).

Plants up to 450 mm tall, laxly erect to sprawling, entwined, single-stemmed reseeder. *Branches:* several lax, spreading main and numerous entwined secondary branches; stems, younger and older with sparse, short, simple and gland-tipped hairs, no infrafoliar ridges, internodes $\pm 5\text{--}10\text{--}(17)$ mm long. *Leaves* 3-nate, ovoid to obovoid, $\pm 3\text{--}4 \times 1.0\text{--}2.5$ mm, flat, open-backed, abaxially with short, simple and gland-tipped hairs, midrib slightly thickened in basal and median portions, adaxially with short, simple and occasional short, gland-tipped hairs, green, margins slightly thickened abaxially, ciliate, with short simple and gland-tipped hairs; petiole $\pm 0.5\text{--}0.75$ mm long, yellowish green. *Inflorescence:* flowers 1 to 3-nate in 1(2) whorls at ends of main branches and secondary branchlets, the latter long or highly reduced; pedicel ± 8 mm long, green turning reddish, with short, simple and gland-tipped hairs; bract partially recaulescent, basal to median, leaf-like, narrowly obovate, $\pm$

0.7 mm long, open-backed, abaxial and adaxial surfaces and margins with short, dense, simple and gland-tipped hairs, pale green; bracteoles 2, basal to median, longer than bract, linear, ± 0.8 mm long, open-backed, leaf-like, abaxial and adaxial surfaces and margins with short, dense, simple and gland-tipped hairs, pale green. *Calyx* 4-lobed; sepals adpressed, ovate, open-backed, $\pm 1.5\text{--}2.0$ mm long, adaxially glabrous, abaxially with short, simple and gland-tipped hairs, margins slightly thickened, ciliate, with short simple and gland-tipped hairs, green. *Corolla* 4-lobed, broadly cup-shaped to slightly ovoid, $3\text{--}4 \times 2.5\text{--}3.5$ mm, with short simple hairs ($\pm 0.1\text{--}0.4$ mm long), translucent white tinged pink in upper half and lobes, becoming deeper pink upon exposure to sunlight and when older, lobes erect, acute, margins smooth. *Stamens* 8, free, included; filaments linear, ± 1.5 mm long, with a slight apical bend, glabrous, white; anthers dorsally fixed at base, bipartite, thecae erect, subfalcately rectangular-elliptic in lateral view, $\pm 0.8\text{--}1.0$ mm long, sparsely aculeate, golden brown with reddish tinge on dorsal ridge; appendages pendulous, dentate, narrowly obcuneate, ± 0.7 mm long, sparsely aculeate, dorsally fixed at bases of thecae, white, often tinged red, pores $\pm 0.25\text{--}0.3$ mm long; pollen in tetrads. *Ovary* 4-locular, subturbinate, slightly flattened, ± 0.85 mm long, with sparse lanate hairs, green turning red; ovules 7 or 8 per locule, placenta apical, nectaries, basal, green; style filiform, ± 2 mm long, glabrous, exserted, occasionally with sparse lanate hairs on upper 0.4 mm, white to pale green, tinged red apically; stigma subcapitate, reddish. *Fruit* a dehiscent capsule, broadly cylindric-ellipsoid, ± 0.85 mm long, sparsely lanate, pale cream-coloured, valves thin and brittle, spreading to $\pm 45^\circ$, septa $\pm 60\%$ on valve, 40% on columella. *Seeds* ellipsoid, ± 0.3 mm long; testa yellowish brown, smooth, shiny; cells irregularly elongate, $50\text{--}80 \times 25\text{--}40$ μm , anticlinal walls unevenly jigsawed, periclinal walls with numerous small pits. *Flowering time:* May to August. Figure 1.

Diagnostic features and discussion: *Erica turneri* is remarkably similar in superficial appearance to *E. oxycoccifolia* Salisb., a species endemic to the Cape Peninsula, as well as to the following species described in this paper, *E. euryphylla*. Character similarities include 3-nate, broad, open-backed leaves, $3\text{--}5 \times 1\text{--}3$ mm, small, finely hairy, cup- to open cup-shaped, white to pink flowers, $3\text{--}4$ mm long, as well as a soft, lax, spreading, intertwined habit. Upon closer inspection however, *E. turneri* possesses

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MS. received: 2005-07-29.

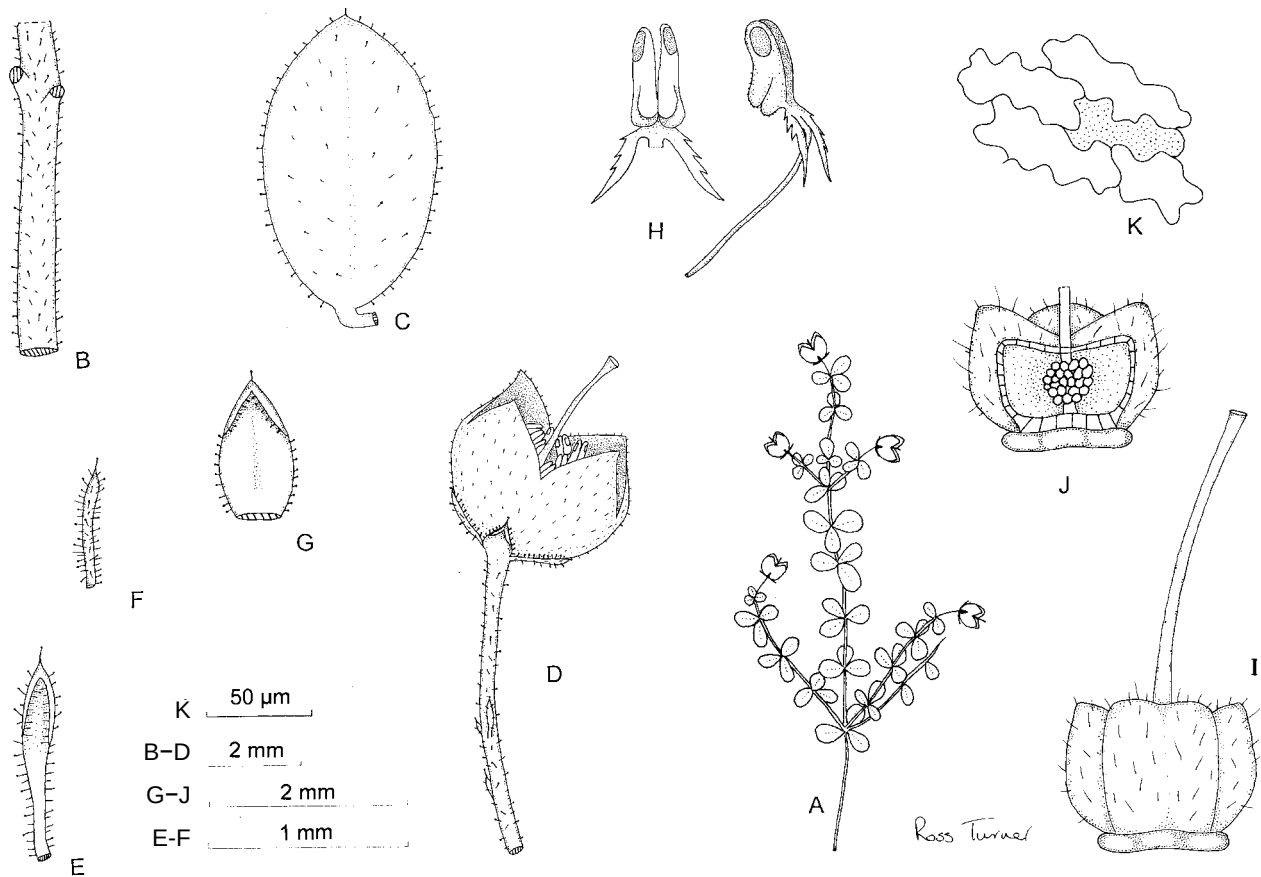


FIGURE 1.—*Erica turneri*, Turner 792. A, flowering branch, natural size; B, stem; C, leaf, abaxial view; D, flower; E, bract; F, bracteole; G, sepal, abaxial view; H, stamen, front and side views; I, gynoecium; J, ovary with one valve removed; K, testa cells. Scale bars: B–D, G–J, 2 mm; E, F, 1 mm; K, 50 µm. Artist: R.C. Turner.

stems with short, simple and gland-tipped hairs, abaxial leaf surfaces with short, simple and gland-tipped hairs, pedicels with short, predominantly gland-tipped, occasionally simple hairs, a turbinate, sparsely hairy, 4-locular ovary with 7 ovules per locule, and sparsely aculeate, prognathous anthers with ± 0.7 mm long, pendulous, dentate appendages. *E. oxycoccifolia* differs in having a glabrous stem, glabrous abaxial leaf surfaces, glabrous pedicels, smooth, muticous anthers and a globose, glabrous, 4-locular ovary with 10 ovules per locule, whereas *E. euryphylla* has stems with long, lanate and occasionally gland-tipped hairs, abaxial leaf surfaces with long woolly hairs, pedicels with long, lanate and occasionally gland-tipped hairs, smooth, muticous anthers, and a globose, 4-locular ovary with 16 ovules per locule.

Pollination syndrome: the pollination syndrome of *Erica turneri* is unresolved. The presence of anther appendages and well-developed nectaries suggest entomophily, although no potential pollinators, flying or crawling, have been observed during visits to the ten known stands. It seems improbable, however, that a flying insect would be able to penetrate the tangled, glandular leaves and stems of the species, to reach flowers that are often pressed against rock faces, or entirely contained by the plants' aforementioned habit. Preliminary studies into the pollination syndromes of *E. limosa* L.Bolus and *E. salteri* L.Bolus, suggest that large ants may play an important role in the pollination of moisture-loving *Erica* species with a low, diffuse, entwined habit, as well as with small (1–5 mm long), cup-shaped flowers (Turner pers. obs.).

Distribution and habitat: *Erica turneri* appears to be confined to the catchment area of the Klein-Sandrivier on the middle north-facing slopes of Zuurbraak Mountain in the Langeberg Range, ± 11 km southwest of Barrydale (Figure 2) (Turner pers. obs.). The species has been seen at altitudes ranging from 580–950 m, on a substratum of quartzitic Table Mountain Sandstone (Turner pers. obs.). Plants occur in seasonally damp or wet, mostly shady crevices and recesses at the bases of rocks and rock

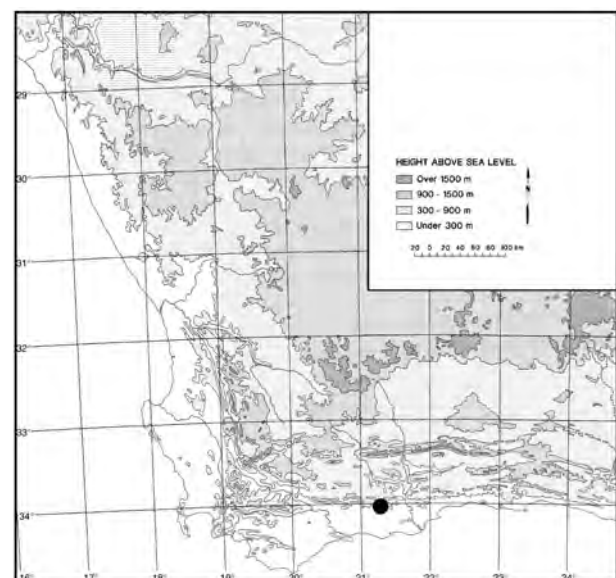


FIGURE 2.—Known distribution of *Erica turneri*.

ledges. This type of microhabitat often provides only a small amount of derived quartzitic sand and darker, peatty, organically derived accumulate in which plants may grow. It is unusual, although not unique, for an *Erica* species with a delicate growth form and markedly open-backed leaves such as *E. turneri*, to inhabit hotter, drier, north-facing mountain slopes, as well as to enjoy a generally north-facing aspect. However, the species grows in seasonally wet or damp, mostly shady crevices and recesses at the bases of rocks and rock ledges, resulting in the majority of specimens receiving potentially direct sunlight only in autumn and midwinter, the period over which the species flowers. Morphologically allied taxa such as *E. oxycoccifolia*, *E. physophylla* Benth. and *E. utriculosa* L.Bolus, which are by contrast confined to damp, shady, montane, south-facing habitats on generally wetter, south-facing slopes, would receive their most direct sunlight as well as optimum moisture availability in spring to early midsummer, the seasons in which their flowering occurs. Although the south and upper north-facing slopes of Zuurbraak Mountain receive much precipitation and resulting seepage, the middle and lower north-facing slopes are comparatively dry.

Stands of *E. turneri* growing in the non-perennial, eastern tributaries of the Klein-Sandrivier do not receive direct runoff or seepage from the wetter, upper slopes, and plants in these more exposed habitats display reddish green leaves and produce flowers with a pink tinge at an earlier stage than well-shaded specimens. Stands growing in the Klein-Sandrivier Kloof enjoy a cooler, moister microclimate and the only south-facing specimens of the entire population are found in this kloof, in a steep, damp side gully. Here plants form low, matted 'hedgerows' at the base of rock faces, individual plants attaining dimensions of up to 450 × 400 mm. Given the populations' general aspect and habitat however (Turner pers. obs.), it is apparent that the species is capable of surviving some relatively dry periods. It is therefore surprising, given its postulated relationship with other species of §*Ceramia*, that in this situation, the species has almost totally open-backed leaves. In its specialized microhabitat, *E. turneri* grows in association with other delicate, lax, shade-loving species such as *Troglophyton capillaceum* (Asteraceae), *Centella macrodis* (Apiaceae) and *Gleichenia polypodioides* (Gleicheniaceae), as well as other moisture-loving species such as *Lobelia neglecta* (Lobeliaceae), *Drosera capensis* (Droseraceae), *Todea barbara* (Osmundaceae), *E. caffra* L., *E. cubica* L., *E. hispidula* L., *E. tenuis* Salisb. (Ericaceae), *Berzelia lanuginosa* and *Raspalia virgata* (Bruniaceae) and several low Restionaceae species. The following species described in this paper, *E. euryphylla*, although growing on the same mountain slope, does not occur in direct association with *E. turneri*. Furthermore, the north- and south-facing slopes of Zuurbraak Mountain together support at least 34 *Erica* species (Turner pers. obs.), nine of these endemic to the Langeberg.

Etymology: this species is named after its discoverer, Ross Turner, who is also the co-author of this paper. He has devoted considerable time and energy to the tracking down, recording and studying of many *Erica* species, especially the rare ones.

Paratype material

WESTERN CAPE.—3320 (Montagu): Langeberg Mountains, Zuurbraak Mountain west of Tradouw Pass; steep gully in Klein-Sandrivier Kloof, above Farm Sandrift, 616 m, (–DC), 26 August 2004, Turner 107 (NBG).

***Erica euryphylla* R.C.Turner, sp. nov.**, foliis 3-natis costa in mediano basique parum crassiore, ramis foliis bractea bracteolisque pilis brevibus sparsis glandulosis et simplicibus, bractea recaulescenti, corolla ± 3–4 × 2.5–3.5 mm pilis brevibus simplicibus et interdum pilis glandulosis, antheris muticis interdum calcaribus minutis, ovario pilis sparsis. Figura 3.

TYPE.—Western Cape, 3320 (Montagu): Swellendam Hiking Trail, in shelter of overhanging rock along path between Boskloof and Goedgeloof huts, Langeberg Mountains, 3500–4000 ft [1 060–1 220 m], (–CD), 5 December 1983, Esterhuysen 36152 (BOL, holo.; NBG, iso.).

Plants up to 300 mm tall, soft, laxly erect, single-stemmed reseeders. **Branches:** several, erect, lax main with short, lax, secondary branches; stems, younger and older with sparse, short, simple and gland-tipped hairs, no infrapetiole ridges, internodes ± 5–10 (–14) mm long. **Leaves** 3-nate, ovate to obovate, 3–5 × 1–3 mm, flat, open-backed, green, abaxially with long, dense, woolly hairs, midrib slightly thickened especially in basal and median portions, adaxially with long, simple and gland-tipped hairs, margins slightly thickened abaxially with long, simple and gland-tipped hairs; petiole ± 0.8–1.0 mm long, yellowish green. **Inflorescence:** flowers (1–)3-nate in 1 to 5 whorls, umbel-like at ends of main and secondary branchlets; pedicel ± 3.5–5.0 mm long, rosy pink, with long, lanate, simple and gland-tipped hairs; bract partially recaulescent, basal to median, when basal leaf-like, ± 2–3 × 1–2 mm, open-backed, green, abaxially with long, woolly, simple hairs and adaxially with long, simple and gland-tipped hairs, when median narrowly obovate, ± 0.7 × 0.5 mm, abaxially glabrous, adaxially with long, simple and gland-tipped hairs and margins with long, simple and gland-tipped hairs; bracteoles 2, ± median, narrowly obovate, ± 0.8 mm long, slightly longer than bract when bract in median position, partially open-backed, abaxially glabrous, margins and adaxial surface with long, simple and gland-tipped hairs. **Calyx** 4-lobed; sepals partially fused at bases, adpressed, narrowly spatulate, ± 1.2–2.0 mm long, open-backed, pink, green apically, abaxially with short, woolly and long, simple and gland-tipped hairs, adaxially glabrous, margins slightly thickened with long, pilose hairs with red apical glands. **Corolla** 4-lobed, open cup-shaped to slightly urn-shaped, 3–4 × 2.5–3.5 mm, viscid, with sparse, simple and occasionally gland-tipped hairs, ± 0.1–0.4 mm long, pale to rosy pink, margins smooth, lobes erect, acute, entire. **Stamens** 8, free, included; filaments linear, ± 1.8 mm long, erect, with a slight apical bend, glabrous, white; anthers basifixed, bipartite, erect, muticous, occasionally with minute, aculeate, spreading appendage near apex of filament, glabrous, golden brown, thecae ± 0.8–1.0 mm long, pores apical, ovoid, ± 0.25–0.32 mm long; pollen in tetrads. **Ovary** 4-locular, ovoid, ± 1 mm long, viscid, green turning red, with short, dense, simple lanate and occasionally gland-tipped hairs; nectaries basal, yellowish green turning red; ovules ± 16 per locule, placenta apical; style simple, ± 3 mm

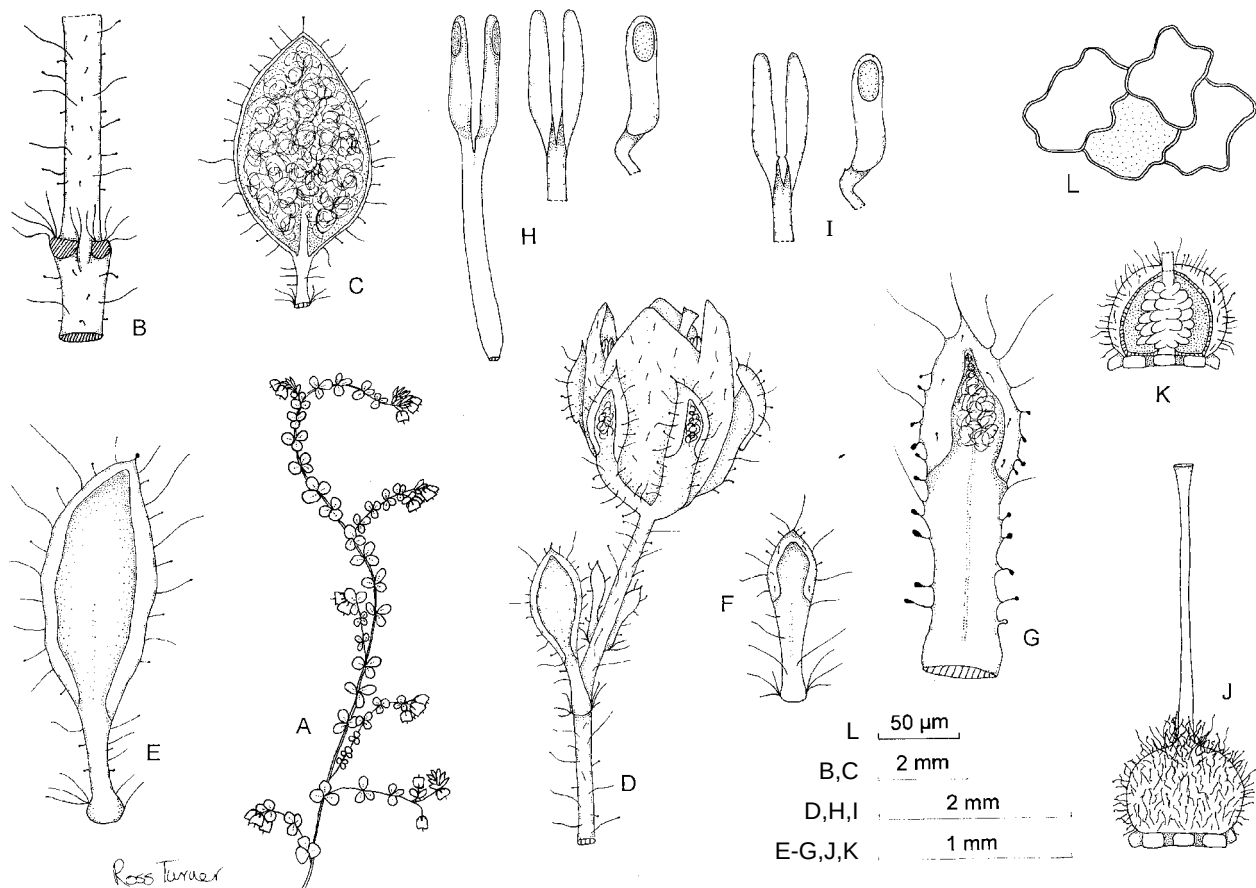


FIGURE 3.—*Erica euryphylla*, Turner 799. A, flowering branch, natural size; B, stem; C, leaf, abaxial view; D, flower; E, bract; F, bracteole; G, sepal, abaxial view; H, stamen, front, side and back views; I, anther, side and back views showing minute appendages; J, gynoecium; K, ovary with one valve removed; L, testa cells. Scale bars: B–D, H, I, 2 mm; E–G, J, K, 1 mm; L, 50 μ m. Artist: R.C. Turner.

long, exserted, glabrous, pink; stigma capitellate, reddish purple. *Fruit* a dehiscent capsule, ± 1 mm long, ovoid, pale brown to cream-coloured with short, lanate hairs, valves spreading to $\pm 45^\circ$, thin, brittle, septa $\pm$ totally on valve. *Seeds* ellipsoid, ± 0.4 mm long; testa smooth, pale creamish brown, cells subequal to slightly elongate, $50\text{--}70 \times 20\text{--}40$ μ m, anticlinal walls slightly thickened, unevenly undulate, inner periclinal walls with numerous small pits. *Flowering time*: May to September. Figure 3.

Diagnostic features and discussion: within §*Ceramia*, *Erica euryphylla* shares several characters in common with species of the *E. cordata* complex, in particular *E. cordata* Andrews, *E. macrophylla* Klotzsch ex Benth. and *E. ocellata* Guthrie & Bolus. These species also possess 3-nate, broad, open-backed leaves with densely woolly abaxial surfaces, adaxial surfaces with long, simple and gland-tipped hairs and a thickened midrib in the basal and median portions but in all instances not protruding beyond the lamina at the apex of the leaf, stems with long, simple and gland-tipped hairs, sepals with red, stalked glands on the margins, glabrous adaxial surfaces, abaxial surfaces with long, simple and gland-tipped hairs, as well as woolly hairs in the sulcus, globose, 4-locular ovaries with lanate hairs, and manifest, muticous anthers. Variation in the anther morphology of *E. euryphylla* has been noted however, with the occasional flower displaying two minute, aculeate, spreading appendages on the margins of the filament just below the attachment to the thecae. These vestiges of appendages are only clearly visible at a

magnification of $25\times$ or more. Such variation pertaining to the presence or absence of anther appendages within a species is not unique, examples being *E. anguliger* (N.E.Br.) E.G.H.Oliv. in which appendages may be present or absent within a single flower (Oliver 2000) and *E. argentea* Klotzsch ex Benth. (Turner in prep.). Significant character differences separating *E. euryphylla* from the *E. cordata* complex include a sparsely hairy, cup- to shortly urn-shaped corolla; variation in the type and placement of the bract on the pedicel (either partially recalcrescent, basal to median and reduced, or partially recalcrescent, basal and leaf-like) and leaves with only very slightly thickened and rolled-under margins as well as less dense, woolly hairs on the abaxial surface. The habit is generally far more lax than those of the compared species, with the exception of *E. ocellata*, which may have a sprawling habit when mature (Turner pers. obs.). Character similarities and differences between *E. euryphylla* and *E. turneri* are discussed under the latter species in this paper.

Pollination syndrome: the pollination syndrome of *E. euryphylla* is unknown. Although the species has mostly muticous anthers, only occasionally displaying minute anther appendages, it does possess well-developed nectaries and a capitellate stigma, suggesting some form of entomophily. A lack of obvious wind-borne pollen discharge when the plants are disturbed, as occurs in wind-pollinated species such as *E. hispidula* L. and *E. muscosa* (Sol.) E.G.H.Oliv., and the colour of the species' flowers, suggest that it is not wind pollinated.

Distribution and habitat: *E. euryphylla* appears to be endemic in the middle and upper north-facing slopes of the Langeberg Range, on Zuurbraak Mountain and in the Marloth Nature Reserve (Figure 4). It was recorded at the latter locality by Elsie Esterhuysen in 1983 on the Swellendam Trail between Boskloof and Goedgeloof huts and by Dave McDonald in 1989 from the western end of the Langkuilen Valley near Misty Point. Both Esterhuysen's and McDonald's specimens were found growing on similar north-facing slopes, in near-identical habitats to specimens from Zuurbraak Mountain—'in shelter of overhanging rock' and 'in deep shade of rocks' respectively, approximately 15 km west of Zuurbraak Mountain. McDonald cited a latitude and longitude with his collection and a projection of this point would appear to place Esterhuysen's collection no more than 2 km distant.

E. euryphylla has been recorded at altitudes between 1 060–1 340 m, always on a substrate of quartzitic Table Mountain Sandstone (Turner pers. obs.). Plants grow in pockets of quartzitic sand and darker, peatty, organically derived accumulate, in seasonally damp or wet, mostly shady crevices and recesses at the bases of rocks and rock ledges. McDonald's specimen indeed cites a substrate of 'light grey soil with humus'. Associated species are similar to those of *E. turneri* above but with *E. ardens* Andrews, *E. triceps* Link and several low Restionaceae species.

The first stand of the Zuurbraak subpopulation of *E. euryphylla* was found by ecologist and walking partner Nick Helme, only minutes after *E. turneri* was discovered by the author of this species.

Etymology: *E. euryphylla* is named for its broad, open-backed leaves from the Greek words, *eurys*, broad/wide, *phyllon*, leaf—a character displayed by only a few *Erica* species.

Paratype material

WESTERN CAPE.—3320 (Montagu): Marloth N.R., Langeberg, western end of Langkuilen Valley on approach to Misty Point, in deep shade of rocks, 1 300 m, (–CD), 22-11-1989, McDonald 1862 (NBG); Zuurbraak Mountain, Langeberg, shady rock crevices on upper north-

facing slopes below summit, 1 287 m, (–DC), 30-08-2003, Turner 794 (NBG); *ibid.*, 1 333 m, 31-08-2003, Turner 799 (NBG); *ibid.*, 1 312 m, 27-07-2004, Turner 1075 (NBG).

ACKNOWLEDGEMENTS

We wish to thank the Western Cape Nature Conservation Board for permission to collect plants in the province and the Buys Family of Sandrivier Farm, Barrydale, for access to their mountain areas. Thanks from the first author are due to Nick Helme for the many and continuing shared journeys made to botanically significant localities throughout the southwestern Cape region, as well as for his willingness to share his extensive field knowledge of the Cape Flora.

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TURNER, R.C. in prep. Studies in *Erica argentea* Klotzsch ex Benth. *Bothalia*.

LIST OF *ERICA* SPP. RECORDED FROM ZUURBRAAK MOUNTAIN

albescens Klotzsch ex Benth.*
anguliger (N.E.Br.) E.G.H.Oliv.
ardens Andrews*
articularis L.
bracteolaris Lam.
brevifolia Sol. ex Salisb.
caffra L.
cerinthoides L.
chartacea Guthrie & Bolus*
conferta Andrews
corifolia L.
cubica L.
curviflora L.
daphniflora Salisb.
denticulata L.
dianthifolia Salisb.
euryphylla R.C.Turner*
gracilis J.C.Wendl.
grata Guthrie & Bolus
hispidula L.
imbricata L.
intermedia Klotzsch ex Benth. subsp. *intermedia**
longimontana E.G.H.Oliv.*
melanthera L.
multumbellifera P.J.Bergius
muscosa (Sol.) E.G.H.Oliv.
ocellata Guthrie & Bolus*
plukenetii L. subsp. *plukenetii*
podophylla Benth.*
polifolia Salisb. ex Benth*
regerminans L.
rosacea subsp. *rosacea* (L.Guthrie) E.G.H.Oliv.
tenuicaulis Klotzsch ex Benth.
triceps Link
turneri E.G.H.Oliv.*
versicolor Andrews

* Langeberg endemic species.

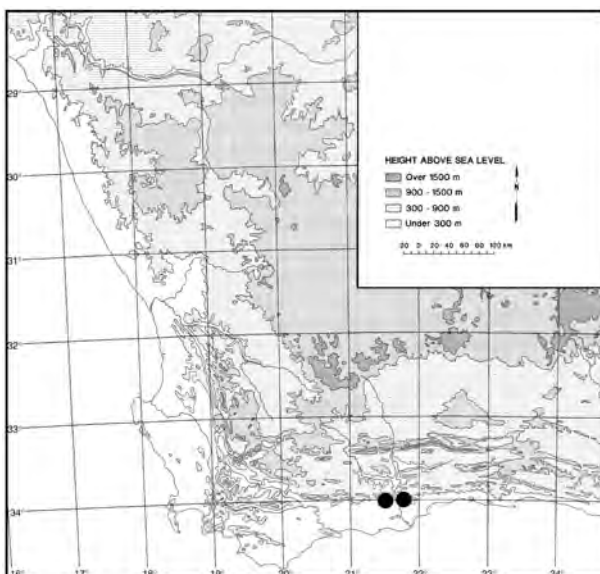


FIGURE 4.—Known distribution of *Erica euryphylla*.

Two new species of *Nemesia* (Scrophulariaceae) from southern Africa

K.E. STEINER*

Keywords: Kamiesberg, Namibia, *Nemesia* Vent., new species, Richtersveld, Scrophulariaceae, seed dimorphism, southern Africa

ABSTRACT

Two new annual species of *Nemesia* Vent. are described from southern Africa. *N. williamsonii* is characterized by bright orange flowers with an inflated yellow palate. It differs from the related *N. maxii* Hiern by having a spur that projects backwards, not downwards, and bracts that are lanceolate with a truncate base, not triangular or cordate. It is unusual for the genus in having dimorphic seeds. *N. williamsonii* occurs almost exclusively in the Richtersveld, but has been collected in a few localities across the Orange River in southern Namibia. *N. hemiptera* is a delicate, wiry-stemmed annual with small white flowers. The flowers are characterized by a tiny nipple-like spur and a seed that is winged on only one side. *N. hemiptera* is endemic to the Kamiesberg from near Garies to Kamieskroon.

INTRODUCTION

Nemesia Vent. is a genus of ± 60 species of annual and perennial herbs endemic to southern Africa (Steiner 1994). It has been over a hundred years since the last revision of the genus (Hiern 1904) and since that time many new species have come to light (Steiner 1989, 1994). A partial revision for species occurring chiefly in KwaZulu-Natal has been published (Hilliard & Burt 1986), but there are many new species that need to be described from the Cape Floral Region and southern Namibia, where $\pm 75\%$ of the species occur. The purpose of this paper is formally to describe two distinctive species, one restricted to Northern Cape and one occurring in the Northern Cape and Namibia.

***Nemesia williamsonii* K.E.Steiner, sp. nov.,** *N. maxi* Hiern proxima, sed differt loborum inferiorum aurantiaco nec rubro, palato majoribus calcare corollae inflexo nec deflexo aut recto et bracteis lanceolatis nec cordatis.

TYPE.—Northern Cape, 2816 (Oranjemund): Richtersveld National Park, road to Kouams Camp, 2.3 km SE of turnoff to Pokkiespram, ± 180 m, (–BB), 28 Sept. 2002, Steiner 3954 (NBG, holo.; CAS, K, iso.).

Annual herb up to 280 mm tall; stems angular in cross section with 4 or 5 sides, up to 2.5 mm wide, corners ridged, glandular pubescent. *Leaves* simple, opposite, mostly sessile, lance-ovate to ovate, $10\text{--}43 \times 5\text{--}20$ mm, sparsely glandular puberulous to nearly glabrous, base rounded to cuneate, apex acute, margins entire to toothed; petioles up to 8 mm long, glandular pilose. *Flowers* axillary or in lax, terminal racemes, racemes up to 150 mm long; bracts alternate, sessile, lanceolate, lowermost leaf-like, uppermost reduced to $\pm 3.6 \times 1$ mm, base truncate, apex acute, margins entire; pedicels $\pm 5\text{--}14$ mm long, glandular pubescent. *Calyx* 5-lobed, central upper lobe $\pm 3.5\text{--}4.1 \times 0.95\text{--}1.00$ mm, lateral upper lobes $\pm 3.3\text{--}3.6 \times 0.8\text{--}1.1$ mm, lower two lobes $\pm 2.8\text{--}3.3 \times 1.0\text{--}1.3$ mm, all lobes lanceolate, acute, sparsely glandu-

lar pilose. *Corolla* bilabiate, $10.1\text{--}16.1 \times 9.6\text{--}14.6$ mm, upper lip four-lobed, two inner (upper) lobes oblong to obovate, $2.7\text{--}5.1 \times 2.8\text{--}3.8$ mm, base strongly oblique, apex rounded to emarginate, two outer (lateral) lobes oblong, $3.1\text{--}5.1 \times 3.2\text{--}4.1$ mm, base strongly oblique, apex rounded to emarginate; upper lip orange (rarely yellow, see Thompson & Le Roux 364) except for a bright yellow patch (2.8×2.8 mm) just above corolla opening, pale orange reverse, lower lip oblong to obcordate, $4.9\text{--}6.7 \times 4.5\text{--}5.6$ mm, orange (occasionally yellow, see Thompson & Le Roux 364), pale orange reverse, basal portion inflated into a convex projecting palate; palate $\pm 2.9\text{--}3.2 \times 3.5\text{--}4.1$ mm, bright yellow, longitudinally grooved, glabrous; hypochile (floor of corolla tube) $\pm 3.1\text{--}3.3$ mm long, sides invaginated to form a narrow channel, base drawn out into a spur, $(2.4\text{--})3.1\text{--}4.2\text{--}(5.3)$ mm long, $\pm$ straight or curving downward in distal third, orange-white. *Stamens* four, whitish, lying in a shallow depression in upper surface of corolla tube; filaments of anticus pair (twisted into posticus position) ± 2.5 mm long, $\pm$ straight, except at base and apex, glabrous or with a few glandular trichomes; posticus filaments ± 0.85 mm long, $\pm$ straight except at base, sparsely glandular pubescent; anthers $0.5\text{--}0.65$ mm long, each pair strongly coherent. *Ovary* oblong-ovate in outline, $1.2\text{--}1.3 \times 1.0\text{--}1.1$ mm, laterally compressed; style ± 0.75 mm, slightly curved, compressed contrary to the ovary, apex wider than base, lying between anther pairs, stigma a crescent-shaped apical band. *Capsules* oblong in outline, $\pm 4.5\text{--}13.1 \times 3.6\text{--}6.9$ mm, laterally compressed contrary to the septum, apex emarginate to bilobed, lobes rounded to acute. *Seeds* dimorphic, plants with either winged or wingless seeds; winged seeds widely ovate, $\pm 1.8\text{--}2.3 \times 1.8\text{--}2.4$ mm, brown, verrucate, wing membranous with numerous parallel, brownish veins, wingless seeds oblong, $\pm 1.5\text{--}1.8 \times 0.8\text{--}1.0$ mm, brown, verrucate. *Flowering time:* June to September. Figure 1.

Diagnostic features: *Nemesia williamsonii* is easily recognized by its bright orange and yellow flowers. It can be distinguished from the similar and related *N. maxii* by its colour (white vs violet), the difference in orientation of the spur, and the shape of the bracts. In *N. williamsonii*, the spur projects straight backwards or back and then downwards distally, whereas in *N. maxii*, the spur

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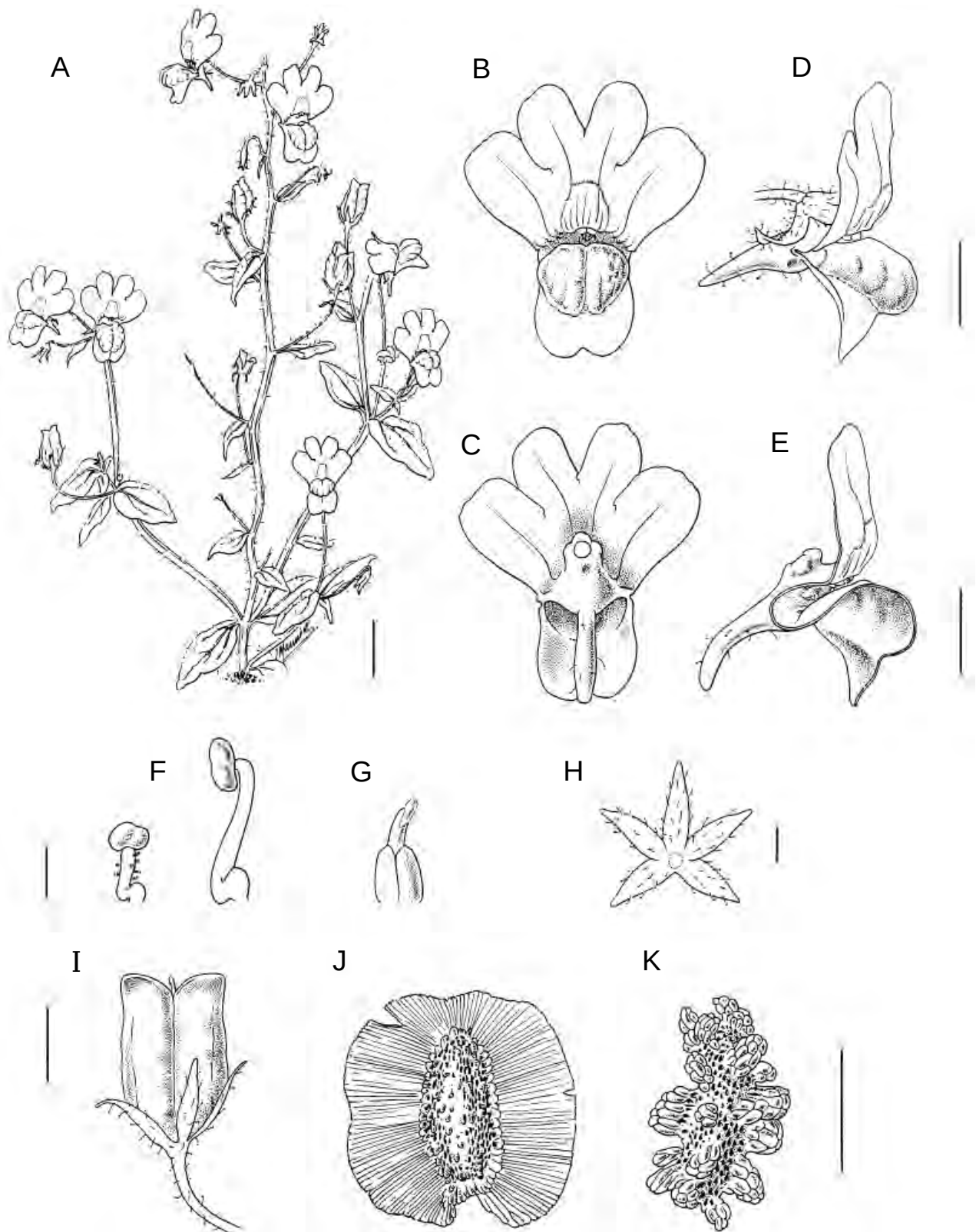


FIGURE 1.—*Nemesia williamsonii*, Steiner 3954 (NBG). A, habit. B–E, flower: B, C, front and rear views; D, E, side views, intact and partially cut away. F, posticus and anticus stamens; G, pistil; H, calyx; I, capsule with calyx; J, K, seed: J, winged type; K, wingless type. Scale bars: A, 10 mm; B–E, 5 mm; F, G, J, K, 1 mm; H, I, 2 mm. Artist: John Manning.

projects straight downwards or down and forwards distally. The bracts of *N. williamsonii* are lanceolate with a truncate base, whereas those of *N. maxii* are triangular or cordate. In some individuals of *N. williamsonii*, flowers

turn blue upon pressing, giving a false impression of the true flower colour. *N. williamsonii* exhibits an interesting seed dimorphism at the plant level, even within a single population. A plant produces either winged or wingless seeds (Figure 1J, K). The wingless seeds, however, are not simply winged seeds that lack the wing. Instead,

there are other morphological features that distinguish the two seed types. The winged seed minus its wing is smaller than a wingless seed. The body of the wingless seed is wider and has much larger and broader verrucae on the seed coat (Figure 1K). A similar dimorphism has been observed in populations of *N. anisocarpa* E.Mey. ex Benth. (W. Metelerkamp unpubl.; K.E. Steiner pers. obs.). The proportion of winged to wingless seeds in populations of these species remains unknown.

Etymology: this plant is named in honour of Dr Graham Williamson who first brought this plant to my attention and who has made a major contribution to knowledge of the natural history of the Richtersveld (Williamson 2000).

Distribution and habitat: *Nemesia williamsonii* is a short-lived annual that comes up sporadically after winter or early spring showers. These showers are often localized, making it difficult to predict where the plants will come up. It is known from the northernmost areas of Northern Cape and adjacent areas in southern Namibia (Figure 2). It has been collected most commonly from the

Richtersveld National Park and from the adjacent Fish River Canyon Park in southern Namibia. Together, these areas now form the Ai-Ais/Richtersveld Transfrontier Conservation Area. In the Richtersveld, the author has observed *N. williamsonii* at the base of small, rocky hills or *koppies* in or adjacent to dry streambeds or drainage lines associated with sandy quartzitic soils. Quartzite pebbles and stones were obvious at the type locality. A few plants were also found associated with a lone *Pachypodium namaquanum* on the slopes of a *koppie*. G. Williamson (pers. comm.) has observed *N. williamsonii* associated with *Pachypodium namaquanum* on south-facing slopes near Oena. He also found (NBG5161) that plants are common in black tillite and on brown-yellow dolomite on the west side of the Dreigratberg.

Like many desert annuals, germination and flowering are largely dependent on localized rainfall patterns. Similarly, the ultimate size of individuals depends, to a large extent, on available moisture and nutrients. The largest individual of *N. williamsonii* at the type locality occurred along the roadside in loose sand. It had obviously received additional rainfall in the form of runoff from the road.

Breeding systems: *Nemesia williamsonii*, like many *Nemesia* species, is self-incompatible. This is based on the absence of capsule formation in cultivated plants. Fruit set in the type locality was good, but no pollinators were observed. Related species with similar looking flowers are pollinated by anthophorid bees (Steiner unpubl.). The spurs of *N. williamsonii* do not secrete nectar, but pollen may act as an attractive food source for the pollinators.

This plant was brought to my attention by Dr Graham Williamson who first encountered it on one of his many excursions into the Richtersveld (Williamson 2000). He showed it originally to Prof. E.A. Schelpe at the Bolus Herbarium at the University of Cape Town, who recognized it as an undescribed species. However, Prof. Schelpe was unable to describe this species before his death and over the years, Dr Williamson made additional collections in the hope that someday it would be described. Although it was clear from herbarium material that this species was new, the author described it only after seeing living material in the field. The annotation '*Nemesia marlothii* Grant' appears on some specimens of *N. williamsonii* at NBG and in the literature (Range 1935), but this is a *nomen nudum*.

Other specimens examined

NAMIBIA.—2717 (Chamaite): hills E of Dabimub River, ± 400 m, (–CC), 4 Sept. 2000, *P. Bruyns* 8865 (NBG); Ai-Ais Reserve, NW of camp, (–CD), 30 June 1986, *Van Jaarsveld* 8786 (NBG); Ai-Ais area, 400 m, (–DC), 26 July 1989, *Oliver* 9153 (NBG); Karibis, Ai-Ais, 800 m, (–DC), Aug. 1909, *Marloth* 4785 (NBG). 2816 (Oranjemund): West Dreigratberg, N of old Sendelingsdrif police post, (–BB), 5 Aug. 1993, *Williamson* 5161 (NBG); Olienhoutplaas, Karagaskloof, 400 m, (–BB), 3 Sept. 1977, *Thompson & Le Roux* 364 (NBG). 2817 (Vioolsdrif): ± 15 km E of Visriviermond on Jan Haak road, (–AA), 7 Aug. 1986, *Williamson* 3551 (NBG); near Aussenkehr, 80 km W of Vioolsdrif, (–AD), 9 Aug. 2000, *Goldblatt & Manning* 11365 (NBG).

NORTHERN CAPE.—2816 (Oranjemund): top of Kodaspiak, (–BB), 20 Sept. 1981, *Van Jaarsveld & Kritzing* 6240 (NBG). 2817 (Vioolsdrif): Likkewaankloof, Richtersveld National Park, (–AA), 23 Aug. 1993, *Zietsman* 2350 (PRE); Abiekwarivier Mountain, (–AC), 20 Aug. 1987, *Jurgens* 22386 (PRE); Rosyntjieberg, close to base,

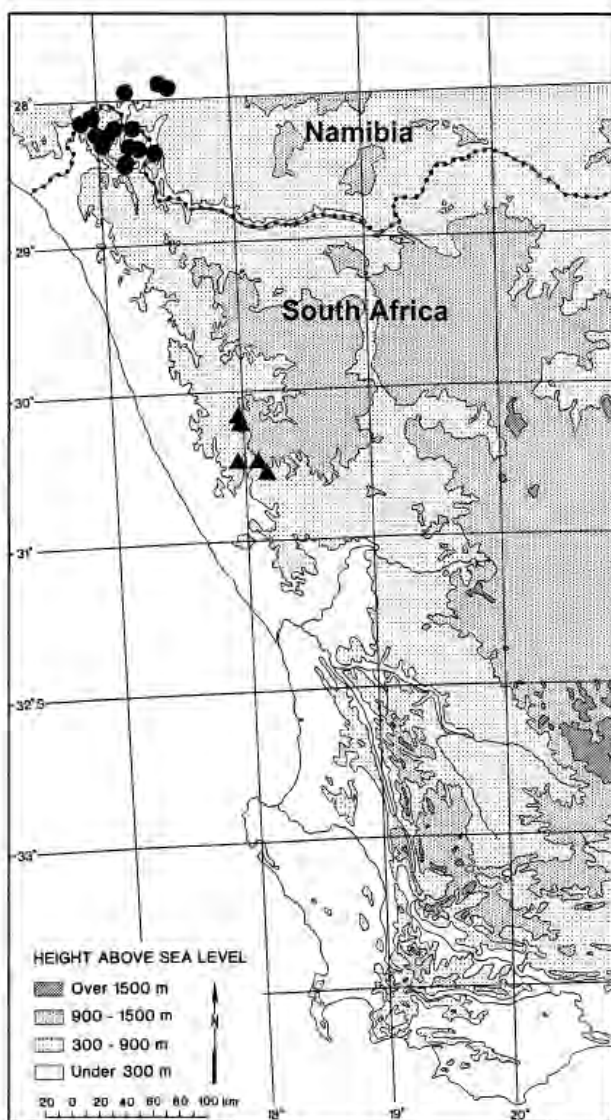


FIGURE 2.—Known distribution of *Nemesia williamsonii*, ●; and *N. hemiptera*, ▲, in southern Africa. Border between South Africa and Namibia is indicated by dotted line.

above Goennakouriep River, (–AC), July 1989, *Williamson 4273* (NBG); Zebra Kloof, just NE of Rosyntjieberg, (–AC), 9 Oct. 1991, *Germishuizen 5582* (PRE); E slope of mountain overlooking Koerogab Vlake, 400 m, (–AC), Sept. 1994, *Williamson 5516* (NBG); Tatasberg River mouth, (–AC), 15 Aug. 1982, *Williamson 3074*; northeastern Richtersveld National Park, De Toon, 500 m, (–AD), Sept. 1994, *Williamson 5519* (NBG); Richtersveld, 10 km W of Springbokvlakte on road to Grasdrift, ± 400 m, (–AD), Sept. 1990, *Williamson 4361* (NBG); Richtersveld, Springbokvlakte, (–AD), July 1989, *Williamson 4272* (NBG); Richtersveld, Tatasberg, Giant's Playground, (–AD), 24 Aug. 1986, *Williamson 3594* (NBG); Richtersveld, Tatasberg (–AD), July 1989, *Williamson 4271* (NBG); Richtersveld, in granite gravel in stream bed below Tatasberg, 400 m, (–AD), Sept. 1990, *Williamson 4360* (NBG).

Locality uncertain: Noaisobis, northern Richtersveld, 3 Sept. 1957, *Herre s.n.* (NBG); Ganaquib, Helskloof, 21 Sept. 1933, *Herre 19005* (NBG).

***Nemesia hemiptera* K.E.Steiner, sp. nov., *N. maxi* Hiern proxima, sed differt florum albo nec rubro, calcarato brevissisimo, seminibus testis in alis expansa unilateribus.**

TYPE.—Northern Cape, 3018 (Kamiesberg): Kamiesberg, Roodeberg's Kloof, 21.3 km from N7 via Farm Doringkraal, 640 m, (–CA), 27 Sept. 2002, *Steiner 3946* (NBG, holo.; CAS, K, iso.).

Annual herb up to 310 mm tall; stems rectangular in cross section, corners ridged, sides up to 0.9 mm wide, minutely glandular pilose, lateral stems up to 250 mm long. *Leaves* simple, opposite, sessile to shortly petiolate; petioles up to 6 mm long, glandular pilose; lamina ovate to lanceolate, 8–21 $\times$ 2–8 mm, subglabrous to sparsely glandular puberulous, base rounded to cuneate; apex rounded to acute; margins entire to shallowly dentate. *Flowers* axillary or in lax terminal racemes, racemes up to 225 mm long; bracts alternate, sessile, lanceolate, lowermost leaf-like, uppermost linear, reduced to $\pm 2 \times 0.3$ mm, base truncate, apex acute; margin entire, glandular pubescent; pedicels ± 5 –14 mm long, glandular pubescent. *Calyx* 5-lobed, spreading, central upper lobe ± 2.6 –2.8 $\times$ 0.6 mm, lateral upper lobes $\pm 2.6 \times 0.5$ –0.7 mm, lower two lobes $\pm 2.2 \times 0.6$ –0.8 mm, all lobes narrowly lanceolate, acute, glandular pilose. *Corolla* bilabiate, 6.2–9.6 $\times$ 6.7–9.1 mm, upper lip four-lobed, two upper lobes oblong to ovate, 3.2–3.7 $\times$ 1.2–2.5 mm, base $\pm$ perpendicular to margins, apex rounded to emarginate, two lateral lobes oblong to elliptic, 3.3–4.4 $\times$ 3.1–3.3 mm, base strongly oblique, apex rounded to emarginate; lobes white except for a brown rectangular nectar guide, $\pm 0.5 \times 0.7$ mm, below sinus of upper two lobes; lower lip with one lobe, widely obovate and emarginate or obcordate, 3.6–5.7 $\times$ 5.0–5.8 mm, white, tube below lip strongly inflated into a convex palate; palate $\pm 2.1 \times 2.8$ mm, white, with dense patch of capitate, non-glandular trichomes at base of palate near corolla opening, hypochile ± 2.4 mm long with a raised central ridge, densely pubescent with clavate trichomes; trichomes on distal $\frac{2}{3}$ of ridge brown, remainder white, base of hypochile drawn out into a short nib-like spur, 0.5–0.8 mm long, entrance to spur flanked by three brown spots visible on outside of corolla around base of spur; inside of corolla tube white with lilac tinge. *Stamens* 4, whitish, lying in a shallow depression in upper surface of corolla tube; filaments of anticus pair (twisted into posticus position) ± 1.6 mm long, $\pm$ straight except at base, glabrous; posticus filaments ± 0.4 mm long, $\pm$ straight except at base, glandular pubescent; anthers

0.4–0.5 mm long, each pair strongly coherent. *Ovary* widely ovate in outline, 0.6–0.7 $\times$ 0.6–0.7 mm, laterally compressed; style ± 0.3 –0.4 mm, compressed contrary to ovary, apex wider than base, lying between anther pairs, slightly deflexed, stigma a crescent-shaped apical band. *Capsules* ovate to oblong in outline, ± 3.4 –4.6 $\times$ 3.5–4.5 mm, laterally compressed contrary to septum, apex emarginate to bilobed, lobes acute. *Seeds* ovate, ± 1.3 –2.0 $\times$ 0.7–1.0 mm, verruculate, winged on one side only, wing membranous, pale brown with numerous parallel veins. *Flowering time*: (July–) August to September (–December). Figure 3.

Diagnostic features: *Nemesia hemiptera* is easily recognized by its small, white flowers with a tiny spur and its seed that is winged on only one side. It can be distinguished from the related *N. maxii* by its colour (white vs violet), the size of the corolla < 10 mm long, the smaller spur (< 1 mm vs > 3 mm).

Etymology: the name refers to its unique, partially winged, seeds.

Distribution and habitat: *Nemesia hemiptera* is a short-lived, wiry-stemmed annual that comes up after winter or early spring showers. It is endemic to Namaqualand and restricted to the Kamiesberg and adjacent rocky hills (Figure 2). It ranges in elevation from about 560 m to 1 250 m. It occurs in sandy, loam soils in Namaqualand Broken Veld, under and around shrubs at the foot of large granite outcrops. Annual rainfall in this area is probably between 200 and 300 mm, but runoff from the surrounding granite outcrops increases the effective rainfall significantly. The late flowering time for this annual is surprising, since the surrounding plants are mostly drying off when these plants flower. Like many annuals from arid areas, the ultimate size of individuals depends to a large extent on available moisture and nutrients. Flowering is largely dependent on localized rainfall patterns.

Breeding systems: based on cultivated specimens transplanted from the field, *Nemesia hemiptera*, despite its small flowers, is self-incompatible. In the wild, it is probably pollinated by small pollen-collecting bees (e.g. halictids or allodapines). The spurs do not secrete nectar, but pollen may serve to lure pollinators to the flowers.

Nemesia hemiptera was first collected by Rudolf Schlechter near Brakdam, ± 16 km north of Garies, on an expedition to Namaqualand that he made with his brother Max in 1897 (Gunn & Codd 1981). Since that time, it has been collected at least a dozen times, but it has never been described formally.

Other specimens examined

NORTHERN CAPE.—3017 (Hondekliptaai): Bowesdorp, (–BB), Aug. 1929, *L. Bolus 19054* (BOL); summit of Sneekop, (–BB), 11 Dec. 1909, *Pearson & Pillans 5818* (K); slopes of Sneekop, NE of Kamieskroon, ± 1 250 m, (–BB), 12 Sept. 1993, *Goldblatt & Manning 9724* (NBG); 4.8 km E of Kamieskroon, 1 090 m, (–BB), 24 Sept. 1948, *Acococks 22616* (PRE); 6.3 km E of Kamieskroon, 1 070 m, (–BB), 27 Sept. 2002, *Steiner 3953* (CAS, NBG); between Garies and Kamieskroon, (–BD), Aug. 1929, *Pillans 6251* (BOL); Brakdam, north of Garies, ± 560 m, (–BD), 7 Sept. 1897, *Schlechter 11103* (PRE); Brakdam, (–BD), 24 Aug. 1941, *Barker 1939* (NBG); Brakdam, (–BD), 4 Sept. 1945, *Barker 3653* (NBG); Garies, (–DB), 24 July 1941, *Esterhuysen 5428* (BOL). 3018 (Kamiesberg): Studer's Pass, 22 km E of Garies, 625 m, (–AC), 27 Aug. 1967, *Thompson 421* (NBG, PRE).

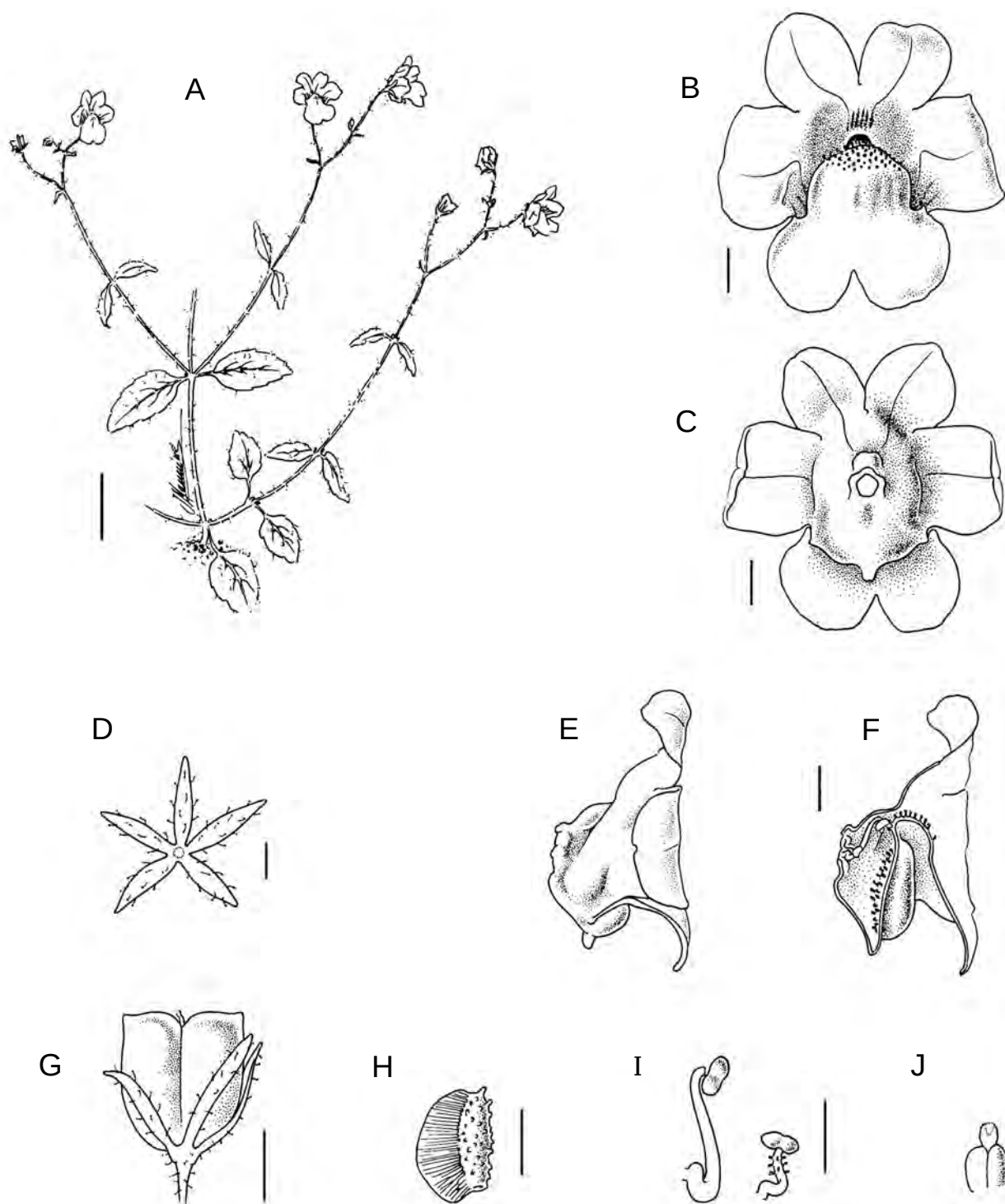


FIGURE 3.—*Nemesia hemiptera*, Steiner 3946. A, habit; B, C, flowers, front and rear views; D, calyx; E, F, flowers, side view, intact and partially cut away; G, capsule with calyx; H, seed; I, posticous and anticus stamens; J, pistil. Scale bars: A, 10 mm; B–F, H–J, 1 mm; G, 2 mm. Artist: John Manning.

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Two new species of *Commiphora* (Burseraceae) from southern Africa

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Keywords: Burseraceae, *Commiphora* Jacq., endemism, Gariep Centre, Kaokoveld, morphology, Namibia, new species, South Africa, taxonomy

ABSTRACT

Commiphora steynii Swanepoel and *C. gariepensis* Swanepoel, here described as new species, are known only from the Kaokoveld and Gariep Centres of Endemism respectively. Illustrations of the plants and distribution maps are provided. Diagnostic characters of *C. steynii* include the pale ashy grey, non-peeling bark and the lack of wart-like projections around the large lenticels. Diagnostic characters of *C. gariepensis* include the stamen number which varies between four and eight, and the milky-watery latex which does not squirt when branches are damaged. When without leaves or fruit, *C. gariepensis* can easily be confused with several other species. Comprehensive tables with diagnostic morphological features to distinguish between the new species and closely related taxa are presented.

INTRODUCTION

Thirty-four species of *Commiphora* Jacq. are presently known from the *Flora of southern Africa* Region of which twenty-six occur in Namibia (Craven 1999; Germishuizen & Meyer 2003; Swanepoel 2005). Ten of these species are more or less restricted to the Kaokoveld Centre of Endemism, northwestern Namibia and four to the Gariep Centre of Endemism along the Namibia-South Africa border (Van Wyk & Smith 2001; Curtis & Mannheimer 2005).

In this contribution, two new species of *Commiphora* are described, *C. steynii* Swanepoel from the Kaokoveld Centre of Endemism and *C. gariepensis* Swanepoel from the Gariep Centre of Endemism. Collections of *C. steynii* were formerly regarded to be conspecific with *C. merkeri* Engl. (Van der Walt 1986) and more recently with *C. viminea* Burt Davy (Coates Palgrave 2002). *C. gariepensis* is a newly discovered, rare species, with a limited geographical distribution.

MATERIALS AND METHODS

Diagnostic morphological features to differentiate between *C. steynii* and *C. viminea* (Van der Walt 1973) and between *C. gariepensis*, *C. oblanceolata* Schinz and *C. dinteri* Engl. (Van der Walt 1974), are presented. Apart from examining the herbarium collections of *Commiphora* in the WIND and PRE herbaria, live material from numerous populations were studied in the field. Unless indicated otherwise, morphological characters were all determined from mature leaves and flowers and from ripe fruit.

Comprehensive comparative tables of salient diagnostic morphological characters to differentiate between *C. steynii* and *C. viminea* and between *C. gariepensis*, *C. oblanceolata* and *C. dinteri* were compiled (Tables 1 & 2). Selected morphological differences between *C.*

steynii, *C. viminea*, *C. merkeri*, *C. habessinica* (O.Berg) Engl. and *C. spathulata* Mattick are presented in Table 3. For *C. steynii* and *C. viminea*, the diagnostic features were determined from herbarium specimens and plants in the field. In addition, some information regarding *C. viminea* was sourced from the literature. Regarding *C. merkeri*, *C. habessinica* and *C. spathulata*, all information presented was sourced from Gillett (1991).

***Commiphora steynii* Swanepoel, sp. nov.**, *C. vimineae* Burt Davy cortice cum lenticellis magnis, ramis ramulisque glabris levibus nitidis, foliis simplicibus vel trifoliolatis similis, sed trunco simplice vel e terra multicaule, cortice sine prominentiis verruciformibus circum lenticellos, non vel exigue deglubenti, foliolis lateralibus usque ad $\frac{2}{3}$ terminalis longitudine, pseudo-arillo carnosio, e basi cum brachiis 4 insignitis differt.

TYPE.—Namibia, 1713 (Swartbooisdrif): Otjirova, south of Steilrandberg, 1 000 m, (–CD), 08-01-2004, *Steyn & Swanepoel 1* (WIND, holo.!, PRE, iso.!).

Illustrations: Steyn: 45, 46 & 87 (2003).

Dioecious small tree up to 3.5 m high, with or without spines; single or multi-stemmed from ground level; trunk and stems cylindrical, up to 200 mm in diam. *Bark* on trunk and older stems pale ashy grey, yellowish grey, greyish brown or khaki, smooth, peeling insignificant, in some specimens peeling in places in small, tough, flake-like pieces or in short, narrow, transverse strips, not papery, occasionally with few dark patches in places, lenticels transversely elongated, often almost completely encircling trunk and stems. *Branches and branchlets* glabrous, smooth, with small lenticels, shiny brown to dark brown, rarely maroon-brown or blackish grey, often with transversely alternating rings of dark and pale bark on older branches, often spine-tipped, spines slender; spines or spine-tipped lateral branchlets rarely in clusters of up to 5 or branched into 2 or 3 spines or spine-tipped lateral branchlets; new growth red or green, often with few glandular hairs, otherwise glabrous; dwarf lateral branchlets often scarred. *Exudate* milky, glutinous, not aromatic, drying to form a soft to hard yellowish cream or caramel-brown resin, often in beads, not transparent.

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TABLE 1.—Salient morphological differences between *Commiphora steynii* and *C. viminea*

Character	States	<i>C. steynii</i>	<i>C. viminea</i>
Habit	Multi-stemmed tree	Often	Never
	Single stemmed tree	Often	Always
Bark	With wart-like projections on stem around lenticels	Never	Always
	Peeling around stem in significant yellow papery strips	Never	Always
	Peeling insignificant	Often	Never
	Smooth	Often	Never
Branches & branchlets			
Spines	Present	Often	Always
	Slender	Always	Never
	Robust	Never	Always
Colour	Brown to dark brown	Usually	Never
	Maroon-brown or blackish grey	Rarely	Never
	Purple	Never	Always
Exudate	Aromatic	Never	Always
Lamina shape			
Simple leaves & terminal leaflets	Obovate or elliptic	Usually	Always
	Broadly oblanceolate or suborbicular	Rarely	Never
Lateral leaflets	Elliptic	Often	Always
	Obovate, lanceolate or oblanceolate	Often	Never
Lamina			
Base pubescence	Long, flexuous hairs	Always	Never
Colour	Glaucous	Often	Always
	Pale green, bright green	Often	Never
Size of lateral leaflets	Length relative to terminal leaflets	Up to two thirds	Up to half
Margin of simple & terminal leaflets	No. teeth on each side	1–15	1–6
Petiole in t/s	Dimensions (mm)	0.9–1.8 × 0.6–1.3	1 × 0.8
	No. vascular bundles	7–15	10 or 11
Inflorescence	Flowers solitary	Rarely	Never
	Clusters	Usually	Always
	Cymes	Rarely	Never
Flowers	Sessile or subsessile	Rarely	Never
	Pedicellate	Usually	Always
Male flowers	On common peduncle	Rarely	Never
Pedicel			
Male flowers	Length (mm)	0.3–5.0	2–10
Trichomes	Glandular hairs	Often	Never
Calyx			
Male flowers	Length (mm)	3.1–4.5	2.0–3.2
Female flowers	Length (mm)	1.6–3.3	1.8–2.5
Trichomes	Scattered short glandular hairs	Often	Never
	Long glandular hairs on lobe margins	Never	Rarely
Calyx lobes			
Male flowers	Length (mm)	0.5–2.0	0.6–0.9
Female flowers	Length (mm)	0.5–1.0	0.6–0.8
Petal shape			
Male flowers	Cultrate, ensiform, linear or oblong	Always	Never
	Narrowly oblanceolate	Never	Always
Female flowers	Linear or oblong	Always	Often
	Narrowly oblanceolate	Never	Often
Disc lobes			
Indentation between lobes	Deep	Always	Never
	Shallow	Never	Always
Male flowers	Deeply grooved on inside	Always	Never
	Shallowly grooved on inside	Never	Often
	Grooved on outside	Never	Always
Female flowers	Bifid at apex	Always	Never
	Grooves on outside limited to apical part	Always	Never
	Grooved on inside	Never	Often
Stamens, long			
	Inserted on outside of disc lobes, just below apex	Always	Never
	Inserted half way up on outside of disc lobes	Never	Always
Filaments: shape over basal part	Flattened & broadened	Never	Always
Anthers			
Long stamens	Length (mm)	0.8–1.6	1.3
Short stamens	Length (mm)	0.7–1.2	0.9
Pistil	Length (mm)	1.7–2.8	3.0–3.4
Stigma	Protruding above petal	Often	Always
	Below top of flower	Often	Never

TABLE 1.—Salient morphological differences between *Commiphora steynii* and *C. viminea* (cont.)

Character	States	<i>C. steynii</i>	<i>C. viminea</i>
Fruit			
Shape	Apex bent over towards sterile locule	Often	Never
Apex	Very apiculate	Never	Always
Putamen			
Shape	Ovoid	Often	Never
Apex	Angle between locules (degrees)	(55–)60–70(–92)	(44–)65–75(–83)
Suture	Rectilinear	Often	Always
	Convex towards fertile locule	Often	Never
Texture	Very rugose on fertile locule	Often	Never
	Slightly rugose	Never	Often
Dimensions	Length (mm)	6.3–8.2 × 3.9–5.9 × 3.5–4.2	6.9–10.2 × 3.3–5.1 × 3.3–4.9
Fertile locule	Narrowly ridged transversely one third from base	Never	Always
Sutural view	Convex	Always	Never
	Triangular	Never	Always
Apical view	Convex	Usually	Often
	Triangular	Rarely	Never
	Rectilinear	Never	Often
Sterile locule: sutural view	Either rectilinear and tapering to apex, rectilinear with 2 (1) humps, rectilinear with indentation in centre	Always	Never
	Triangular	Never	Always
Pseudo-aril			
Shape	Four distinct arms	Always	Never
	All enveloping	Never	Always
Thickness	Membranous	Never	Always
	Fleshy	Always	Never
Colour	Red or orange	Never	Often
	Yellow	Always	Often

Leaves simple or trifoliate; clustered on branches and dwarf lateral branchlets, spirally on shoots; glaucous or pale green with a dullish lustre, bright green when young, occasionally retaining bright green colour, different shades of green occasionally together on same tree but on different branches; simple leaves and terminal leaflets with few glandular and long, shaggy, flexuous hairs adaxially at base, few short, glandular hairs on both sides of lamina, especially adaxially on midrib, very short glandular hairs clustered in corners of serrations and occasionally on lamina margin, otherwise glabrous; lateral leaflets with few glandular hairs adaxially on midrib, with or without long flexuous hairs ad- and abaxially on midrib, short glandular hairs clustered in corners of serrations, otherwise glabrous; minute lateral leaflets with few glandular and long flexuous hairs abaxially, otherwise glabrous; all long flexuous hairs achromatous at first, becoming brown with age; lamina of simple leaves and terminal leaflets usually narrowly obovate to broadly obovate, elliptic to broadly elliptic or rarely broadly oblanceolate or suborbicular, (5–)12–35(–58) × (3–)6–22(–36) mm, apex acute, obtuse, truncate or retuse, minute tip usually acute, base cuneate, acuminate or shortly attenuate onto the petiole; margin usually crenate-serrate with (1–)5–9(–15) teeth on each side, basal third to half usually entire, occasionally crenate-serrate from base, margin occasionally almost entire; lamina of lateral leaflets narrowly elliptic to elliptic or narrowly obovate, often asymmetric especially over basal part, up to two thirds length of terminal leaflets, (2–)4–20(–30) × (1–)2–10(–15) mm, apex acute, base cuneate or acuminate, margin crenate-serrate with (1)2–4(5) teeth on each side, basal third to half entire, margin occasionally almost entire; where clustered, lamina of lateral leaflets very small, lanceolate, oblanceolate or narrowly elliptic, often

asymmetric, (0.5–)5.0–12.0(–15.0) × (0.2–)3.0–6.0(–8.0) mm, apex acute, base cuneate, margin entire; midrib conspicuous abaxially, broadest at base, gradually narrowing towards apex, prominently raised adaxially, less so abaxially, on lateral leaflets often curved, especially over basal part, in minute lateral leaflets often obscure; leaves subsessile or petiolate; petiole with few glandular hairs and long flexuous hairs adaxially, otherwise glabrous, from less than 1 mm up to 5 mm long, crescent-shaped in t/s with 7–15 vascular bundles, sectional dimensions (0.9–)1.1–1.5(–1.8) × (0.6–)0.8–1.1(–1.3) mm; petiolules up to 1 mm long or leaflets sessile.

Inflorescence: flowers borne in clusters, solitary or male flowers rarely in much-reduced, simple or dichasial cymes with peduncle up to 1 mm long; axillary. *Flowers* sessile, subsessile or pedicellate; pedicel often with short glandular hairs; unisexual, hypogynous, precocious or appearing with or after leaves. *Bracteoles and bracts* narrowly triangular, apex acute, with glandular and long hairs, bracteoles up to 1.5 mm long, bracts up to 2.3 mm long. *Calyx* greenish yellow, yellow or greenish red, often with scattered, short, glandular hairs, otherwise glabrous, lobes triangular, apex acute. *Petals* greenish yellow, yellow, greenish red or red, glabrous, recurved towards top but minute tip inflexed. *Disc* cylindrical with 4 distinct lobes, not adnate to calyx or corolla. *Male flowers* 4.9–12.5 mm long; pedicel 0.3–5.0 mm long; calyx 3.1–4.5 mm long; calyx lobes 0.5–2.0 mm long; petals cultrate, ensiform, linear or oblong, 3.0–8.5 × 0.6–1.0 mm; disc with indentation between lobes deep, disc lobes very fleshy, not bifid at apex, deeply grooved on inside over basal part; stamens 8, 4 long ones with filaments 1.4–4.7 mm long, inserted on outside of disc lobe just below apex; 4 short ones with filaments 0.6–2.8 mm long, inserted on outside of disc

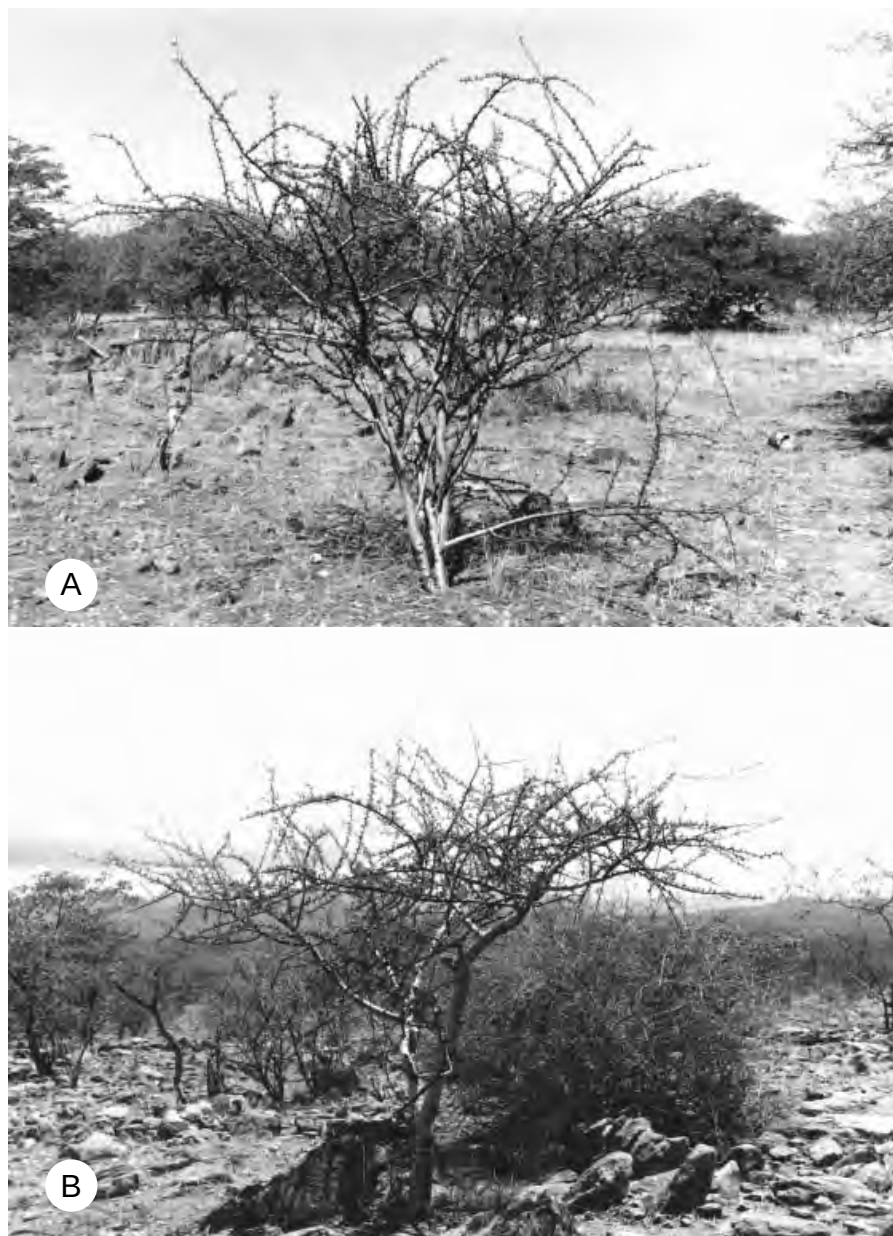


FIGURE 1.—*C. steynii*. A, multi-stemmed tree, 2.5 m tall; B, tree with single stem, 3 m tall.

between lobes; anthers on long stamens 0.8–1.6 mm long; anthers on short stamens 0.7–1.2 mm long, usually 0.1–0.2 mm shorter than anthers on long stamens or anthers rarely equal in size; filaments slender, thread-like, not flattened or broadened over lower part; gynoecium rudimentary. *Female flowers* 3.5–4.7 mm long; pedicel 0.3–0.8 mm long; calyx 1.6–3.3 mm long, calyx lobes 0.5–1.0 mm long; petals linear or oblong, 2.8–4.4 × 0.6–0.9 mm; disc lobes not very fleshy, bifid at apex, grooved on outside over apical part; staminodes 8, 4 long and 4 short; ovary superior; style relatively long, sutures deeply grooved; stigma obscurely 4-lobed, either protruding up to 0.5 mm above petals, level with petals or 1.4 mm below top of flower; pistil 1.7–2.8 mm long.

Fruit a drupe, obovoid, ellipsoid or oblong-ellipsoid, apiculate, slightly flattened, asymmetrical, 10–14 × 8–9 × 7–8 mm, apex occasionally bent over towards sterile locule; pericarp 2-valved; exocarp glabrous, not glutinous, reddish green or red in ripe fruit; mesocarp fleshy; putamen flattened, asymmetrical, ovoid, obovoid, ellipsoid or

oblong-ellipsoid, with one fertile and one sterile locule, rugose; fertile locule often very rugose, 6.3–8.2 × 3.9–5.9 × 3.5–4.2 mm, fertile locule convex in sutural view and convex or triangular in apical view; sterile locule dorsally ridged, variable in sutural view, either rectilinear and tapering to apex, rectilinear with a hump near apex and occasionally with an additional smaller hump near base, or rectilinear with an indentation in centre, triangular in apical view; suture rectilinear or convex towards fertile locule; angle between locules at apex (44–)65–75(–83)°; pseudo-aril greenish yellow or yellow, fleshy, with 4 long narrow arms from base of putamen, commissural arms reaching the 2 large apical pits, facial arms reaching apex, arm on fertile locule usually broader than arm on sterile locule. *Flowering time*: August to March. Figures 1–4.

Diagnostic characters and affinities: *Commiphora steynii* probably is most closely related to *C. viminea* (until recently misidentified as *C. merkeri* in southern Africa), the species with which it has hitherto been confused (Table

TABLE 2.—Salient morphological differences between *Commiphora gariepensis*, *C. oblanceolata* and *C. dinteri*

Character	States	<i>C. gariepensis</i>	<i>C. oblanceolata</i>	<i>C. dinteri</i>
Exudate	Watery	Never	Always	Never
	Milky-watery	Always	Never	Never
	Milky	Never	Never	Always
	Squirts when branches damaged or cut	Never	Always	Never
Lamina shape				
Terminal leaflets	Oblanceolate	Usually	Always	Never
	Cultrate	Rarely	Never	Never
	Obovate	Never	Never	Always
Lateral leaflets	Oblanceolate	Often	Always	Never
	Narrowly elliptic	Often	Never	Never
	Elliptic	Never	Never	Always
	Cultrate	Often	Never	Never
Simple leaves	Lanceolate-oblong	Often	Never	Never
	Oblong	Often	Never	Never
	Narrowly elliptic	Often	Often	Never
	Oblanceolate	Often	Often	Never
	Deeply trilobed	Rarely	Often	Never
	Obovate, elliptic, ovate, cordate, oblate, slightly oblong	Never	Never	Always
Lamina				
Terminal leaflets	Dimensions (mm)	5–36 × 2–13	7–45 × 3–9	6–22 × 4–15
Lateral leaflets	Dimensions (mm)	3–25 × 1–10	8–45 × 3–9	3–12 × 2–9
Margin	Serrate	Often	Never	Never
	Serrate-dentate	Often	Usually	Rarely
	Crenate-serrate	Rarely	Rarely	Usually
Teeth on margin				
Terminal leaflets	No. on each side	3–11	1–45	3–16
Lateral leaflets	No. on each side	2–9	1–38	4–10
Inflorescences	Simple dichasial cymes up to 3 mm long	Often	Never	Never
	Simple dichasial cymes up to 13 mm long	Never	Often	Never
	Thyrsoïd	Never	Rarely	Never
	Clusters	Never	Never	Often
Flowers	Sessile	Often	Never	Never
	Subsessile	Often	Never	Always
	Pedicellate	Often	Always	Never
Petal shape				
Male flowers	Oblanceolate	Never	Often	Often
	Narrowly elliptic	Often	Never	Often
	Narrowly obovate	Often	Often	Never
Female flowers	Oblanceolate	Never	Often	Often
	Oblong	Never	Often	Never
	Lanceolate	Never	Often	Never
	Narrowly obovate	Always	Never	Never
	Narrowly elliptic	Never	Never	Often
Disc lobes				
Male flowers	Distal part not adnate to hypanthium	Always	Never	Always
	Distinctly bifid at apex	Often	Never	Always
	Obscurely bifid at apex	Often	Always	Never
Female flowers	Distinctly bifid at apex	Often	Never	Never
	Obscurely bifid at apex	Often	Never	Always
	Not bifid at apex	Often	Always	Rarely
Stamens	No. per flower	4–8	4	8
Filaments				
Long stamens	Length (mm)	1.1–2.9	0.8–1.9	1.4–2.2
Short stamens	Length (mm)	0.6–1.8	Never	0.7–1.3
Anthers	Length (mm)	0.7–1.3	1.0–1.1	0.6–1.1
Pistil	Glandular	Never	Always	Always
Fruit				
Shape	Globose	Never	Often	Never
	Subglobose	Never	Often	Rarely
	Ovoid	Often	Never	Often
	Ellipsoid	Often	Often	Often
	Obovoid	Never	Rarely	Rarely
Apex	Bent over towards sterile locule	Never	Often	Never
	Apiculate	Never	Often	Usually
Exocarp	Distinctly glutinous	Always	Never	Usually
	Slightly glutinous to non-glutinous	Never	Always	Rarely

TABLE 2.—Salient morphological differences between *Commiphora gariensis*, *C. ob lanceolata* and *C. dinteri*. cont.

Character	States	<i>C. gariensis</i>	<i>C. ob lanceolata</i>	<i>C. dinteri</i>
Putamen Shape	Ellipsoid	Always	Often	Often
	Obovoid	Never	Often	Never
	Ovoid	Never	Never	Often
	Subglobose	Never	Often	Rarely
Apex Suture	Angle between locules (degrees)	70–105	(55–)70–90(–104)	(51–)80–105(–120)
	Convex towards fertile locule	Always	Never	Never
	Rectilinear	Never	Often	Never
	Rectilinear but curved at apex	Never	Often	Always
Texture	Slightly rugose	Always	Often	Always
	Smooth	Never	Often	Never
	Convex	Always	Often	Often
Sterile locule shape: sutural view	Triangular	Never	Often	Often
	Varying from convex at base to concave at apex	Never	Never	Rarely
Pseudo-aril				
Size	Extent of commissural arms relative to length of putamen (pseudo-aril removed) (%)	80–90	72–97	57–95
	Proportion of fertile locule covered by cup (%)	24–30	19–53	15–41
	Proportion of sterile locule covered by cup (%)	40–50	35–70	21–49
Colour	Orange	Always	Often	Often
	Red	Never	Often	Often

1). It also shows morphological resemblance to a number of Central and East African species, in particular to *C. merkeri*, *C. habessinica* and *C. spathulata* (Gillett 1991). *C. steynii* differs from these taxa (Table 3) mainly in habit, bark, exudate, internal features of the flowers, in the fruit and in geographical distribution. *C. steynii* differs conspicuously from *C. viminea* in that its bark does not peel, or peels



FIGURE 2.—*C. steynii*. Bark.

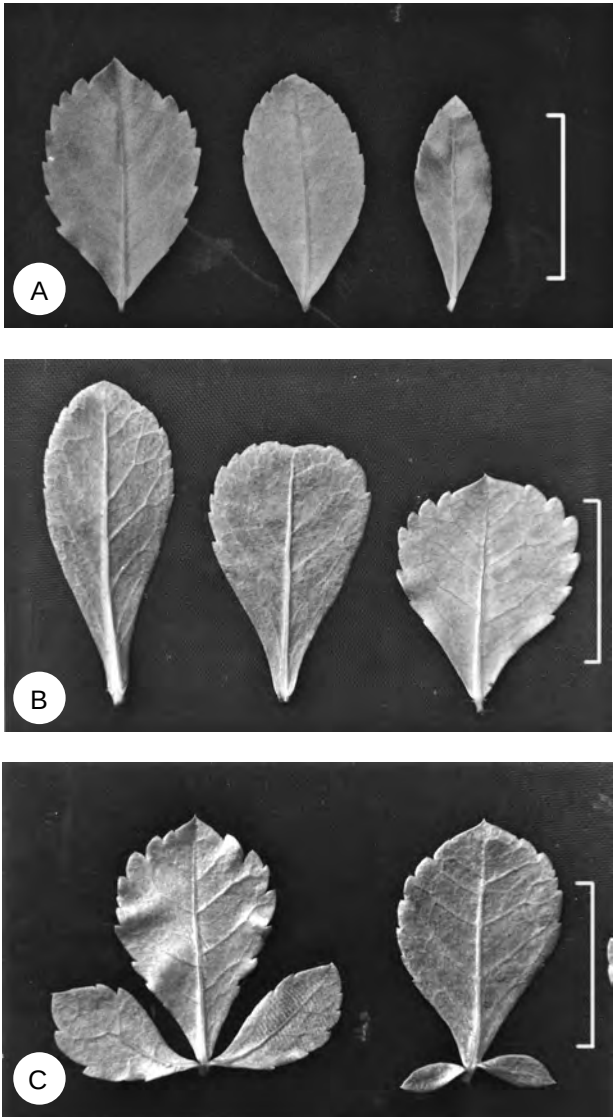


FIGURE 3.—*C. steynii*, leaves: A, B, simple; C, trifoliate. Scale bars: 20 mm.

TABLE 3.—Selected morphological differences between *Commiphora steynii*, *C. viminea*, *C. merkeri*, *C. habessinica* and *C. spathulata*

Character	States	<i>C. steynii</i>	<i>C. viminea</i>	<i>C. merkeri</i>	<i>C. habessinica</i>	<i>C. spathulata</i>
Bark	Peeling significant	Never	Always	Always	Always	Always
Branches & branchlets: colour	Brown	Usually	Never	Never	Never	Never
	Purple	Never	Always	Always	Never	Often
Exudate	Grey	Rarely	Never	Never	Always	Often
	Strongly aromatic	Never	Always	Always	Never	Never
Leaves	Faintly aromatic	Never	Never	Never	Always	Never
	Simple only	Never	Never	Always	Never	Never
	Simple with varying no. trifoliate leaves	Always	Always	Never	Always	Always
Lamina shape	Sub-orbicular	Rarely	Never	Never	Never	Never
Lamina margin on simple & terminal leaflets	No. teeth on each side	1–15	1–5	3–5	6–16	3–6
Inflorescence	Cymes	Rarely	Never	Often	Always	Never
Pedicels: male flowers	Length (mm)	0.3–5.0	2–10	5–6	0–1.5	± 1.0
Calyx: male flowers	Length (mm)	3.1–4.5	2.0–3.2	± 2.6	2.2–2.5	± 1.7
Calyx lobes: male flowers	Length (mm)	0.5–2.0	0.6–0.9	± 0.6	± 0.6	± 0.7
Filaments						
Long stamen	Length (mm)	1.4–4.7	Up to 5.0	3.7	3.5–4.0	2.0
Short stamen	Length (mm)	0.6–2.8	Up to 3.5	2.0	2.5–3.0	1.5
Anthers						
Long stamens	Length (mm)	0.8–1.6	1.3	0.9	0.7	0.7
Short stamens	Length (mm)	0.7–1.2	0.9	0.6	0.5	0.5
Pseudo-aril	All enveloping	Never	Always	Never	Never	Always
	Arm on fertile locule broadest	Never	Never	Always	Never	Never
	Arm on sterile locule shortest	Never	Never	Never	Always	Never
	Facial arms longer than sutural arms and reaching apex	Always	Never	Never	Never	Never

insignificantly only and is without the characteristic wart-like projections around the large lenticels. At a distance, the bark appears pale ashy grey to white. Young branches are brown or blackish grey in colour. In *C. viminea* the bark peels around stems in significant, yellow, papery strips and young branches are purple. *C. steynii* is a small, single or multi-stemmed tree up to 3.5 m tall, with or without slender spines, whereas *C. viminea* is a larger tree up to 5 m tall, single-stemmed, always spinescent with robust spines. In *C. steynii* the exudate is non-aromatic, whereas in *C. viminea* it is aromatic. The lamina margin on simple and terminal leaflets of *C. steynii* are with up to 15 teeth on each side and the lateral leaflets are up to two thirds the length of terminal leaflets. The petiole in *C. steynii* is usually thicker in *t/s*, 0.9–1.8 × 0.6–1.3 mm, and it has 7–15 vascular bundles. In *C. viminea*, the lamina margin on simple and terminal leaflets has only up to 6 teeth on each side and the lateral leaflets are only up to half the length of terminal leaflets, the petiole is usually smaller, 1.0–0.8 mm in transverse section and with 10 or 11 vascular bundles. The flowers and fruit provide additional distinguishing features. In *C. steynii* the pedicel and calyx are often with short glandular hairs and the pseudo-aril is yellow and fleshy, with four long, narrow arms. In *C. viminea* the pedicel and calyx are always glabrous, the putamen has the fertile locule narrowly ridged transversely one third from the base and the pseudo-aril is membranous, yellow, orange or red and covers the stone completely (Table 1). A study of herbarium material in PRE shows that collections from the Zambezi River Valley are true *C. viminea* and not *C. steynii*. These plants also have the typical peeling bark with black patches characteristic of *C. viminea*.

Eponymy: the specific epithet honours Marthinus H.

Steyn, born in 1935, tree enthusiast, amateur botanist, author and publisher of *A field guide, southern Africa*, Commiphora (2003), and various other field guides on southern African trees. Marthinus was the first person to propose that *C. steynii* should be regarded as a distinct taxon (Steyn 2003). I would like to propose the names ring-bark corkwood and *ringbaskanniedood* as the English and Afrikaans vernacular names, respectively.

Distribution: *C. steynii* is only known from the Kaokoveld Centre of Endemism (Van Wyk & Smith 2001), in northwestern Namibia (Figure 5). It most probably also occurs in southern Angola, as it was collected within only 1 km from the Namibian/Angolan border near Ruacana in the Kunene River Valley. *C. steynii* varies from locally common to uncommon or rare within its range. It is absent from many areas with seemingly suitable habitat.

Habitat and ecology: *C. steynii* occurs in the Kaokoveld, including the pro-Namib Desert, the escarpment and to the east on the inland plateau. It occurs 70–260 km from the coast at altitudes of 800–1 200 m, where the annual rainfall is 75–300 mm. It grows mainly in *Colophospermum-Commiphora* woodland, where it prefers rocky areas and mixed soil and gravel substrates on hill slopes and plains. In the extreme south of its range at Palm and Gomakukous, it occurs on Etendeka basalt of the Damaraland Igneous Province. In the Sesfontein area, it grows on sedimentary dolomite and metasedimentary schist of the Damara Supergroup and in the Omuhiva area on calcrete. South of the Steilrandberg and in the Rooidrom area it occurs on quartzite of the Damara Supergroup. In the northeast of its range at Ruacana, it is found on limestone of the Karoo Supergroup (Miller &

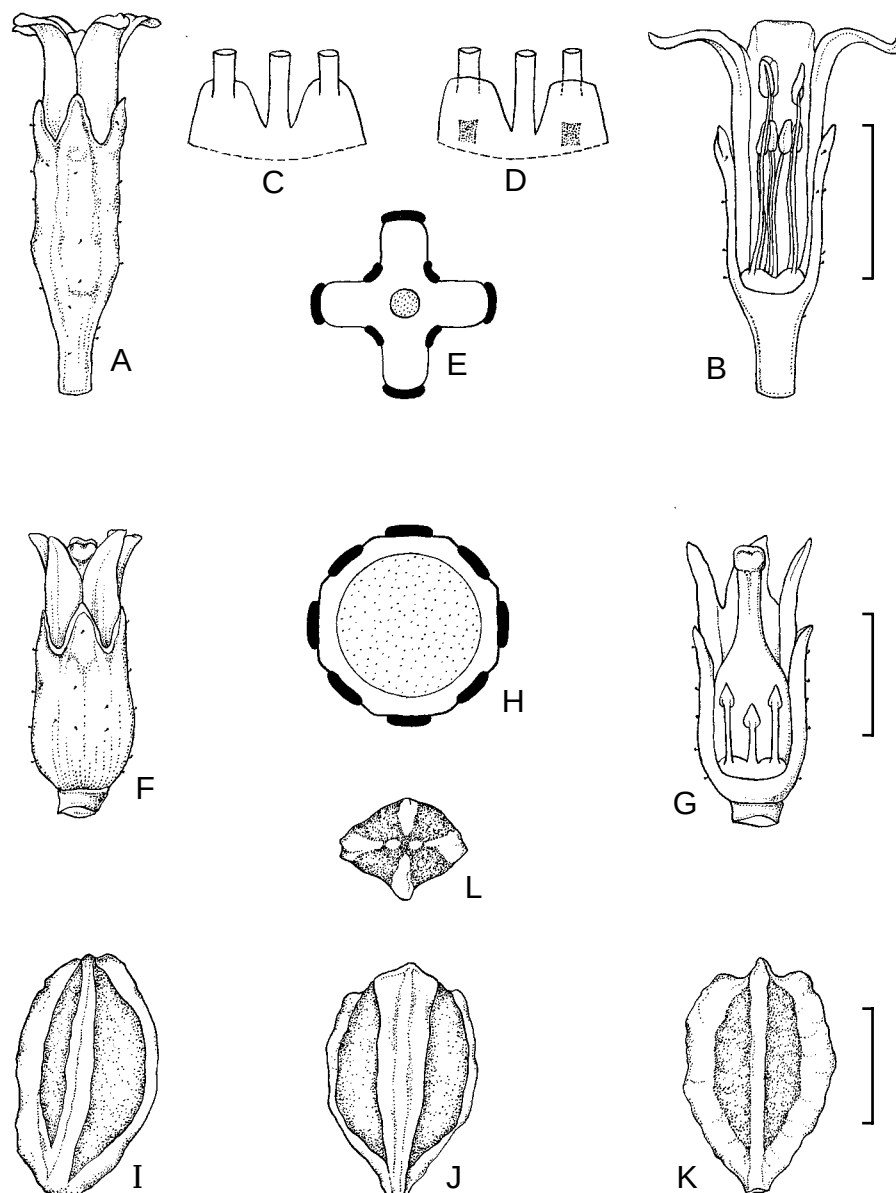


FIGURE 4.—*C. steynii*. A–E, male flower: B, calyx and corolla partly removed. C–E, disc: C, from outside; D, from inside; E, from above to depict position of stamens (black) and rudimentary ovary (circle). F–H, female flower: G, calyx and corolla partly removed; H, disc as seen from above to depict position of stamens (black). I–L, putamen with pseudo-aril: I, lateral view, fertile locule right, sterile locule left; J, fertile locule; K, sterile locule; L, apical view. A, B, *Steyn & Swanepoel* 1; F, G, *Swanepoel* 109; I–L, *Swanepoel* 145. Scale bars: A, B, 5 mm; F, G, 2 mm; I–L, 4 mm. Artist: Charmaine Baardman.

Schalk 1980; Mendelsohn *et al.* 2002).

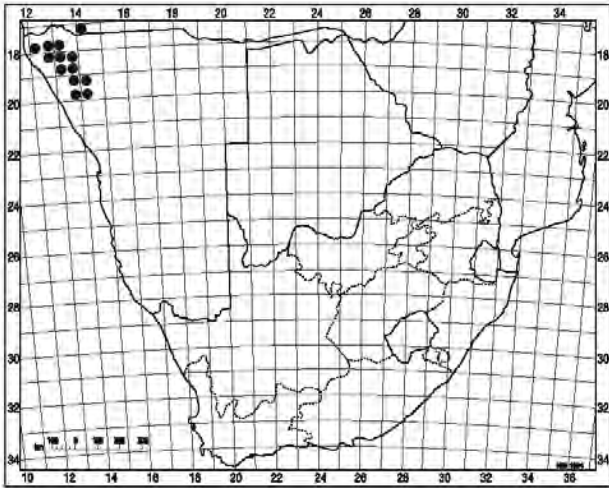
Other specimens examined

NAMIBIA.—1712 (Posto Velho): 5 km W of Rooidrom, (–CD), *Swanepoel* 135 (WIND); 2 km S of Rooidrom, (–DC), *Swanepoel* 109 (WIND). 1713 (Swartbooisdrif): Etanga, (–CC), *Swanepoel* 99, 100 (WIND); 19°50.3' S, 13°16.2' E, (–CD), *Swanepoel* 101 (WIND). 1714 (Ruacana Falls): 8 km W of Ruacana Falls in Kunene River Valley, (–AC), *Swanepoel* 133. 1812 (Sanitatas): between Sanitatas and Otjikongo, (–BA), *Merxmüller & Giess* 1457 (PRE, WIND). 1813 (Opuwo): Omuhiva, (–AD), *Swanepoel* 88 (WIND); along road from Opuwo to Marienfluss via Etanda, (–BB), *Hilbert* 177 (WIND); Outuwo, (–CB), *Swanepoel* 136 (WIND); 13 km SW of Tomakas, (–CC), *Swanepoel* 134 (WIND); 2 km S of Okovikuti, (–CD), *Swanepoel* 141 (WIND); Orurupiza, (–CD), *Swanepoel* 144 (WIND); 3 km S of Robbiespas, (–DA), *Swanepoel* 142 (WIND); Otjikondavirongo, (–DC), *Owen-Smith* 298 (WIND), *Swanepoel* 145 (WIND). 1913 (Sesfontein): 3 km N of Otjondundu Fountain, (–BB), *Swanepoel* 143 (WIND); near Gomakukous on Palmwag to Sesfontein road, (–DB), *Swanepoel* 127 (WIND); 32 km N of Palmwag on Sesfontein road, (–DB), *Swanepoel* 128, 129, 130 (WIND); near Gomakukous, N of Palmwag on Palmwag–Sesfontein road, (–DB), *Swanepoel* 131, 138, 158 (WIND); near Gomakukous, (–DB), *Swanepoel* 137, 139, 140 (WIND). 1914 (Kamanjab): 49 km SE of Sesfontein on road to Otjovasandu, (–AC), *Van der Walt* 239 (PRE, WIND); Farm Palm OU 708, (–CC), *Giess* 7727 (PRE, WIND).

***Commiphora gariepensis* Swanepoel, sp. nov.**, *C. oblanceolatae* Schinz habitu et foliis plerumque trifoliatis cum paucis simplicibus similis; exsudato lacteo-aquoso, non emicanti ubi rami laesi vel secti, foliolis terminalibus oblanceolatis ve; cultratis, lateralibus oblanceolatis, anguste ellipticis vel cultratis, lamina pro ratione latiori, staminibus 4–8 in quoque flore differt.

TYPE.—Namibia, 2819 (Ariamsvlei): escarpment of Blydeverwacht Plateau, 31 km SSW of Ariamsvlei, 950 m, (–BD), 09-12-2003, *Swanepoel* 148 (WIND, holo.!; PRE, iso.).

Dioecious shrub or small tree, 0.6–3.0 × 0.7–2.2 m; trunk short, branching repeatedly above ground level into thick stems with succulent appearance; younger branches slender. *Bark* greenish brown, greenish grey or pale grey with small dark spots and longitudinal, narrow, dark markings in places, transverse folds at base of stems and at bends of older branches, usually with few parallel longitudinal ridges on stems and older branches in places, otherwise smooth, not peeling. *Branches* glabrous with few small lenticels, glutinous when young, not spine-

FIGURE 5.—Known distribution of *C. steynii*.

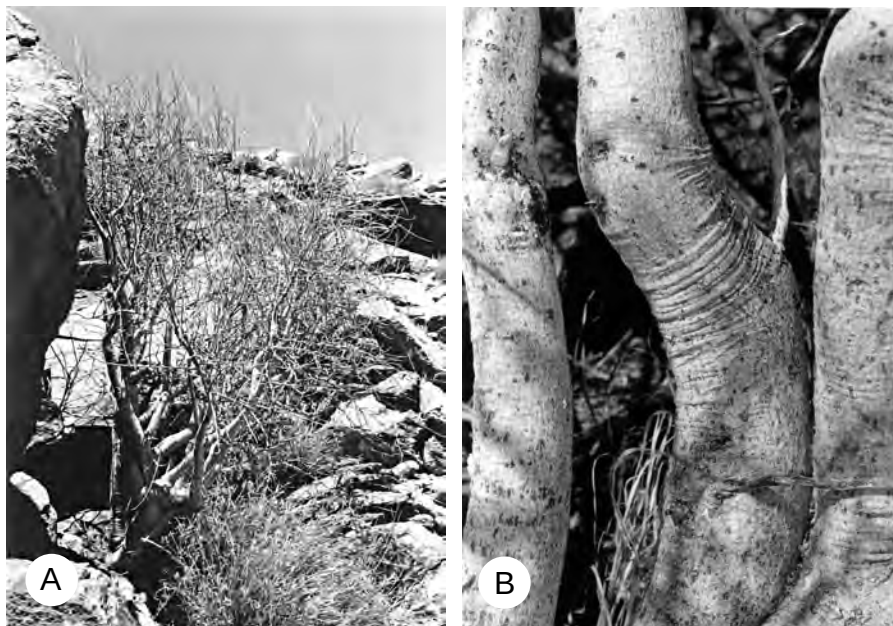
tipped. *Exudate* watery-milky (initially watery, followed by a milky secretion), not squirting upon branches or branchlets being damaged or cut, glutinous, aromatic, forming a soft, transparent, pale cream-yellowish resin.

Leaves trifoliolate with in addition a few scattered, simple and occasionally few, intermediate leaves, clustered on dwarf lateral branchlets, spirally on shoots, glabrous, green; lamina of terminal leaflets oblanceolate or rarely cultrate, (5–)10–18(–36) × (2–)4–8(–13) mm, apex acute to obtuse, base cuneate or slightly acuminate; lamina of lateral leaflets narrowly elliptic, oblanceolate or cultrate to broadly cultrate, often asymmetrically, up to (50–)60–70(–100)% as long as terminal leaflet, (3–)6–14(–25) × (1–)3–6(–10) mm, apex acute to obtuse, base cuneate or slightly acuminate; lamina of simple leaves lanceolate-oblong, oblong, narrowly elliptic, oblanceolate or deeply trilobed, (10–)12–18(–20) × (5–)6–8(–10) mm or when trilobed (10–)17–26 (–30) × (15–)19–23(–26) mm, apex acute to obtuse, base cuneate or obtuse; margin serrate, serrate-dentate or rarely crenate-serrate or margin rarely subentire with teeth on terminal leaflets 3–7(–11), on lateral leaflets 2–6(–9) and on simple leaves 5–9(–13) on each side, entire near base; midrib either

slightly raised, plane or sunken ad- and abaxially; petiole usually slightly grooved adaxially especially over basal part, 1–18 mm long on trifoliolate and 1–8 mm long on simple leaves, variable in t/s: circular, reniform, elliptic, triangular, crescent-shaped or pentagonal with 3–5 vascular bundles, sectional dimensions (0.4–)0.6–0.7(–0.9) × (0.4–)0.5–0.6(–0.7) mm, leaflets sessile or subsessile.

Inflorescence: flowers borne in much reduced or short simple dichasial cymes, up to 3 mm long, glandular, or flowers solitary, axillary. *Flowers* sessile, or when solitary, subsessile or pedicellate, unisexual, perigynous, appearing before leaves and often continuously while in leaf. *Bracteoles* ovate, up to 0.4 mm long, apex acute, glandular. *Calyx* green, continuous with hypanthium, glandular otherwise glabrous, lobes triangular to ovate, apex acute. *Petals* green to yellowish green, occasionally sparsely glandular, otherwise glabrous, narrowly elliptic or narrowly obovate, recurved apically but the minute tip inflexed, inserted on hypanthium. *Disc* cylindrical, with 4 fleshy lobes, adnate to hypanthium but distal part of lobes free. *Male flowers* 2.6–4.7 mm long with pedicel up to 0.3 mm long; calyx 2.1–3.3 mm long; calyx lobes 0.8–1.3 mm long; petals 2.6–4.8 × 0.8–1.6 mm; disc lobes with apices distinctly to obscurely bifid; stamens 4–8, 4 long ones with filaments 1.1–2.9 mm long, inserted on top of disc lobes, 1–4 short ones with filaments 0.6–1.8 mm long, inserted on top of disc between lobes, short stamens rarely completely absent; anthers 0.7–1.3 mm long, equal in length on short and long stamens; filaments rarely flattened and broadened over lower part; gynoecium rudimentary. *Female flowers* 2.5–4.0 mm long; pedicel up to 0.7 mm long; calyx 2.3–2.9 mm long; calyx lobes 0.8–1.0 mm long; petals 1.3–2.5 × 0.7–1.2 mm; disc lobes distinctly bifid to entire; staminodes present; ovary half inferior; style variable in length from relatively short to relatively long, sutures deeply grooved; stigma obscurely 4-lobed; pistil with stigma from 0.9 mm below top of flower to level with top of flower, 1.7–2.4 × 0.9–1.2 mm.

Fruit a drupe, ovoid or ellipsoid, 8.2–9.3 × 6.7–7.4 × 5.6–6.0 mm, flattened, asymmetrical, pericarp 2-valved;

FIGURE 6.—*C. gariepensis*. A, natural habitat, tree ± 2.5 m tall; B, bark.

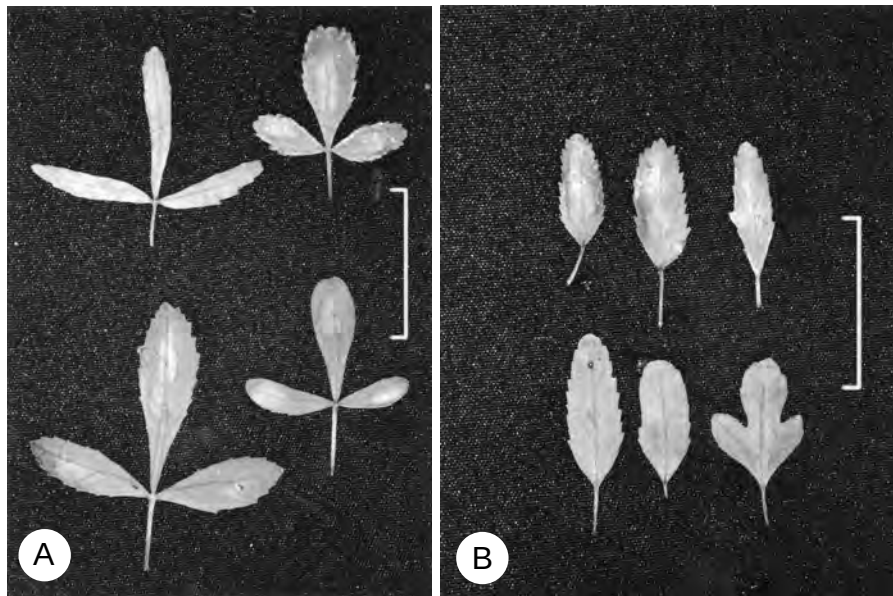


FIGURE 7.—*C. gariepensis*, leaves: A, trifoliolate; B, simple. Scale bar: 20 mm.

exocarp glabrous, glutinous, green, greenish brown or red when ripe; mesocarp not very fleshy; putamen flattened, asymmetrical ellipsoid with one fertile and one sterile locule, $6.8\text{--}7.4 \times 4.8\text{--}5.2 \times 3.9\text{--}4.3$ mm, slightly rugose; fertile locule convex in sutural and apical view; sterile locule convex in sutural view, convex or triangular in apical view, often broadly ridged dorsally; suture convex towards fertile locule, especially towards apex; angle between locules at apex $70\text{--}105^\circ$; pseudo-aril orange, fleshy, cupular, covering 24–30% of fertile locule and 40–50% of the sterile locule, with 2 commissural arms and short facial lobe on sterile locule, extent of commissural arms relative to length of putamen (with pseudo-aril removed) 80–90%, facial lobe convex or triangular, 0.6–0.8 mm long, apical pits small. *Flowering time*: September to February. Figures 6–9.

Diagnostic characters and affinities: *C. gariepensis* has the same habit as *C. oblancoolata* and *C. gracilifrons* Dinter ex J.J.A. van der Walt, but differs from them mainly in the shape of the leaves, in the morphology of the flowers and in the type of exudate. All three of these taxa have trifoliolate leaves, but *C. gariepensis* and *C.*

oblancoolata have simple leaves in addition. Trifoliolate leaves in *C. gariepensis* have the lamina on terminal leaflets oblanceolate or rarely cultrate with up to 11 teeth on each side of the margin, whereas the lamina in lateral leaflets is narrowly elliptic, oblanceolate or cultrate to broadly cultrate with up to nine teeth on each side of the margin. In *C. oblancoolata* the lamina on both terminal and lateral leaflets is always oblanceolate, with up to 45 and 38 teeth respectively on each side of the margin. In *C. gracilifrons*, the linear or cultrate leaflets, very variable in size and form, distinguish it from the other two taxa. The leaves of some specimens of *C. gariepensis* and *C. gracilifrons* resemble each other superficially (Figures 7 & 8). However, the leaves of *C. gariepensis* are broader than those of *C. gracilifrons* for corresponding length. In *C. gariepensis* the flowers are borne in much reduced or short cymes up to 3.0 mm in length, in *C. oblancoolata* in thyrses or cymes up to 13 mm long and in *C. gracilifrons* on cymes up to 50 mm long. The flowers of *C. gariepensis* have 4–8 stamens per flower, whereas those of *C. oblancoolata* and *C. gracilifrons* have four stamens only. Unlike *C. oblancoolata* and *C. gracilifrons*, the latex of *C. gariepensis* is milky-watery (not watery) and does not squirt when branches or branchlets are damaged or cut. When without leaves or flowers, *C. gariepensis* is virtually indistinguishable from *C. gracilifrons* with which it shares the same habitat. The only notable difference then between the two taxa, is the milky-watery exudate which does not squirt in *C. gariepensis*, as opposed to being copious and only watery in *C. gracilifrons*. Although they share the same habitat throughout the known range of *C. gariepensis*, *C. gracilifrons* is common and much more widespread. Some specimens of *C. gariepensis* could easily be mistaken for *C. oblancoolata* due to the similarity of the leaves. However, the geographical distribution of the two taxa differs markedly, *C. gariepensis* being restricted to the Gariep Centre of Endemism and *C. oblancoolata* to the northern Central Namib and the Kaokoveld Centre of Endemism (Van der Walt 1986). Herbarium specimens of *C. dinteri* and *C. gariepensis* with leaves only, could also be confused. However, the leaves of *C. dinteri* are $\pm$ twice as broad as those of *C.*

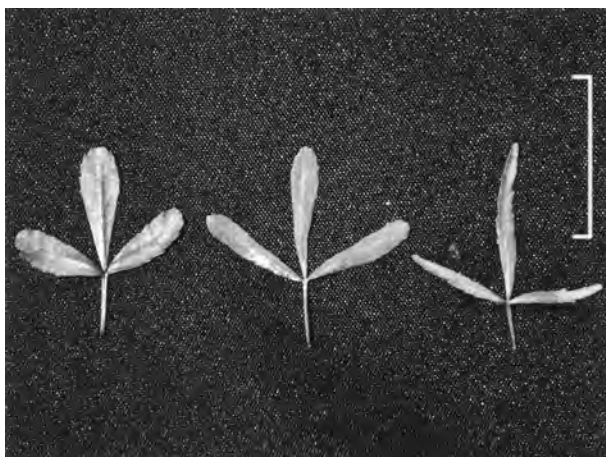


FIGURE 8.—Trifoliolate leaves: left, *C. gariepensis*; centre, *C. oblancoolata*; right, *C. gracilifrons*. Scale bar: 20 mm.

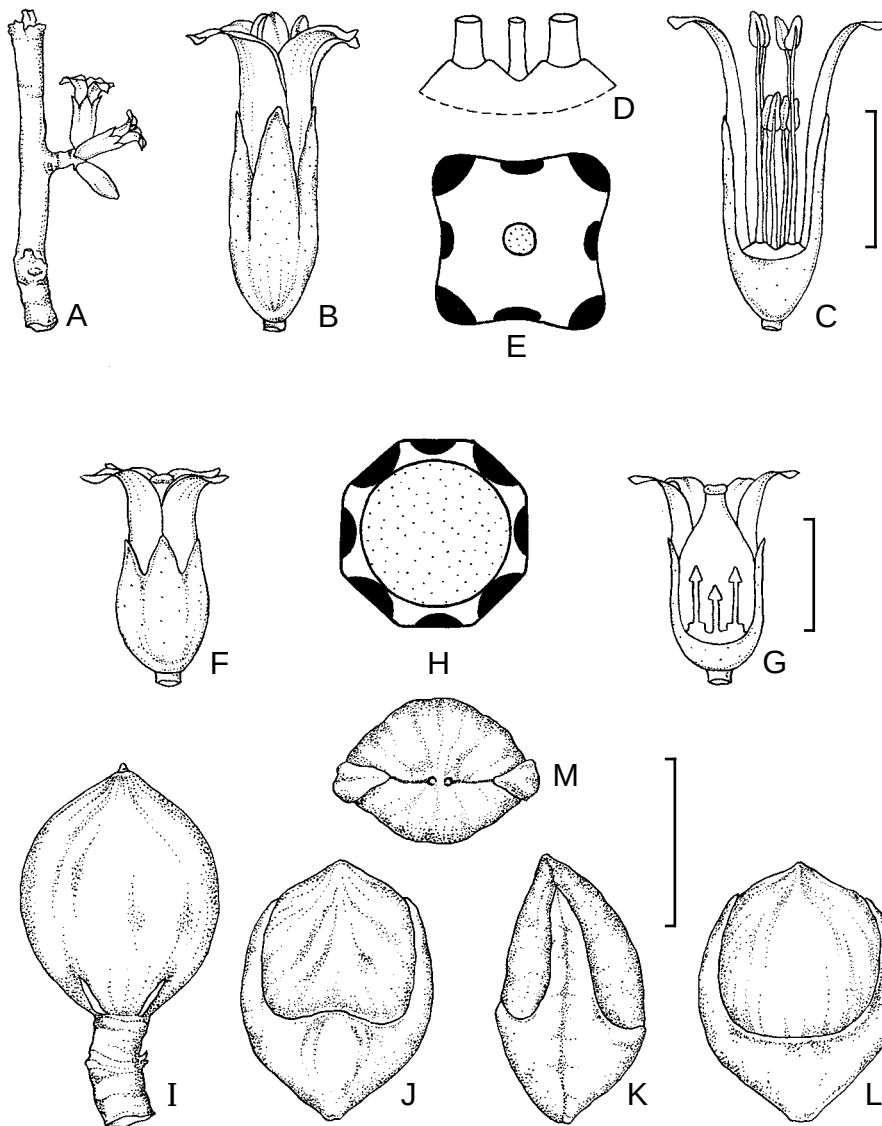


FIGURE 9.—*C. gariepensis*. A, male inflorescence. B–E, male flower: C, calyx and corolla partly removed; D, disc, depicting insertion of stamens; E, disc as seen from above to depict position of stamens (black) and rudimentary ovary (circle). F–H, female flower: G, calyx and corolla partly removed; H, disc as seen from above to depict position of stamens (black). I, fruit. J–M, putamen with pseudo-aril: J, sterile locule; K, lateral view, fertile locule right, sterile locule left; L, fertile locule; M, apical view. A–C, Swanepoel 148; F, G, I–M, Swanepoel 157. Scale bars: B, C, F, G, 2 mm; I–M, 5 mm. Artist: Charmaine Baardman.

gariepensis for corresponding length. The distribution of the two taxa does not overlap, with *C. dinteri* occurring from south central Namibia northwestwards (Van der Walt 1986). For a comprehensive comparative table of diagnostic characters to differentiate between *C. gariepensis*, *C. ob lanceolata* and *C. dinteri* see Table 2.

Etymology: the specific epithet refers to the Gariep Centre of Endemism along the lower Orange River in western southern Africa, the region to which *C. gariepensis* is endemic. *Gariep* is the Khoekhoe name for the Orange River. As English and Afrikaans vernacular names, I propose Gariep corkwood and *Gariep-kanniedood*, respectively.

Distribution: *C. gariepensis* is known from three localities, all within the Gariep Centre of Endemism. It is rare in these areas, growing in loose colonies of a few plants each, in association with *C. gracilifrons* (Figure 10).

Habitat and ecology: habitat preferences of *C. gariepensis* are quite specific. It occurs in the hot, arid Orange River Valley, at altitudes of 300–1000 m, where the annual rainfall is 50–150 mm, at the base of rocky outcrops and on rocky slopes of escarpments

and river valleys. It is restricted to biotite rich gneiss of the Namaqua Metamorphic Complex/Province at the Blydeverwacht Plateau and at the Bak River, and to the gneisses of the Haib Group along the Goodhouse Poort (Miller & Schalk 1980; Van der Walt 2000; Mendelsohn et al. 2002).

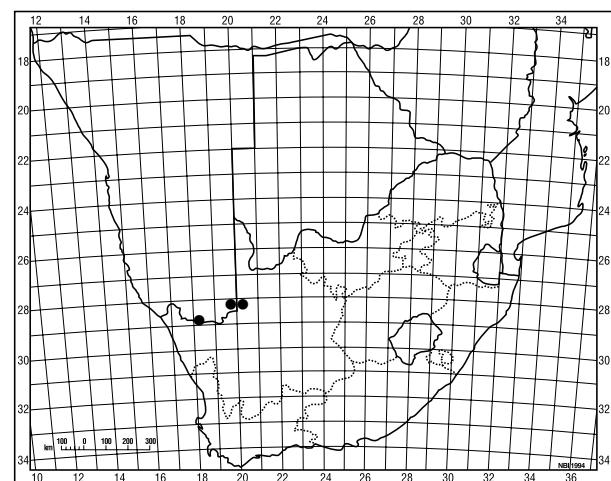


FIGURE 10.—Known distribution of *C. gariepensis*.

Other specimens examined

NAMIBIA.—2818 (Warmbad): near river, road D208, (–CC), *Mannheimer CM 2318* (WIND); up valley off road D208, (–CD), *Mannheimer CM 2312* (WIND). 2819 (Ariamsvlei): 32 km SSW of Ariamsvlei at base of rocky outcrop, escarpment of Blydeverwacht Plateau, (–BC), *Swanepoel 146* (WIND); 31 km SSW of Ariamsvlei on hill slope, escarpment of Blydeverwacht Plateau, (–BD), *Swanepoel 98, 147, 157* (WIND).

NORTHERN CAPE.—2820 (Kakamas): slopes of Bak River Valley, 21 km SW of Naroegas Station, (–AC), *Swanepoel 149* (PRE); slopes of Bak River Valley 22 km SSW of Naroegas Station, (–AC), *Swanepoel 150* (PRE).

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Notes on the systematics and nomenclature of *Tritonia* (Iridaceae: Crocoideae)

P. GOLDBLATT* and J.C. MANNING**

Keywords: Iridaceae, southern Africa, systematics, *Tritonia* Ker Gawl., *Tritonia crispa* (L.f.) Ker Gawl., *Tritonia flava* (Aiton) Ker Gawl., *Tritonia securigera* subsp. *watermeyeri* (L.Bolus) J.C.Manning & Goldblatt, *Tritonia undulata* (Burm.f.) Baker

ABSTRACT

Study of some early types of species now known to belong to the genus *Tritonia* Ker Gawl., a member of Iridaceae, subfamily Crocoideae, comprising some 28 species of southern and south tropical Africa, has shown the need for some nomenclatural adjustments. *Ixia undulata* Burm.f. (1768) is an earlier name for *T. crispa* (L.f.) Ker Gawl. based on *Gladiolus crispus* L.f. (1782) and the combination *T. undulata* (Burm.f.) Baker must be used for the species, which is native to the western half of Western Cape, South Africa. The variety *T. crispa* var. *parviflora* is also reduced to synonymy. The type specimen of *Ixia gladiolaris* Lam. (1789), currently considered a synonym of *Tritonia securigera* (Aiton) Ker Gawl., has flowers that lack the characteristic tooth-like ridges on the lower tepals of the latter, and corresponds closely to the eastern southern African *T. lineata* (Salisb.) Ker Gawl., based on *Gladiolus lineatus* Salisb. (1796). The new combination *T. gladiolaris* (Lam.) Goldblatt & J.C. Manning is made and *T. lineata* is reduced to synonymy. *Montbretia lacerata* and *Tritonia lacerata*, erroneously regarded as synonyms of *T. crispa*, are combinations based on *Gladiolus laceratus* Burm.f., a species that remains unidentified because no type is known and the description is too vague to permit its identification. Lastly, field studies have shown that the crisped-leaved *T. watermeyeri* is connected by a series of morphological intermediates to typical *T. securigera*, which has straight leaves and identical flowers. The new combination *T. securigera* subsp. *watermeyeri* (L.Bolus) J.C.Manning & Goldblatt is proposed for this taxon.

INTRODUCTION

Our continuing studies of the systematics and biology of the African Iridaceae led us to examine type material of several species thought to belong to the genus *Tritonia* Ker Gawl. but excluded by De Vos (1982, 1983) from her revision of the genus as insufficiently known because of the difficulty in relating type material to any known species. Among the names in question are *Gladiolus flavus* [Sol. in] Aiton (1789), *G. laceratus* Burm.f. (1768), *G. undulatus* Burm.f. (1768), and *Ixia gladiolaris* Lam. (1789). The type of *Ixia gladiolaris* is what is currently called *Tritonia lineata* (Salisb.) Ker Gawl., which thus becomes *T. gladiolaris*. *Gladiolus flavus* was based on a specimen of *T. flabellifolia* (D.Delaroche) Ker Gawl., to which it is now assigned as a later synonym. The type of *G. undulatus* matches *T. crispa* (L.f.) Ker Gawl. The latter, based on *G. crispus* L.f. (1782), closely resembles the shorter-tubed *T. crispa* var. *parviflora* Baker, and the species must therefore be known by the earlier name *T. undulata*, a combination made by Baker in 1877. We have, however, failed to locate authentic material that can be associated with *G. laceratus* and this species must continue to be excluded from *Tritonia*. Taxonomic adjustments required as a result of our investigation are made below. Lastly, new collections of *T. securigera* (Aiton) Ker Gawl. have led us to re-examine the distinction between this species and the western Little Karoo plants referred to as *T. watermeyeri*. The latter species, defined by its crisped and undulate leaves, is now known to be connected by a series of intermediates to the widespread *T. securigera*, which has plane leaves but flowers identical to those of *T. watermeyeri*. We conclude that it

is most appropriate to treat the latter as a subspecies of *T. securigera*.

1. ***Tritonia flabellifolia*** (D.Delaroche) G.J.Lewis in Journal of South African Botany 7: 30 (1941). *Ixia flabellifolia* D.Delaroche: 24 (1766). Type: South Africa, without precise locality or collector (L.–Herb. Van Rooyen, neo.), designated by Goldblatt & Barnard 1970: 310).

Gladiolus flavus [Sol. in] Aiton: 65 (1789). *Tritonia flava* (Aiton) Ker Gawl.: 228 (1804). Type: South Africa, without precise locality, cultivated in Great Britain, Paterson s.n. (BM, holo.), syn. nov.

The type of *Gladiolus flavus* is readily identified as a specimen in the British Museum (Natural History) collected in early bloom (Figure 1). The long-tubed flowers are quite evident, and the characteristic dry, brown, long-attenuate and acuminate bracts immediately identify the plant as the Western Cape species, *Tritonia flabellifolia*. This plant has white to cream-coloured flowers and it is puzzling that Solander, who drew up the description, should have called it *G. flavus* (actually describing the flower as intensely yellow). Possibly the flower buds were sufficiently cream-coloured for him to have thought they deserved the epithet he chose. Despite the apparent inconsistency in flower colour we are confident that *G. flavus* is a synonym of *T. flabellifolia*.

2. ***Tritonia gladiolaris*** (Lam.) Goldblatt & J.C.Manning, comb. nov.

Ixia gladiolaris Lam., Encyclopédie méthodique 3: 341 (1789). Type: South Africa, Cape of Good Hope, cultivated in Paris, flowering March and April, original collector unknown (P.–Herb. Lamarck, holo.).

Gladiolus lineatus Salisb.: 40 (1796). *Tritonia lineata* (Salisb.) Ker Gawl.: 228 (1804); M.P.de Vos: 369 (1983); M.P.de Vos: 111 (1999). *Montbretia lineata* (Salisb.) Baker: 169 (1877). *Tritonixia lineata* (Salisb.) Klatt: 357 (1882). Type: South Africa, without precise locality, grown at the Royal Botanic Gardens, Kew in 1781 (BM, lecto., designated by M.P.de Vos 1983: 371), syn. nov.

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FIGURE 1.—Holotype of *Gladiolus flavus* [Sol. in] Aiton (BM).

Ixia gladiolaris, represented by a single sheet in the Herbarier Lamarck in the Laboratoire de Phanerogamie, Paris, was included in the synonymy of *T. securigera* by De Vos (1983, 1999) in her accounts of *Tritonia*. The narrowly sword-shaped leaves have prominent submarginal veins, and the four or six flowers on the two preserved spikes have large, firm, dry bracts that are rust-coloured in the upper half. The flowers still show the rather prominent darker venation on the tepals characteristic of the genus, particularly of *T. lineata*, as well as the low, thickened ridges (raised, yellow, truncate scales according to Lamarck) on the lower tepals. Lamarck described the corolla as orange or yellow, lightly flushed with red. The association by De Vos (1983, 1999) of *Ixia gladiolaris* with *T. securigera* is refuted by two features: the presence of prominent submarginal veins on the leaves,

and the low ridges on the lower tepals. The leaves of *T. securigera* have no obvious submarginal veins and the lower tepals of the flower bear large, tooth-like ridges, 3–4 mm high, that resemble elaborate axeheads.

We regard the type and associated description of *Ixia gladiolaris* as representing one of two largely eastern southern African species, either *Tritonia disticha* (Klatt) Baker or *T. lineata*. Both these species have leaves with prominent submarginal veins, unusual in *Tritonia*, and flowers with low median ridges on the lower tepals. The two species are distinguished largely by flowering time, flower size and perianth colour (De Vos 1999): *T. disticha* blooms in summer, mainly January to March, and has red to pink (or rarely yellow) flowers 20–30 mm long, whereas *T. lineata* flowers earlier, mainly September to

November, and has yellow to apricot (pale orange) flowers (25–)30–40 mm long. *Ixia gladiolaris* most closely matches the latter morphologically and is evidently also early flowering. Plants grown in Paris bloomed in spring, March and April in the northern hemisphere, whereas we would expect *T. disticha* to flower in June or July, even under glass. *I. gladiolaris* is an earlier name for *T. lineata*, which thus falls into synonymy under the new combination *T. gladiolaris*.

3. ***Tritonia undulata* (Burm.f.) Baker** in Journal of the Linnean Society 16: 163 (1877). *Ixia undulata* Burm.f.: 1 (1768). *Tritonixia undulata* (Burm.f.) Klatt: 357 (1882). Type: South Africa [Western Cape], without precise locality, collector unknown (G-BU, holo.!).

Gladiolus crispus L.f.: 94 (1782). *Tritonia crispa* (L.f.) Ker Gawl. 18: t. 678 (1803); M.P.de Vos: 144 (1982); M.P.de Vos: 99 (1999). Type: South Africa [Western Cape], without precise locality, A. Sparrmann s.n. (LINN 59.18, holo.–microfiche!), syn. nov.

Tritonia crispa var. *parviflora* Baker: 192 (1892); M.P.de Vos: 149 (1982); M.P.de Vos: 100 (1999). Type: South Africa [Western Cape], Winterhoek, Tulbagh, C.L. Pappe s.n. (K, holo. not seen), syn. nov.

The identity and generic disposition of *Ixia undulata*, described by N.L. Burman in 1768, has proved enduringly controversial. It was referred to *Tritonia*, as *T. undulata* by Baker (1877), and remained so treated in *Flora capensis* (Baker 1896). Klatt (1882), however, referred *I. undulata* to his new genus *Tritonixia*, a segregate of *Tritonia* erected for the shorter-tubed members of the genus (but including the type of *Tritonia*, *T. crocata*). Brown (1929) actually made a new combination, *T. undulata*, because although Baker had already made the same combination, he had included plants of *Ixia crispa* L.f. (now *I. erubescens* Goldblatt) under the same.

Later, Lewis (1962) in her monograph of *Ixia* excluded *Ixia undulata* from that genus but did not explicitly say to what genus she thought the plant belonged. Then, De Vos (1983, 1999) excluded the species from *Tritonia* in her accounts of the genus, commenting that although it superficially resembled a *Tritonia*, the short, stout anthers recalled *Ixia* subgenus *Dichone*, although the funnel-shaped tube did not. She therefore suggested that the type might represent a hybrid between *I. crispa* and *I. vanzijliae* M.P.de Vos.

We have examined the type specimen of *Ixia undulata*, a single plant without a corm, in the Burman Herbarium at Geneva (Figure 2), and are amazed that its identity could have caused such confusion. It is an exact match for plants from the Tulbagh District of Western Cape, referred by both Baker (1892, 1896) and De Vos (1983, 1999) to *Tritonia crispa* var. *parviflora*. The leaf margins are tightly crisped and the entire blade is loosely undulate and twisted, while the salver-shaped flower has a narrow, almost cylindric (not funnel-shaped as De Vos stated) perianth tube, ± 18 mm long with [apparently] spreading tepals, stamens with filaments exserted ± 5 mm from the tube, and anthers ± 3 mm long.

We have no hesitation in regarding *Ixia undulata* as conspecific with *Tritonia crispa* (basionym *Gladiolus crispus* L.f. (1782)). *I. undulata* is the earlier name, and *T. crispa* now falls into the synonymy of *T. undulata*.

We also question the merit of recognizing infraspecific taxa in this species. Perianth tube length is variable, ranging from 18–85 mm across its range. Flowers with the longest tubes are recorded from the Olifants River Mountains (85 mm in Goldblatt & Manning 10345, NBG), south to Joostenberg (60 mm in Lewis 5901, NBG). Plants with shorter-tubed flowers, 25–40 mm long, occur inland and in the south, as at Sir Lowry's Pass (35–40 mm in Barker 3378, NBG), and Somerset West (25–30 mm in Lewis 5675, NBG). Some plants from the Tulbagh Valley fall at the lower extreme of the range with a tube 22–25 mm (Hansford 4 from Welgelegen House, NBG). In contrast, plants from the slopes of Roodezandberg, not far from Tulbagh, have a tube ± 50 mm long (Compton et al. 1882/36, NBG). The pattern is not entirely clear but there is a trend for shorter tubes in populations in the south and interior of its range and any division into subspecific taxa based on tube length would be arbitrary. Tube length is closely associated with the local pollinators, long-proboscid flies (Manning & Goldblatt 1997). Where the long-proboscid species *Moegistorhynchus longirostris* occurs within the range of *T. undulata*, the perianth tube is longest but inland and on the Cape Peninsula where *M. longirostris* does not occur, shorter-proboscid flies, presumably either *Philoliche gulosa* or *P. rostrata*, are the inferred pollinators. Predictably, tube length tracks the proboscis length of the pollinator, a situation that has been documented in *Disa draconis* and *Geissorhiza confusa* (Johnson & Steiner 1997). We therefore include var. *parviflora* in *T. undulata*.

4. ***Tritonia lacerata* (Burm.f.) Klatt**, Ergänzungen und Berichtigungen zu Baker's Systema Iridacearum. Abhandlungen der Naturforschenden Gesellschaft zu



FIGURE 2.—Holotype of *Ixia undulata* Burm.f. (G-BU).

Halle 15: 358 (1882). *Gladiolus laceratus* Burm.f.: 2 (1768). *Montbretia lacerata* (Burm.f.) Baker: 168 (1877). Type: unknown, not in G-BU (Brown 1929) or L (J.Veldkamp pers. comm.).

No type for this species, described by Burman fil. in 1768, has ever been identified, and the description is too brief to permit its association with any known species. Baker (1877), who referred the species to *Montbretia* (now included in *Tritonia*), believed it to be an earlier name for *T. crispa*, now *T. undulata*. Both Baker and Klatt, who made the combination in *Tritonia*, are silent on their reasons for identifying Burman's species as a *Tritonia*. In her most recent account of *Tritonia*, De Vos (1999) placed *Montbretia lacerata* Baker (sic) and *T. lacerata* (Baker) Klatt (sic) as synonyms of *T. crispa*, and designated the type of *T. crispa* as the lectotype of *M. lacerata*. She thus ignored the fact that Baker's name is a combination based on Burman's *Gladiolus laceratus* (and thus has no type of its own but is nomenclaturally identical to *G. laceratus*). De Vos did not specifically deal with the identity of the latter. In our search for type material we have confirmed that no type is located at G (Herb. Burman) or L (the Leiden Herbarium), the only places where it is likely to be preserved.

5. *Tritonia securigera* (Sol. in Aiton) Ker Gawl. in Annals of Botany 1: 228 (1804); M.P.de Vos: 384 (1983); M.P.de Vos: 115 (1999). *Gladiolus securiger* Sol. in Aiton: 65 (1789). Type: South Africa, without precise locality or date, cultivated at Chelsea Gardens in 1778, F. Masson s.n. (BM, lecto., designated by De Vos 1983).

Ixia thunbergii Roem. & Schult.: 391 (1817), replacement name for *I. squalida* Thunb. in Hoffmann, Phytogeographische Blätter: 4 (1803), nom. illeg. non Aiton (1789). Type: South Africa, Cape of Good Hope, without precise locality, Thunberg s.n. (UPS-Herb. Thunberg 996, microfiche!).

There is no question about the identity of the type of this predominantly Little Karoo species, to our knowledge first collected by Masson and Thunberg in the early 1770s. Masson's collection was later grown at the Royal Botanic Gardens, Kew, where plants in flower were described as *Gladiolus securiger* a decade later by Solander for Aiton's *Hortus kewensis* (Aiton 1789). Plants of the same collection were illustrated in *Curtis's Botanical Magazine* in 1797 under that name (Ker Gawler 1797) but the species was later transferred to *Tritonia* (Ker Gawler 1804).

Distinctive features of the species, in the narrow sense, are a basal fan of firm, plane leaves (4–)6–12 mm wide with acute tips, a typically unbranched stem (robust plants may have one or more lateral branches), and an erect spike of (3)4–8 orange, rarely yellow, and evidently unscented flowers. The dorsal tepal is largest, 16–18 × 13–15 mm, and the lower tepals each bear a pronounced bright yellow median tooth, ± 4 × 2.5 mm, shaped like an axehead (*securiger* is Latin for axe-bearer). These teeth, called calli in the early literature and calluses by De Vos (1982, 1983, 1999) in her accounts of *Tritonia*, are not unique to the species but are frequent in *Tritonia*. They are particularly well developed in most species of section *Montbretia*, but in the remaining sections usually form low, thickened ridges, and are not developed at all in some species, such as *T. tugwelliae* L.Bolus. The teeth

are especially well developed in *T. securigera* and its western Little Karoo relative, *T. watermeyerii* L.Bolus. In fact there is little difference between the flowers of the two taxa, apart from the slightly smaller tepal teeth (± 3.0 × 1.3 mm) and faint woody scent in *T. watermeyerii*. The major difference between the two are in their leaves, and the crisped and undulate leaf blades of *T. watermeyerii* contrast strikingly with the plane leaves of typical *T. securigera*. Scent in flowers of Iridaceae is notoriously variable, even within a species (Goldblatt & Manning 1998) and little reliance can be placed on it alone as a specific character.

The distinction between *Tritonia securigera* and *T. watermeyerii* becomes even less clear when plants with flowers matching the two species from sandy habitats in the Anysberg and at the foot of the Little Swartberg in the western Little Karoo are taken into consideration. These plants are often dwarfed, up to 0.6 m high, and have either fairly soft-textured, undulate leaves (Goldblatt & Porter 12060, NBG, from the foothills of the Little Swartberg), or narrow, twisted leaves with straight to slightly crisped margins (Martin 60, NBG, from Anysberg Nature Reserve) while the spikes may have 1–3 flowers in the most dwarfed individuals, or up to 4 flowers in taller plants. Both *T. securigera* and typical *T. watermeyerii* are usually taller plants, at least 150 mm high, and grow on shale slopes. The plants with undulate leaves seem perfectly intermediate between typical examples of *T. securigera* and *T. watermeyerii* and maintenance of the latter as a separate species seems arbitrary. Existence of plants with leaves of intermediate form, either undulate or loosely twisted, make it more appropriate to treat *T. watermeyerii* as a subspecies of *T. securigera*. Typical *T. securigera* ranges widely through the southern Cape, from the Touwsberg in the western Little Karoo to Bedford in the Eastern Cape, whereas subsp. *watermeyerii* is restricted to the extreme west, between Montagu and Anysberg (Figure 3).

subsp. ***watermeyerii*** (L.Bolus) J.C.Manning & Goldblatt, comb. et stat. nov.

Tritonia watermeyerii L.Bolus in Annals of the Bolus Herbarium 4: 44 (1926); M.P.de Vos: 395 (1983). Type: South Africa [Western Cape], allegedly Vanrhynsdorp, without date, *Watermeyer s.n.* (BOL18050, holotype!).

Specimens examined

WESTERN CAPE.—3320 (Montagu): Allemorgens, 1 km N of T-junction near Syfer-se-Kop on road to Bloutoring, red sandy loam, (–CB), 7 Sept. 1979, *Malan 112* (NBG); 8 km from Montagu on road to Ouberg Pass, (–CB), 27 Sept. 1981, *Perry 1682* (NBG); 26 Sept. 1995, *Goldblatt & Manning 10329* (MO, NBG). 3321 (Ladismith): sandy slopes north of Anysberg, (–BC), 18 Aug. 2002, *Goldblatt & Porter 12066* (MO, NBG, PRE); Anysberg Nature Reserve, NW boundary, (–BC), 3 Sept. 1989, *Martin 60* (NBG); Laingsburg–Ladismith road, E of Anysberg turnoff, (–BD), 17 Aug. 2002, *Goldblatt & Porter 12060* (MO, NBG). Without precise locality: Hoëveld naby Touwsrivier, Apr. 1930, *Huysteen s.n.* (NBG179592).

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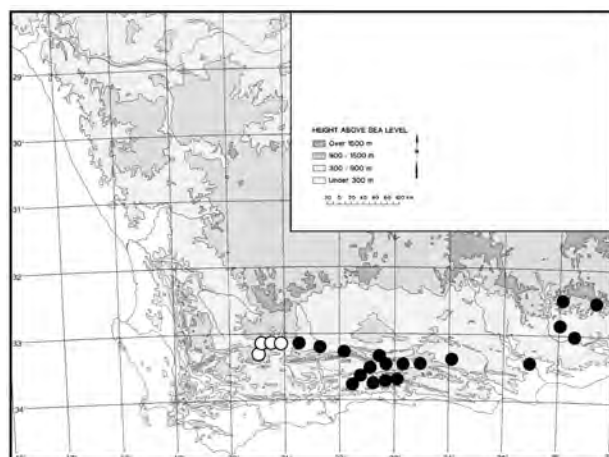


FIGURE 3.—Distribution of *Tritonia securigera* subsp. *securigera*, ●; and subsp. *watermeyeri*, ○.

helped us identify *Ixia gladiolaris* in the Herbarium Lamarck at P; and J. Veldkamp, Leiden Herbarium, for searching for a possible type of *Gladiolus laceratus*. We are also grateful to Mary Stiffler who cheerfully helped solve bibliographic questions and provided copies of numerous articles not readily available to us.

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Notes on African plants

VARIOUS AUTHORS

APOCYNACEAE

NEW RECORDS OF *ADENIUM BOEHMIANUM* IN THE FSA REGION

Currently four species of *Adenium* Roem. & Schult. are recognized for the *Flora of southern Africa* (FSA) region, namely *A. boehmianum* Schinz, *A. multiflorum* Klotzsch, *A. oleifolium* Stapf and *A. swazicum* Stapf (Codd 1963; Victor *et al.* 2003). In the region, *A. boehmianum* has a northwestern distribution and the other species a central to eastern distribution (Figure 1). *A. boehmianum* was previously only known from the northern parts of Namibia and extending just over the border into Angola. In May 2005, Mr J.H. Vahrmeijer gave a specimen to PRE (Vahrmeijer HV00702), collected at the 'Sonop Koppies' near the northwestern border of the Central Kalahari Game Reserve in Botswana on 15 April 2005. At the time, it was thought to be the first collection of this taxon from Botswana.

On further investigation, Ms Q. Turner from the Botswana National Herbarium (GAB) informed me of another collection of *Adenium boehmianum* from Botswana (M. Kabelo 2), collected on 17 February 2005, at the base of the Pimple hill in the vicinity of the Tsau Hills. This locality is near to that of the Vahrmeijer specimen.

Setshogo (2005) listed this taxon for Botswana, and indicated that the voucher specimen was housed in the National Herbarium in Zimbabwe (SRGH). When requesting the precise locality for this specimen (no collector or number was cited) from SRGH, the curator informed me that the specimen could not be traced. Apart from the listing, *Adenium boehmianum* has not been reported from Botswana in the literature.

All known Botswana records come from the north-western borders of the Central Kalahari Game Reserve, in central Botswana. These records extend the known distribution range of the species by at least 650 km to the east (Figure 1). The distribution map was compiled from information obtained from the National Herbarium of Namibia (WIND) database: SPMNDB and Flora DB; records from the Namibian Tree Atlas project; and the National Herbarium Pretoria Computerised Information System (PRECIS) database. Information on one of the new records was obtained from GAB.

Vahrmeijer indicated on the collecting label that plants were found locally, frequently growing on rocky hillsides. Kabelo (Q. Turner pers. comm.) indicated that the species was rare and grew only at the base of hills. Succulents are generally sought after and sometimes threatened by plant collectors and because of this and the limited distribution in Botswana, the species was listed as rare and a possible candidate for Red Data listing by Setshogo (2005). *Adenium boehmianum* is an exceptional, attractive plant when in full flower, and with its glossy foliage, it has great horticultural potential (Figure 2).

The disjunct distribution may indicate that Botswana as a whole is undercollected, or at least that the flora of that country is inadequately covered in PRECIS. Only 9.8% of the quarter-degree grids in Botswana have more than 50 specimens at PRE, according to PRECIS records in 2005, and almost a third of all Botswana quarter-degree grids do not have any specimens in PRE.

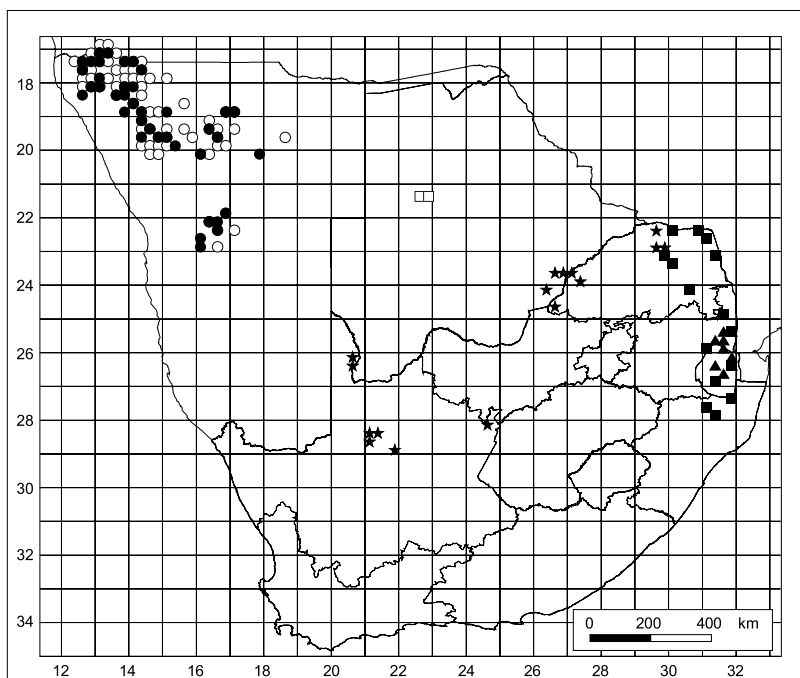


FIGURE 1.—Distribution in the FSA region of *Adenium boehmianum*: from WIND and PRE, ●; from Namibia Tree Atlas Project, ○; new records, □. *A. oleifolium*, from GAB and PRE, ★; *A. multiflorum*, from PRE, ■; and *A. swazicum*, from PRE, ▲.



FIGURE 2.—Flowering *Adenium boehmianum* photographed in the nursery of the Pretoria National Botanical Garden, $\times 0.5$. Plant grown from a cutting collected in 1976 by Leistner *et al.* PNBG294.

Further investigation may prove whether the occurrence of *Adenium boehmianum* in Botswana indicates a disjunct distribution or not. It is probably an indication that Botswana is still undercollected, or not well represented at PRE.

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of data from PRECIS; and Ms H. Steyn, SANBI, for compiling the distribution map.

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HYACINTHACEAE

DRIMIA MONTANA (URGINEOIDEAE), A NEW SPECIES FROM EASTERN CAPE, SOUTH AFRICA

Drimia montana A.P.Dold & E.Brink, sp. nov., *D. marginatae* (Baker) Jessop affinis sed foliis numero 3–6, usque ad 80 mm longis, bracteis pedicellorum usque ad 1.4 mm longis cum calcari complanato pluteiformi usque ad 0.8 mm longo, filamentis erecto-patentibus fusiformibus flexum sigmoideum lenem externum usque ad 3.6 mm longum formantibus, ovario conico truncato trigono usque ad 2 mm longo, lineis sex longitudinalibus purpureo-guttatis angulos flavidos delineantibus, atque seminibus quinque in quoque loculo, differt.

TYPE.—Eastern Cape, 3226 (Fort Beaufort): The Hoek Farm, Groot Winterberg, 2 150 m, (–AD), 01-01-2004, Dold 4633 (GRA, holo.).

Deciduous geophyte, colonial, $\pm$ (30–)40–60(–80) mm tall, densely aggregated in matted, cushion-forming colonies of more than 100 individuals. *Bulb* globose

to ovoid, 10–15 $\times$ 10–15 mm, hypogeal, firm, tinged purplish within; roots many, spreading, white, fleshy, bulbiliferous; inner tunic reddish purple, forming a short, loose neck; outer tunic loosely flaking, papery, greyish brown. *Leaves* (2–)3–6, linear, 15–50 $\times$ 1.0–1.5 mm (2)3–, erect, entire, somewhat flattened, $\pm$ concave adaxially, apices acute, dry and withered but persistent at flowering, glabrous, glossy green. *Inflorescence* solitary, subcapitate-racemose; peduncle slender, erect, (45–)50–60(–80) $\times$ 0.7–0.8 mm at base, with minutely white-puberulous hairs in vertical rows, dark, glossy, purple-red, swollen around and below pedicel forming a saddle-shaped, whitish cushion of tissue subtending pedicel and bract; bracts thinly flattened, up to 1.4 $\times$ 1.0 mm wide at base, loosely clasping, somewhat cupped, with a flattened, horizontal fold up to 0.8 $\times$ 0.6 mm broad at base, smooth, fawn-coloured, drying quickly but persistent; pedicels spreading-erect, (3.0–)5.0–6.0(–6.5) $\times$ 0.5–0.7 mm, dark, glossy,

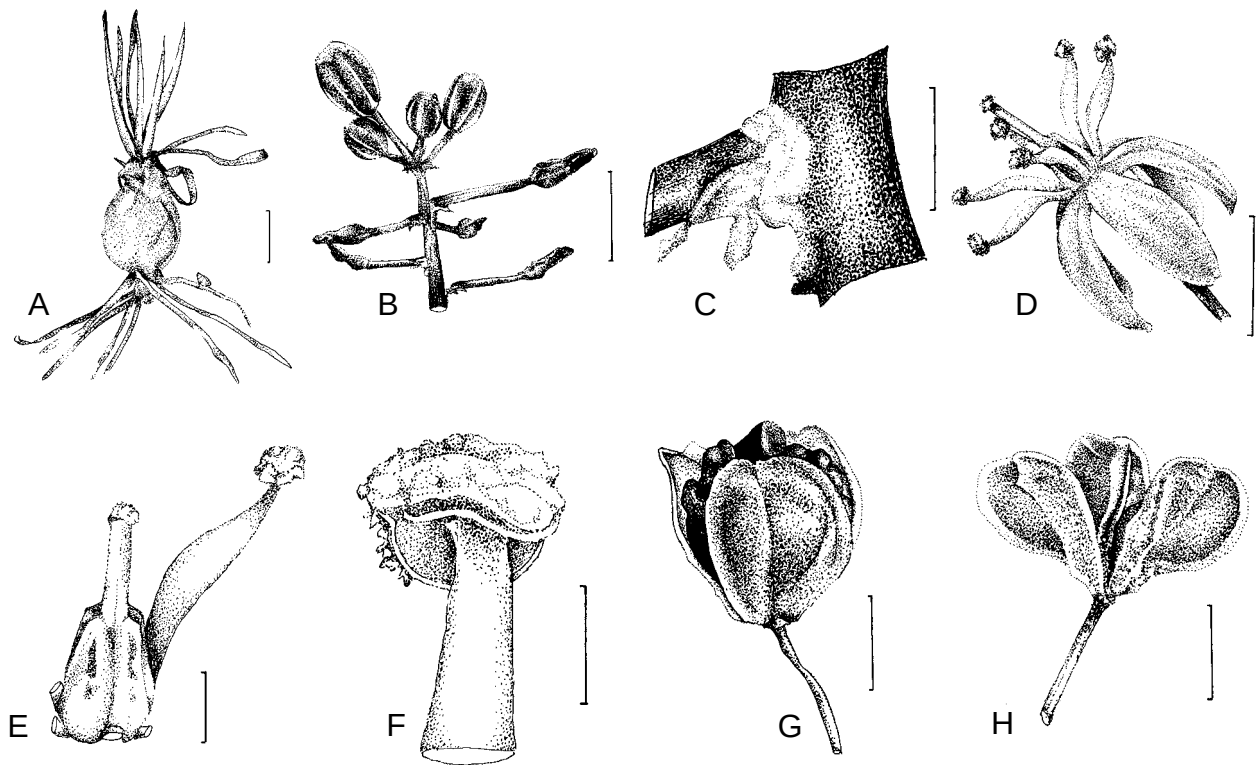


FIGURE 3.—*Drimia montana*, Dold 4633: A, plant habit; B, inflorescence; C, pedicel bract; D, perianth; E, gynoecium with a single stamen; F, anther; G, capsule; H, dehiscent capsule. Scale bars: A, B, D, G, H, 5 mm; C, E, 1 mm; F, 0.5 mm. Illustrations: L. de Wet.

purple-red, becoming erect as fruit develops; base thickened. *Flowers* (6–)8–12(–15), opening one or two per day, aborted flowers abscising 0.4 mm below insertion of tepals leaving a skirt of tissue as pedicel dries. *Perianth* reflexed, tepals elliptic, convex, 6.0–6.4 × 2.2–2.4 mm, fused for 0.8 mm at base, abaxial surface maroon with broad white recurved margins, adaxial surface white, apices truncate, penicillate. *Stamens* spreading-erect; filaments fusiform, weakly sigmoid, 3.2–3.6 × 0.8 mm, flattened, 0.6 mm thick, white; anthers broadly ovoid, bilobed, 1 × 0.7 mm diam., dorsifixed, versatile, yellow-green, dehiscing longitudinally; pollen ellipsoid, 60 × 20 µm, monosulcate, yellow. *Ovary* a truncate obtusely angled trigonous cone, up to 2.0 × 1.6 mm at base, up to 1 mm diam. at apex, white, with six longitudinal lines of purple speckling delineating yellow tinged corners; style triangular in cross section, 1.4–2.4 × 0.4 mm, white; stigma swollen, 3-angled with stalked stigmatic papillae in three rows, white. *Capsule* obovate, 8–10 × 6–8 mm, pale yellow-brown with the persistent circumscissile perianth capping apex and leaving a basal annulus, lobes spreading and twisting outwards at dehiscence, leathery with thickened margins, cream-coloured. *Seeds* ± 5 per locule, flat, oval in outline, 5–8 × 3.8–5.0 mm, up to 1.2 mm thick; testa glossy, black, shallowly reticulate; cotyledon fusiform, 4–7 × 1.0–1.2 mm, yellow. *Flowering time*: ± 14.30 to ± 19:00 each day in December to January. Figures 3, 4.

Distribution and biology: based on an ongoing study of herbarium specimens, wild populations and cultivated material of *Drimia* Jacq., *D. montana* is known to us from only two mountain peaks in the Eastern Cape (Figure 5) growing in Karroid *Merxmuellera* Mountain Veld (Acocks 1988), latterly known as South-eastern Mountain Grassland (Lubke *et al.* 1996), at ± 2 000 m. The annual

rainfall is between 450–600 mm, falling predominantly in the summer months, with severe frost and only occasional snow in winter (Lubke *et al.* 1996). The habitat of these two localities corresponds closely with each other [typical habitat is illustrated by Acocks (1988) in Figure 95: 112]. Plants form large mats, up to 0.5 m in diameter, of densely aggregated bulbs on flat, exposed sandstone rock slabs where, together with several dwarf succulent species, they are partly concealed by lichen and moss. Associated species include *Cheilanthes hirta*, *Crassula corallina*, *Euphorbia aggregata*, *E. epicyparissias*, *Felicia filifolia*, *Melolobium candicans*, and *Pelargonium aridum*. Plants are dormant for two to three weeks in late January. It is likely that *D. montana* occurs elsewhere on the Stormberg and Winterberg where the inaccessible habitat is under no immediate threat.

Diagnosis and relationships: following Goldblatt & Manning (2000), *D. montana* falls within the *Urginea* group of the genus *Drimia* within the Urgineoideae, Hyacinthaceae. The new species appears to be related to the *D. depressa* alliance comprising *D. depressa*, *D. marginata* and *D. sphaerocephala*, all with ± capitate inflorescences. The last two named species have corresponding recurved tepals (Jessop 1977), a character previously used to separate *Drimia* from *Urginea* (Baker 1897; Mauve 1976), but they are separated by less distinct characters including the length of the pedicel bracts. The new species is, however, clearly differentiated by its dwarf habit, the small pedicel bract with flattened horizontal fold, the fusiform, weakly sigmoid filaments and the truncate, trigonous ovary with distinct purple and yellow markings. In addition, the presence of bulbils forming at the base of the bulb and along the roots, appears to be an unusual character within the genus.

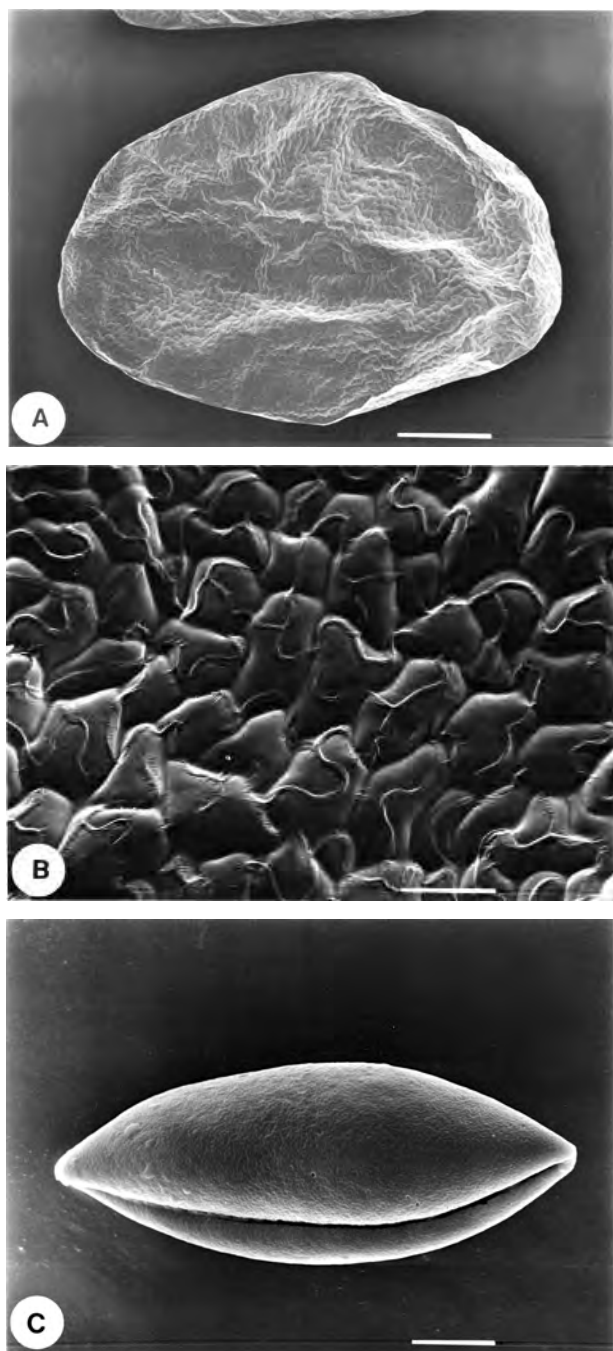


FIGURE 4.—*Drimia montana*, Dold 4633: A, seed; B, seed testa; C, pollen. Scale bars: A, 1 mm; B, 100 µm; C, 10 µm.

Additional material examined

EASTERN CAPE.—3126 (Queenstown): summit of Andriesberg, Carnarvon Estate, Black Eagle Nature Reserve, 1 885 m, (–DA), 15-12-2002, Dold & Cocks 4700 (GRA).

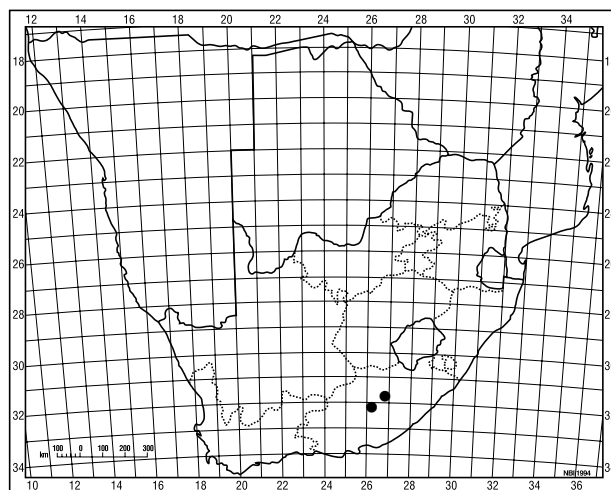


FIGURE 5.—Known distribution of *Drimia montana*.

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AMARYLLIDACEAE

A NEW VARIETY OF *CLIVIA ROBUSTA*

Recently, the genus *Clivia* (Lindl.) Regel saw the introduction of two new species, *C. mirabilis* Rourke and *C. robusta* Murray *et al.*, as well as a new variety, *C. gardenii* var. *citrina* Swanevelder *et al.* (Rourke 2002; Murray *et al.* 2004; Swanevelder *et al.* 2005). All six currently rec-

ognized species, including four varieties, are indigenous to South Africa, with two species extending into Swaziland (Watson 1899; Phillips 1931; Duncan 1985, 1992, 1999; Rourke 2002; Snijman & Archer 2003; Murray *et al.* 2004; Swanevelder 2003; Swanevelder *et al.* 2005).

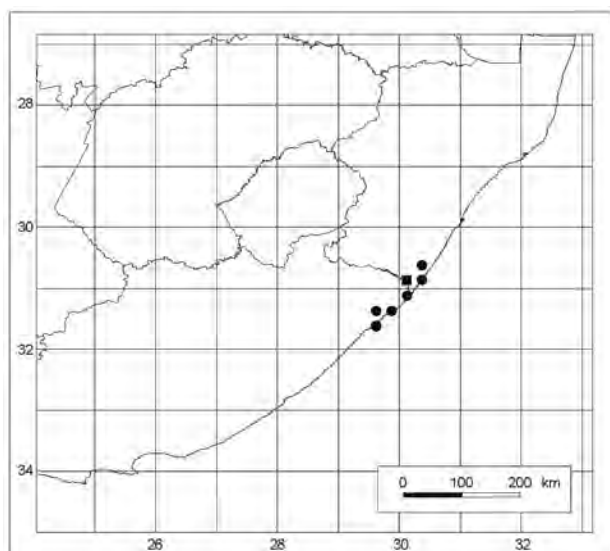


FIGURE 6.—Known distribution of *C. robusta* var. *robusta*, ●; and *C. robusta* var. *citrina* as well as the typical variety, ■.

Clivia robusta, the tallest member in the genus, is confined to the Pondoland Centre of Endemism, South Africa (Figure 6). Plants occur as isolated populations distributed mainly from Port St Johns (Eastern Cape), through to Port Edward (KwaZulu-Natal), with a few outliers as far north as Oribi Gorge (Van Wyk 1994; Van Wyk & Smith 2001; Swanevelder 2003; Murray *et al.* 2004). Restricted to isolated patches of forest, *C. robusta* is usually closely associated with swamps or seepage areas, though individuals have been found in well-drained, humus-rich soils, in shallow soil on rocky ledges of cliffs and even on rocks (Swanevelder 2003, Murray *et al.* 2004). The forest type with which it is associated is Swamp Forest, or in most instances a floristically enriched form of Afromontane Forest sometimes referred to as Coast Scarp Forest (MacDevette *et al.* 1989).

In the description of *Clivia robusta*, Murray *et al.* (2004) noted that yellow-flowered individuals are rarely encountered in this species, the flowers of which are usually orange or red. Such sporadic occurrences of yellow-flowered forms are preferably named at forma level (Stuessy 1990). However, Watson (1899) described the sporadic yellow-flowered form of *C. miniata* as a variety, namely *C. miniata* var. *citrina*, a name that has been widely adopted. A second yellow-flowered infra-specific taxon in the genus, *C. gardenii* var. *citrina*, was also described at variety level (Swanevelder *et al.* 2005). Following these precedents, we here formally describe the yellow-flowered form of *Clivia robusta* Murray *et al.* as a new variety.

***Clivia robusta* B.G.Murray, Y.Ran, P.J.De Lange, K.R.W.Hammett, J.T.Truter & Z.H.Swanevelder var. *citrina* Z.H.Swanevelder, A.Forbes-Hardinge, J.T.Truter & A.E.van Wyk, var. nov., floribus pallide luteis vel citrinis, apicibus laete vel atro-viridibus, non aurantiacis vel rubris apicibus viridibus ut in varietate typico distinguitur.**

TYPE.—KwaZulu-Natal, 3030 (Port Shepstone): Maringo Flats, (–CC), 7 June 2003, *Forbes-Hardinge FH01* (PRU, holo.).

Flowers with perianth pale yellow or lemon yellow with light to dark green apices, not dark orange-red, pale orange or pink-orange with green apices as in the typical variety.

Clivia robusta has flowers that are usually various shades of red and orange (Murray *et al.* 2004). We regard plants with flowers in all shades of these colours (at anthesis) as belonging to *Clivia robusta* var. *robusta*, with only the rare yellow-flowering form comprising var. *citrina*.

The holotype of *C. robusta* var. *citrina* was collected in an area known as Maringo Flats, located ± 20 km inland from Port Edward on the KwaZulu-Natal south coast (Figure 6). A single yellow-flowered specimen was collected at the time, but more than one yellow individual was observed. The frequency of the yellow form in this particular stand is intermediate to the large stands of *Clivia gardenii* var. *citrina* in nature (Ngome Forest, Ngotshe District, KwaZulu-Natal) and the single yellow-flowering specimen on which Watson based *C. miniata* var. *citrina* (Watson 1899; Swanevelder 2005). Hitherto, *C. robusta* var. *citrina* has only been recorded in this one population.

The habitat at the type locality is typical for *Clivia robusta*, in this case, a swamp-like area with forest covering ± 2 ha. Most of the *C. robusta* population grows as dense stands in very heavy mud on a stream bank. The type specimen was growing in a silt deposit on the side of the stream that runs through the forest on its way to the Umtamvuna River. Associated forest species include *Strelitzia nicolai*, *Protorhus longifolia*, *Erythrina caffra*, *Macaranga capensis*, *Voacanga thouarsii*, *Syzygium cordatum*, *Phoenix reclinata*, *Zantedeschia aethiopica* and *Cyathea dregei*.

Even though *Clivia robusta* is present in a number of conservation areas throughout its range, the distribution of individual populations is very localized due to the species' specialized habitat requirements (Swanevelder 2003). In this particular case, even the inhospitable marshy habitat does not prevent the removal of plants by traditional healers and illegal plant collectors; it does, however, restrain the complete removal of whole populations. All known plants of *C. robusta* var. *citrina* occur on private land and enjoy the protection of the current landowner.

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RUBIACEAE

CORRECT AUTHOR CITATIONS FOR NAMES OF THREE SOUTHERN AFRICAN SPECIES OF *CANTHIUM*

There is confusion in the literature concerning the correct author citations for the names of the southern African taxa *Canthium ciliatum*, *C. pauciflorum* (now *C. kuntzeanum* Bridson) and *C. spinosum*. All three taxa are based on type material from South Africa. *C. ciliatum* is confined to the *Flora of southern Africa* (FSA) region, *C. kuntzeanum* extends from here to the Eastern Highlands of Zimbabwe and adjacent parts of Mozambique and *C. spinosum* just enters southern Mozambique (although not treated in *Flora zambeziaca*). *C. ciliatum* and *C. spinosum* have received only brief mention in Bridson's (1992) revision of *Canthium* in tropical Africa. Here we clarify the author citations for the relevant correct names as well as their synonyms, based in part on the work of Tilney (1986) and Bridson (1992, 1998).

One cause of author citation variation is provisions of the International Code of Botanical Nomenclature [ICBN] itself. For example, the use of 'ex' in author citations is not mandatory (ICBN, Art. 46.4; Greuter *et al.* 2000). An author is free to use or not to use it. It is nevertheless essential in all instances to cite the author(s) after the 'ex'. Citations with 'ex' are cumbersome, and for the sake of brevity the 'ex' and the author names preceding it are often dropped, resulting in a shorter but still correct citation. For the sake of completeness we have retained 'ex' in all the author citations supplied below. This is the option we prefer when author citations are supplied in scholarly publications.

***Canthium ciliatum* (Klotzsch ex Eckl. & Zeyh.) Kuntze** in *Revisio generum plantarum* 3, 3: 545 (1898).

Psilostoma ciliata Klotzsch ex Eckl. & Zeyh.: 362 (1837). *Plectronia ciliata* (Klotzsch ex Eckl. & Zeyh.) D.Dietr.: 856 (1839), non Sonder: 18 (1865).

Apparently unaware of the earlier work of Dietrich (1839), Sonder (1865) also made the combination

'*Plectronia ciliata* (Klotzsch ex Eckl. & Zeyh.) Sond.', resulting in many subsequent authors incorrectly attributing the combination in *Plectronia* to Sonder.

***Canthium kuntzeanum* Bridson** in *Kew Bulletin* 47: 393 (1992).

Plectronia pauciflora Klotzsch ex Eckl. & Zeyh.: 363 (1837). *Canthium pauciflorum* (Klotzsch ex Eckl. & Zeyh.) Kuntze: 545 (1898), non Blanco: 165 (1837), nec Baill.: 189 (1878), nec King & Gamble: 58 (1904), nec Pierre ex Pitard: 291 (1924).

Over the years the specific epithet *pauciflorum*, meaning few-flowered, has been applied in combinations with *Canthium* by Blanco (1837), Baillon (1878), King & Gamble (1904) and Pierre ex Pitard (1924). However, in all these instances, a different plant from the southern African taxon was being referred to. Because of the earlier names of Blanco and Baillon, Kuntze's combination is a later homonym, hence a new name, *C. kuntzeanum*, was proposed for the southern African taxon by Bridson (1992).

***Canthium spinosum* (Klotzsch ex Eckl. & Zeyh.) Kuntze** in *Revisio generum plantarum* 3, 3: 545 (1898).

Plectronia spinosa Klotzsch ex Eckl. & Zeyh.: 362 (1837), non K.Schum.: 459 (1897).

P. klotzschiana K.Schum.: 460 (1897), nom. superfl.

Based on a specimen from Sierra Leone ('Guinea'), Schumacher & Thonning (1827) published the name *Phaliaria spinosa* for the taxon currently known as *Vangueriella spinosa* (Schumach. & Thonn.) Verdc. Benth. (1849) gave the name *Canthium thonningii* Benth. to the same taxon. Schumann (1897: 459) proposed that *C. thonningii* be transferred to *Plectronia*, with the new combination *P. spinosa* (Schumach. & Thonn.) K.Schum. Realizing that this name had already been used

by Ecklon & Zeyher (1837) for a different taxon from southern Africa, Schumann proposed a new (yet superfluous) name for the latter, namely *Plectronia klotzschiana* K.Schum.

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POACEAE

CONCEPT OF *STIPAGROSTIS UNIPLUMIS* VAR. *UNIPLUMIS* REDEFINED TO INCLUDE SPECIMENS WITH HAIRY GLUMES

At present, following Smook (1990), the varieties of *Stipagrostis uniplumis* (Licht.) De Winter and *S. hirtigluma* (Trin. & Rupr.) De Winter in the *Flora of southern Africa* (FSA) region are characterized as follows:

Stipagrostis uniplumis var.:

uniplumis: perennial; inflorescence with spikelets numerous; glumes glabrous, up to 10 mm long; callus of the *uniplumis*-type (short hairs continuous from naked tip up entire length of callus to long hairs at junction of callus and lemma); widespread in FSA region.

neesii (Trin. & Rupr.) De Winter: perennial; inflorescence with spikelets few; glumes glabrous, usually longer than 10 mm; callus of the *uniplumis*-type; occurs in northwestern Northern Cape, western Free State, North-West and adjoining area of Botswana and extreme northern Limpopo.

intermedia (Schweick.) De Winter: annual; inflorescence with spikelets numerous; glumes hairy, usually up to 8 mm long; callus of the *uniplumis*-type; dry northwestern Namibia.

Stipagrostis hirtigluma var.:

hirtigluma: annual; inflorescence narrow; glumes hairy; callus of the *hirtigluma*-type (with a distinct glabrous break between short hairs on body of callus and long hairs at junction of lemma and callus, best seen at back of callus).

pearsonii (Henrard) De Winter: annual; inflorescence open; glumes hairy; callus of the *hirtigluma*-type.

patula (Hack.) De Winter: perennial; inflorescence open; glumes densely hairy; callus of the *hirtigluma*-type.

The main characters separating *Stipagrostis uniplumis*

from *S. hirtigluma* are the hairs on the callus (see above) and the presence of a distinct pencil of hairs at the branching point of the awns in the former. In the latter species, the column is sometimes hairy, but without a distinct pencil of hairs.

Perennials with hairs on the glumes and a *uniplumis*-type callus have been referred to as a hybrid, *Stipagrostis uniplumis* × *hirtigluma*—see De Winter (1965) and note under *S. uniplumis* var. *intermedia* in couplet 30 of the key in Smook (1990).

Re-examination of all the specimens at PRE that key out as *Stipagrostis uniplumis* × *hirtigluma* showed that a large number of the specimens fitted the description of *S. uniplumis* var. *uniplumis* except for the hairs present on the glumes. It is therefore proposed, for the reasons given below, that the description of var. *uniplumis* be expanded to accommodate those specimens that fulfill all the other criteria for *S. uniplumis* var. *uniplumis* but have hairs on the glumes:

1, hairy glumes are not unknown in *S. uniplumis*, also occurring in var. *intermedia*, an annual from the more arid northwest of Namibia;

2, the density of hairs, even the presence of hairs on the glumes, can vary on spikelets of the same inflorescence. The hairs are often difficult to see (a black background makes them more visible). Hairiness appears not to be a stable character in *S. uniplumis*. De Winter (1965) points out that the presence or absence of hairs on glumes has proved to be diagnostically unreliable in other species of the genus. Therefore, not too much weight should be placed on this character;

3, there are a large number of specimens from across the entire distribution area of var. *uniplumis* that differ from

the typical form only in having hairs on the glumes (see specimens examined below);

4, the callus is of the *uniplumis*-, not *hirtigluma*-type.

In the *Flora zambesiaca* region, Melderis (1971) also placed most specimens from Botswana and Zimbabwe differing only by hairy glumes in var. *uniplumis*, acknowledging that some specimens in Namibia could possibly be hybrids.

The new expanded description of *S. uniplumis* var. *uniplumis* is as follows: perennial; inflorescence with spikelets many; spikelets 8–10(–11) mm long (measured from base of spikelet to apex of longest glume, excluding awns); tuft of hairs at branching point of awns and often hairy partly down column, hairs longer than 1.5 mm; glumes glabrous or long-hairy, hairs dense to sparsely scattered but at least always present on margins; callus of the *uniplumis*-type.

There are still a number of perennial specimens with a pencil of hairs at the branching point of the awns, hairy glumes and a callus of the *uniplumis*-type that are difficult to place in either var. *neesii* or the new extended var. *uniplumis* and will key out as the hybrid *S. uniplumis* × *S. hirtigluma* (see key below).

The emended key in Gibbs Russell *et al.* (1990: 319, 320) is given below, starting at couplet 28 (22) of the original key:

- 28(22) Glumes with long hairs, sometimes sparse and along margins only 29
- Glumes puberulous, scabrid or glabrous 35
- 29(28) Inflorescence spiciform, subsecund; culms not visibly or obviously striate, usually densely scabrid *S. gonatostachys*
- Inflorescence open or contracted but not spiciform; culms obviously striate, smooth 30
- 30(29) Callus with short hairs along entire length (except for naked tip) until long hairs at junction of lemma and callus (*uniplumis*-type) 31
- Callus with distinct glabrous break between short hairs along length of callus and long hairs at junction of lemma and callus (*hirtigluma*-type, best seen at back) 33
- 31(30) Plant annual *S. uniplumis* var. *intermedia*
- Plant perennial 32
- 32(31) Glumes 8.0–10(–11) mm long *S. uniplumis* var. *uniplumis*
- Glumes longer than 12 mm *S. uniplumis* × *S. hirtigluma*
- 33(30) Inflorescence narrow, when fully exerted much longer than wide; annual *S. hirtigluma* subsp. *hirtigluma*
- Inflorescence open, spreading, when fully exerted not much longer than wide; annual or perennial 3
- 34 (33) Annual with very few leaves at base *S. hirtigluma* subsp. *pearsonii*
- Perennial with dense tuft of basal leaves *S. hirtigluma* subsp. *patula*
- 35(28) Branching point of awns and short distance down column with hairs longer than 1.5 mm 36
- Branching point of awns and short distance down column glabrous or with hairs shorter than 1.5 mm 37
- 36(35) Inflorescence with numerous spikelets; glumes 8–10 mm long; central awn usually straight *S. uniplumis* var. *uniplumis*

Inflorescence with a few spikelets; glumes 10 mm or longer; central awn bent at right angles *S. uniplumis* var. *neesii*

37 (35) Inflorescence subsecund, branched only in the lower part, spikelets in upper part solitary continue key from couplet 35 in Gibbs Russell *et al.* (1990) advancing the numbers appropriately.

Specimens of S. uniplumis var. *uniplumis* with hairy glumes examined:

NAMIBIA.—1714 (Ruacana Falls): Kaokoland, about 4 km S of Omarundu, (–CC), Smook 7830. 1812 (Sanitatas): 8 miles W of Orowanja Fountain on road to Orupembe, (–BA), De Winter & Leistner 5649. 1813 (Ohopoho): Kaokoland, S of Opuwa on road to Sesfontein, (–DA), Smook 7841. 2014 (Welwitschia): Farm Driekrone OU 516, (–BC), Giess 7915. 2114 (Uis): Messumberge, (–AC), Giess 9662. 2117 (Otjosondú): Farm Omupanda, (–DD), Gibbs Russell & Smook 5371. 2118 (Steinhausen): Farm Merx, (–AB), Gibbs Russell & Smook 5408. 2216 (Otjimbingwe): Farm Friedenau, (–DB), Müller & Kolberg 2112. 2317 (Rehoboth): 24 km S of Rehoboth on main road to Kalkrand, (–CA), Gibbs Russell & Smook 5480. 2417 (Mariental): 20 km W of Mariental on road to Maltahöhe, (–DB), Gibbs Russell & Smook 5509A.

BOTSWANA.—1821 (Andara): Tsodilo Hills, (–DC), Guy 121/64. 1922 (Nokong): Mojey area, (–CD), Smith 1302. 1923 (Maun): Chiefs Island, (–CA), Biggs M462. 2021 (Koanaka Hills): on sides of Groot Laagte fossil river valley, (–CD), Smith 3205.

MPUMALANGA.—2431 (Acornhoek): Farm Rietvley, (–AB), Zambatis 573. 2331 (Phalaborwa): 15 km SE of Shingwidsi, (–AB), Ellis 537.

LIMPOPO.—2229 (Waterpoort): Langjan Nature Reserve, (–CC), Zwanziger 522.

NORTHERN CAPE.—2820 (Kakamas): Augrabies National Park, (–CB), Wörger 378. 2824 (Kimberley): Olie River, (–CC), Leistner 1292.

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POACEAE

A LONG-AWAITED NAME CHANGE IN *POLYPOGON*

In 1955 Chippindall noted that *Agrostis griquensis* Stapf should be classified as a species of *Polygogon* Desf.

Gibbs Russell (1990) placed this taxon correctly, but the combination was never validly published.

According to Clayton & Renvoize (1986), the genus *Polypogon* is characterized by the spikelet falling entire with the upper part of the pedicel still attached. In contrast, the spikelet in *Agrostis* disarticulates above the glumes.

***Polypogon griquensis* (Stapf) Gibbs Russ. & L.Fish, comb. nov.**

Agrostis griquensis Stapf in Kew Bulletin, Additional ser. 1897: 290 (1897). Type: Northern Cape, 2823 (Griquatstad): near Griquatown, (–CC), December 1811, Burchell 1863 (K, holo.; PRE fragment of holo.).

Other specimens examined

FREE STATE.—2926 (Bloemfontein): Bloemfontein, near Tempe Farm, (–AA), Geo Potts 2467, fragment of Geo Potts 2470; both October 1917.

NORTHERN CAPE.—2824 (Kimberley): in Barkly West area, Holpan, (–CB or –BC; there are two places with the same name in this area), October 1937, Acocks 2466.

Gibbs Russell (1990) also placed *Polypogon minutiflorus* Pilg. into synonymy under *P. griquensis*. Pilger (1941) described *P. minutiflorus* based on the specimen 'Rusch. Jun. in herb. Dinter 7944, Leutwein'. The locality is Namibia and may refer to a locality near Windhoek and date of collecting as October 1934. Although the type seems to have disappeared and has not been traced, Gibbs Russell (pers. comm.) felt that the description matched that of *P. griquensis* and that the two entities were therefore conspecific.

At PRE the only specimen from Namibia was collected in the Naukluft River by Volk (Volk 848) in October 1939. It was originally identified as '*Polypogon minutiflorus* ex descr.' but according to Gibbs Russell it is a good match of the type of *Agrostis griquensis* housed at K.

Is *Polypogon griquensis* extinct or an alien grass?

According to the information gathered from collections at PRE, *Polypogon griquensis* grows under wet conditions,

flowers in October and has not been collected since 1939. The question is: is this an endemic species that is extinct, rare or threatened, or was it an alien that never really became naturalized? Some 18 species of *Polypogon* are found in the warm temperate regions of the world and the tropical mountains. Three species occur in the FSA (*Flora of southern Africa*) region of which two, *P. monspeliensis* (L.) Desf. and *P. viridis* (Gouan) Breistr., are naturalized, whereas *P. strictus* from the Eastern and Western Cape is widely regarded as endemic. The author has not seen any species other than those occurring in southern Africa.

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POACEAE

A NEW SPECIES OF *SPOROBOLUS* (SPOROBOLINAE) IN SOUTH AFRICA

Sporobolus sp. (Smook 3429) in Gibbs Russell *et al.*: 313 (1990) is hereby named.

***Sporobolus oxyphyllus* L.Fish, sp. nov., S. virginico** (L.) Kunth affinis sed foliis convolutis, paniculo aperto axe principali visibili, habituque differt; etiam *S. pungenti* (Schreb.) Kunth affinis, a quo partibus omnibus parvioribus brevioribusque differt.

TYPE.—North-West, 2625 (Delareyville): Barberspan, (–DA), Ellis 3628 (PRE, holo.).

Mat-forming perennial with robust rhizomes. Culms erect, up to 500 mm tall, branched at base; nodes pale to dark purple or black, glabrous, commonly covered by leaf sheaths. Leaf sheaths persistent, strongly ribbed in upper half, veins becoming less numerous and obvious nearer base, sometimes flushed with purple, glabrous,

except sheath mouth with hairs up to 1.5 mm long. Ligule with a fringe of hairs 0.2 mm long. Leaf blades stiff, pungent, convolute, 20–90(–115) × 1.5–4.5 mm, apex boat-shaped, veins numerous, midrib usually not distinct, glabrous, adaxial surface with prickles and papillae; margins smooth or scabrid. Inflorescence an open, ovate panicle, 30–100 × 10–30 mm, rarely contracted, extending above main leaves, but often closely associated with uppermost leaf; branches smooth or with scattered prickles, primary branches not in whorls, ascending to spreading at about 45° from main axis, lower part without spikelets; yellow to red, glabrous pulvinus present in axils of branches. Spikelets 1.8–2.4 mm long, pallid to grey-green sometimes flushed purple, these colours often mixed on same spikelet, palea usually obvious, being darker than rest of spikelet. Glumes unequal, obtuse to acute, sometimes apiculate, 1-nerved, nerve thickening towards apex, upper 1/2 scabrid; lower glume 1.0–1.6 mm



FIGURE 7.—Habit of *Sporobolus oxyphyllus*, $\times 0.7$. Artist: Sibonela Chiliza.

long; upper glume nearly as long as or as long as spikelet, but length of both glumes variable even within same panicle. *Lemna* ovate-elliptic, acute at tip, 1-nerved. *Palea* as long as spikelet to slightly longer, 2-keeled, with a deep median groove. *Stamens* 3; anthers 1.2–1.4 mm long, pallid, yellow to greenish often flushed purple. *Caryopsis* ellipsoid, strongly laterally compressed, up to 1.1 mm long. *Flowering time*: November to February with one specimen collected June. Figure 7.

Distribution and habitat: *Sporobolus oxyphyllus* occurs in the drier parts of the interior of South Africa, namely in the southern North-West, western Free State and the Eastern and Northern Cape bordering the Free State

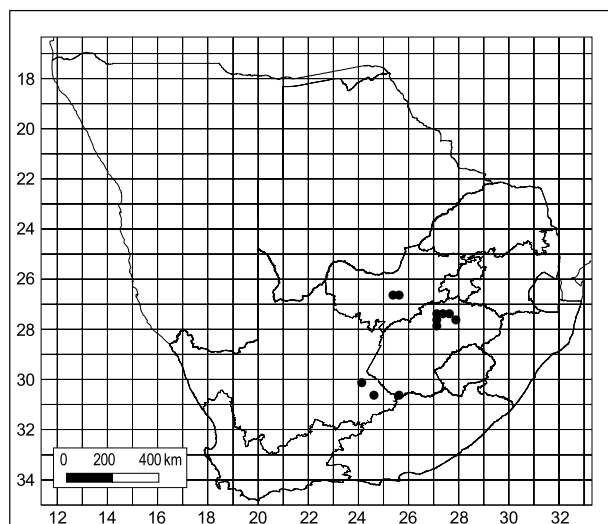


FIGURE 8.—Known distribution of *Sporobolus oxyphyllus*.

(Figure 8). It forms dense stands and is locally abundant in areas of high 'sodic' soils especially at the edges of salt pans and in salt vleis. It has been recorded growing in water and is often found growing in association with *Cynodon dactylon*.

Relationships: *Sporobolus oxyphyllus* is similar to *S. virginicus* (L.) Kunth which is found in saline areas in coastal localities throughout the world in the tropics and subtropics with some inland localities with sodic conditions. In the *Flora of southern Africa* (FSA) region, *S. virginicus* occurs along the coast, whereas inland localities lie mostly east and northeast of the distribution area of *S. oxyphyllus* in KwaZulu-Natal (2632CD; 2632AB), Mpumalanga (2231BA, –CC) and Limpopo (2228DA, 2230CA). It also differs in having a dense, spike-like panicle and leaves which are cauline and not mostly basal. *S. pungens* (Schreb.) Kunth [*S. arenarius* (Gouan) Duval-Jouve] from the Mediterranean, appears to be even more similar, with open panicles and a comparable growth form, but in *S. oxyphyllus*, all parts especially the plant itself and the spikelets are larger and longer.

Etymology: the specific epithet *oxyphyllus* refers to the sharply pointed leaves.

Other specimens examined (all housed in PRE)

NORTH-WEST.—2625 (Delareyville): Paardefontein, (–CB), Allan 174; Farm Boskop, (–CB), Smook 6273; Barberspan, (–DA), Davidse & Loxton 6026; Zimbatis 4, 10.

FREE STATE.—2727 (Kroonstad): Middelspan Noord, (–CA), Scheepers 1654. 2825 (Boshof): Du Plessis Dam, (–AD), Peyer 1077; Berlyn, (–BC), Muller 1299; Myburgs Pan, Lynfontein Farm, (–DB). Edwards 4152. 2826 (Brandfort): Bulfontein, (–AC), Smook 2721; Krugersdrift Dam Nature Reserve, (–CC), Muller 1906.

NORTHERN CAPE.—3024 (De Aar): near Potfontein station, (–AA), Acocks 13532; Farm Biesiespan, (–DA), Smook 3429.

EASTERN CAPE.—3025 (Colesberg): Oviston, (–DA), Anderson 349.

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ASPHODELACEAE

ALOE VANROOYENII: A DISTINCTIVE NEW MACULATE ALOE FROM KWAZULU-NATAL, SOUTH AFRICA

INTRODUCTION

Although material of *Aloe vanrooyenii* Gideon F.Sm. & N.R.Crouch from Weenen was known to well-known aloe expert, Dr Gilbert W. Reynolds, he noted (Reynolds 1950: 266) in a somewhat noncommittal way that plants 'appear to be outlying forms of *A. barbertoniae*'. However, Reynolds acknowledged that both morphological and phenological differences were evident: Weenen plants flowered later in the year (October and November) and bore more crowded marginal teeth on the leaf. Our view is that *A. barbertoniae* Pole Evans is a distinctly subtropical entity centred on Nelspruit and Barberton in Mpumalanga and that material from the KwaZulu-Natal Midlands is sufficiently different to warrant recognition at species rank. Pending a full pan-African revision of *Aloe* sect. *Pictae* Salm-Dyck, we regard the closest affinities of the new taxon to lie with *A. parvibracteata* Schönland. Although Van Wyk & Smith (2004) followed the proposed inclusion of *A. barbertoniae* in *A. greatheadii* Schönland var. *davyana* (Schönland) Glen & D.S.Hardy (Glen & Hardy 1987), we consider that *A. barbertoniae* will likely be reinstated in the course of a re-evaluation of *A. sect. Pictae*. On the other hand, *A. parvibracteata* has a geographical distribution range centred in the mountainous areas to the east and south of Nelspruit, Mpumalanga. Although extending into northeastern KwaZulu-Natal, this allied species is a distinctly winter-flowering entity, which has longer, less deltoid-shaped leaves which are paler green or distinctly purple, and smaller fruit.

One of the main distinguishing characters of *A. vanrooyenii* is the large size of its erect, matt green to purple-brown, cylindrical-oblong fruit. In the fresh condition, shortly before dehiscence and seed dispersal, individual capsules are typically 25–28 × 14–18 mm. In the dry condition, and on herbarium specimens, the fruit shows slight shrinkage, yielding capsules of (20–)21(–22) × (10–)12 mm. In fact, this is the only maculate aloe in which the robust inflorescence peduncle and side branches carrying developed fruit, cannot support the weight of the large, mature capsules and invariably bend towards the ground.

Aloe vanrooyenii, flowering between October and November, is the only early summer-flowering maculate aloe from KwaZulu-Natal (Van Wyk & Smith 2004). To the north of its distribution range, predominantly in the Gauteng and Limpopo Provinces, *A. transvaalensis* Kuntze, which is often included in the synonymy of *A.*

zebrina Baker, flowers from November to April. These species respectively occupy similar summer-reproductive niches in what is essentially more open grassland and savanna vegetation.

***Aloe vanrooyenii* Gideon F.Sm. & N.R.Crouch**, sp. nov., apparetur *A. parvibracteatae* Schönland arctissime affinis, a qua fructibus capsularibus constanter multo majoribus, fasciis perlatis albis longitudinalibus secus margines secus quos capsulae dehiscunt ornatis, mensibusque aestivus florens differt.

TYPE.—KwaZulu-Natal, 2830 (Dundee): alongside road in hilly country, 25 km from Muden towards Weenen (–CC), (S 28.93140, E 30.25385), *N.R. Crouch* & *G.F. Smith* 2 (NH, holo.).

Small, slow-growing, herbaceous, succulent, perennial herb, very rarely branching from base, not forming clusters, consisting of small to medium-sized, densely foliate, open rosettes, 240–300 mm diam. *Roots* terete, 4–5 mm diam. *Stems* usually absent, if rarely present then up to 80 mm long and 45–55 mm diam., erect. *Leaves* 15–20, rosulate, attenuate, tapering to apex, 120–150 mm long, 60–80 mm broad at base, basally sheathing, distinctly spreading, apex dry, reflexed, dry leaves persistent; upper surface shallowly and broadly canaliculate, flat near base, shiny pale green, spotted, spots pale milky green to whitish, variously shaped and sized, often ± confluent in transverse bands; lower surface convex, uniformly milky green, rarely with longitudinal darker greenish striations, sometimes with small teeth arranged in a central row near leaf apex; margins with a whitish, near-translucent edge, armed with very pungent teeth; teeth brownish orange, recurved like shark's teeth, 3–4 mm long, 3–4 mm apart, ± evenly spaced; leaf sap drying translucent, cut end eventually turning purple. *Inflorescence* a sparsely branched panicle, 500–800 mm tall, branched at or near lower third with 1 or 2 branches, lowest branches re-branched; 2 or 3 panicles produced consecutively, peduncle and branches below racemes sometimes sterile bracteate, branches subtended at base by thin, scarious, pale brown, many-nerved bracts up to 40 mm long, 15–22 mm broad at base. *Peduncle* basally plano-convex, 10–20 mm broad at base, matt greenish brown with a soft, whitish bloom, sometimes sterile bracteate. *Racemes* cylindrical to slightly conical, laxly flowered, flowering portion 250–470 × 70–90 mm; buds suberect, horizontal or subpendulous, somewhat congested at apex, lowest open flowers horizontal to subpendulous, racemes varying

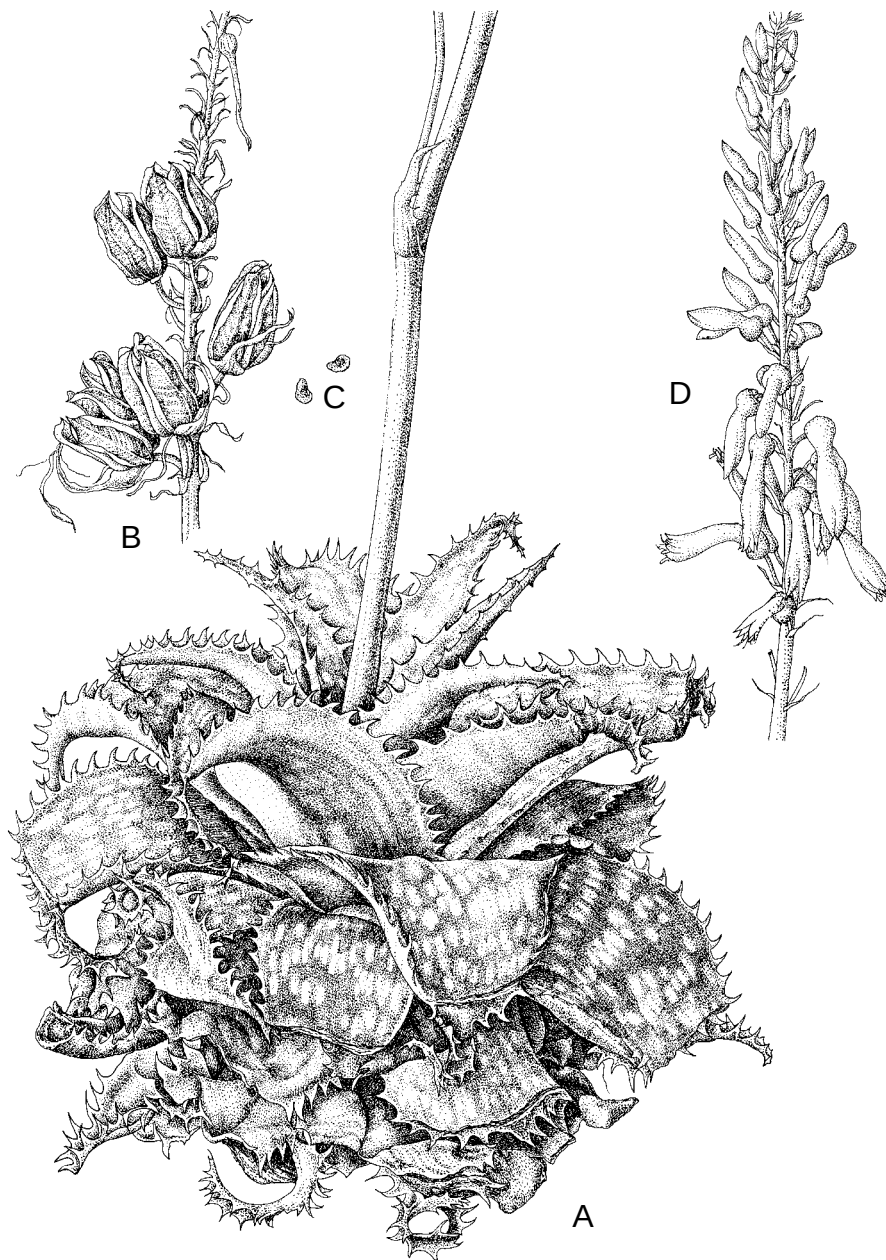


FIGURE 9.—*Aloe vanrooyenii*. A, habit, $\times 0.8$; B, dried capsules showing prominent white marginal strips along which fruit dehiscence, $\times 0.8$; C, seeds showing short wings, $\times 0.8$; D, raceme removed from an inflorescence, $\times 0.8$. Artist: Gillian Condry.

in size according to age of plants, larger in old plants, smaller in young plants. *Bracts* amplexicaul, small, thin, scarious, dirty brownish white, margins creamy white, 8–10 mm long. *Pedicels* 8–10 mm long. *Flowers* 33–38 mm long, swollen at base, basal swelling 8–10 mm diam., cylindric-trigonous, usually monochrome; buds with creamy white tips, otherwise uniformly orange or red; mature flowers 8 mm diam. in middle, distinctly trigonously indented above ovary, thence enlarging towards throat and forming wide open mouth; outer segments free for 8–15 mm from apex, free portion with 1 distinct, central, somewhat more intense orange or red section, with 1 mm broad creamy white border and subacute, recurved apex; inner segments broader than outer ones, with 1.0–1.5 mm broad creamy white border and more obtuse, spreading apex, dorsally adnate to outer ones for their greater length. *Stamens* 6, hypogynous; filaments slightly flattened, pale lemon-yellow, 30–33 mm long, all 6 of equal length, withering concertina-like with age; anthers small, purple-black, versatile, exerted for

up to 3 mm. *Ovary* 6–7 $\times$ 3 mm, pale greenish yellow; style 25–30 mm long, minutely capitate; stigma small. *Fruit* a large capsule, erect, matt green to purple-brown, cylindric-oblong, 25–28 $\times$ 14–18 mm, apically truncate, trilocular, dehiscing loculicidally, chartaceous to woody when dry, margins of valves, along which split occurs, broad, white, very conspicuous, for some time wrapped in remains of dry perigone. *Seed* angled, 2.0 $\times$ 2.5 mm, dark brown with pale brown to greyish white wing. Chromosome number: unknown. Figure 9.

Distribution: the species is centred around Ladysmith, and is known from the Dundee, Harrismith and Underberg Districts (Figure 10). Within this region it is commonly found as a thornveld savanna component.

Eponymy: the species is named after Mr Gert van Rooyen of Greytown who prompted further investigation into wild populations of the species.

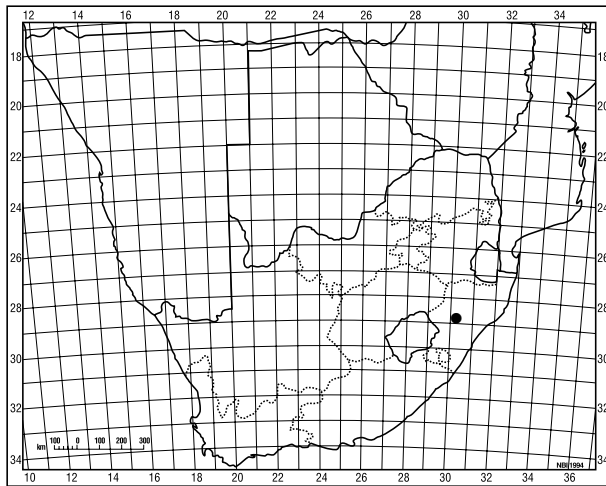


FIGURE 10.—Known distribution of *Aloe vanrooyenii* based on specimens at NH and NU.

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ASPHODELACEAE

ALOE KAOKOENSIS, A NEW SPECIES FROM THE KAOKOVELD, NORTHWESTERN NAMIBIA

Aloe kaokoensis Van Jaarsv., Swanepoel & A.E.van Wyk, a new species allied to *A. littoralis* Baker, is described from the Otjihipa Mountains, Kaokoveld, northwestern Namibia. It is one of 28 currently recognized species of *Aloe* L. in Namibia (Rothmann 2004). Nine of them have been recorded in the Kaokoveld. This is the second new species recently described from the Kaokoveld, an indication of the poor state of botanical exploration in this arid, mountainous region. The first, *Aloe omavandae* Van Jaarsv. & A.E.van Wyk, was described from the cliff faces of the eastern Baynes Mountains (Van Jaarsveld & Van Wyk 2004; Van Jaarsveld *et al.* 2005).

***Aloe kaokoensis* Van Jaarsv., Swanepoel & A.E.van Wyk**, sp. nov., *A. littoralis* affinis, sed caulibus senectis decumbentibus, foliis dense rosulatis laete glaucis cum dentibus nigris sursum spectantibus, perianthio 35 mm longo differt.

TYPE.—Namibia, 1712 (Swartbooisdrif): Kaokoveld, Otjihipa Mountains, ± 5 km ESE of Otjinhungwa growing on rocky outcrops, 1 000 m, (–BC), *Van Jaarsveld & Swanepoel 19504* (WIND, holo.).

Plants solitary, rosulate, up to 0.73 m tall and 1.3 m diam., shortly caulescent; stem up to 1 m long and 100 mm in diam., erect when young, becoming decumbent with age, covered with remains of old dry leaves; bark grey. *Roots* grey, 3–4 mm thick. *Juvenile leaves* distichous at first, lorate-triangular and biconvex, both surfaces distinctly spotted, some spots with short spines; apex mucronate. *Mature leaves* 35–40, in a dense rosette,

arcuate-ascending, lower leaves spreading, tough, with asymmetric keel near apex, triangular-lanceolate, 380–670 × 70–140 mm; upper surface flat, but becoming channelled in upper half, pale glaucous, slightly rough to touch, sparsely white-spotted in basal third, occasionally without spots, with lenticular spots irregularly arranged; lower surface flat to slightly convex at first, becoming convex, copiously white-spotted, with lenticular spots arranged in obscure white bands; margin yellowish green, cartilaginous, translucent, armed with deltoid-acuminate, small, black (yellowish to reddish brown at first) teeth 3–4 × 4–5 mm, 7–15 mm apart (8–9 mm apart near apex), projecting towards apex; apex acute, ending in 1–3 teeth. *Leaf sap* copious, yellowish, drying honey-coloured to dark brown to black. *Inflorescence*: 1 or 2 per plant, a much-branched panicle, 1.23–1.42 × 0.6–0.85 (–1.12) m, bearing many lateral branches in upper half; peduncle biconvex, grey-green, up to 40 mm diam. at base and unbranched for up to 220 mm, with powdery bloom, flattened and marginiform (bearing an acute margin opposite to each other) at base for 150–200 mm; racemes cylindrical-acuminate, 330–470 × 700 mm; flowers laxly arranged; pedicels 11(–14) mm long; bracts ascending, navicular, linear-lanceolate, 10–12 × 3 mm, channelled, acuminate, whitish, thin, scarious. *Perianth* orange-red becoming slightly yellowish when open, cylindrical-trigonal, 35 × 6.0–6.5 mm, rounded at base; outer segments free to halfway down; inner segments free but dorsally adnate to outer over basal half; apices acute to subacute. *Stamens* included but sometimes shortly exerted; anthers oblong, 3 × 1 mm; filaments filiform-flattened, pale yellow, inner 3 narrower and slightly longer; pollen orange.

Ovary green, cylindrical, 6-grooved, $8 \times 2\text{--}3$ mm; style 25 mm long, shortly exserted (sometimes up to 7 mm); stigma capitate. Capsule cylindrical-trigonal, erect, $20\text{--}26 \times 8\text{--}11$ mm. Seed 3×2 mm, angular, winged, grey-black. Figure 11.

Aloe kaokoensis is distinguished by its large, solitary rosettes (up to 1.3 m in diameter) of pale, glaucous leaves with black teeth, of which the apices project towards the leaf apex, and large dense panicles (young erect plant depicted in Figure 11) and stems that are invariably decumbent in old plants. It is clearly related to *Aloe littoralis* in its floral features. *A. littoralis* is found throughout Namibia in suitable habitats and also occurs in Angola, Zimbabwe, Mozambique and Botswana. *A. littoralis* always has an erect stem up to 3 m tall and greyish green leaves that are mottled or spotted when young, but usually without spots in adult plants. Furthermore, the leaves have brown to reddish brown teeth. The perianth of *A. kaokoensis* is 35 mm long, thus slightly longer than in *A. littoralis* (23–34) (Reynolds 1974). *A. kaokoensis* contains copious quantities of yellow leaf sap, which turns honey-coloured to dark brown when exposed to air. Its

large, branched, paniculate inflorescence bears ascending racemes of orange-red flowers, 35 mm long. *A. kaokoensis* may also be confused with two other aloes with pale glaucous leaves (Table 1). The first, *A. namibensis* Giess, is a much smaller species occurring to the south and its flowers are coral-pink. The second, *A. dewinteri* Giess, is a cliff dweller from the Sesfontein region, bearing coral-pink flowers that turn white when fully open.

Aloe kaokoensis grows at altitudes of 700 to almost 2 000 m on the northwestern extreme of the granitic Otjihipa Mountains (eastern margin of the Marienfluss) (Figure 12). The plants are sometimes locally abundant where they grow in granitic soil and quartz fragments, usually in full sun. *A. kaokoensis* is a constituent of arid *Colophospermum mopane* (mopane) woodland, with several species of *Commiphora* prominent, for example, *Commiphora glaucescens*, *C. multijuga*, *C. tenuipetiolata*, *C. virgata* and *C. wildii*. Other associated species include *Adenium boehmianum*, *Aloe dinteri*, *Boschia tomentosa*, *Ceraria longipedunculata*, *C. carrissoana*, *Euphorbia guerichiana*, *E. monteiroi*, *E. virosa*, *Ledebouria* sp., *Lycium* sp., *Rhigozum virgatum*, *Sterculia africana*, *S.*

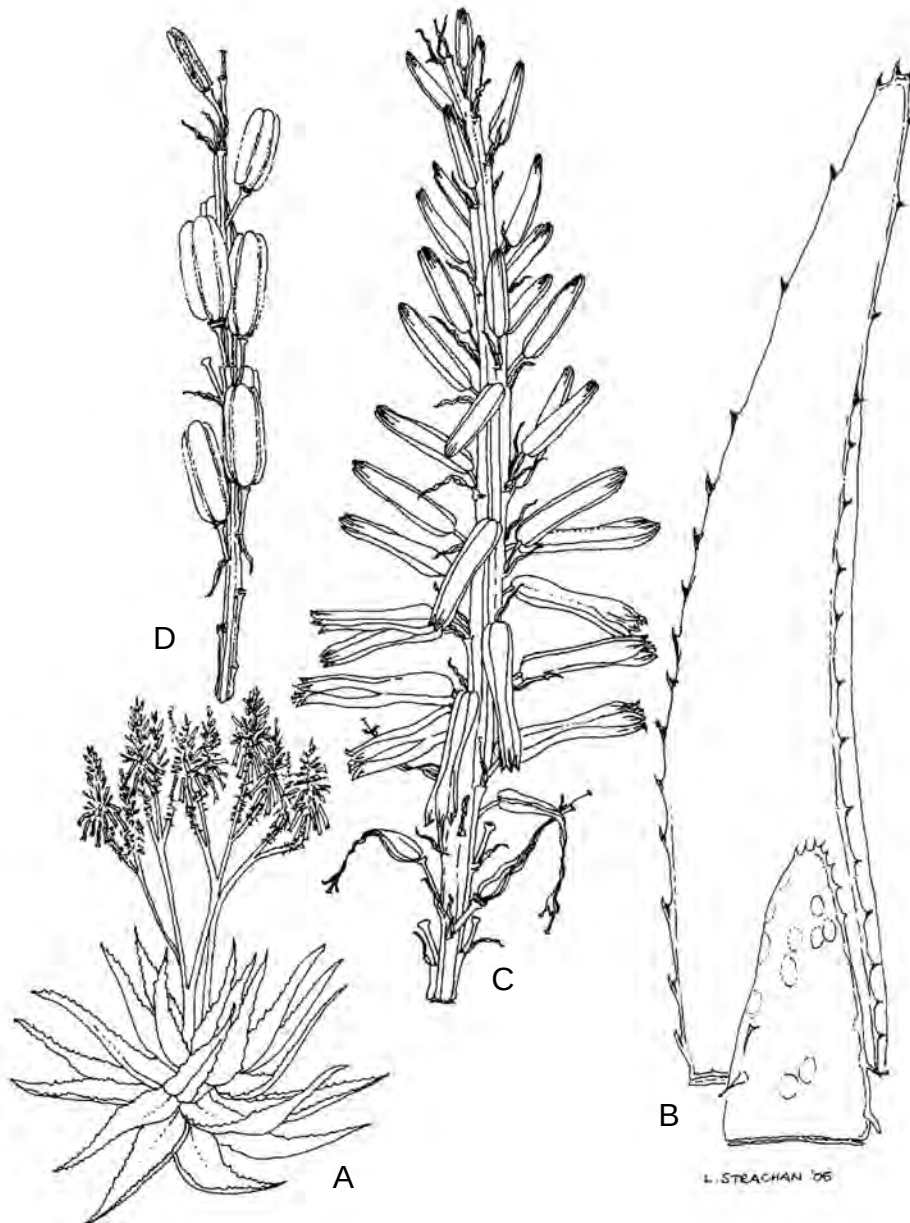
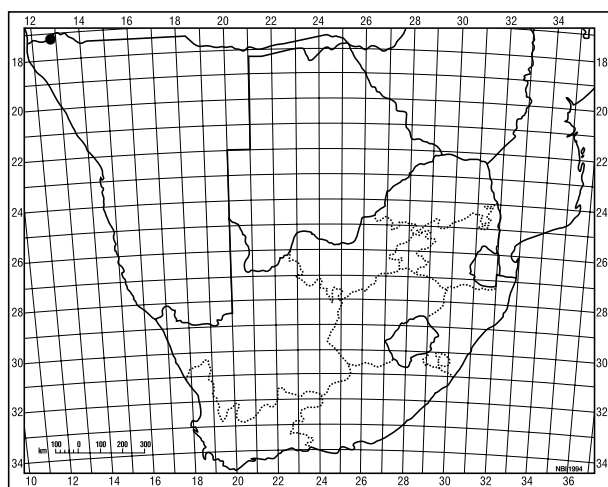


FIGURE 11.—*Aloe kaokoensis*. A, young adult plant (stem not yet decumbent) with inflorescence, $\times 0.08$; B, mature and juvenile leaf apex, $\times 0.8$; C, raceme, showing flowers, $\times 0.6$; D, infructescence showing capsules, $\times 0.6$. Artist: Lisa Strachan.

TABLE 1.—Main differences between *Aloe kaokoensis*, *A. dewinteri*, *A. namibensis* and *A. littoralis*

	<i>A. kaokoensis</i>	<i>A. dewinteri</i>	<i>A. namibensis</i>	<i>A. littoralis</i>
Habit	solitary, stem short, decumbent	solitary, stemless, rarely with short stem, decumbent	solitary, stemless, erect	solitary, erect stem up to 3 m tall
Leaf				
colour	pale glaucous, spotted when young, faintly spotted or not spotted	grey-green with slight powdery bloom, not spotted	glaucous, not spotted	grey-green, spotted when young, non spotted or sometimes spotted when mature
surface	slightly rough to touch (when mature)	smooth to touch	slightly rough to touch	smooth to touch
margin	yellowish to reddish brown teeth turning black	brown, deltoid teeth	brown, triangular teeth	brown to reddish brown teeth
sap	drying honey-coloured, dark brown to black	drying honey-coloured, dark brown	drying light yellow to honey-coloured	drying reddish-brown
Perianth	35 mm long, orange-red, slightly yellowish at mouth	30–33, coral-pink, at maturity turning white or yellowish	30 mm, coral-pink	23–34 mm, dull rose-red to bright red, turning yellowish at mouth

FIGURE 12.—Known geographical range of *Aloe kaokoensis*.

quinqueloba and a *Polygala* sp. The discovery of *Aloe kaokoensis* brings to four the number of *Aloe* species endemic or largely confined to the Kaokoveld Centre of Endemism (Van Wyk & Smith 2001), the others being *A. corallina* I. Verd., *A. dewinteri* and *A. omavandae*.

The flowering time of *A. kaokoensis* ranges from March to May. Dusky sunbirds (*Nectarina fusca*) have been observed visiting the plants, and appear to be the main pollinators. Average annual rainfall in the Kaokoveld varies from less than 50 mm along the coast to ± 350 mm in the highlands (Mendelsohn *et al.* 2002). Rainfall is erratic and occurs mainly in the form of thundershowers in summer. On the Otjihipa Mountains where the new species is found, the average annual rainfall is estimated at ± 150 –200 mm. The coastal mountains are also subject to fog from the Atlantic Ocean (60 km from the Otjihipa Mountains).

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AMARYLLIDACEAE

A NATURAL HYBRID IN THE GENUS CLIVIA

The genus *Clivia*, with six described species, is endemic to South Africa and Swaziland (Duncan 1999; Rourke 2002; Swanevelder 2003; Murray *et al.* 2004).

The group is of considerable horticultural significance and its members, including many cultivars, are extensively grown all over the world (Swanevelder 2003).

Artificial hybridization between the different species of *Clivia* results in attractive progeny, currently highly sought after in cultivation (Koopowitz 2002; Swanevelder 2003). Numerous references to such hybrids between *C. miniata* (Lindl.) Regel and *C. nobilis* Lindl.; *C. miniata* and *C. gardenii* Hook.; and *C. miniata* and *C. caulescens* R.A.Dyer have been recorded in the literature (Koopowitz 2002; Rourke 2003; Swanevelder 2003). Natural inter-specific hybridization in the genus has, however, rarely been documented. Rourke (2003) reported a natural hybrid between *C. miniata* and *C. caulescens* from the Bearded Man Mountain near Barberton, Mpumalanga, and its subsequent cultivation at Kirstenbosch National Botanical Garden. Swanevelder (2003) reviewed both the natural and artificial hybrids known in the genus.

The recognition of hybrids in nature is sometimes regarded as somewhat speculative and the existence of such entities is usually based on circumstantial evidence. Generally, the possession of intermediate morphological features, proximity to the putative parents, hybrid fertility with segregation recognizable in the F_2 progeny, preferably supplemented by the artificial hybridization of the putative parents, are applied as criteria in support of a natural hybrid (Stewart & Manning 1982).

Hitherto, no natural hybrids (nothotaxa) have been formally described in *Clivia*—despite the existence of numerous records indicating that at least two species grow sympatrically in different localized populations (over the full distribution range of the genus). Here, for the first time, we formally describe a natural hybrid in *Clivia*. The identity of the hybrid is supported by the four criteria stipulated above (Stewart & Manning 1982). The new nothospecies is intended to cover all hybrids between *C. miniata* (both var. *miniata* and var. *citrina*) and *C. caulescens*.

Clivia* × *nimbicola Z.H.Swanevelder, J.T.Truter & A.E.van Wyk, nothosp. nov., hybrida naturalis inter *Cliviam miniatam* et *C. caulescentem*. Rhizoma aerea inter illos specierum parentalium intermedia. Folia arcuata, 250–350 mm longa, 55–70 mm lata, marginibus integris, apice acuta. Flores numero 10–20(–30); pedicellis suberecto, perianthio tubiformi, 30–60 mm longo, suberecto, segmentis patulis.

TYPE.—Swaziland, 2531 (Barberton): Bearded Man Mountain, (–CB), 30-05-2003, Pearton TP01 (PRU, holo.).

Rhizomatous, solitary or clumping, stout, evergreen perennial, 0.4–1.2 m tall. *Leaf sheath* green to pale red. *Leaves* long-lived, arching, strap-shaped, 250–350 × 55–70 mm, apex acute; margins usually entire, rarely ± serrated. *Scape* 200–600 × 10–30 mm, green. *Inflorescence* umbel-like, 10–20(–30)-flowered, usually loose/open and ± flat-topped; pedicels stiff, erect to drooping, 15–40 mm long, green. *Flowers* semi-erect to drooping, *Perianth* tubular to trumpet-shaped, 30–60 mm long, segments spreading, pastel orange to pastel pink, occasionally with green apices. *Stamens* 6, variable in degree of exsertion at anthesis. *Style* 30–55 mm long; stigma trilobed, apex penicillate. *Ovary* ovoid, green, trilocular. *Fruit* 10–30

berries, green maturing to red. *Seeds* 1–4, subglobose, ± 10–15 mm in diam., pearly white. Figure 13.

Clivia × *nimbicola* is intermediate between *Clivia caulescens* and *Clivia miniata* with regards to rhizome, leaf, umbel and flower morphology (Table 2). Flower colour ranges from pastel orange to pastel pink, with green tepal apices in some specimens. Flowering is erratic, occurring all year round, mainly from July through to December, with some specimens flowering twice yearly—February to May. This long flowering period connects the flowering periods of the two putative parents in the Bearded Man Mountain locality, namely October–November in *C. miniata* and October–December in *C. caulescens*. The extended flowering period of *C. × nimbicola* is regarded as further evidence in support of the taxon's hybrid origin. The formal description of *C. × nimbicola* is also supported by the observation that the hybrid plants bear berries in the wild, thereby inferring fertility and the possibility to maintain populations by means of subsequent breeding among hybrid plants.

Field observations suggest some introgression between *Clivia* × *nimbicola* and its putative parents. Where populations of *C. × nimbicola* occur close to or amongst *C. caulescens*, back-crossing of the hybrid with *C. caulescens* produces umbels with fewer flowers which are tubular, yet more open than in typical *C. caulescens*. Likewise, where the hybrid occurs close to or amongst *C. miniata*, the umbels are less floriferous and the flowers are more funnel-shaped, yet not as open as in typical *C. miniata*. It is suggested that from the inferred initial progeny cross, subsequent generations have resulted from various backcrossings, resulting in a hybrid-swarm. Artificial hybridization between *C. miniata* and *C. caulescens* is usually successful with records dating back to 1945 (e.g. 1945/66, R. Marais PRE37106). Morphologically the resultant hybrids closely match the plants of *C. × nimbicola* in the wild.

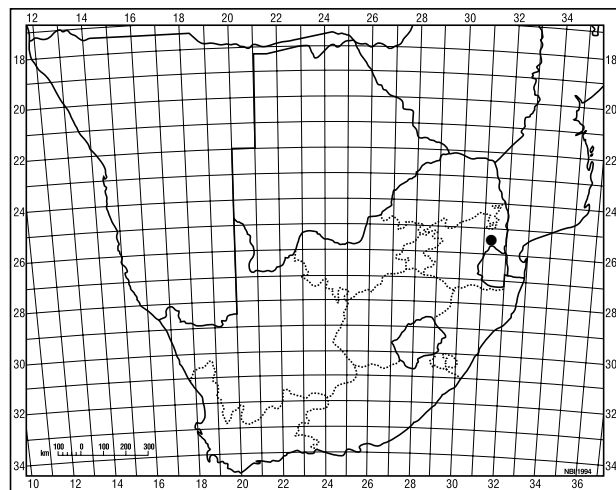
The holotype of *Clivia* × *nimbicola* was collected on the Bearded Man Mountain near Barberton (Figure 14), on the border between South Africa and Swaziland. In this area these natural hybrids are quite common (50 or more individuals) in sympatric stands of *C. miniata* and *C. caulescens*. Judging by plant sizes and the height of aerial stems, original hybrids are as old as their putative parents. Toppled plants with long aerial stems, from either parentage of hybrid, freely produce suckers when in contact with the soil. Seedlings, when present, were usually distributed around its putative parent. The natural distribution range of *C. × nimbicola* is confined to the Barberton Centre of Endemism (Van Wyk & Smith 2001), the only known region in which the distribution ranges of *C. caulescens* and *C. miniata* overlap (Swanevelder 2003). At least three separate, well-established populations of *C. × nimbicola* were recorded, with stands extending into both Swaziland and South Africa. *C. caulescens* prefers steep cliff faces or steep rocky embankments, whereas *C. miniata* generally prefers gentler scree embankments or flatter forest habitats. The *C. × nimbicola* plants are distributed between and amongst both parents, occupying both specific habitats found in the Afromontane Forest. The epithet *nimbicola* means dweller in the mist, and



FIGURE 13.—Type specimen of *Clivia × nimbicola*: A, inflorescence; B, flower in l/s. Scale bars: A, 30 mm; B, 15 mm. Artist: Magda Nel.

TABLE 2.—Comparison of *Clivia × nimbicola* with its putative parents at Bearded Man Mountain, Mpumalanga and Swaziland

Character	<i>C. caulescens</i>	<i>C. × nimbicola</i>	<i>C. miniata</i>
Aerial stem	present in mature plants, length age-dependant	present in mature plants, length age-dependant but shorter than in <i>C. caulescens</i>	present in populations when plants are mature, length age-dependant, usually shorter than in hybrid
Leaf			
sheath colour	green to pale red	green to pale red	green to pale red
orientation	arching	arching	arching
length × width (mm)	300–600 × 35–45	250–350 × 55–70	450–600 × 35–70
apex	obtuse - acute	acute	acute
margin	rarely serrated	usually entire, occasionally serrated	usually entire
Umbel form	usually compact, flattened on one side	loose/open, ± flat-topped	loose, almost globose
Pedicle			
orientation	stiff, erect, drooping just below flower	stiff, erect to drooping	stiff and erect
colour	usually green	green	green
length (mm)	15–35	15–40	30–70
Flower			
number	14–40(–50)	10–20(–30)	7–10(–15)
orientation	drooping	semi-erect to drooping	erect
length (perianth and ovary)	30–45 mm	30–60 mm	60–80 mm
perianth shape	tubular and curved; inner segments slightly spreading	trumpet-shaped and curved with segments open, funnel-shaped, mostly spreading	open, funnel-shaped, ± straight, segments spreading
Protrusion from perianth tube			
anthers	slight	slight, variable	variable
stigma	< 7 mm	< 5 mm, variable	< 10 mm
Seed			
number	1–4	1–4	1–4
size (diam.)	± 8–10 mm	± 10–15 mm	± 12–15 mm
maturation time	± 9 months	± 9 months	± 12 months
Flowering time	October–December	Erratic, mainly July–December and/or February–May	October–November
Whole distribution range	Limpopo (Soutpansberg) Mpumalanga and Swaziland	Bearded Man Mountain, Mpumalanga and Swaziland	Eastern Cape (Transkei), KwaZulu-Natal, Mpumalanga and Swaziland

FIGURE 14.—Known geographical range of *Clivia × nimbicola* in nature.

refers to the mist belt habitat in which this hybrid and its putative parents are found.

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CAPPARACEAE

MAERUA KAOKOENSIS, A NEW SPECIES FROM NAMIBIA

INTRODUCTION

Maerua kaokoensis Swanepoel, a new species confined to the Kaokoveld Centre of Endemism (Van Wyk & Smith 2001), is described. During fieldwork for the Namibian Tree Atlas Project, the author encountered *Maerua* trees in the remote Okakora Mountains, Kaokoveld, with the peculiar habit of being tall, erect and extremely slender, with a few long, thin branchlets near the apex, all of which are distinctly drooping or pendulous. At a distance, the trees superficially resembled *Acacia robynsiana* Merxm. & A.Schreib., a Kaokoveld endemic with a remarkably similar habit. Subsequently, another population of this *Maerua* was discovered in the Otjihipa Mountains further to the west where flowers and fruit were collected.

A study of the *Maerua* holdings in PRE and WIND revealed several earlier collections of the new species, all filed under *M. schinzii* Pax. When without flowers, herbarium specimens of *M. kaokoensis* can easily be mistaken for *M. schinzii* or *M. angolensis* DC. (Killick 1970). This resemblance is due to similarities in leaf and fruit morphology. In the field, however, *M. kaokoensis* is quite conspicuous due to its unusual weeping habit (Figure 15), which is unlike that of any other member of *Maerua* in southern Africa.

Maerua kaokoensis Swanepoel, sp. nov., *M. schinzii* Pax similis foliis nonnullis lamina elliptica, disco flori coronato, impariter laciniato, fructu moniliformi; sed caule pergracillimo, foliorum lamina non solum elliptica sed etiam oblanceolata, lanceolata, lineari-elliptica, lineari-oblonga vel oblonga, non solum flavoviridi sed etiam prasina vel atro-olivacea marronino-suffusa, coriacea vel chartacea, petiolo semper gracillimo, saepe longiori, margine disci semper cum fibrillis longis irregularibus; androphora filamentisque staminum longioribus, gynophora plerumque longiori, ovulis pluribus, tota semper glabra praeter sepalorum faciem adaxialem et sutura, Novembri usque ad Julio florenti differt.

TYPE.—Namibia, 1712 (Swartbooisdrif): Otjihipa Mountains, 8 km ESE of Otjinhungwa, 1 850 m, (–BC), 17-01-2005, Swanepoel 172 (WIND, holo.!; PRE, iso.!).

Slender tree up to 10 m tall. *Trunk* single or rarely with 2 or 3 stems from ground level, occasionally branching into 2 or 3 stems, erect and $\pm$ straight, extremely slender with no lateral branches except for few drooping or pendulous branches near apex, apex usually drooping; stems 20–40(–60) mm in diam. *Bark* smooth, pale ashy grey to reddish grey, with scattered, small indentations in places. *Branches* glabrous with numerous, scattered, small, whitish lenticels, young branches pale ashy grey, reddish brown or yellowish brown, new growth yellowish green or maroon. *Leaves* simple, petiolate, alternate, spirally arranged, drooping or pendulous, glabrous, yellowish green, green or dark olive-green with a maroon tinge, emitting audible clatter when flapping against each other in wind; lamina lanceolate, oblanceolate, narrowly elliptic to elliptic, linear-elliptic, linear-oblong or oblong,

(16–)25–60(–95) $\times$ (5–)7–17(–30) mm, apex acute or obtuse, rarely truncate or emarginate, mucronate, mucro small, up to 0.8 mm long, base cuneate or cuneate to rounded, rarely abruptly attenuate onto petiole, chartaceous to coriaceous; margin entire; midrib conspicuous and prominently raised abaxially, yellowish green or maroon; lateral veins 4–10, looping before margin, usually somewhat or often completely immersed abaxially; petiole very slender, (10–)21–43(–50) $\times$ 0.3–1.2 mm, often slightly swollen over basal part, channelled in basal part, yellowish green, reddish brown or maroon, glabrous. *Inflorescences* short corymbose racemes, borne terminally or on short lateral branches. *Flowers* pedicellate; pedicel glabrous, 4–13 mm long. *Receptacle* cylindrical, 9–13 mm long, 2–3 mm wide at mouth, slender, ribbed, glabrous; disc square in surface view, shortly coronate, solid basal portion 0.4–2.4 mm high, margin unequally lacinate with long, irregular fimbriae; fimbriae usually branched as well as irregularly curved and recurved, up to 2.6 mm long. *Sepals* 4, elliptic or spatulate, often somewhat cucullate, 9.8–14.5 $\times$ 4.0–5.7 mm, apex acute or obtuse, green, puberulous adaxially, glabrous abaxially, margin woolly. *Petals* absent. *Androphore* equal in length to receptacle, or extending to 1 mm below or 2.5 mm above its upper rim, 11–13 mm long. *Stamens* 32–42, pale yellowish green; filaments 18–35 mm long; anthers oblong, ovate-elliptic or narrowly elliptic, basifixed, 1.8–2.5 mm long. *Gynophore* 18–28 mm long, yellowish green. *Ovary* cylindrical, 4.8–7.1 $\times$ 0.9 mm, green; ovules 48–52; stigma capitate. *Fruit* moniliform, up to 180 $\times$ 5–8 mm, green, faintly colliculate. *Seeds* globose, 4–5 mm diam., testa thinly textured, rather fragile, faintly granulate, yellowish cream-coloured. *Flowering time*: November to July. Figures 15, 16.

Diagnostic characters and affinities: *Maerua kaokoensis* differs from *M. schinzii* and *M. angolensis* in habit as well as in leaf and flower characters. Plants of *M. kaokoensis* are markedly different from *M. schinzii* and *M. angolensis* in being extremely slender, yet tall, with only a few drooping or pendulous branches at the apex. Usually the apical part of the main stem (leader shoot) also droops. Trees of *M. schinzii* and *M. angolensis* have a thick stem(s), which branches repeatedly to form a distinct, rounded crown.

The leaf lamina of *Maerua kaokoensis* is lanceolate, narrowly elliptic to elliptic, linear-elliptic, linear-oblong, oblong or oblanceolate, with 4–10 lateral veins on each side of the midrib. In *M. schinzii* the lamina is elliptic to broadly elliptic or ovate to narrowly ovate with only 4 or 5 lateral veins on each side. In the *Flora of southern Africa* [FSA] region, *M. angolensis* has the lamina elliptic, ovate, or obovate, also with only 4 or 5 lateral veins on each side. Outside the FSA region, *M. angolensis* has leaves, in addition to those mentioned, with lamina lanceolate, ovate-lanceolate, linear-lanceolate or suborbicular, with 5 or 6 lateral veins on each side. Furthermore, the lamina in *M. kaokoensis* is coriaceous to chartaceous, whereas in *M. schinzii* it is coriaceous only and in *M. angolensis* softly chartaceous only, although outside the



FIGURE 15.—*M. kaokoensis* in its natural habitat: A, $\pm$ 5 m tall; B, $\pm$ 7 m tall.

FSA region, *M. angolensis* can be coriaceous too. The petiole of *M. kaokoensis* is conspicuously slender, up to 50 mm long, whereas in *M. schinzii* and *M. angolensis* it is thicker, much more sturdy and up to 30 mm long. The leaf lamina of *Welwitsch 968b* in BM (holotype of *M. angolensis* var. *heterophylla* Welw. ex Oliv.), a shrub, 1.0–1.3 m high, from Luanda, Angola, superficially resembles those in one collection of the new species, namely *Swanepoel 173*. However, the lamina in the latter collection is linear-elliptic or linear-oblong with the petiole long and very slender, whereas the lamina in the *Welwitsch* specimen is linear-lanceolate and the petiole is much shorter and not very slender.

The disc margin in *Maerua kaokoensis* differs from *M. schinzii* by the apices being consistently fimbriate. In *M. schinzii* the fimbriellae are often absent and in *M. angolensis* (FSA region) they are always absent. In *M. kaokoensis*, the 11–13 mm long androphore is equal in length to the receptacle, or extends to just above or below its rim. In *M. schinzii*, the androphore is much shorter, 5–7 mm long and equal to or exserted above the receptacle, whereas in *M. angolensis* (FSA region), it usually is longer (12–17 mm) than in *M. kaokoensis* and projected beyond the receptacle. The gynophore is usually longer in *M. kaokoensis* (18–28 mm) than in *M. schinzii* (15–20 mm) and shorter than in *M. angolensis* (35–37 mm).

All parts of *Maerua kaokoensis* are glabrous, except for the sepals, which are puberulous adaxially and woolly on the sutures. On the other hand, all parts of *M. schinzii*, are usually puberulous, whereas *M. angolensis* is gla-

brous or rarely puberulous. Flowering time is also diagnostic: November to July in *M. kaokoensis*, September and October in *M. schinzii* and July to December in *M. angolensis* (Coates Palgrave 2002). As to habitat preference, *M. kaokoensis* occurs in mountains only, whereas *M. schinzii* and *M. angolensis* grow on plains and in river valleys as well.

Some of the more prominent morphological features to differentiate *Maerua kaokoensis*, *M. schinzii* and *M. angolensis* are compared in Table 3. Diagnostic features were determined through examination of herbarium specimens and for *M. kaokoensis* and *M. schinzii*, plants were also examined in the field. For *M. angolensis*, plants in the Weenen District (KwaZulu-Natal) were examined. Additional information for *M. schinzii* and *M. angolensis* (in the FSA region) is mainly from Killick (1970) and Roessler (1966). Information on *M. angolensis* from outside the FSA region was sourced from literature (Oliver 1868; Exell & Mendonça 1937; Hauman & Wilczek 1951; Wild 1960; Elffers *et al.* 1964).

Etymology: the specific epithet refers to the Kaokoveld of northwestern Namibia. The distribution of *M. kaokoensis* falls within the previous politically demarcated Kaokoland, now called the Kunene Region.

Distribution: *M. kaokoensis* is presently known only from the Okakora (part of the Baynes Mountains) and Otjihipa Mountains, south of the Kunene River in northwestern Namibia (Figure 17). It is localized and uncommon to rare in these areas. The species almost certainly

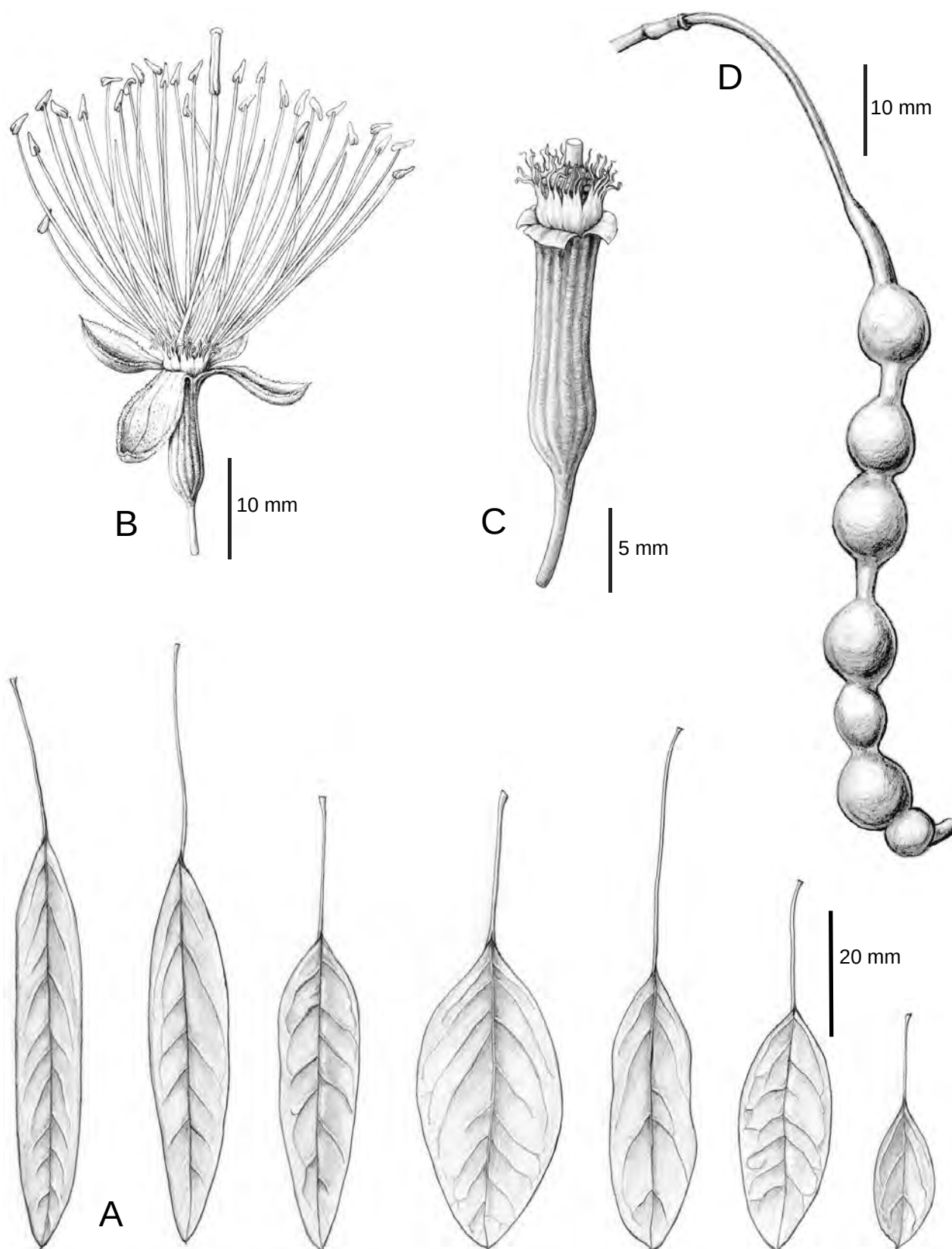


FIGURE 16.—*Maerua kaokoensis*. A, mature leaves from different plants to show variation in size and shape; B, flower, Swanepoel 175; C, receptacle and disc, Swanepoel 175; D, fruit, Swanepoel 172. Scale bars: A, 20 mm; B, D, 10 mm; C, 5 mm. Artist: Julia Kreiss.

occurs in the adjacent mountainous parts of southwestern Angola as well, especially the Serra Cafema range, and may eventually prove to be more widespread on the high mountains of the Kaokoveld Centre of Endemism (Van Wyk & Smith 2001), most of which remain botanically poorly explored.

Habitat and ecology: *M. kaokoensis* grows on dolomite of the Otavi Group in the Okakora/Baynes Mountains and on paragneiss of the Epupa Metamorphic Complex in the Otjihipa Mountains (Miller & Schalk 1980; Mendelsohn *et al.* 2002). It occurs on steep mountain slopes and less often on plateaus and mountaintops. Its distribution

TABLE 3.—Prominent differences between *Maerua kaokoensis*, *M. schinzii* and *M. angolensis*

Character	<i>M. kaokoensis</i>	<i>M. schinzii</i>	<i>M. angolensis</i>
Habit			
trunk	extremely slender	not slender	not slender
apex of leader shoot(s)	drooping or pendulous, sparsely branched; trees without distinctive crown	not drooping or pendulous, densely branched; trees with distinctive crown	not drooping or pendulous, densely branched; trees with distinctive crown
Leaf lamina: lateral veins (each side)	4–10	4 or 5	4 or 5
Petiole			
length (mm)	10–50	8–30	5–30
diam. in middle (mm)	0.3–1.2 (very slender)	0.8–2.5 (sometimes slender)	0.8–1.8 (sometimes slender)
Disc margin	unequally lacinate with apices grown into long, irregular fimbriae; fimbriae branched and usually curved and recurved	unequally lacinate, apices sometimes grown into irregular fimbriae; fimbriae rarely curved	unequally lacinate
Androphore	equal to or extends to 1.0 mm below or 2.5 mm above receptacle	equal to or exserted 2.0 mm above receptacle	exserted 2.0 mm above receptacle
length (mm)	11–13	5–7	5–25 (12–17 in FSA region)
Stamens			
number	32–42	30–70	40–60
filament length (mm)	18–35	14–16	15–40 (20–26 in FSA region)
Gynophore length (mm)	18–28	15–20	35–40
Seed: testa texture	faintly granulate	granulate	smooth
Indumentum			
young branches and leaves	glabrous	puberulous, rarely glabrous	glabrous, rarely puberulous
pedicel	glabrous	puberulous to tomentose	glabrous, rarely puberulous
receptacle	glabrous	puberulous or tomentose, rarely glabrous	glabrous, rarely puberulous
sepals	glabrous abaxially, puberulous adaxially	glabrous or puberulous	glabrous or puberulous
Distribution	confined to Kaokoveld Centre of Endemism	widespread in Namibia, also in southwestern Angola and Northern Cape Province, South Africa	polymorphic species, widespread in sub-Saharan Africa, except Guinea-Congolese region and extreme southern parts of continent

ranges from 75–120 km from the Atlantic Ocean, from the edge of the Great Escarpment eastwards, at altitudes ranging from 700–1 850 m. Average annual rainfall varies from 100–200 mm in these areas.

Specimens examined

NAMIBIA.—1712 (Swarthoofdrif); Otjihipa Mtns, 5 km ESE of Otjihungwa, (–AD), *Swanepoel* 173, 174 (WIND); Otjimborombonga, (–BB), *Leistner, Oliver, Steenkamp & Vorster* 142 (PRE); Baynes Mtns,

Okombambi, (–BB), *Rusch* 77 (WIND); Okakora Mtns, 2 km NW of Okombambi, (–BB), *Swanepoel* 121 (WIND); Otjihipa Mtns, (–BC), *Craven* 945 (WIND); Otjihipa Mtns 7 km SE of Otjihungwa, (–BC), *Swanepoel* 171 (WIND); Otjihipa Mtns, 8 km ESE of Otjihungwa, (–BC), *Swanepoel* 172 (PRE, WIND); Otjihipa Mtns 7.8 km ESE of Otjihungwa, (–BC), *Swanepoel* 175 (WIND); Orukatoa, Otjihipa Mtns, (–BC), *Viljoen* 575 (WIND); NW of Otjitanda, (–DB), *Meyer* 1289 (WIND).

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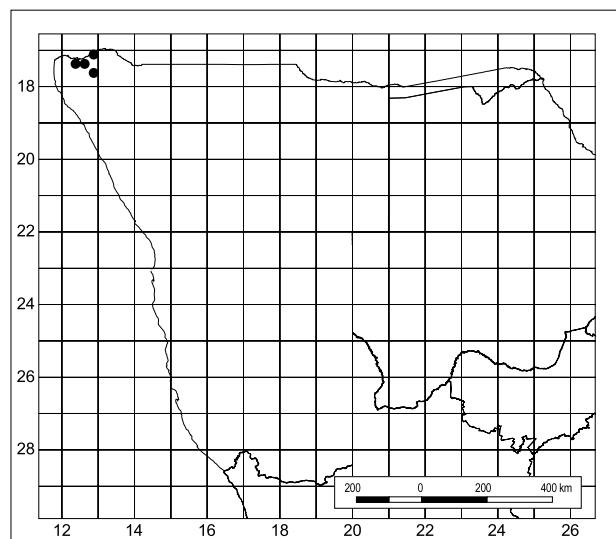


FIGURE 17.—Known distribution of *Maerua kaokoensis*.

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DATA DEFICIENT FLAGS FOR USE IN THE RED LIST OF SOUTH AFRICAN PLANTS

The first Red Data List for southern African plants was published in 1980 (Hall *et al.* 1980), and was followed 16 years later by an update (Hilton-Taylor 1996). These publications classified plants as Rare, Vulnerable, Endangered, Indeterminate or Insufficiently Known. Since then the Species Survival Commission (SSC) of IUCN—World Conservation Union has introduced a new system with improved methods of assessing extinction rates of taxa. This system makes use of prescribed quantitative criteria to place taxa into different categories according to their extinction risks (IUCN 1994, 2001). Many taxa that were previously classified as Rare are now in the category Least Concern (LC) since they are not facing increased extinction risk. However, they may still require conservation attention. For this reason, Victor & Keith (2004) introduced the Orange List concept and proposed a quantitative system of assessing, recording and documenting taxa that should be considered for legal protection and conservation. The Orange List includes taxa that are rare but not declining, as well as taxa that are declining but not fast enough to trigger a threatened listing according to the IUCN Red List Criteria. Two other categories that are considered under the Orange List are Data Deficient (DD) and Near Threatened (NT).

According to IUCN (2001), a taxon qualifies for the category Data Deficient when 'there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status'. Although this usually applies to taxa that are poorly known, this category might also contain well-known taxa that lack sufficient data required for using the IUCN Red List Criteria. Whereas DD is not considered to be one of the categories of threat, listing of taxa in this category acknowledges the possibility that future research may show that threatened classification is appropriate.

During the seven years of compilation of South Africa's Red List of threatened plants according to the revised Red List assessment process, it has become apparent that there is a need to distinguish between different scenarios for listings within the DD category. A set of flags is proposed to distinguish between the different reasons for listing, with the aim of facilitating conservation planning and highlighting research needs for the taxa.

Three main reasons for listing taxa in the DD category are apparent. In the first scenario, taxa have been listed as Data Deficient but are suspected to have taxonomic problems (such as being indistinguishable from closely related taxa) that make it difficult for them to be accurately assessed. Only once these taxonomic problems are sorted out, can a proper assessment be made of the taxon. It is proposed that the taxa that are unable to be assessed due to unclear taxonomic delimitation, or suspected to be synonymous with other taxa, are listed as DD with a flag of 'Taxonomically uncertain' (abbreviated as DDT). Because these taxa are often thought to be synonymous with more widespread taxa, they are usually unlikely to warrant conservation attention. An example is *Erica obconica*, which is probably conspecific with the widespread *Erica mucronata*. However, this has not yet been formalized so the species is classified as DDT for now.

The second flag deals with taxa that could very well qualify for a category of threat but have insufficient information required for the assessment process (such as distribution or rate of decline). It is proposed that such taxa are classified as DD with the flag 'Distribution and/or other information lacking' (abbreviated as DDD). Taxa classified as DDD are likely to be of high conservation importance and high research priority. An example is *Phyllica apiculata*, a shrub found on mountain slopes of the Caledon District. Since much of the natural land in the Caledon area is transformed, it is likely that this species is threatened with extinction. It is therefore classified as DDD until more information becomes available.

A third flag is proposed for taxa that are so poorly known that it is impossible to determine whether or not they could be classified as threatened. Whereas most DD taxa are suspected to be threatened, some taxa have so little information that it is not known whether they are undercollected, rare, taxonomically problematic or poorly known; but there is no cause to suspect that they are threatened with extinction. These taxa are represented by very few collection records in herbaria and have insufficient information about them in the literature. These taxa are flagged to indicate that they are of high research priority, but low conservation priority until such time more information becomes available. These taxa are flagged DDX. An example is *Anderbergia fallax*, which

is known from a single collection made from Goedgeloof Peak in the Langeberg near Swellendam. It is likely to be undercollected as it is a fairly inconspicuous plant; furthermore it is unlikely to be threatened on the high mountain peaks where it grows.

The advantage of flagging subsections of the Data Deficient category is that conservationists will no longer have to divest efforts into the taxa in the DDT and DDX categories. The DDT flag will serve to highlight those taxa that need taxonomic attention; whereas DDD and DDX flags would serve to highlight those taxa in need of more field work and research attention.

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HYACINTHACEAE

ORNITHOGALUM KIRSTENII (ALBUCA GROUP), A NEW SPECIES FROM WESTERN CAPE, SOUTH AFRICA, AND NEW COMBINATIONS IN THE GROUP

INTRODUCTION

The circumscription of the sub-Saharan genera of Hyacinthaceae has recently undergone substantial revision as a result of molecular studies (Manning *et al.* 2004). One of the more radical changes has been the inclusion within a widely circumscribed *Ornithogalum* L. of all genera previously assigned to the subfamily Ornithogaloideae (Speta 1998), among them the sub-Saharan African and Arabian species segregated as the genus *Albuca* L. *Ornithogalum* in this broad sense is defined by its flattened or angular seeds and distinctly trifid or trifurcate stigma. While sinking these genera into synonymy in an expanded *Ornithogalum* has its critics, the alternative taxonomy consistent with the molecular phylogeny not only requires the recognition of *Albuca*, *Dipcadi*, *Galtonia*, *Neopaterersonia* and *Pseudogaltonia*, but also requires several (the final number is uncertain) additional genera to accommodate the sub-Saharan African species currently assigned to *Ornithogalum*, with *Ornithogalum* itself restricted to the Mediterranean and Near East (Speta 1998). Any other taxonomy would render *Ornithogalum* paraphyletic.

The taxonomy of the *Albuca* alliance remains one of the least understood in the Hyacinthaceae. One estimate places the total number of species in the group at ± 60 (Speta 1998) but the most recent listing of the southern African species alone includes 72 current names (Manning & Goldblatt 2003). Many of these will undoubtedly prove to be synonyms. The last complete revision of the southern African species of *Albuca* remains that of Baker (1897) but the revisions of subgenus *Albuca* and subgenus *Falconera* (Salisb.) Baker by Müller-Doblies (1994, 1995), albeit incomplete, represent a substantial advance in our understanding of the genus and provide a basis from which to assess and identify about half of the southern African species currently known. One of their most significant contributions is the proposed division of the species in this alliance into four infrageneric groupings (subgenera).

Albuca subgenus *Falconera*, comprising 19 species from southern Africa, mainly the winter rainfall region of Western Cape, is distinguished by relatively unspecialized inner tepals lacking hinged or hood-shaped apices (Müller-Doblies 1995). The subgenus is further divided into two sections based on the condition of the anthers of the inner whorl of stamens. In section *Falconera* all six stamens are fertile, whereas in section *Trianthera* U.Müll.-Doblies, the stamens of the inner whorl bear rudimentary anthers. Populations of an unusual autumn- and early winter-flowering taxon of section *Falconera* were recently discovered near Swellendam in Western Cape by Kirsten Louw, a young Cape Town naturalist. They represent an unknown species, described here as *Ornithogalum kirstenii*, in memory of his tragic and untimely death in 2005, just weeks after he brought the species to our attention (Cohen *et al.* 2005).

***Ornithogalum kirstenii* J.C.Manning & Goldblatt, sp. nov.**

Plantae deciduae (100–)200–300 mm altae, bulbo solitario vel fasciculis parvis conico non profunde infosso vel partim supra terram 15–20(–40) mm diam., tunicis externis tenuiter coriaceis griseis, internis arcte imbricatis albis vel pallide viridibus ubi expositis, foliis 2, inflorentia leviter brevioribus vel subaequalibus lineari-convolutis sed ad apicem teretibus 10–20(–30) $\times$ 1.5–3.5 mm succulentibus, in quarta vel tertia parte basali caulem amplectentibus; inflorescentia racemus laxis erectis vel inclinatus parum flexuosus ad apicem in alabastro nutans, (2)3–18-florus; bracteis ovato-acuminatis, 5–7(–10) $\times$ 2–3 mm viridibus initio demum pallide brunneis marginibus latis pellucidis, pedicellis patentibus anthesis initio 10–15(–20) mm longis, suberectis ad erectis ubi fructificantibus ad finem 30–50 mm longis; floribus nutantibus flavis carinis viridibus leviter vanillariodori, tepalis biseriatis laminis externis connatis ad ± 1 mm patentibus oblongo-oblancoatis 13–15 $\times$ 4.0–4.5 mm ad apicem papillois, internis suberectis leviter divergentibus ubi apertis oblancoatis concavis 13–14 $\times$ 4.5–5.5 mm ad

apicem pauciter tumidis succulentibusque in pagina interiore fascia longitudinali papillarum, staminibus parum dimorphis, externis subteretibus decrescentibus infra leviter expansis canaliculatisque ± 11 mm longis, internis lateraliter expansis; antheris erectis ± 3 mm longis, ovario oblongo ± 4 mm longo cristis paraseptalibus obscuris, stylo columnari trigono transverse ruguloso ± 8 mm longo, stigmate obtuso-trigono papilloso.

TYPE.—Western Cape, 3420 (Bredasdorp): 2 km WSW of Malgas, Farm Malgaskraal, W bank of gully leading into Breede River opposite Perdekloof, (–BC), 17 April 2005, J. Manning 2942 (NBG, holo.; K, MO, iso.).

Deciduous geophyte, (100–)200–300 mm high. *Bulb* solitary or in small clusters, conical, shallowly buried or partially epigeal, 15–20(–40) mm diam.; outer tunics thinly leathery, pale grey; inner tunics tightly overlapping, white but pale green when exposed. *Leaves* 2, erect, slightly shorter than or subequal to inflorescence, fleshy but firm-textured, linear-convolute for most of length but terete in apical 5–15 mm, 100–200(–300) $\times$ 1.5–3.5 mm, dull green, clasping stem in basal fourth or third. *Inflorescence* an erect or inclined, lax raceme, weakly flexuose, (10–)20–30 mm long, apex nodding in bud, (2)3–18-flowered; bracts ovate-acuminate, 5–7(–10) $\times$ 2–3 mm, green when young but soon drying pale brown, with broad transparent margins; pedicels spreading, nodding at tip at anthesis, 10–15(–20) mm long, becoming subsecund in fruit and suberect to erect, lengthening and ultimately 30–50 mm long. *Flowers* pendulous, canary yellow with green tepal keels, faintly vanilla-scented; tepals biseriate with blades of outer series overlapping inner, joined at base for ± 1 mm, outer tepals spreading, oblong-oblancheolate, 13–15 $\times$ 4.0–4.5 mm, apices papillate, inner tepals suberect, weakly diverging when fully open, oblancheolate, concave, 13–14 $\times$ 4.5–5.5 mm, apices slightly swollen and fleshy with longitudinal band of papillae on inner face. *Stamens* adnate to perianth for ± 1 mm, weakly dimorphic, outer three erect around style, inner three suberect and lying against inner tepals; outer filaments subterete and tapering, slightly widened and channelled in basal third, ± 11 mm long, inner laterally expanded and pinched in lower fifth; anthers erect, ± 3 mm long, cream-coloured. *Ovary* oblong, slightly narrowed at waist, green, ± 4 mm long, paraseptal ridges obscure; style columnar, trigonous, transversely rugulose, yellow, ± 8 mm long, obtuse with trigonous, papillate stigma. *Capsule* narrowly ovoid to flask-shaped, 3-angled, 15–16 $\times$ 5.5–6.5 mm. *Seed* angular-pyriform or D-shaped with flattened sides, minutely papillose, dull black, 2.0–2.5 $\times$ 1 mm. *Flowering time*: April to June. Figure 18.

Distribution and ecology: known from several populations along the lower reaches of the Breede River Valley and its tributaries near Malgas and De Hoop, south of Swellendam (Figure 19), *Ornithogalum kirstenii* is unique among related species in flowering in the late autumn and early winter. Populations of the species occur on both sides of the Breede River (K. Louw pers. comm.), growing on shale cliffs along gulleys and rivers with the bulbs partially exposed or shallowly buried in the decaying rock on the exposed banks and cuttings. The vegeta-

tion on the cliffs is dominated by succulents, especially various Crassulaceae: *Crassula rupestris*, *Cotyledon orbiculata* and an *Adromischus* species. *O. kirstenii* is restricted to this particular habitat and is not found on the adjacent, more gentle, stony or gravelly slopes that support renosterveld shrubland.

Diagnosis and relationships: among the species of *Ornithogalum* previously segregated as the genus *Albuca*, the pendulous flowers with weakly cucullate inner tepals (not apically hinged nor hooded) and six fertile stamens, place *O. kirstenii* in section *Falconera* of subgenus *Falconera* as defined by Müller-Doblies & Müller-Doblies (1995). Of the fourteen species recognized in this section by Müller-Doblies & Müller-Doblies, just six lack glandular hairs. Among these, *O. clanwilliamsae* (U.Müll.-Doblies) J.C.Manning & Goldblatt and *O. fragrans* (Jacq.) J.C.Manning & Goldblatt from Western Cape are distinguished by their smooth styles, *O. bifoliatum* (R.A.Dyer) J.C.Manning & Goldblatt from Eastern Cape by its unique, 3-horned stigma, and *O. angolense* J.C.Manning & Goldblatt (= *Albuca monophylla* Baker) from Angola and Namibia by the single leaf and well-developed, diverging paraseptal ridges on the ovary. This leaves just two species, *O. hesquaspoortense* (U.Müll.-Doblies) J.C.Manning & Goldblatt and *O. robertsonianum* (U.Müll.-Doblies) J.C.Manning & Goldblatt, with which *O. kirstenii* may be confused. Both occur in the Breede River Valley in the general vicinity where *O. kirstenii* has been collected, and both have few or just two leaves, and weakly developed or obsolete paraseptal ridges. These features are all characteristics of *O. kirstenii* but the absence of the types of *O. hesquaspoortense* and *O. robertsonianum* from the herbaria in which they are purported to have been deposited, makes direct comparison with them impossible. The type material of both of these species was, however, apparently collected in the spring, between August and October, rather than in the late autumn or early winter, when *O. kirstenii* flowers. In addition, *O. hesquaspoortense* is distinguished in the protologue from other species by the basally scabrid scape, and *O. robertsonianum* by its thickly fibrous, outer bulb tunics. The scape in *O. kirstenii*, like the leaves, is completely glabrous and the outer bulb tunics are thinly leathery and not at all fibrous. On the available morphological and phenological evidence, therefore, it appears that *O. kirstenii* warrants recognition as a species, at least until more is known about *O. hesquaspoortense* and *O. robertsonianum*.

Other specimens examined

WESTERN CAPE.—3420 (Bredasdorp): 23.5 km along road to De Hoop, shale cliff 300 m S of road, (–AD), 16 May 2005, C. Cohen s.n. (NBG); 2 km WSW of Malgas, Farm Malgaskraal, W bank of gully leading into Breede River opposite Perdekloof, (–BC), 10 April 2005, K. Louw s.n. (NBG).

Among the extensive list of new names and combinations in *Ornithogalum* that accompanied the synonymy of *Albuca* (Manning *et al.* 2004), are several that are inadvertently preoccupied. New names for the taxa concerned are provided here.

***Ornithogalum glutinosum* J.C.Manning & Goldblatt**, nom. nov., pro *O. hallii* (U.Müll.-Doblies)

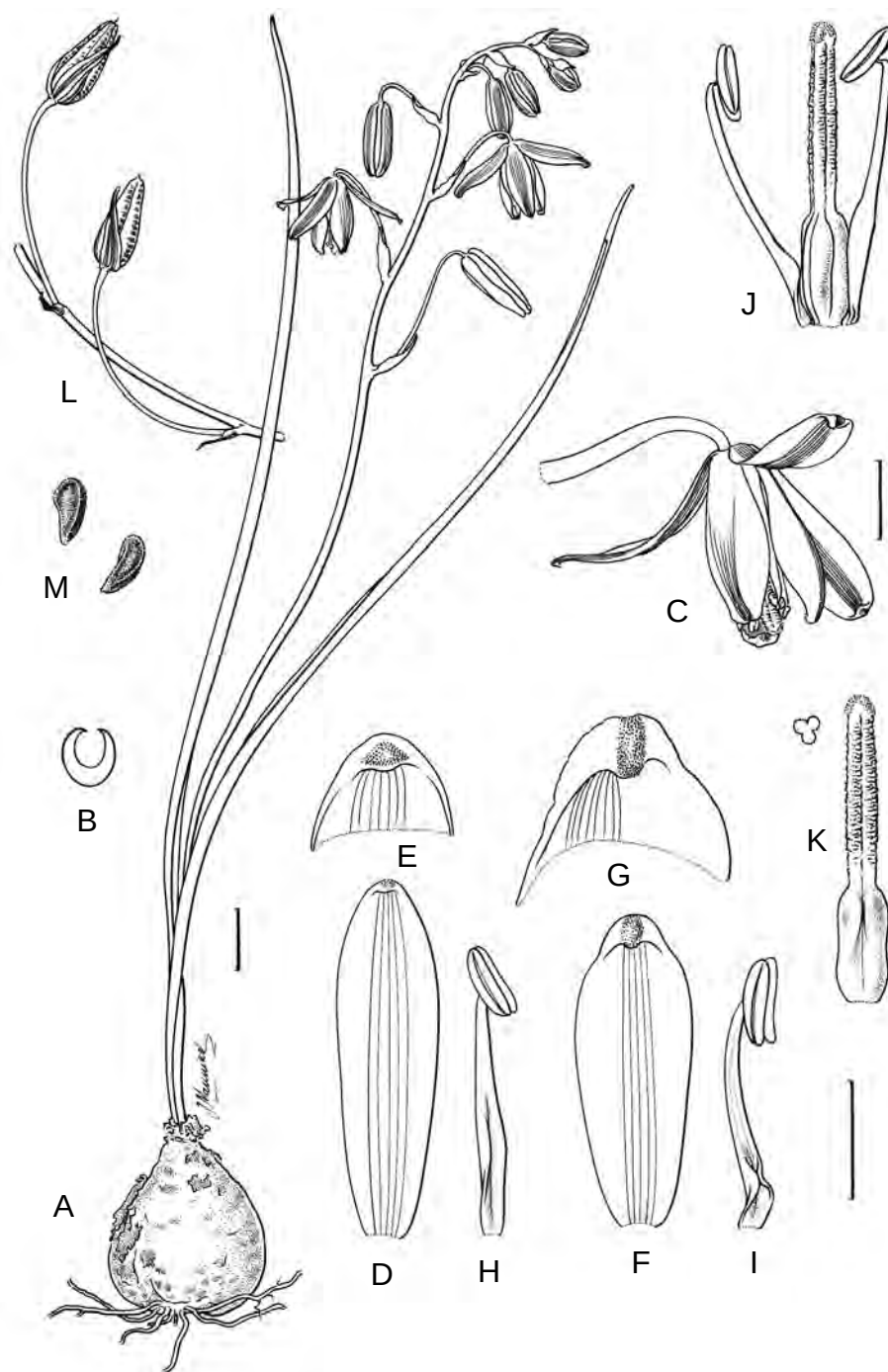


FIGURE 18.—*Ornithogalum kirstenii*, Manning 2942 (NBG). A, whole plant; B, t/s leaf; C, flower; D, outer tepal; E, apex of outer tepal; F, inner tepal; G, apex of inner tepal; H, outer stamen; I, inner stamen; J, gynoecium and two stamens; K, gynoecium with t/s style; L, capsule; M, seeds. Scale bars: A, L, 10 mm; B–D, F, H–K, M, 5 mm; E, G, 2.5 mm. Artist: John Manning.

J.C.Manning & Goldblatt in J.C.Manning et al. in *Edinburgh Journal of Botany* 60: 548 (2004), non *O. hallii* Oberm. (1978).

Ornithogalum melleri Baker in *Journal of the Linnean Society, Botany* 13: 280 (1873).

Ornithogalum abyssinicum (Jacq.) J.C.Manning & Goldblatt in J.C.Manning et al. in *Edinburgh Journal of Botany* 60: 546 (2004), syn. nov., non *O. abyssinicum* Fresen. (1835).

Ornithogalum neopatersonia J.C.Manning & Goldblatt, nom. nov., pro *O. uitenhagense* (Schönland) J.C.Manning & Goldblatt in J.C.Manning et al. in *Edinburgh Journal of Botany* 60: 553 (2004), non *O. uitenhagense* Poelln. (1944).

Ornithogalum soleae J.C.Manning & Goldblatt, nom. nov., pro *O. diphyllum* J.C.Manning & Goldblatt in J.C.Manning et al. in *Edinburgh Journal of Botany* 60: 548 (2004), non *O. diphyllum* Baker (1895).

Ornithogalum volutare J.C.Manning & Goldblatt, nom. nov., pro *O. circinatum* J.C.Manning & Goldblatt in J.C.Manning et al. in *Edinburgh Journal of Botany* 60: 547 (2004), non *O. circinatum* L.f. (1781).

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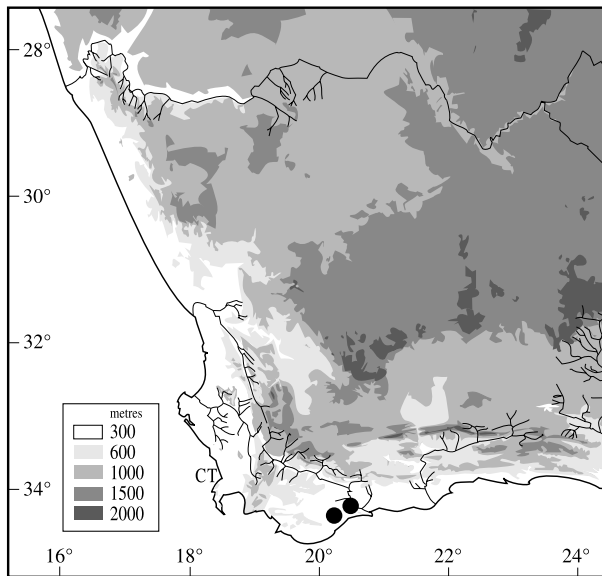


FIGURE 19.—Distribution of *Ornithogalum kirstenii* in Western Cape.

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Reappraisal and identification of *Olinia rochetiana* (Oliniaceae) in South Africa

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Keywords: habit, hypanthium, morphology, *Olinia rochetiana* A.Juss., phenetic, population, South Africa, taxonomy, variation

ABSTRACT

A numerical phenetic analysis of data obtained from populations of the *Olinia rochetiana* A.Juss. complex occurring in South Africa (Mpumalanga and Limpopo Provinces) revealed the existence of two forms: 1, a shrubby form (up to 2.5 m tall), with thick terminal branches, coriaceous leaves with a tinge of red on margins (towards the apices), short inflorescence axes, peduncles and deeply red pedicels and floral tubes/hypanthia; and 2, a slender tree form, measuring more than 4 m tall with slender terminal branches, glossy and slightly thin, papery leaves, margin colour the same as the entire lamina, and the inflorescence axes, peduncles, pedicels and hypanthia pale green to creamy white. Differences in floral features between the two forms correlate with differences observed in vegetative features. The two forms occupy distinct ecological niches and show tolerances and preferences for different environmental conditions such as soil type, elevation and humidity. An identification key for the two forms is presented.

INTRODUCTION

Olinia rochetiana A.Juss. *sensu lato* is a morphologically variable and widespread forest species occurring on foothills and mountain ravines in Angola, Zambia, Zimbabwe, South Africa, Mozambique, Malawi, Tanzania, Kenya, Rwanda, Burundi, Democratic Republic of the Congo, Uganda, Sudan and Ethiopia. The plants prefer moist habitats at the foot of mountains, often along ravines. In this kind of habitat plants often reach quite considerable heights ($\pm$ 4–6 m), whereas in exposed areas the plants are associated with rocky outcrops and quartzitic soils, and mostly measure just less than 3 m tall. The description of *O. rochetiana* by Jussieu (1846) was based on *Rochet d'Héricourt 18*, collected during his voyage in Abyssinia (Ethiopia). The current taxonomic concept of *O. rochetiana* s.l. includes *O. aequipetala* Gilg, *O. discolor* Mildbr., *O. huillensis* Welw., *O. ruandensis* Gilg, *O. usambarensis* Gilg and *O. volkensis* Engl., all of which Verdcourt (1975, 1978) and Verdcourt & Fernandes (1986) treated as conspecific in their regional treatments of Oliniaceae. Commenting on the nature of the morphological variation, Verdcourt (1975, 1978) remarked that South African populations of *Olinia* from the northern and eastern parts of the former Transvaal (now split into four provinces: Gauteng, Limpopo, Mpumalanga and some eastern parts of North-West) with short, broad petals could be recognized as a variety of *O. rochetiana*. Since then material collected from the escarpment in Mpumalanga and Limpopo has been referred to *O. rochetiana*, despite Burt Davy's (1926) recognition of the plants collected from the mist belt forests in Graskop and Pilgrim's Rest, Mpumalanga, as *O. usambarensis*. Gilg (1895) described this latter species based on *Holst 9115*, collected from the elevated forests of Usambara in Tanzania. Cufodontis (1960) and Fernandes & Fernandes

(1962) recognized *O. usambarensis*, but their concepts did not include the South African populations, which represent the most southern limits of the present distribution of the *O. rochetiana* complex in Africa. Thus, the confusion between *O. rochetiana* and *O. usambarensis* has persisted in South Africa. Information gleaned from herbarium sheets of material collected from Usambara, Tanzania, consistently indicates *O. usambarensis* to be a medium to large tree with large and broadly elliptic leaves, and sparsely pubescent hypanthia, as opposed to the shrubby form with shorter obovate leaves, robust and glabrous hypanthia that occurs in misty heights and windswept outcrops in Graskop and within the Pilgrim's Rest area in Mpumalanga.

During October/November to March/April it is possible to observe significant morphological variation in floral and fruit characteristics among populations of *Olinia rochetiana* occurring in Mpumalanga and Limpopo. In undertaking field studies on populations of *O. rochetiana* in South Africa, as part of an Africa-wide revision of this species complex, it became apparent that what is currently referred to *O. rochetiana* in South Africa shows considerable discontinuities in morphological variation between populations. It was therefore decided to study and analyse the morphological variation within and between populations of *O. rochetiana* occurring in South Africa, and determine whether the variation is sufficiently discrete to justify splitting the populations into species or infraspecific taxa. Population level data are often preferred over other kinds of data, and have the potential to provide useful information on the extent and distribution of variation within and between sympatric taxa (Balfour & Linder 1990; Wiltshire *et al.* 1991; Astholm & Nyman 1994; Chandler & Crisp 1998; Hong *et al.* 1998). Most populations of *O. rochetiana* in South Africa are allopatric, separated by mountain blocks of varying elevation/altitudes, rainfall and different soil formations. However, in the Pilgrim's Rest area, some of the populations occur in close proximity to each other, suggesting that the observed morphological variation may have a genetic basis and that the populations are maintained possibly by some sexual reproductive system.

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In this paper, only results from studies on morphological variation among populations of *Olinia rochetiana* in South Africa are presented. The study focused on comparing morphological variation among populations of the *O. rochetiana* complex occurring in Limpopo and Mpumalanga in order to examine to what extent the patterns of morphological variation between populations can be related to environmental factors. A comprehensive taxonomic treatment of the *O. rochetiana* species complex over its entire range of distribution is currently being prepared, and will be published shortly.

MATERIAL AND METHODS

Morphological variation within and between populations was assessed during their flowering (December/January) and fruiting periods (March/April) from 1997 to 2001. A total of fourteen populations of the *Olinia rochetiana* complex occurring in South Africa were sampled (Table 1). In addition, six populations belonging to *O. emarginata* Burt Davy were also sampled and included in the analyses as a standard taxon to aid in an objective evaluation and interpretation of the variability within and between the populations. *O. emarginata* is a clearly defined species in the genus, and is endemic to but widely distributed in South Africa. A Geographic Positioning System (GPS) and the 1: 50 000 topographical maps (published by the Chief Directorate, Surveys and Maps, Cape Town) were used to determine altitude as well as the geographic co-ordinates. Some characters were studied in the field (those pertaining to colour, size and shape of floral features as well as growth form characteristics) and others in the laboratory, using the Zeiss dissecting microscope. Measurements on vegetative and floral parts were made to the nearest 0.5 mm. A minimum of five measurements were made for all the quantitative characters per specimen and averaged. In total, 35 characters, 16 of which are quantitative continuous (obtained by

measurements), three qualitative discontinuous (obtained by counting) and 16 qualitative discontinuous (obtained by scoring each specimen into states) were measured per specimen (Table 2) and entered into a $t \times n$ (taxon $\times$ character) data matrix. The character states of the variation in the measurements or observations made for the characters were discrete and assumed to be under unique genetic control (Stevens 1991; Gift & Stevens 1997). Voucher specimens were prepared and accessioned into J.

The data matrices were analysed using the clustering and ordination algorithms of NTSYS-pc (Numerical Taxonomy and Multivariate Analysis System) version 2.0 (Rohlf 1998). Firstly, the analyses were performed using individuals within populations as operational taxonomic units (OTUs). Secondly, the means of each character for all individuals within each population were averaged and then used in subsequent phenetic analyses with the populations as OTUs. As a recommended procedure in phenetic analyses (Sneath 1976; James & McCulloch 1990; Crisp & Weston 1993), the data matrices were first standardized using the 'STAND' algorithm to render characters dimensionless and to reduce all characters to a scale of comparable range so that each character contributes towards the overall resemblance in proportion to its variability among the set of OTUs.

The data matrices were subjected to an ordination procedure by means of Principal Coordinate Analysis (PCoA), which is preferable and more reliable over the Principal Component Analysis (PCA) when analysing mixed data of both qualitative and quantitative characters (Austin 1985; Kent & Coker 1992) as was the case in this study (Table 2). PCoA was performed on the correlation matrix obtained from the standardized data matrix by using the procedure SIMINT, DCENTER, EIGEN, and MOD3D available in the NTSYS-pc package (Rohlf 1998).

TABLE 1.—Descriptions of localities and populations of plants of *Olinia emarginata* and *O. rochetiana* complex in South Africa

Province	Locality	Abbr.	¼ DS	Alt. (m)	No.	Tot. no.	Height (m)	Habit & branching
<i>O. emarginata</i>								
Limpopo	Haenertsburg	E	2329 DD	± 1 085	5	5	5.5 ± 0.79	Trees, branch at >1.5 m
North-West	Magaliesberg, Hekpoort	P	2526 CD	± 1 540	4	4	8.3 ± 1.1	Large trees, branch at >1.5 m
Gauteng	Florida, Witpoortjie	I	2526 BD	± 1 400	3	3	7.3 ± 1.4	Large trees, branch at >2 m
	JHB, Melville Koppies	L	2625 AB	± 1 200	2	2	9.4 ± 2.4	Large trees, branch at >2 m
Mpumalanga	Roosenekal, Uitkijk	U	2529 BB	± 1 850	8	10	5.8 ± 0.96	Large trees, branch at >1.5 m
	Roosenekal, Naapoort	R	2529 BB	± 1 800	8	8	5.4 ± 1.01	Large trees, branch at >1.5 m
<i>O. rochetiana</i>: slender, tree-like form								
Limpopo	Tate Vondo Forests	V	2230 DD	± 1 250	9	9	3.6 ± 0.66	Slender tree, branch at ±1 m
	Blouberg Mountains	B	2329 AA	± 1524	11	15	1.3 ± 0.35	Slender trees, branch at ± 0.75 m
	Soutpansberg, Letjuma	J	2329 AB	± 1 282	19	24	1.3 ± 0.51	Shrubs, branch at ± 1 m
	Soutpansberg, Llewelyn	W	2329 AB	±1 560	4	4	0.9 ± 0.31	Shrubs, branch at ± 1 m
	Soutpansberg, Ontmoet	M	2329 AB	± 1 530	9	9	1.7 ± 0.38	Shrubs, branch at ± 1 m
	Soutpansberg, Sussens	S	2329 BB	± 1 650	7	7	1.4 ± 0.28	Shrubs, branch at ± 1 m
	Wolkberg, Bewaarkloof	F	2429 BB	± 1 650	4	4	1.6 ± 0.37	Shrubs, branch at ±1 m
Mpumalanga	Blyde, Potholes	H	2430 DB	± 1 300	4	4	1.8 ± 0.58	Shrubs, branch at < 0.5 m
	Themeda Hill	T	2430 DC	± 1 767	4	4	1.4 ± 0.36	Slender tree, branch at ±1 m
<i>O. rochetiana</i> shrubby, dwarf form								
Mpumalanga	Blyde, Mariepskop	K	2430 DB	± 1 980	5	5	1.4 ± 0.23	Shrubs, branch at < 0.5 m
	Mt Sheba, Lost City	C	2430 DC	± 1 958	11	15	1.1 ± 0.32	Shrubs, branch at < 0.5 m
	Blyde, The Pinnacle	N	2430 DD	± 1 476	10	12	0.9 ± 0.55	Shrubs, branch at < 0.5 m
	Blyde, God's Window	G	2430 DD	± 1 700	6	6	1.2 ± 0.32	Shrubs, branch at < 0.5 m
	Blyde, Quartz Hill	Q	2430 DD	± 1 730	8	10	1.2 ± 0.32	Shrubs, branch at < 0.5 m

¼ DS, quarter degree square; No., number plants sampled (either flowering or fruiting) in a population; Tot. no., total number plants observed in a population; Height (m), mean height of plants in a population and ±, standard deviation.

TABLE 2.—Descriptions of characters used in phenetic analyses of *O. rochetiana* complex and *O. emarginata* populations. * Denotes characters defined as in Hickey (1973), Hill (1980) and Herman *et al.* (1987)

1. Mean lamina length (mm).
2. Mean lamina width (mm).
3. Mean petiole length (mm).
4. Mean inflorescence axis length (mm).
5. Mean hypanthium length (mm).
6. Mean petal length (mm).
7. Mean petal width (mm).
8. Mean pedicel length (mm).
9. Lamina obovate, broadly elliptic or narrowly elliptic.
10. Apex emarginate, or acuminate.
11. Base cuneate to round, or decurrent.
12. Lamina midrib channeled above, or not channeled above.
13. Secondary veins loop once, or more than once before margins.
14. Secondary veins branch at 30–45° or at more than 45° from midrib.
15. Lamina paler above, or below.
16. Margins on apex reddish, or same color as lamina.
17. Midrib pinkish to red, or pale green.
18. Terminal branches pink to reddish, or pale green.
19. *Leaf Shape Index (200M/W, where M = mean perpendicular distance from the midrib to the margin, and W = maximum width of the leaf).
20. *Mean number of secondary veins, counted on both sides of midrib on adaxial surface.
21. *Mean secondary vein branching angle (°) on adaxial surface.
22. *Mean areole length (mm) measured on adaxial surface.
23. *Mean areole width (mm) measured on adaxial surface.
24. *Mean number of veinlets per areole counted on adaxial surface.
25. *Mean number of branches per veinlet expressed as branching orders.
26. *Leaf apex angle (°) measured on adaxial surface.
27. *Leaf base angle (°) measured on adaxial surface.
28. Leaf lamina coriaceous /leathery, or soft to slightly papery.
29. Mean hypanthium width (mm) i.e. narrow (2–3 mm) or broad (> 3 mm)
30. Hypanthium deep red, or pale green to cream-white, turning pink with age.
31. Petal pink to deep red, or cream-white.
32. Petal oblong to spatulate, or obovate.
33. Petal apex distinctly mucronate, or without a mucro.
34. Mean width of inflorescence axis (mm).
35. Habit tree form or shrubby.

Cluster analysis was used to test whether groups similar to those obtained in the ordination analyses could be recovered, and also to visualize the level of morphological similarity/dissimilarity using appropriate coefficients between and within populations. Only those characters that were effective in discriminating between populations (as judged by high eigenvalues i.e. > 0.6) in the first three axes of ordination analyses were used in cluster analyses. This approach was followed since cluster analysis is known to 'impose' a hierarchical structure on any data set (Thorpe 1983), and often shows clusters that may not be recoverable in ordination analyses (Chandler & Crisp 1998). Clustering was performed using the Euclidean distances among means through the Unweighted Pair Group Method of Arithmetic Averages (UPGMA).

RESULTS

The PCoA of the data in which individual specimens were used as OTUs, separated specimens of *Olinia rochetiana* from those of *O. emarginata* along the first axis (Figure 1). Specimens belonging to *O. emarginata* are grouped neatly into one unit on the left side of the plot, whereas specimens of *O. rochetiana* occupy the right side

of the plot. Characters most strongly correlated with the first PCoA axis were, in decreasing order, leaf dimensions (leaf width, leaf base angle, leaf apex angle, number of veins looping before margins, angle of branching of veins from the midrib, and petiole length), petal length and shape. Two groups of specimens belonging to *O. rochetiana* are clearly discernible along the second PCoA axis. Specimens belonging to *O. emarginata* are slightly intermediate between the two subgroups of *O. rochetiana* along the second PCoA axis, but overlap with the slender tree form populations of *O. rochetiana*. To the right side of specimens of *O. emarginata* at the top corner is a group comprising populations of the *O. rochetiana* complex from Lost City, The Pinnacle, God's Window, Quartz Hill and Mariepskop, all in Mpumalanga, whereas at the bottom corner is a group of specimens representing the *O. rochetiana* complex populations from the Blouberg, Soutpansberg and the Wolkberg in Limpopo as well as Blyde and Themeda Hill in Mpumalanga. Characters most strongly correlated with the second PCoA axis were, in decreasing order, the habit, leaf texture, size and colour of the hypanthium, petals and terminal branches. The close phenetic similarity of members of the two groups of the *O. rochetiana* complex to each other and their dissimilarity to the *O. emarginata* group can be visualized easily along the first axis. This indicates lower levels of variation within the OTUs of the same populations than between the OTUs of the two groups of the *O. rochetiana* populations. The large gaps and sharp differences between the clusters along the phenetic spaces, as well as the high density or compactness within the clusters (Figure 1) suggest a predominance of discontinuous-state quantitative characters over overlapping continuous-state characters in the data set, thus casting aspersions on the realness of the gaps or discontinuities and how accurately they reflect the morphological differences between the plants studied (Ratliff & Pieper 1981; Stevens 1991; Gift & Stevens 1997). However, the data analysed (Table 2) is a balanced mixture of both quantitative continuous and qualitative discontinuous characters.

The UPGMA cluster analysis using only the fourteen characters with high eigenvalues (> 0.6) in the first two PCoA axes, also separates three groups (Figure 2) corresponding to those obtained in the PCoA analysis. The *Olinia emarginata* specimens form a distinct uniform cluster separate from the *O. rochetiana* specimens at the dissimilarity levels indicated by the two phenon lines (a and b). The clustering of individual specimens belonging to *O. emarginata* did not reflect their representative populations (seven in total). Instead, the specimens were mixed among each other, indicating a low level of variability among the sampled populations of *O. emarginata*. The *O. rochetiana* specimens are split into two major subclusters at the 1.33 dissimilarity level (phenon line a in Figure 2) for which the specimens of *O. emarginata* remain coherent in a single cluster.

The means of each character for all individuals within each population were averaged and cluster analysis performed with the populations used as OTUs. The results (Figure 3) revealed similar groupings and associations between populations as in Figures 1 and 2. The populations of *Olinia emarginata* form a distinct cluster a separate from the populations of the *O. rochetiana* complex,

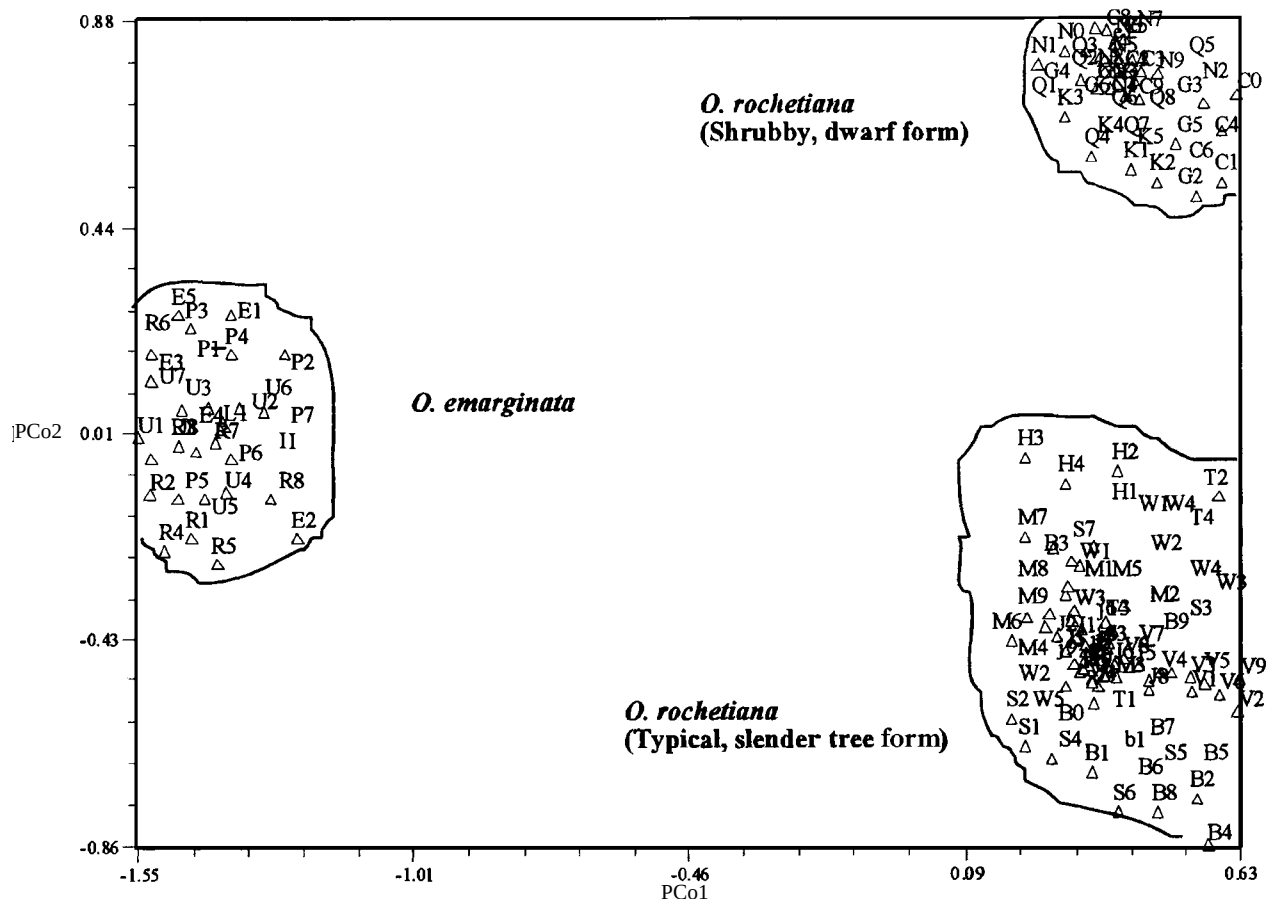


FIGURE 1.—Plot of first two principal co-ordinate analyses obtained from analysing morphological data from populations of *Olinia rochetiana* complex and *O. emarginata*. First and second PCoA axes explain 47.3% and 10.4% of total variation respectively.

which are split into clusters **b** and **c** (Figure 3). The separation of populations belonging to *O. emarginata* (cluster **a**) from those populations (clusters **b** and **c**) belonging to the *O. rochetiana* complex, occurs at a high level of dissimilarity (i.e. 1.83), indicating that these clusters represent morphologically dissimilar entities.

Cluster **b** comprises populations of *Olinia rochetiana* characterized by a slender, tree-like habit; slender terminal branches and branchlets; thin, glossy and papery leaves; slender inflorescence axes, peduncles, pedicels and hypanthia which are pale green to creamy white and turning slightly pink when mature. These are plants from the Soutpansberg (on the Farms Letjuma, Llewellyn, Ontmoet and Sussens), Tate Vondo in Venda, the Blouberg, the Wolkberg in Limpopo, and at Blyde (Potholes) and Themeda Hill in the Pilgrim's Rest area in Mpumalanga (Figure 4). With the exception of populations from Tate Vondo in Venda, which occur in well-shaded, less exposed areas and reaching up to 5 m high, all others occur in fairly exposed environments and at most reach 4 m high. Cluster **c** comprises plants collected exclusively from Mpumalanga at Lost City, The Pinnacle, God's Window, Quartz Hill and Mariepskop (Figure 5). These plants are morphologically distinct from those in cluster **b** in their shrubby, often multi-stemmed form; coriaceous leaves with a tinge of red on margins; and strikingly short inflorescence units relative to inflorescence axes, and hypanthia and petals which are deep red.

The distinctions among the populations are further illustrated by the box plots using selected characters contributing most to the discriminations among populations in the PCoA. The box plots (Figure 6A–D) illustrate variations among populations for leaf width, petiole length, hypanthium length and petal width. These characters, including habit and flower colour, are used in the key.

DISCUSSION

The phenetic analysis, using both cluster and principal co-ordinate analyses, of the specimens of *O. rochetiana* in South Africa indicate that there are two major groups of populations which are identifiable largely by their habit, leaf texture and colour of inflorescence units, hypanthium and sepals. This partly supports the observations that size and shape of floral features are taxonomically significant in *Olinia* (Sebola & Balkwill 1999). Data on floral features indicate that the two major groups of populations can be reliably distinguished from one another on the basis of petiole length, petal length, petal width, and the floral colour.

The conspicuous red flowers in the shrubby form produce less or no scent compared to the creamy white flowers observed in populations with a slender, tree-like habit. The hypanthia (floral tubes) in the shrubby form, were consistently damaged at the base (i.e. at the attachment to the ovary), and their petals often chewed by crawling insects. Both young and old flowers among the shrubby

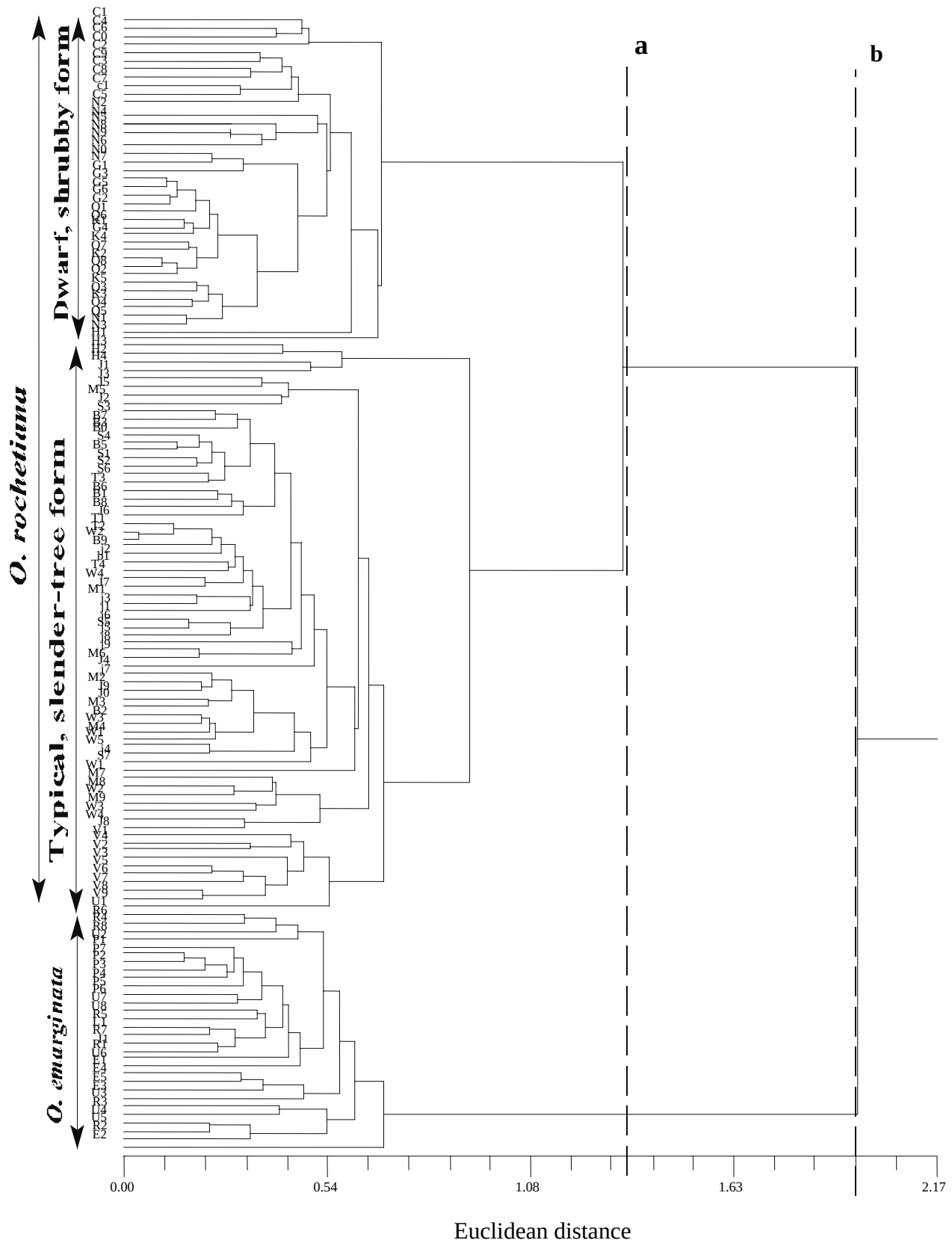


FIGURE 2.—Phenogram, based on analysis of only morphological characters with high eigenvalues (>0.6) in PCoA analysis, using individual specimens from populations of *Olinia rochetiana* complex and *O. emarginata* as OTUs; cophenetic correlation (r) = 0.979. Vertical lines indicate phenon lines a and b.

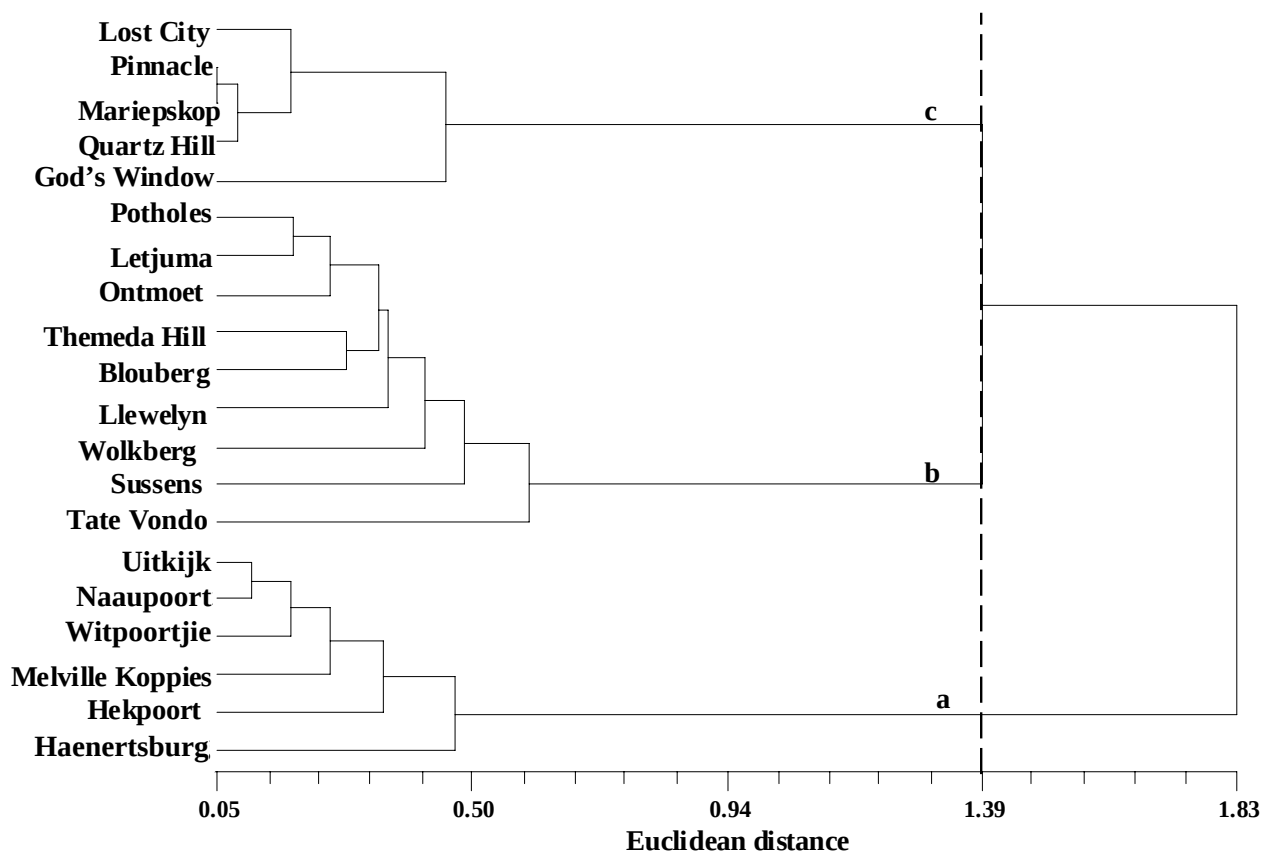


FIGURE 3.—Phenogram, based on analysis of only morphological characters with high eigenvalues (> 0.6) from PCoA analysis, using populations as OTUs; cophenetic correlation (r) = 0.993. Letters **a**, **b** and **c** indicate distinct clusters corresponding to *O. emarginata*, slender, tree-like form populations of *O. rochetiana* and shrubby dwarf form populations of *O. rochetiana* respectively.

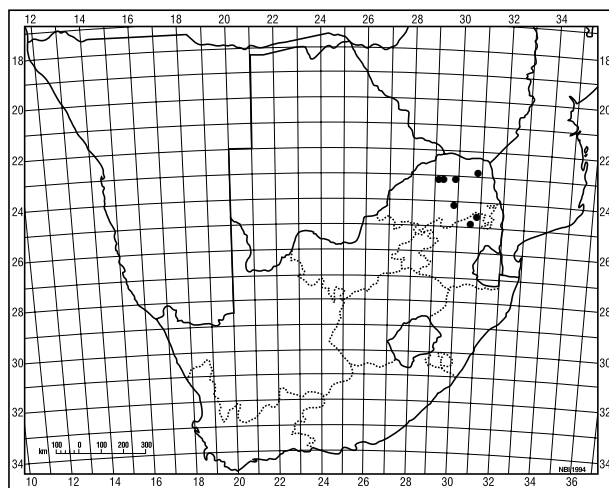


FIGURE 4.—*Olinia rochetiana* in South Africa. Known geographical distribution of slender, tree-like form populations, ●.

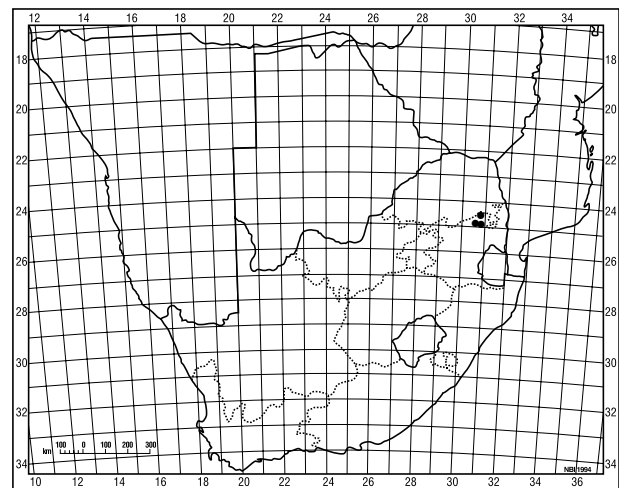


FIGURE 5.—*Olinia rochetiana* in South Africa. Known geographical distribution of shrubby dwarf form populations, ●.

form populations showed signs of damage. The creamy white to pink flowers among the slender tree populations produce sweet scent (observed from morning to mid-day), and bees were observed visiting. No damage was observed on the young and mature flowers. Once pollination has been effected, the hypanthia start wilting, and the signs of ageing appear first on the white petals, which turn brown. In all the populations studied, the flowers appear superficially simple, but closer examination revealed the existence of some structural differences between the two forms of populations. The deep red hypanthia in the

shrubby form are robust, strong, hard and short relative to the petal lengths, and have a wider diameter allowing insects as large as 5 mm access into the tube, whereas among the slender tree populations, the creamy white to pink hypanthia are slightly narrower, weak, twice as long as the petals and the tube hardly opens until anthesis, soon after which petals start wilting. The effectiveness of this barrier to insects would be enhanced by the occurrence of some recognition and rejection system to avoid hybridization among populations given their overlap in flowering periods. Currently, there are no records of

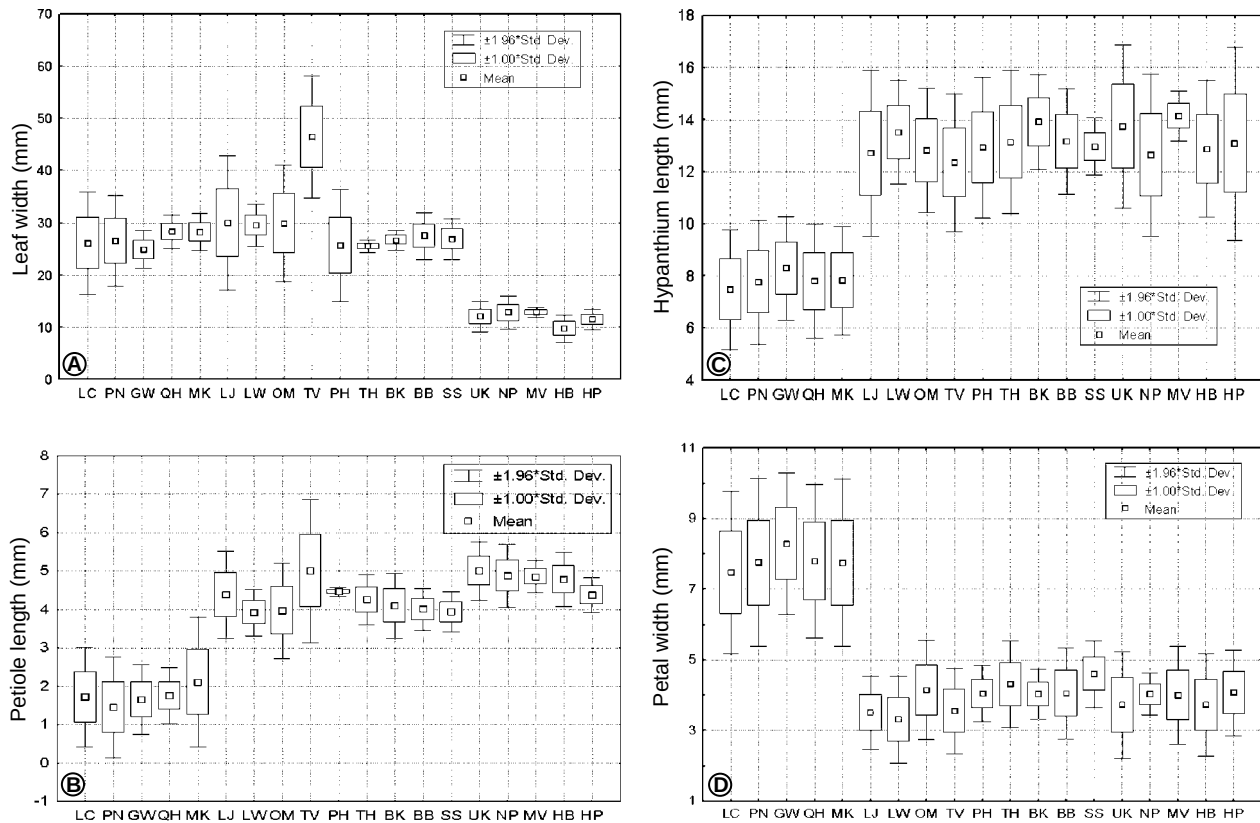


FIGURE 6.—Box and whisker plots showing variation between populations for A, leaf width; B, petiole length; C, hypanthium length; and D, petal width. LC, Lost City; PN, The Pinnacle; GW, God's Window; QH, Quartz Hill; MK, Mariepskop; LJ, Letjuma; LW, Llewellyn; OM, Ontmoet; TV, Tate Vondo; PH, Potholes; TH, Themeda Hill; BK, Wolkberg; BB, Blouberg; SS, Sussens; UK, Uitkijk; NP, Naapoort; MV, Melville Koppies; HB, Haenertsburg; HP, Hekpoort.

sympatric populations for the two forms in South Africa. The nature of the breeding systems among populations of the *O. rochetiana* complex, and other species within *Olinia* needs to be determined to provide clarity on existing isolation mechanisms among taxa.

Both the PCoA and the box and whisker plots indicate that characters that contribute to this differentiation vary significantly among populations and are from diverse plant structures (habit, vegetative and reproductive structures). Leaf texture consistently distinguishes the shrubby plants with coriaceous and/or leathery leaves from the slender, tree-like plants with membranous and/or papery leaves. The shrubby form populations occur in dry conditions, and are found consistently in exposed, windswept sites on rocky outcrops, whereas the slender tree forms occur in moist conditions and in shaded, less exposed areas or near ravines and streams. Plant height is a vegetative feature known to show variation in response to micro-environmental differences, and was thus not included in the phenetic analyses. Of the slender tree-like group of populations, only those from Tate Vondo growing in semi-shaded areas were between 5 and 6 m high, whereas other populations measured between 3 and 4.5 m high. A possible explanation for the plants reaching up to 6 m high could be due to phototropism as a result of limited direct sunlight in shaded areas. There was a correlation between general plant height, habit and altitude. The shrubby form populations characteristically measured well below 2.5 m high and all occurred at elevations between $\pm 1\ 547$ m and $\pm 1\ 980$ m above sea level, where-

as the slender tree form populations measured above 3.5 m high and occurred at altitudes below 1 500 m above sea level. Thus, a trend exists for decreasing plant height at high altitude for the two forms of populations.

The morphological differentiation of the two forms of *Olinia rochetiana* in South Africa seems to reflect adaptations to the micro-climates and ecological conditions in which they occur. Some general habitat characteristics and ecological features such as rainfall, temperature and soil types seem to influence the distributions and occurrence of the two forms of *O. rochetiana* populations in South Africa. Of the slender, tree-like populations, those on the Blouberg and Wolkberg are geographically isolated from those on the Soutpansberg, which have intermediate populations between them along the southern slopes. Materials collected from Leolo Mountains and the rocky outcrops around the Steelpoort area in Sekhukhuneland have particularly glaucous branchlets and young leaves, and are often confused with *O. emarginata* (M. Lötter pers. comm.). In their descriptions of Oliniaceae, Schmidt *et al.* (2002) made reference to a unique form of *O. rochetiana* populations from Sekhukhuneland with young twigs densely hairy. However, the phenetic analyses in this study indicate a strong phenetic similarity between populations from Sekhukhuneland with those from the Blouberg, Wolkberg, Leolo Mountains and the Soutpansberg than they are to those from The Pinnacle (Graskop) and Lost City (Pilgrim's Rest). The larger size of leaves (5–8 mm long) for *O. rochetiana* referred to by Schmidt *et al.* (2002) appears dubious, and extremely

small compared to *O. rochetiana* plants in Mpumalanga (26–48 mm long) and those from Letjuma (Soutpansberg) and Tate Vondo (Thohoyandou, Venda), which range from 34.5–65.0 mm long.

The causes of the morphological variation between the two forms of populations remain unclear. An explanation of the apparent morphological variation on the basis of phenotypic plasticity and considering the varying micro-climates and the environmental differences, appears inadequate to account for the variation in reproductive structures (size, shape and colour) which are generally understood to be less phenotypically plastic than vegetative features (Davies 1983). Variation in reproductive structures is often associated with recognition/rejection mechanisms and successful pollination (Oliveira 1998; Prance 1998). Any hypothesis regarding the causes for the morphological variation among the *Olinia rochetiana* populations in South Africa, would be enriched by an investigation of the mating patterns and reproductive traits to provide insights into gene flow, taking into consideration the geographic distances and plant-pollinator interactions and relationships.

Our phenetic analyses indicate that at least two taxa can be recognized among the populations of *Olinia rochetiana* in South Africa. Formal taxonomic status for these groups of populations will be made in a comprehensive study of the morphological variation within *O. rochetiana* s.l. over its known range of distribution (Sebola & Balkwill in prep.). This study will indicate if any of the two forms of populations overlap with other taxa that might be delimited within the *O. rochetiana* complex. However, the two forms of populations in South Africa can be identified as follows:

Shrub, up to 2.5 m tall, semi-deciduous; internodes of terminal branches shorter than 45 mm, thick and compact, deep red; leaves coriaceous; inflorescence axes and peduncles 6–10 mm long, thick; pedicels, hypanthia and petals deep red shrubby dwarf form

Slender tree, up to 4 m tall; internodes of terminal branches longer than 45 mm, slender and loose, pale green to grey; leaves thin and papery; inflorescence axes and peduncles longer than 10 mm, slender and narrow; pedicels, hypanthia and petals pale-green to creamy white slender tree-like form

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Floristic composition of gold and uranium tailings dams, and adjacent polluted areas, on South Africa's deep-level mines

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Keywords: acid mine drainage (AMD), mine rehabilitation, natural plant establishment, pyrite tailings, slimes dams, tailings storage facilities (TSFs), vegetation survey

ABSTRACT

Gold and uranium tailings ('slimes') dams and the adjacent polluted soils in the deep-level mining regions of South Africa (Carletonville, Klerksdorp and Welkom) were surveyed for the frequency of occurrence of naturally colonizing, actively introduced and persisting plant species. Fifty-six tailings dams with a combined area of 5864 ha, and a similar area of tailings-polluted soils, were surveyed between July 1996 and March 1997. During the survey, 376 plant species and subspecies were recorded from the dams and adjacent polluted soils, with an additional 86 records obtained between 1998 and 2003 (i.e. a total of 462 taxa: species and infraspecific species). Overall, the most commonly represented families were the Poaceae (107 species and subspecies), Asteraceae (81), Fabaceae (55) and Anacardiaceae (16), with other families represented by just one to 14 species. Only 60 species were common to all three regions, and of these 24 had been introduced during rehabilitation attempts. Most of the species found on tailings were persisters or natural colonizers (53–88%, depending on substrate), with the vast majority being indigenous and perennial taxa (76% and 85% respectively), with semi-woody to woody growth forms (66% being resprouters, forbs, shrubs and trees). Less than 4% of the naturally-colonizing taxa found during the survey had also been introduced by vegetation practitioners. The majority of introduced plants were alien herbaceous taxa. The number and frequency of annuals was only high on recently vegetated sites, whereas annuals were rarely present on old-vegetated and never-vegetated dams. This list includes a wide range of indigenous plant species that may be suitable for phytoremediation of tailings dams and polluted soils due to their apparent tolerance of acid mine drainage and salinity.

INTRODUCTION

Tailings storage facilities (TSF) containing waste rock or milled rock slurry from the gold and uranium-mining industry, cover vast areas in South Africa. Gold TSF and 'footprints' (the area of contaminated soil and residual slimes left behind after re-mining of the original TSF) cover about 400 km² in the Witwatersrand Basin goldfields alone, comprising about 6 billion tonnes of gold and uranium tailings (Chevrel *et al.* 2003), and contain an estimated 430 000 tons of uranium (Council for Geosciences 1998; Winde 2004a, b, c) and approximately 30 million tonnes of sulphur (Witkowski & Weiersbye 1998). The volume of waste generated by mining in South Africa increases at the rate of 315 million tonnes per annum, mostly in the form of tailings, of which 105 million tonnes per annum is generated by the gold mining industry on the Witwatersrand Basin alone, at the rate of 200 000 tonnes of waste per ton of gold (Department of Tourism, Economic and Environmental Affairs, 2002; Chamber of Mines of South Africa, 2004). Environmental degradation from gold TSF spreads far beyond the waste deposit sites in the form of air pollution (Van As *et al.* 1992; Mizelle *et al.* 1995), soil pollution (Coetzee 1995; Rosner & van Schalkwyk 2000; Rosner *et al.* 2001; Witkowski & Weiersbye 1998a) and pollution of streams, rivers, dams and sediments (Funke 1990; Pulles 1992; Hodgson *et al.* 2001; Naiker *et al.* 2003; Tutu *et al.* 2003; Coetzee *et al.* 2004; Winde *et al.* 2004a, b, c). Since the TSF for slurry (referred to as slimes dams) are elevated above the natural ground contours and have steep slope angles, they are particularly sus-

ceptible to erosion (Mizelle *et al.* 1995; 1996). Whereas erosion from agricultural fields may be as high as 10 to 15 tons ha⁻¹ year⁻¹, losses from the slopes of gold slimes dams may exceed 500 tons ha⁻¹ year⁻¹ (Blight 1991). Erosion and acid mine drainage from gold slimes dams have severe impacts on nutrient cycling in polluted soils (Witkowski & Weiersbye 1998a), on the regeneration of vegetation (Witkowski & Weiersbye 1998b; Weiersbye & Witkowski 2003) and on the biogeochemical cycling of potentially toxic elements (Weiersbye *et al.* 1999; Winde *et al.* 2004a, b; Weiersbye & Cukrowska 2005).

Prior to 1991, South Africa had little legislation specifically directed towards environmental protection from mining impacts, although recommendations and statutes existed for the structure and abandonment of tailings dams (James 1964; James & Mrost 1965; Chamber of Mines of South Africa 1968, 1979; Blight 1969). Mines did not have a legal obligation to prevent dust pollution until the promulgation of the Atmospheric Pollution Prevention Act 45 (1965), amended in 1973. The Chamber of Mines Guidelines (1979) recommend that wind and water erosion of dams be controlled by the most practical means possible using the BATNEEC (Best Available Technology Not Entailing Excessive Cost) concept. Erosion control included covering the surface of tailings dams with waste rock, or vegetating the tailings; the latter ('grassing') is still considered the most effective means of reducing dust by the industry. This acceptability is based on the speed with which the grass cover establishes, rather than on its long-term persistence or effective erosion control. The earliest recorded attempts at rehabilitation (dust control) of gold tailings dams on the Witwatersrand occurred in 1894, with the planting of *Ammophila* sp. (seed from Kew Gardens, UK), and have been followed by a series of vegetation trials between 1932 and the present day (Thatcher 1979; Weiersbye &

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Witkowski 1998). Slimes dams are inhospitable environments for plant growth, and various combinations of leaching, liming, fertilization and irrigation are used to facilitate the growth of a small suite of herbaceous, mostly pasture species. As predicted by Halliday (1978), the grass cover achieved is temporary and the methods have proven economically and ecologically unsustainable (Thatcher 1979; Weiersbye & Witkowski 1998; Witkowski & Weiersbye 1998a, b). The cost of grassing the steep (30°–45°) slopes of tailings dams ranged from R70 000 to R160 000 ha⁻¹ in the period 1994 to 2002, whereas the cost of grassing the flat tops of dams and dam 'footprints' (polluted areas left after the dam itself has been removed for re-processing to recover residual gold) was between R10 000 and R60 000 ha⁻¹ during the same period (Weiersbye & Witkowski 2002a; Weiersbye *et al.* 2002). Although grassing and irrigation of tailings dam slopes significantly abates wind-borne erosion in the short term (Blight 1991), long-term erosion control and containment of water pollution from gold TSF by grassing has been unsuccessful (Blight 1991, 1998; Weiersbye & Witkowski 1998; Rosner *et al.* 2001).

South Africa now has some of the most stringent environmental legislation in the world, with the right to a healthy environment elevated to a basic human right in the Constitution of South Africa (Act No. 108 of 1996). A number of Acts stress the responsibility of industry to prevent environmental damage, and provide for the prosecution of polluters. These include the Environment Conservation Act (ECA) No. 73 of 1989 and ECA Amendment Act 50 of 2003, the Conservation of Agricultural Resources Act No. 43 of 1983 and amendments of 2001, the National Environmental Management Act 107 of 1998 and amendments, the National Water Act 36 of 1998, the National Nuclear Regulator Act 47 of 1999, the National Environmental Management: Biodiversity Act No. 10 of 2004, the National Environmental Management: Air Quality Act No. 39 of 2004, the Minerals and Petroleum Resources Development Act 28 of 2002, the National Environmental Management: Protected Areas Act No. 57 of 2003, and the National Environmental Management Amendment Act No. 46 of 2003, which facilitated the 'Green Scorpions' unit to investigate environmental offences. In addition, the new regulatory framework for water usage renders industry liable for the cost of water used, and polluted, as a result of operations and rehabilitation under the new Waste Discharge Charge System of the Department of Water Affairs and Forestry. This environmental legislation means that novel, sustainable and cost-effective methods of containing pollution from tailings dams, have to be established.

The aim of this study was to undertake a broad-scale survey of the plant species composition on gold and uranium slimes dams, and slimes-polluted soils, in the deep-level mining regions of South Africa. The underlying rationale was to assess the feasibility of a more sustainable ecological engineering and phytoremediation approach to slimes dam rehabilitation, through identifying a greater suite of suitable species. The dams surveyed ranged in age (from 9 to 58 years since commissioning), in planted vegetation status (present or absent) and in the time elapsed since planting of vegetation (from 3 to

± 50 years). The survey objectives were: (i) to provide a systematic list of indigenous and alien plant species found on slimes dams, and slimes-polluted soils; (ii) to distinguish natural colonizers and persisters (i.e. individuals present prior to slimes deposition but still surviving despite the new conditions) from species intentionally introduced during vegetating attempts; (iii) to broadly classify species according to functional groups; (iv) to assess the number of plant species and their frequency on tailings dams differing in vegetation history at each mining locality; and (v) to assess the number of plant species and their frequency on each of the different substrates that together constitute a tailings dam. These substrates were identified in a parallel study and are characterized mainly by differences in slope angle, elevation (i.e. time since slurry deposition), texture, soil organic matter, water content, conductivity, pH and redox potential (Witkowski & Weiersbye 1998a).

THE STUDY AREA

Vegetation, soils and climate

The study was carried out at Anglo American Ltd (subsequently AngloGold, and FreeGold) mines in the Gauteng, North-West and Free State Provinces. Tailings dams situated around Carletonville (Gauteng), Klerksdorp (North-West) and Welkom (Free State) were surveyed for plant species composition. The survey covered ± 12 000 ha, situated within an overall area of 150 × 100 km over the Upper Witwatersrand Basin, on the West Wits, Vaal and Welkom Reefs (Figure 1). All tailings dams at the West Wits and Elandsrand gold mines (Gauteng), at the Vaal River and Afrikaander gold mines (North-West), and at the Free State Gold, Freddie's, Western Holdings, President Brand, President Steyn, Free State Saaiplaas and Free Gold mines (Free State) were included in the survey. Most of the surveyed tailings dams occur within the Grassland Biome (Acocks 1988; Rutherford & Westfall 1994; O'Connor & Bredenkamp 1997), with one dam in the east occurring in the transition zone between grassland and savanna (Afrikaander Leases in the North-West). The Vaal River and Afrikaander dams are situated on doleritic and sandy soils within the A2 vegetation subdivision (O'Connor & Bredenkamp 1997) of the Grassland Biome at an altitude of 1 300 to 1 350 m. The Free State dams occur on clayey to sandy soils within the A2 and B3 subdivisions at 1 300 to 1 400 m. The Carletonville dams are constructed on rocky quartzite, shale and dolomitic soils in the C6+7 subdivisions at 1 600 to 1 650 m. Tailings dams in the Carletonville region are situated within various combinations of bank-envel, xeric grassland (klipveld) and *Acacia karroo* savanna (Acocks 1988). The main veld type in the Vaal River and Afrikaander mine areas is a combination of dry transitional *Cymbopogon-Themedra* veld, with some development of a mixed grassy false Karoo veld, and dry *Cymbopogon-Themedra* veld. However, most of the surveyed dams here were surrounded by xeric grassland (klipveld) and *Acacia karroo* savanna (Bredenkamp & Brown 1995a, b). In the Welkom mine lease area, most dams are surrounded by mesic to seasonally inundated hydromorphic grassland on clays, endorheic saline pans supporting halophytic grasses, sedges and *Atriplex* spe-

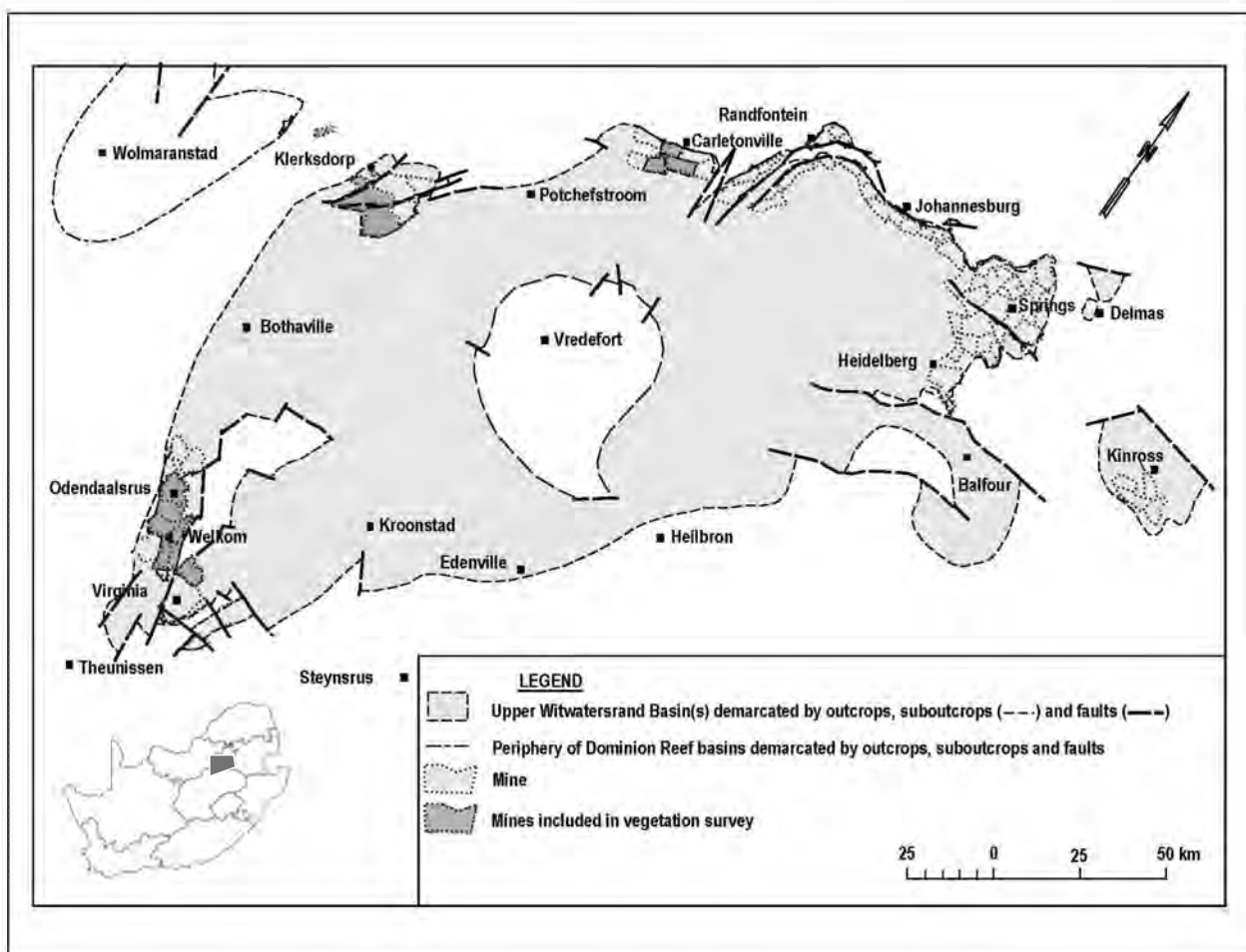


FIGURE 1.—Sketch map showing the location of the study sites (dark grey shading), in relation to the Witwatersrand Basin (light grey shading) (after Anhauser 1987).

cies, and perennial swamps dominated by *Phragmites australis* and *Tamarix* spp. Two tailings dams near Carletonville, three near Klerksdorp, and most of the Welkom dams are situated on pans, vleis or streams.

The climate of the region surveyed is highly seasonal and falls within the Austral summer rainfall belt (Schulze 1997). Mean annual precipitation is 662, 630 and 604 mm for Carletonville, Klerksdorp and Welkom respectively, with high inter-annual variability (25–30%). The regions all experience seasonal extremes of temperature. Mean daily minima (July) and maxima (January) were 0–2 °C and 25–27.5 °C respectively for Carletonville and Klerksdorp, and < 0 °C and 27.5–30 °C respectively for Welkom during the study period. Evaporation is 2–2.5× higher than rainfall, frosts occur frequently in winter (mean frost days is 150–175) (Schulze 1997), and frequent veld fires occur in winter. Regional land use includes cattle and game farming (rangelands), maize and sunflower cropping. Wastelands (derelict, degraded lands with little plant cover) and swampy lands inundated by seepage from slimes dams are common within these landscapes.

Tailings dam construction and composition

The dams were constructed using the paddock system, which involves construction of peripheral slimes dykes

during the day ('day walls'), and filling of the central dam ('night pan') with slimes slurry during the night (Mcphail & Wagner 1987). Excess water is drained away during construction and the construction rate of the dam is limited by the drying rate of the day walls. Moisture content is high on the tops and upper slopes of current dams due to the deposition of fresh slurry, and decreases with distance down the slope. Moisture content increases sharply again at the base of the lower slope and in the toe-paddock due to seepage from the dam. The slopes of the dams surveyed ranged between 29° and 35°; these steep slopes result in high erosive losses (Blight 1991).

The tailings are derived from gold and uranium-bearing conglomerates associated with the sediments of the Witwatersrand Basin up to 4 000 m below surface. Pyrite is the dominant sulphide in the conglomerates, up to 3% of the ore mass, with an additional 2% of other sulphides namely, pyrrhotite, galena, cobaltite, arsenopyrite and chalcopyrite (Anhaesser 1987). The 'all sliming' process was introduced in 1921. Slimes particles are cohesionless, predominantly siliceous and of the size range associated with clays and silts (Clausen 1973); the deposition of such fine particles in an aqueous slurry results in dense compaction and poor aeration in the rooting zone. However, the reactive clay content is negligible, with slimes consisting primarily of unreactive quartz and pyrophyllite. The virtual absence of organic matter con-

tributes further to the negligible cation exchange capacity. The chemical composition of the slimes surveyed varied according to the parent substrate, the metallurgical recovery ('sliming') process used, the composition of the mined ore and the age of the deposits (Bosch 1987; Witkowski & Weiersbye 1998a). The main geochemical divisions of slimes deposits in this study occurred between high (up to 5%) and low (< 1%) pyrite dams. Although slimes produced using older processing techniques have high sulphur contents, slimes derived from the more recent 'Acid Plant' process are lower in sulphur (Bosch 1987). Freshly deposited slimes are grey in colour, saline, moist and alkaline (up to pH 10.0) due to the addition of liming agents during processing. On exposure to air and water, the oxidation of pyrite results in the production of sulphuric acid and ferric hydroxide, with the tailings substrate consequently becoming acidic and yellow. As the substrate acidifies, ferric iron also contributes to oxidation, and sulphur-utilizing *Thiobacillus* bacteria that occur in the tailings facilitate further ferrous oxidation (James & Mrost 1965; Bradshaw & Chadwick 1980). On the slopes of current dams there is consequently a steep pH and acidity gradient between the top (comprising recent, alkaline deposits) and the base comprising older deposits of increasing acidity (Witkowski & Weiersbye 1998a).

METHODS

Site classification

The tailings dams varied in age (from 9 to 58 years since commissioning), in planted vegetation status (vegetated or never vegetated) and in the time elapsed since planting of vegetation (from 3 to $\pm$ 50 years ago). The tailings dams were grouped according to region (Carletonville, Klerksdorp, Welkom), and slopes were classed according to their vegetation history. Vegetation history classes were: (i) recently-vegetated (RV) slopes: amelioration (liming, fertilizing, seeding and irrigation) had ceased >1 to < 4 years previous to 1996; (ii) old-vegetated (OV) slopes: amelioration had ceased > 4 < 50 years previously; and (iii) never-vegetated (NV) slopes: slopes on record as never having been intentionally ameliorated or vegetated. Vegetation records (dates and duration of planting, method and lists of species used) were obtained from vegetation contracts stored with the individual mines and from vegetation contractors. Most dams have had some form of vegetating attempted during the last 50 years. Distinguishing very OV slopes (> 20 years ago) from NV slopes was made difficult both by poor record-keeping prior to the 1980s, and the

rapid reversal of vegetated slopes to eroded, seemingly never-vegetated conditions. This necessitated a forensic approach to determining whether or not a dam had previously been vegetated. Previously vegetated areas were identified from old photographs (including aerial survey), and the remains of old plantings, irrigation pipes and chemical signatures in the slimes as a result of liming and intensive fertilization (Witkowski & Weiersbye 1998a). All the dams except NV had received similar liming and fertilization regimes. In most cases vegetation had been established using intensive irrigation, and in seven cases, vegetation had been established using dry-land methods. In many cases dam slopes had been subjected to repeated grassing attempts over the years, as each attempt had failed.

Each slope was further subdivided into substrate classes based upon marked differences in physical and chemical properties (Figure 2). From the top of the dam downwards, substrates comprised the flat tops, upper-to-mid slopes and berms, mid-to-lower slopes and berms, retaining walls (rock and soil mixed or overlaid with slimes) and toepaddocks (a strip of veld from 20 to 60 m wide surrounding the base of the dam and bordered by an earthen wall). The toepaddocks are heavily inundated by slimes, strongly acidic and often damp (Witkowski & Weiersbye 1998a). The tops, berms and slopes were further categorized according to whether they comprised younger or recently ameliorated and marginally acidic to alkaline (pH > 6.0) slimes deposits, or older and more acidic (pH < 5.9) slimes deposits.

Sampling methods

Lists of species planted on each tailings dam, and planting methods, were obtained from vegetation contracts and assessments archived with Anglo American Mines and from individual contractors, from unpublished theses and reports (including those lodged with individual mines and the Chamber of Mines of South Africa; Thatcher 1979 (and references therein); Wiegenhagen 1996) and from publications (James & Mrost 1965; Wild & Wiltshire 1971; Cresswell 1973; Grove 1974; Clausen 1976; Bradshaw & Chadwick 1980). Two replicate surveys were carried out on the same dams within a nine-month period, in winter (June to September, 1996; Witkowski & Weiersbye 1996) and subsequently in summer (December 1996 to March 1997; Weiersbye & Witkowski 1997). Fifty-six tailings dams comprising 738 different slopes with the same number of toepaddocks were assessed. Intensive searches were carried out on dams, retaining walls and toepaddocks. These comprised (i) large-scale assessments of vegetation cover (data not

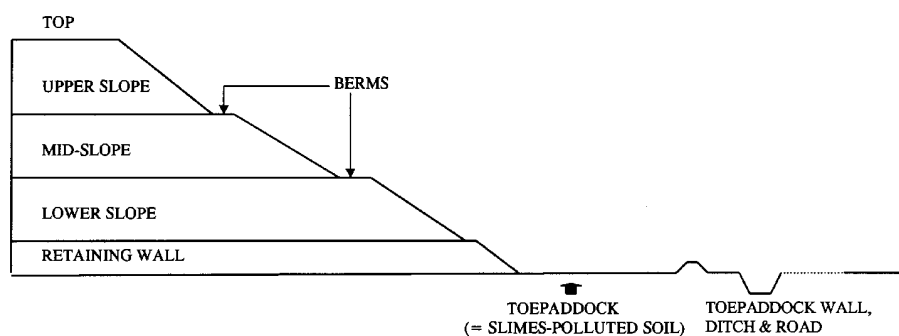


FIGURE 2.—Aspect of a gold slimes dam divided into the substrate classes.

shown, Weiersbye & Witkowski 1998), vegetation structure (proportions of trees and shrubs, forbs and herbs, and grasses) and species presence on all 738 slopes, retaining walls and toepaddocks; and (ii) 254 one hundred metre wide belt transect surveys on a sub-suite of dams (those which had > 0.5% aerial vegetation cover). Data from these 100 m belt transects were then subdivided for each substrate on the slimes dam (upper, middle and lower slopes, tops, berms and toepaddocks) as these invariably differed in species composition. All species present on transects were identified and the number of individuals present for most species recorded. Additional records of species presence only on slimes dams, retaining walls and toepaddocks were obtained from the same mines during 1998 to 2003.

Representative specimens of each taxon were collected and pressed. Plants were identified using the keys of Dyer (1975, 1976), Gibbs Russell *et al.* (1985, 1987, 1991), Venter & Joubert (1985), Coates-Palgrave (1996) and Retief & Herman (1997), and by comparison with specimens at the C.E. Moss and National Herbariums (PRE) of South Africa. Taxa were named according to Arnold & De Wet (1993). A few taxa (reputedly introduced from Namibia and the Northern Cape) defied identification beyond genus. Voucher specimens have been lodged with the C.E. Moss Herbarium, University of the Witwatersrand.

Data classification

Species, subspecies and varieties found in the 100 m transect survey ($n = 327$) were categorized according to their % frequency of occurrence: (i) overall, (ii) in each of the three regions, (iii) on dams of different vegetation history classes, and (iv) on each substrate class. The relative contribution of each family (in terms of component species) was also calculated for each slimes dam substrate class.

Using the 1998 PRECIS database and vegetation distribution records (Arnold & De Wet 1993; Retief & Herman 1997), all species, subspecies and varieties found during the 1996–1997 survey ($n = 376$) were categorized for each dam substrate and overall according to: (i) whether they were indigenous to South Africa or alien (including naturalized species), and (ii) whether they were indigenous to each of the three regions surveyed. Species were also grouped on the basis of: (iii) annual or perennial habit; (iv) broad growth habit (shrubs and trees, forbs and perennial herbs, annual herbs, annual and perennial grasses); and (v) whether they were persisters or naturally colonizing species, or intentionally planted on dams, or combinations. Persisters were generally considered to be plants that pre-dated slimes dam construction. These were categorized as old woody plants present on toepaddocks and/or growing through retaining walls, but usually not present on other substrates. Naturally colonizing species were those present on other substrates (berms and/or slopes and/or tops), either solely or in addition to being present on toepaddocks and/or retaining walls. All non-woody species present on retaining walls were categorized as natural colonizers. Species found subsequent to the survey in 1998 to 2003 ($n = 86$) were not included in the frequency analysis or categorization.

RESULTS

Broad species-compositional patterns

A total of 376 species, subspecies and varieties were recorded during the intensive winter (1996) and summer (1997) surveys, of which the frequency of 327 species and subspecies was recorded using the detailed 100 m transects (Appendix 1). The other (49) species and subspecies are listed in Appendix 2. However, all 376 taxa were included in the general analyses (Tables 1–5). Thirty-six taxa could only be identified to genus level. The number of species on dams in the three provinces was in the order of Klerksdorp (216 species in 1 488 ha), Carletonville (168 in 765 ha), Welkom (120 in 3 611 ha) (Appendix 1). The highest number of species was found on the 100 old-vegetated and 139 never-vegetated slopes (260 and 231 species respectively). The 15 recently-vegetated slopes contained 86 species, of which 21 had been intentionally introduced during grassing, with another 18 weedy annuals and short-lived perennials.

Most species occurred on toepaddocks and retaining walls (287 and 264 species respectively, of which 246 and 231 respectively were natural colonizers and persisters), followed by the acidic slopes (149 species of which 106 were natural colonizers) and acidic tops and berms (137 species of which 103 were natural colonizers). Species composition differed markedly between substrates (Appendix 1). Only 32 species (14 of which had been introduced) were common to more than five substrates, and 161 (16 of which had been introduced) occurred on just one or two substrates. When considering species common to tops and berms and slopes, only six species were common to both acidic ($\text{pH} < 6.0$) and marginally acidic to alkaline substrates ($\text{pH} \geq 6.0$), whereas for tops and berms only, 12 species were common to both acidic and marginally acidic to alkaline substrates. For slopes, 28 species were common to both acidic and marginally acidic to alkaline substrates. Sixty species were common to flat and sloped acidic substrates, and just eight were common to flat and sloped marginally acidic to alkaline substrates. Of the 376 taxa recorded during the survey, only 60 were common to all three mining regions, and of these, 24 were introduced during vegetating attempts (Appendix 1). Only 10% of taxa overall (including < 4% of those which were natural colonizers and persisters) are known to have been introduced during vegetating attempts (Table 1; Appendix 1).

In addition to the 376 taxa, 86 taxa (species, subspecies and varieties) were recorded from 1998 to 2003 (Appendix 3), but were not included in the general analyses (Tables 1–4) or frequency survey (Appendix 1). Of the 86 taxa listed in Appendix 3, 40 were introduced species (three were indigenous trees), and 46 natural colonizers and persisters (39 were indigenous). Thus a grand total of 462 taxa (species, subspecies and varieties) have been identified on gold mine tailings and tailings-polluted soils in the three regions.

Plant families and higher taxa

No gymnosperms were found on slimes during the survey (two species were found post-survey). Dicotyledons dominated the vegetation on all substrates. The high-

TABLE 1.—Percentages of persisting, naturally colonizing and intentionally introduced plants on each substrate class for surveyed slimes dams. Categories mutually exclusive and values in parentheses are no. taxa found (species, subspecies and varieties, $n = 376$). Note that category 'introduced and colonizing' is for those introduced species that can also colonize unaided

Substrates	Persisters	Naturally colonizing	Intentionally introduced	Introduced & colonizing	Total no. taxa
Tops & berms ($\text{pH} \geq 6$)	7.0 (4)	45.6 (26)	19.3 (11)	28.1 (16)	(57)
Tops & berms ($\text{pH} < 6$)	0 (0)	75.2 (103)	2.2 (3)	22.6 (31)	(137)
Slopes ($\text{pH} \geq 6.0$)	0 (0)	59.6 (31)	11.5 (6)	28.9 (15)	(52)
Slopes ($\text{pH} < 6.0$)	0 (0)	71.1 (106)	13.4 (20)	15.4 (23)	(149)
Retaining wall ($\text{pH} < 6$)*	29.2 (77)	58.3 (154)	3.0 (8)	9.5 (25)	(264)
Toepaddock ($\text{pH} < 6$)	32.8 (94)	53.0 (152)	3.8 (11)	10.5 (30)	(287)

* Twenty-one taxa included here as persisters occurred only on retaining walls and may actually be natural colonizers.

est proportion of monocot taxa was observed on the two moistest and on flat substrates (regardless of pH): 35% on tops and berms, and 31% on toepaddocks. The majority of monocots on these two substrates were grasses (up to 28%), with Asparagaceae, Hyacinthaceae, Hypoxidaceae and Juncaceae each contributing up to 1.8% of the total taxa on the former substrate, and Alliaceae, Amaryllidaceae, Asphodelaceae, Commelinaceae, Cyperaceae and Typhaceae only present on toepaddocks, with each of the latter families containing just 0.3–1.0% of the total species detected (Appendix 1 & 2).

The dominant families represented overall were the Poaceae (containing 23.4% of all species found), Asteraceae (17.2%), Fabaceae (10.5%) and Anacardiaceae (3.8%), with other plant families containing between 0.3% and 3.5% of the total (Table 2; Appendices 1 & 2). A similar pattern was observed on toepaddocks and retaining walls. On acidic ($\text{pH} < 6.0$) substrates (tops, berms and slopes), most species belonged (in descending order of frequency) to the Asteraceae, Poaceae, Fabaceae and Chenopodiaceae, whereas on marginally acidic to alkaline ($\text{pH} \geq 6.0$) substrates (tops, berms and slopes) most species belonged to the Poaceae, Fabaceae and Asteraceae, followed by equal representation of the Anacardiaceae, Chenopodiaceae and probably the Tamaricaceae. Identification of *Tamarix* spp. was difficult due to the presence of putative hybrids between *T. usneoides*, *T. ramosissima*, *T. chinensis*, *T. gallica* and *T. aphylla*. Genera represented by ≥ 4 species on slimes dams were *Acacia* (12 spp.), *Aristida* (7), *Asparagus* (4), *Eragrostis* (8), *Felicia* (4), *Helichrysum* (6), *Hermannia* (4), *Paspalum* (5), *Rhus* (12), *Senecio* (6), *Solanum* (6) and *Sporobolus* (4) (Appendix 1). An additional two *Acacia* spp., five *Eragrostis* spp., five *Helichrysum* spp., three *Rhus* spp., three *Senecio* spp. and two *Sporobolus* spp. were recorded subsequent to the survey (Appendices 2 and 3).

Indigenous versus alien species

The survey yielded a total of 90 alien species (including naturalized species) and 286 species indigenous to the southern African region. Fifty-five alien and 152 indigenous species occurred on tailings dams (slopes, berms and tops), whereas 59 alien and 143 indigenous species occurred on retaining walls and toepaddocks (Appendix 1). Eight alien and 14 indigenous species (of which four had been introduced to dams from other regions) occurred only on dams, and not on polluted soils. Overall, the majority of species growing on slimes (76.1%), and

the vast majority of natural colonizers and persisters were indigenous to southern Africa (Table 3), with most (91%) normally found in the local province (Table 4). With the exception of marginally acidic to alkaline slopes (where numbers of indigenous species only slightly exceeded those of alien species), the same pattern prevailed on all slime substrates.

Species characteristic of particular substrates

The number of naturally colonizing and persisting species was higher on acidic ($\text{pH} < 6.0$) substrates, in order of abundance: retaining walls and toepaddocks > slopes and tops and berms > marginally acidic to alkaline ($\text{pH} \geq 6.0$) substrates (Table 1). Although species number was slightly higher on slopes than on flat substrates (tops & berms), overall vegetation cover was always much higher on flat surfaces (Weiersbye & Witkowski 1998). On marginally acidic to alkaline substrates, a relatively high proportion of introduced taxa were also natural colonizers (28–30%, Table 1). However, once the substrate became more acidic ($\text{pH} < 6.0$), this proportion decreased to 10–23%. Few species (8–11%) on retaining walls and toepaddocks had been introduced. These two substrates had the highest levels of vegetation cover and number of species, dominated by indigenous, naturally colonizing and persisting perennial taxa (Appendix 1).

Ecological traits of species

The vegetation of tailings was dominated by perennial species (Table 5), with most also characterized by a deciduous habit. The majority of natural colonizers and persisters were perennial plants, whereas the majority of introduced species were annual and short-lived perennials (Table 5, Appendices 1, 2 and 3). Very few indigenous, perennial species had been intentionally introduced to

TABLE 2.—Percentages of alien (including naturalized) and indigenous plants on tailings dams. Values in parentheses are no. taxa (species, subspecies and varieties) found

Substrates	Alien	Indigenous
Tops and berms ($\text{pH} \geq 6.0$)	38.6 (22)	61.4 (35)
Tops and berms ($\text{pH} < 6.0$)	24.8 (34)	75.2 (103)
Slopes ($\text{pH} \geq 6.0$)	44.2 (23)	55.8 (29)
Slopes ($\text{pH} < 6.0$)	28.9 (43)	71.1 (106)
Retaining wall ($\text{pH} < 6.0$)	18.2 (48)	81.8 (216)
Toepaddock ($\text{pH} < 6.0$)	20.2 (58)	79.8 (229)
All substrates combined	23.9 (90)	76.1 (286)

TABLE 3.—Percentages of taxa occurring on particular substrates within plant families ($n = 65$) during 1996 to 1997 survey. Values in parentheses are actual no. taxa (species, subspecies and varieties) found

	Tops and berms (pH $\geq$ 6.0) ($n = 57$)	Tops and berms (pH < 6.0) ($n = 137$)	Slopes (pH $\geq$ 6.0) ($n = 52$)	Slopes (pH < 6.0) ($n = 149$)	Retaining walls (pH < 6.0) ($n = 264$)	Toepaddocks (pH < 6.0) ($n = 287$)	All substrates combined ($n = 376$)
Acanthaceae					0.8 (2)	1.0 (3)	0.8 (3)
Aizoaceae	1.8 (1)	1.5 (2)	5.8 (3)	2.7 (4)	2.3 (6)	1.0 (3)	1.6 (6)
Alliaceae						0.3 (1)	0.3 (1)
Amaranthaceae		2.2 (3)	1.9 (1)	2.7 (4)	1.9 (5)	0.7 (2)	1.6 (6)
Amaryllidaceae						0.3 (1)	0.3 (1)
Anacardiaceae	7.0 (4)	2.2 (3)	1.9 (1)	3.4 (5)	4.2 (11)	3.8 (11)	3.8 (14)
Apocynaceae					0.4 (1)	0.3 (1)	0.3 (1)
Asclepiadaceae	1.8 (1)	0.7 (1)	1.9 (1)	1.3 (2)	1.1 (3)	1.0 (3)	0.8 (3)
Asparagaceae	1.8 (1)	0.7 (1)	3.8 (2)	0.7 (1)	1.5 (4)	1.4 (4)	1.1 (4)
Asphodelaceae		0.7 (1)			0.4 (1)	0.7 (2)	0.5 (2)
Asteraceae	7.0 (4)	26.3 (36)	15.4 (8)	21.5 (32)	21.6 (57)	16.4 (47)	17.2 (65)
Boraginaceae					0.4 (1)	0.3 (1)	0.3 (1)
Brassicaceae		2.2 (3)	1.9 (1)	2.0 (3)	1.1 (3)	0.7 (2)	1.1 (4)
Cactaceae				0.7 (1)		0.3 (1)	0.3 (1)
Capparaceae						0.3 (1)	0.3 (1)
Caryophyllaceae	1.8 (1)	0.7 (1)	1.9 (1)	0.7 (1)	0.4 (1)	0.3 (1)	0.3 (1)
Celastraceae	3.5 (2)			1.3 (2)	0.8 (2)	0.7 (2)	0.5 (2)
Chenopodiaceae	5.3 (3)	2.9 (4)	5.8 (3)	5.4 (8)	1.5 (4)	2.4 (7)	2.4 (9)
Commelinaceae					0.4 (1)	0.3 (1)	0.3 (1)
Convolvulaceae		1.5 (2)		1.3 (2)	1.9 (5)	1.7 (5)	1.3 (5)
Crassulaceae		0.7 (1)	1.9 (1)	0.7 (1)			0.3 (1)
Cucurbitaceae	1.8 (1)	0.7 (1)	1.9 (1)	2.0 (3)	1.9 (5)	2.1 (6)	1.6 (6)
Cyperaceae		0.7 (1)				1.0 (3)	0.8 (3)
Dichapetalaceae					0.4 (1)	0.3 (1)	0.3 (1)
Dipsacaceae					0.4 (1)	0.3 (1)	0.3 (1)
Ebenaceae	1.8 (1)			0.7 (1)	2.3 (6)	2.1 (6)	1.6 (6)
Euphorbiaceae		0.7 (1)			1.9 (5)	1.7 (5)	1.6 (6)
Fabaceae	15.8 (9)	12.4 (17)	7.7 (4)	8.7 (13)	7.6 (20)	10.8 (31)	10.5 (39)
Geraniaceae				0.7 (1)	1.1 (3)	1.0 (3)	1.1 (4)
Hyacinthaceae	1.8 (1)				0.4 (1)	1.0 (3)	0.8 (3)
Hypoxidaceae	1.8 (1)					0.7 (2)	0.5 (2)
Illecebraceae					0.4 (1)	0.3 (1)	0.3 (1)
Juncaceae	1.8 (1)	0.7 (1)		0.7 (1)	0.4 (1)	0.3 (1)	0.3 (1)
Lamiaceae		2.2 (3)	1.9 (1)	1.3 (2)	2.3 (6)	1.4 (4)	1.6 (6)
Malvaceae		0.7 (1)			1.2 (3)	0.7 (2)	0.8 (3)
Meliaceae	1.8 (1)					0.3 (1)	0.3 (1)
Menispermaceae				0.7 (1)	0.4 (1)	0.3 (1)	0.3 (1)
Mesembryanthemaceae		1.5 (2)	1.9 (1)	4.7 (7)	0.8 (2)	0.7 (2)	2.2 (8)
Moraceae					0.4 (1)		0.3 (1)
Myrtaceae				2.0 (3)	0.8 (2)	1.0 (3)	1.1 (4)
Oleaceae	1.8 (1)	0.7 (1)			0.4 (1)	0.3 (1)	0.5 (2)
Onagraceae		0.7 (1)			0.4 (1)		0.3 (1)
Papaveraceae				0.7 (1)	0.4 (1)		0.3 (1)
Pedaliaceae					0.4 (1)	0.3 (1)	0.3 (1)
Phytolaccaceae		0.7 (1)	1.9 (1)	0.7 (1)	0.4 (1)	0.3 (1)	0.3 (1)
Poaceae	28.1 (16)	24.1 (33)	23.1 (12)	21.5 (32)	20.1 (53)	24.0 (69)	23.4 (87)
Polygalaceae					0.4 (1)	0.3 (1)	0.3 (1)
Polygonaceae				0.7 (1)	0.4 (1)	0.3 (1)	0.3 (1)
Proteaceae					0.4 (1)	0.3 (1)	0.3 (1)
Ranunculaceae		0.7 (1)		0.7 (1)	0.4 (1)	0.3 (1)	0.3 (1)
Resedaceae			1.9 (1)	0.7 (1)		0.3 (1)	0.3 (1)
Rhamnaceae	1.8 (1)			0.7 (1)	0.8 (2)	0.7 (2)	0.5 (2)
Rosaceae						0.3 (1)	0.3 (1)
Rubiaceae		1.5 (2)		1.3 (2)	1.1 (3)	2.1 (6)	2.2 (8)
Santalaceae					0.4 (1)	0.3 (1)	0.3 (1)
Sapindaceae					0.4 (1)	0.3 (1)	0.3 (1)
Scrophulariaceae		0.7 (1)			0.4 (1)	0.3 (1)	0.3 (1)
Selaginaceae	1.8 (1)				0.8 (2)	0.3 (1)	0.5 (2)
Solanaceae	3.5 (2)	2.9 (4)	7.7 (4)	2.0 (3)	3.8 (10)	2.4 (7)	3.5 (13)
Sterculiaceae		0.7 (1)		0.7 (1)	1.5 (4)	1.4 (4)	1.1 (4)
Tamaricaceae	* (3–5)	* (3–5)	* (3–5)	* (3–5)	* (3–5)	* (3–5)	1.3 (5)
Tiliaceae	1.8 (1)	0.7 (1)		1.3 (2)	1.1 (3)	1.0 (3)	0.8 (3)
Typhaceae						0.3 (1)	0.3 (1)
Ulmaceae	1.8 (1)		1.9 (1)	0.7 (1)	0.4 (1)	0.7 (2)	0.5 (2)
Verbenaceae		2.2 (3)	1.9 (1)	0.7 (1)	1.9 (5)	1.0 (3)	1.3 (5)

*Percentages could not be calculated for Tamaricaceae as some of the 5 species were not always distinguishable in the field.

TABLE 4.—Percentages of occurrence of plant species found on tailings dams (based on PRECIS database). Values in parentheses are no. taxa (species, subspecies and varieties) found

Substrates	Not found in region	Found in region
Tops and berms (pH $\geq$ 6.0)	14.0 (8)	86.0 (49)
Tops and berms (pH < 6.0)	10.9 (15)	89.1 (122)
Slopes (pH $\geq$ 6.0)	17.3 (9)	82.7 (43)
Slopes (pH < 6.0)	12.7 (19)	87.3 (130)
Retaining wall (pH < 6.0)	6.4 (17)	93.6 (247)
Toepaddock (pH < 6.0)	6.6 (19)	93.4 (268)
All substrates combined	9.3 (35)	90.7 (341)

slimes. Overall, 84.6% of species were perennials versus 15.4% for annuals and short-lived perennials. The vast majority of species found on slimes overall had semi-woody to woody growth forms: perennial forbs and herbs (47.6%), followed by perennial grasses (18.6%), and shrubs and trees (18.4%), with annual herbs (11.2%) and annual grasses (4.3%) forming minor components (Table 5). A similar pattern was seen on each substrate. The relatively high contribution of shrubs and trees to the persisting vegetation of marginally acidic to alkaline tops and berms ($\pm$ 30%) was due to the low height (depth of slimes) of three current (recently commissioned) dams included in the survey. These dams contained large live trees that were rooted in the underlying soil and had survived tailings dam construction and inundation by slimes for a number of years. Islands of fertility had formed on the slimes under the canopies of these trees, and contained a number of herbaceous species that were not found on this substrate under any other conditions. Trees and shrubs were often abundant on the lowest reaches of dams (base of lower slope and retaining wall). The large size and/or morphology of many of these plants suggests that they pre-date dam construction, and had grown through the slimes. In contrast, trees and shrubs on the slopes, berms and tops appear to be rooting only within the slimes.

The naturally colonizing and/or persisting taxa comprised mostly woody and semi-woody growth forms, whereas the majority of introduced taxa were herbaceous forms (Appendix 1). The majority of naturally colonizing grasses were C_4 species, while virtually all the introduced grass taxa were pasture species comprising a mixture of C_3 and C_4 taxa (Appendix 1; Gibbs Russell *et al.* 1991). The introduced species mirror the commercial availabil-

ity of grass seed in South Africa. Most of these species are intended for intensively managed pasture cultivation on agricultural lands, and not for the rehabilitation of low nutrient, saline and acidic tailings dams. In a previous survey of slimes dam tops in Johannesburg, Thatcher (1979) recorded a total of 142 species, 94 of which were also recorded in this survey. Thatcher (1979) also found that the majority of species were natural colonizers and the Asteraceae, Fabaceae and Poaceae were well represented. Woody species diversity was higher on more acidic sites, whereas grasses dominated on less acidic sites.

Few of the 376 species, subspecies and varieties found in the 1996–1997 intensive survey are known to have been intentionally introduced to slimes dams during vegetating attempts over the last 50 years. Some species were introduced to slimes dams in the surveyed region by the Chamber of Mines Vegetation Unit in the 1950s (B. Cook, B. Dawson, J. Easton, pers. comm.) However, it is not known whether existing conspecifics are remnants of the introduced populations, or individuals that have naturally colonized tailings. Some species exhibiting unusual regional distributions may be remnants of these attempts by the Chamber of Mines Vegetation Unit (e.g. *Bassia salsoloides* colonizing old slimes dams in the Welkom region), whereas other species were collected in remote regions and introduced to tailings dams by mine personnel (e.g. *Ruschia* spp. in the Welkom region).

DISCUSSION

This survey found a surprisingly high number of plant species growing on tailings and tailings-polluted soils. Earlier (pre-1980) attempts at vegetating slimes utilized a number of woody, alien species such as Australian acacias (wattles), eucalypts and tamarix in addition to herbaceous legumes and pasture grasses (Thatcher 1979), whereas more recent attempts utilized herbaceous (pasture) species and cultivars. On the basis of old photographs, many of these planted trees still survive on the slopes and tops of tailings dams. Although the contribution of natural colonizers and persisters to cover could be substantial on the flatter surfaces of dams (tops, berms, toepaddocks), the contribution to cover on slopes was extremely low and individual plants were transient due to the high rates of erosion (Weiersbye & Witkowski 1998). The lower number of species found on marginally acidic to alkaline (pH $\geq$ 6.0) tops, berms and slopes could be due to some influence of pH, but also to the much younger

TABLE 5.—Categories of plants found on gold slimes dams. Values are percentages, and values in parentheses are no. taxa (species, subspecies and varieties) found

Substrates	Annual & biennial herbs (excl. grasses)	Perennial & resprouting herbs & forbs (excl. grasses)	Annual & biennial grasses	Perennial grasses	Shrubs & trees	Total annuals	Total perennials
Tops and berms (pH > 6.0)	7.0 (4)	33.3 (19)	7.0 (4)	22.8 (13)	29.8 (17)	14.0 (8)	86.0 (49)
Tops and berms (pH < 6.0)	15.3 (21)	46.7 (64)	5.8 (8)	17.5 (24)	14.5 (20)	21.2 (29)	78.8 (108)
Slopes (pH > 6.0)	25.0 (13)	38.5 (20)	3.8 (2)	17.3 (9)	15.4 (8)	28.8 (15)	71.2 (37)
Slopes (pH < 6.0)	18.1 (27)	43.0 (64)	4.7 (7)	17.5 (26)	16.8 (25)	22.8 (34)	77.2 (115)
Retaining wall (pH < 6.0)	12.5 (33)	53.0 (140)	2.3 (6)	14.4 (38)	17.8 (47)	14.8 (39)	85.2 (225)
Toepaddock (pH < 6.0)	11.8 (34)	48.0 (138)	3.1 (9)	17.0 (49)	19.9 (57)	15.0 (43)	85.0 (244)
All substrates combined	11.2 (42)	47.6 (179)	4.3 (16)	18.6 (70)	18.4 (69)	15.4 (58)	84.6 (318)

age of these substrates in comparison to acidic ($\text{pH} < 6.0$; i.e. older and more oxidized) substrates, the low number of species introduced to recently ameliorated slopes by contractors, and the fact that many dams were current dams, with slurry still being deposited on the top. As a consequence, the tops of current dams only supported reeds and sedges (*Phragmites* sp. and Cyperaceae), if any vegetation. Marginally acidic to alkaline substrates are also usually further and higher (in altitude) removed from seed sources (i.e. surrounding veld) than the older, acidic substrates on the lower slopes of dams. In addition, vegetating efforts were seldom undertaken on slimes of more recent genesis as the Chamber of Mines vegetation guidelines (1979) recommended a dormant period for slimes dams prior to leaching and grassing.

According to species distributional databases, the pattern of species number found on slimes dams is similar to that for the provinces as a whole, with the North-West and Gauteng having the highest number of species, and the Free State the lowest (Arnold & De Wet 1993; Retief & Herman 1997). At the local scale, many Free State dams occur within a degraded agricultural and semi-industrial setting, with the only natural seed source emanating from wastelands, hydromorphic grasslands, perennial swamps dominated by *Phragmites australis*, and alkaline pans. This landscape context limits the diversity and availability of natural colonizers. Most dams in the North-West and Gauteng region were in close proximity to natural, albeit degraded veld and private (mine) nature reserves, and this environmental setting provides a wider diversity of suitable species for natural colonization.

Of the species identified, < 5% had been actively introduced during grassing. Despite the high species diversity of natural colonizers and persisters, most individuals were detected on toepaddocks, retaining walls and on the flatter surfaces of the dams (berms and tops), with the actual contribution to cover on slopes being extremely low. In contrast, the number of species introduced during vegetating efforts was extremely low, despite the high cover achieved on recently grassed dam slopes. However, most introduced species are herbaceous and weedy, and both cover and number of species declines rapidly once liming, fertilization and supplemental watering has ceased. Watering occurs either in the form of irrigation on dormant dams (slimes are no longer deposited) or water from slurry deposition on current dams. Less than five species remained on any particular tailings slope by four years after amelioration had ceased (Weiersbye & Witkowski 1998). Although we recorded an additional 14 introduced pasture species in 1998–2003 from the same slimes dam slopes surveyed in 1996–1997, these plants occurred on dams that were undergoing grassing. These same species had not been detected in the previous survey on post-amelioration grassed sites (despite having been originally planted), which suggests that they lack persistence.

Although introduced species on dams were predominantly pasture grasses, the naturally colonizing species were predominantly perennials with woody and semi-woody growth forms. In the case of tailings dams in the Carletonville and Klerksdorp regions, the predominance of indigenous, woody growth forms as natural colonizers

and persisters is expected as these growth forms are common in the localities surrounding the dams (Arnold & De Wet 1993; Bredenkamp & Brown 1995a,b; Retief & Herman 1997). However, tailings dams in the Free State are surrounded by hydromorphic grasslands, degraded wetlands and alkaline pans, with woody and semi-woody plants largely restricted to low, dry rocky outcrops (Fuls *et al.* 1992, 1993; Malan *et al.* 1998). The colonization of tailings in this latter region by semi-woody/woody species despite their restricted availability strongly suggests that these are suitable growth forms for tailings dam rehabilitation.

The dominance of Poaceae, Asteraceae, Fabaceae and Anacardiaceae on acid slimes suggests an inherent tolerance to the prevailing conditions in species of these families. These results are further reinforced by seed biology studies (Witkowski & Weiersbye 1998b; Weiersbye & Witkowski 2002b, 2003) and by plant growth and water-use trials in acid slimes and AMD conditions in which hard-seeded legumes and *Rhus* spp. perform especially well (Weiersbye *et al.* 1998; Dharamraj *et al.* 1999; Dye *et al.* 2005). More recently, the use of AFLP analysis has demonstrated that there is genetic evidence for local adaptation of some woody species to the slimes-polluted soils around tailings dams (Angus 2005). Some species examined during this survey showed no signs of physiological stress despite growth on slimes, e.g. *Tamarix* spp., *Acacia* spp., *Lessertia* spp. (= *Sutherlandia* spp.), *Rhus* spp., *Asparagus* spp. and perennial *Eragrostis* spp. Seed production and seed viability levels in these taxa approaches that of conspecifics growing in unpolluted veld, and seed production and viability in *Asparagus* spp., woody legumes and *Rhus* spp. on tailings is high, with seedlings establishing around parent plants. In contrast, seed production and viability in most grasses and Asteraceae growing on tailings is low and regeneration on tailings would therefore be dependent on seed dispersal from beyond the dam (Witkowski & Weiersbye 1998b). A parallel survey found that the majority of plants persisting on tailings were infected by arbuscular mycorrhizal (AM) fungi (Straker *et al.* 2006a, b). In addition, plant growth experiments have demonstrated that slimes-tolerant AM fungi, and, for most indigenous hard-seeded legumes, compatible tolerant rhizobia, contribute significantly to host plant survival and growth in acidic slimes (Weiersbye *et al.* 1998; Straker *et al.* 2006c).

The dominant plant functional growth forms (i.e. woody and semi-woody perennials, resprouters) of slimes dams are typical of stressful environments (Grime 1979), whereas many of the grass and forb species are characteristic of nutrient-poor (especially nitrogen), low competition environments in the Grassland Biome (O'Connor & Bredenkamp 1997). The distribution of species on particular tailings substrates appears to be associated with known physiological tolerances to moisture and nutrient availability regimes. For example, species of *Eragrostis* and *Sporobolus* that were prevalent on the arid substrates typical of old vegetated and never vegetated tailings can tolerate dehydration of foliage to the point of air dryness (Gaff 1971; Gaff & Ellis 1974). The grass *Cenchrus ciliaris* is tolerant of high nitrogen and phosphorus availability (O'Connor & Bredenkamp 1997) and is an indicator of nutrient enrichment in natural ecosystems,

being characteristic of environments such as iron-age kraal sites (Blackmore *et al.* 1990). *C. ciliaris* was only prevalent on recently vegetated sites, with few individuals surviving the transition to old vegetated sites and the concomitant decline in nutrient availability. In contrast, *Stoebe vulgaris* and some dominant indigenous grasses on tailings are inhibited by high nitrogen availability (Roux 1969), and these species were abundant only on the low nutrient substrates typical of the oldest vegetated and never vegetated sites. Populations of *S. vulgaris* and similar species present on never vegetated sites that were subsequently grassed and fertilized have died out.

Tailings solution extracts have extremely high conductivity and salinity (Witkowski & Weiersbye 1998a). Halophytic plants such as *Tamarix* spp. and *Atriplex* spp. naturally colonize, and may form dense cover, on the moist and marginally acidic to alkaline slopes and tops of tailings dams. However, there is no analogous natural environment to the combination of acidity, salinity, high heavy metal availability and low macronutrient (N, P, K, Ca and Mg) availability that is found on the lower reaches of dams. Plants that naturally colonize gold tailings, or persist on tailings-polluted substrates are therefore exhibiting a remarkable combination of adaptive or constitutive physiological tolerances and are being subjected to massive selection pressures (Bradshaw 1952; 1970; Mehary 1994). For example, the majority of species growing on slimes dams and polluted substrates in the goldfields have depressed seed production and viability levels in comparison to conspecifics on unpolluted substrates (Weiersbye & Witkowski 2002b). However, those species that occur frequently on slimes and slimes-polluted soils are also the species that maintain regeneration potential on these same substrates (Witkowski & Weiersbye 1998). Tree species such as *Acacia karroo*, *A. hereroensis*, *A. hebeclada* and *Rhus lancea* maintain relatively high levels of seed viability and germination despite elevated inorganic contents, and high frequencies of seedling abnormalities (Weiersbye & Witkowski 2003). *Rhus lancea* is also capable of vigorous growth in acid mine drainage, maintaining high evapotranspiration rates (Dye *et al.* 2005). Salinity and acid-tolerant land-races of the grass *Cynodon dactylon*, and local ecotypes of *Hyparrhenia hirta* are now used in slimes dam rehabilitation (B. Dawson, EMPR Services, pers. comm.). Apparently healthy *C. dactylon* growing in gold tailings can contain 30 mg g⁻¹ dry mass of iron in the root epidermis and cortex, and 3 mg g⁻¹ dry mass of uranium within the root stele, with even higher Fe and U concentrations associated with arbuscular mycorrhizal structures (Weiersbye *et al.* 1999).

Some indigenous, naturally-colonizing or persisting species that were frequently encountered on slimes dams, have also been recorded from gold tailings in Zimbabwe and Botswana (Wild 1974a, b), and from andalusite, asbestos, gold, platinum and base metal tailings in the Limpopo and Mpumalanga Provinces (I.M. Weiersbye, K. Balkwill & E.T.F. Witkowski unpublished). Land-races that persist and colonize gold tailings and acid mine drainage-polluted soils can be expected to have phytoremediation potential for the gold mining industry in South Africa.

CONCLUSIONS

Of the 376 species found in the intensive survey, only 60 were common to all three regions, and of these 24 had been introduced during rehabilitation attempts. Most of the species found on tailings were persisters or natural colonizers (53–88%, depending on substrate), with the vast majority being indigenous and perennial taxa (76% and 85% respectively) with semi-woody to woody growth forms (66% being resprouters, forbs, shrubs and trees). The present rehabilitation aims of mine management (i.e. the requirement for rapid green cover) forces vegetation contractors to expend massive effort and expense in modifying tailings dams to become temporarily suitable substrates for high basal cover pastures. In contrast, those species actually persisting on, and naturally colonizing tailings and tailings-polluted soils, are non-pasture species, of which < 5% have also been introduced during vegetating efforts. Naturally colonizing and persisting species are predominantly indigenous perennials comprised of resprouting, semi-woody and woody plants and C₄ tussock grasses, which, by virtue of the comparatively longer life-span of individuals and apparent tolerance to native slimes conditions are more likely to assist in the establishment of self-sustaining cover and rehabilitation of gold tailings. Finally, only multi-stemmed/shrubby or ground-covering woody plants and other growth forms with high basal cover are suitable for planting on the slopes of the dams due to erosion foci that may develop around large, single-stemmed-trees. However, plantings of shrubs and trees are suitable for the berms and tops of slimes dams, providing that planting densities are optimized in order to survive on incoming rainfall alone in an increasingly arid environment as the dam dries out. Woody plantings on the berms and tops of dams could minimize recharge of the phreatic surface within the dam, and thus limit the potential for seepage, as well as lowering the risk of fire that is ever-present in highveld winter grasslands, provide large canopies in order to abate wind and dust generation, and facilitate nutrient cycling processes and 'safe-sites' for seedling establishment more effectively than grasses (Cresswell 1973). The results of this broad-scale survey show conclusively that the rehabilitation industry needs to pay much greater attention to the use of indigenous plant species and growth forms on TSF that have a higher probability of contributing to sustainable cover, dust control and hydrological containment than the currently used pasture species.

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APPENDIX 1.—Percentage frequency of species and subspecies within each substrate, vegetation class and region for plants found in the 100 m transects. Although 327 species and subspecies were identified, for the purposes of this frequency analysis the 5 *Tamarix* spp. and putative hybrids were combined due to difficulty in telling them apart in the field (i.e. n = 323)

	Substrates						Vegetation			Region			Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom	
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87	254
Acanthaceae (n = 3)													
<i>Barleria macrostegia</i> Nees	0.0	0.0	0.0	0.0	4.3	3.8	0.0	1.0	2.2	0.0	3.6	0.0	1.6
<i>Crabbea angustifolia</i> Nees	0.0	0.0	0.0	0.0	4.3	1.9	0.0	2.0	0.7	3.6	0.0	1.1	1.2
<i>Justicia anagaloides</i> (Nees) T.Anderson	0.0	0.0	0.0	0.0	0.0	3.8	0.0	1.0	0.7	0.0	0.0	2.3	0.8
Aizoaceae (n = 6)													
<i>Aizoaceae</i> sp. 1	0.0	0.0	0.0	0.0	4.3	0.0	0.0	2.0	0.0	0.0	1.8	0.0	0.8
<i>Aizoaceae</i> sp. 2	0.0	12.5	2.1	2.7	4.3	0.0	0.0	5.0	1.4	12.7	0.0	0.0	2.8
* <i>Aizoaceae</i> sp. 3	6.3	12.5	2.1	2.7	6.4	3.8	33.3	4.0	1.4	0.0	0.0	12.6	4.3
<i>Aizoaceae</i> sp. 4	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.7	0.0	0.0	1.1	0.4
<i>Hypertelis salsoloides</i> (Burch.) Adamson var. <i>salsoloides</i>	0.0	0.0	0.0	2.7	10.6	5.8	0.0	7.0	2.2	0.0	7.1	2.3	3.9
<i>Suessenguthiella scleranthoides</i> (Sond.) Friedrich	0.0	0.0	4.2	4.0	6.4	7.7	6.7	1.0	7.2	0.0	8.0	3.4	4.7
Aliaceae (n = 1)													
<i>Agapanthus campanulatus</i> F.M. Leight.													
subsp. <i>patens</i> (F.M.Leight.) F.M.Leight.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.0	0.0	0.0	0.9	0.0	0.4
Amaranthaceae (n = 6)													
<i>Achyranthes aspera</i> L. var. <i>aspera</i>	0.0	6.3	0.0	2.7	6.4	1.9	6.7	4.0	1.4	1.8	0.0	6.9	2.8
<i>Alternanthera pungens</i> Kunth	0.0	6.3	8.3	2.7	4.3	0.0	6.7	5.0	2.2	5.5	5.4	0.0	3.5
* <i>Amaranthus hybridus</i> L. subsp. <i>hybridus</i>	0.0	0.0	0.0	1.3	2.1	0.0	13.3	0.0	0.0	0.0	0.0	2.3	0.8
* <i>Amaranthus</i> sp.	0.0	0.0	0.0	1.3	4.3	5.8	0.0	0.0	4.3	0.0	5.4	0.0	2.4
* <i>Amaranthus thunbergii</i> Moq.	0.0	6.3	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	1.1	0.4
<i>Gomphrena celosioides</i> Mart.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	1.0	0.0	1.8	0.0	0.0	0.4
Amaryllidaceae (n = 1)													
<i>Boopha disticha</i> (L.f.) Herb.	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	1.4	0.0	1.8	0.0	0.8
Anacardiaceae (n = 13)													
<i>Rhus burchellii</i> Sond. ex Engl.	0.0	6.3	0.0	0.0	2.1	1.9	0.0	3.0	0.0	5.5	0.0	0.0	1.2
<i>Rhus dentata</i> Thunb.	6.3	0.0	0.0	1.3	17.0	13.5	20.0	8.0	4.3	12.7	8.9	0.0	6.7
<i>Rhus discolor</i> E.Mey. ex Sond.	0.0	0.0	0.0	0.0	6.4	3.8	0.0	3.0	1.4	5.5	1.8	0.0	2.0
<i>Rhus gracillima</i> Engl. var. <i>gracillima</i>	6.3	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.4	3.6	0.0	0.0	0.8
+ <i>Rhus lancea</i> L.f.	6.3	12.5	4.2	9.3	42.6	40.4	6.7	22.0	21.6	20.0	34.8	3.4	20.9
<i>Rhus leptodictya</i> Diels	0.0	0.0	0.0	1.3	10.6	5.8	6.7	5.0	2.2	9.1	3.6	0.0	3.5
<i>Rhus magalismontana</i> Sond. subsp. <i>magalismontana</i>	0.0	0.0	0.0	1.3	2.1	1.9	0.0	0.0	2.2	5.5	0.0	0.0	1.2
+ <i>Rhus pendulina</i> Jacq.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.7	1.8	0.0	0.0	0.4
+ <i>Rhus pyroides</i> Burch. var. <i>pyroides</i>	6.3	6.3	0.0	5.3	19.1	30.8	0.0	14.0	12.2	18.2	18.8	0.0	12.2
<i>Rhus rigida</i> Mill.	0.0	0.0	0.0	0.0	4.3	0.0	0.0	1.0	0.7	3.6	0.0	0.0	0.8
<i>Rhus tenuinervis</i> Engl.	0.0	0.0	0.0	0.0	4.3	0.0	0.0	1.0	0.7	3.6	0.0	0.0	0.8

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APPENDIX 1.—Percentage frequency of species and subspecies within each substrate, vegetation class and region for plants found in the 100 m transects. Although 327 species and subspecies were identified, for the purposes of this frequency analysis the 5 *Tamarix* spp. and putative hybrids were combined due to difficulty in telling them apart in the field (i.e. n = 323) cont.

	Substrates						Vegetation			Region			Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom	
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87	254
Asteraceae (cont.)													
<i>Corymbium</i> sp.	0.0	0.0	0.0	0.0	2.1	1.9	0.0	2.0	0.0	0.0	1.8	0.0	0.8
<i>Dicoma anomala</i> Sond.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.0	0.0	0.0	0.9	0.0	0.4
<i>Dicoma zeyheri</i> Sond. subsp. <i>zeyheri</i>	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.0	0.0	1.8	0.0	0.0	0.4
<i>Erigeron</i> sp.	0.0	0.0	2.1	4.0	8.5	9.6	20.0	5.0	3.6	0.0	11.6	0.0	5.1
<i>Felicia fascicularis</i> DC.	0.0	0.0	0.0	1.3	12.8	5.8	0.0	6.0	2.9	0.0	7.1	2.3	3.9
<i>Felicia filifolia</i> (Vent.) Burt Davy subsp. <i>filifolia</i>	0.0	6.3	0.0	0.0	6.4	0.0	0.0	2.0	1.4	1.8	1.8	1.1	1.6
<i>Felicia mossamedensis</i> (Hier) Mendonça	6.3	12.5	0.0	0.0	2.1	0.0	0.0	3.0	0.7	5.5	0.9	0.0	1.6
<i>Felicia muricata</i> (Thunb.) Nees subsp. <i>muricata</i>	0.0	6.3	0.0	0.0	8.5	1.9	0.0	5.0	1.4	9.1	0.0	2.3	2.8
<i>Flaveria bidentis</i> (L.) Kuntze	6.3	0.0	0.0	8.0	4.3	19.2	26.7	14.0	0.7	0.0	6.3	13.8	7.5
<i>Gazania krebsiana</i> Less. subsp. <i>serrulata</i> (DC.) Roessler	0.0	0.0	0.0	4.0	6.4	1.9	0.0	3.0	2.9	0.0	4.5	2.3	2.8
<i>Geigeria brevifolia</i> (DC.) Harv.	0.0	6.3	0.0	0.0	6.4	3.8	0.0	1.0	3.6	0.0	5.4	0.0	2.4
<i>Geigeria burkei</i> Harv. subsp. <i>burkei</i>	0.0	12.5	0.0	0.0	2.1	1.9	0.0	4.0	0.0	7.3	0.0	0.0	1.6
<i>Helichrysum argyrophaeum</i> DC.	0.0	6.3	0.0	8.0	6.4	7.7	0.0	9.0	3.6	0.0	12.5	0.0	5.5
<i>Helichrysum caespititium</i> (DC.) Harv.	0.0	12.5	0.0	0.0	4.3	0.0	6.7	2.0	0.7	1.8	2.7	0.0	1.6
<i>Helichrysum dasymallum</i> Hilliard	0.0	0.0	0.0	1.3	12.8	5.8	6.7	4.0	3.6	0.0	8.0	1.1	3.9
<i>Helichrysum kraussii</i> Sch. Bip.	0.0	6.3	0.0	0.0	2.1	1.9	0.0	4.0	0.0	1.8	0.0	3.4	1.6
<i>Helichrysum melanacme</i> DC.	0.0	0.0	0.0	0.0	2.1	3.8	0.0	0.0	2.2	5.5	0.0	0.0	1.2
<i>Helichrysum rugulosum</i> Less.	0.0	25.0	0.0	10.7	29.8	9.6	6.7	21.0	6.5	16.4	13.4	8.0	12.2
<i>Lopholena coriifolia</i> (Sond.) E. Phillips & C.A.Sm.	0.0	6.3	0.0	1.3	6.4	3.8	0.0	3.0	2.9	12.7	0.0	0.0	2.8
<i>Nidorella anomala</i> Steetz	0.0	6.3	0.0	2.7	2.1	7.7	0.0	2.0	4.3	5.5	4.5	0.0	3.1
<i>Nidorella hottentotica</i> DC.	0.0	18.8	0.0	4.0	17.0	13.5	0.0	11.0	7.2	12.7	10.7	2.3	8.3
<i>Nolletia rarifolia</i> (Turcz.) Steetz	6.3	6.3	0.0	2.7	4.3	0.0	0.0	3.0	2.2	0.0	0.9	5.7	2.4
<i>Oncosiphon puliferum</i> (L.f.) Källersjö	0.0	6.3	0.0	0.0	2.1	0.0	0.0	2.0	0.0	3.6	0.0	0.0	0.8
<i>Osteospermum leptolobium</i> (Harv.) Norl.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	1.0	0.0	1.8	0.0	0.0	0.4
<i>Pentzia incana</i> (Thunb.) Kuntze	0.0	18.8	2.1	2.7	17.0	13.5	6.7	6.0	10.1	7.3	15.2	0.0	8.3
<i>Phymaspermum athanasoides</i> (S. Moore) Källersjö	0.0	0.0	0.0	0.0	4.3	0.0	0.0	1.0	0.7	0.0	1.8	0.0	0.8
<i>Pseudognaphalium luteo-album</i> (L.) Hilliard & B.L.Burt	0.0	12.5	0.0	6.7	10.6	15.4	0.0	11.0	6.5	3.6	10.7	6.9	7.9
<i>Pseudognaphalium undulatum</i> (L.) Hilliard & B.L.Burt	0.0	6.3	2.1	8.0	6.4	9.6	0.0	13.0	2.2	0.0	14.3	0.0	6.3
<i>Schkurgia pinnata</i> (Lam.) Cabrera	0.0	0.0	2.1	1.3	4.3	0.0	0.0	2.0	0.7	0.0	0.0	3.4	1.2
<i>Senecio consanguineus</i> DC.	0.0	31.3	2.1	10.7	23.4	9.6	0.0	19.0	7.9	16.4	8.0	13.8	11.8
<i>Senecio coronatus</i> (Thunb.) Harv.	0.0	12.5	0.0	4.0	6.4	5.8	0.0	7.0	2.9	3.6	0.9	9.2	4.3
<i>Senecio erubescens</i> Aiton. sens. lat.	0.0	18.8	0.0	0.0	6.4	5.8	0.0	7.0	1.4	10.9	0.9	2.3	3.5
<i>Senecio isatideus</i> DC.	0.0	0.0	0.0	0.0	2.1	1.9	0.0	2.0	0.0	1.8	0.9	0.0	0.8
<i>Senecio latifolius</i> DC.	0.0	6.3	0.0	0.0	2.1	1.9	0.0	2.0	0.7	0.0	1.8	1.1	1.2
<i>Senecio scitrus</i> Hutch. & Burt Davy	0.0	6.3	0.0	0.0	4.3	3.8	0.0	4.0	0.7	9.1	0.0	0.0	2.0
<i>Sonchus oleraceus</i> L.	0.0	6.3	0.0	4.0	12.8	3.8	6.7	7.0	2.9	0.0	2.7	10.3	4.7
<i>Sonchus wilmsii</i> R.E.Fr.	0.0	6.3	0.0	1.3	4.3	0.0	0.0	2.0	1.4	1.8	0.0	3.4	1.6

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	Substrates						Vegetation			Region		Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87
254												
Asteraceae (cont.)												
<i>Stoebe vulgaris</i> <i>Levy</i>	0.0	18.8	0.0	12.0	14.9	25.0	20.0	16.0	9.4	16.4	20.5	0.0
<i>Tagetes minuta</i> <i>L.</i>	0.0	12.5	4.2	6.7	14.9	15.4	0.0	17.0	5.0	7.3	13.4	5.7
<i>Taraxacum officinale</i> complex <i>Weber</i> sens. lat.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	1.0	0.0	0.0	0.0	1.1
<i>Taraxacanthus camphoratus</i> <i>L.</i>	0.0	0.0	0.0	0.0	0.0	9.6	0.0	2.0	2.2	0.0	4.5	0.0
<i>Ursinia nana</i> <i>DC.</i> subsp. <i>nana</i>	0.0	12.5	0.0	1.3	4.3	1.9	0.0	4.0	1.4	10.9	0.0	0.0
<i>Vernonia oligocephala</i> (<i>DC.</i>) <i>Sch.Bip. ex Walp.</i>	0.0	0.0	0.0	0.0	6.4	5.8	0.0	4.0	1.4	0.0	5.4	0.0
<i>Vernonia</i> sp.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.7	0.0	0.0	1.1
Boraginaceae (n = 1)												
<i>Ehretia rigida</i> (<i>Thunb.</i>) <i>Druce</i>	0.0	0.0	0.0	0.0	10.6	19.2	13.3	3.0	7.2	3.6	11.6	0.0
Brassicaceae (n = 3)												
<i>Lepidium africanum</i> (<i>Burm.f.</i>) <i>DC.</i>	0.0	6.3	0.0	1.3	2.1	1.9	0.0	3.0	0.7	5.5	0.9	0.0
<i>Lepidium bonariense</i> <i>L.</i>	0.0	6.3	2.1	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.8	0.0
<i>Sisymbrium thellungii</i> <i>O.E.Schulz</i>	0.0	0.0	0.0	2.7	4.3	0.0	0.0	3.0	0.7	0.0	0.0	4.6
Cactaceae (n = 1)												
<i>*Opuntia ficus-indica</i> (<i>L.</i>) <i>Mill.</i>	0.0	0.0	0.0	4.0	0.0	1.9	0.0	4.0	0.0	0.0	2.7	1.1
Capparaceae (n = 1)												
<i>Boscia albitrunca</i> (<i>Burch.</i>) <i>Gilg & Gilg-Ben.</i>	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.7	0.0	0.9	0.0
Caryophyllaceae (n = 1)												
<i>Spergularia</i> sp. <i>L.</i>	12.5	6.3	4.2	2.7	2.1	3.8	33.3	2.0	2.2	1.8	0.0	10.3
Celastraceae (n = 2)												
<i>Gymnosporia buxifolia</i> (<i>L.</i>) <i>Szyszl.</i>	6.3	0.0	0.0	1.3	4.3	15.4	13.3	2.0	5.8	0.0	10.7	0.0
<i>Gymnosporia polyacantha</i> (<i>Sond.</i>) <i>Marais</i>	6.3	0.0	0.0	1.3	6.4	23.1	6.7	3.0	9.4	0.0	15.2	0.0
Chenopodiaceae (n = 8)												
<i>*Atriplex semibaccata</i> <i>R. Br.</i> var. <i>typica</i> <i>Aellen</i>	25.0	43.8	54.2	49.3	46.8	32.7	33.3	56.0	37.4	40.0	47.3	43.7
<i>*Atriplex lindleyi</i> <i>Moq.</i> subsp. <i>inflata</i> (<i>F.Muell.</i>) <i>Paul G. Wilson</i>	0.0	0.0	0.0	2.7	4.3	3.8	0.0	3.0	2.2	0.0	0.9	5.7
<i>*Atriplex suberecta</i> <i>J. Verd.</i>	6.3	0.0	0.0	2.7	0.0	3.8	0.0	5.0	0.0	0.0	0.0	5.7
<i>Bassia salsoloides</i> (<i>Fenzl</i>) <i>A.J.Scott</i>	0.0	25.0	0.0	8.0	6.4	1.9	0.0	10.0	2.9	0.0	0.0	16.1
<i>*Chenopodium album</i> <i>L.</i>	0.0	12.5	6.3	2.7	4.3	1.9	26.7	3.0	2.2	0.0	1.8	9.2
<i>*Chenopodium multifidum</i> <i>L.</i>	0.0	6.3	0.0	1.3	0.0	0.0	13.3	0.0	0.0	0.0	0.0	2.3
<i>*Monochlamys albicans</i> (<i>Aiton</i>) <i>Aellen</i>	6.3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.1
<i>Salsola kali</i> <i>L.</i>	0.0	0.0	0.0	1.3	0.0	1.9	13.3	0.0	0.0	0.0	0.0	2.3
Commelinaceae (n = 1)												
<i>Commelina africana</i> <i>L.</i> var. <i>africana</i>	0.0	0.0	0.0	0.0	6.4	13.5	13.3	2.0	4.3	3.6	7.1	0.0
3.9												

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	Substrates						Vegetation			Region			Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom	
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87	254
Convolvulaceae (n = 5)													
<i>Convolvulus sagittatus</i> Thunb.	0.0	0.0	0.0	0.0	2.1	3.8	0.0	3.0	0.0	0.0	2.7	0.0	1.2
<i>Convolvulus</i> sp.	0.0	0.0	0.0	0.0	2.1	1.9	0.0	2.0	0.0	0.0	1.8	0.0	0.8
<i>Ipomoea crassipes</i> Hook.	0.0	12.5	0.0	0.0	10.6	13.5	0.0	4.0	7.2	9.1	8.0	0.0	5.5
<i>Ipomoea ommaneyi</i> Rendle	0.0	6.3	0.0	1.3	4.3	1.9	0.0	3.0	1.4	9.1	0.0	0.0	2.0
<i>Merremia tridentata</i> (L.) Hallier f. subsp. <i>angustifolia</i> (Jacq.) Van Oostr.	0.0	0.0	0.0	2.7	6.4	3.8	0.0	3.0	2.9	0.0	3.6	3.4	2.8
Crassulaceae (n = 1)													
<i>Crassula thunbergiana</i> Schult.	0.0	6.3	2.1	2.7	0.0	0.0	0.0	4.0	0.0	0.0	3.6	0.0	1.6
Cucurbitaceae (n = 6)													
<i>Acanthosicyos naudinianus</i> (Sond.) C. Jeffrey	0.0	0.0	0.0	8.0	23.4	19.2	13.3	1.0	17.3	0.0	22.3	2.3	10.6
<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai	6.3	0.0	0.0	0.0	6.4	1.9	0.0	2.0	2.2	0.0	2.7	2.3	2.0
<i>Coccinia sessilifolia</i> (Sond.) Cogn.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.7	0.0	0.9	0.0	0.4
<i>Cucumis anguria</i> L.	0.0	0.0	2.1	1.3	2.1	1.9	0.0	0.0	2.9	0.0	3.6	0.0	1.6
<i>Cucumis myriocarpus</i> Naudin subsp. <i>myriocarpus</i> + <i>Cucumis zeyheri</i> Sond.	0.0	6.3	0.0	1.3	2.1	3.8	0.0	3.0	1.4	0.0	4.5	0.0	2.0
	0.0	0.0	0.0	0.0	2.1	5.8	0.0	2.0	1.4	0.0	3.6	0.0	1.6
Cyperaceae (n = 3)													
<i>Cyperus fulgens</i> C.B. Clarke var. <i>contractus</i> Kük.	0.0	0.0	0.0	0.0	0.0	1.9	6.7	0.0	0.0	0.0	0.9	0.0	0.4
<i>Mariscus rehmannianus</i> C.B. Clarke	0.0	12.5	0.0	0.0	0.0	19.2	6.7	4.0	5.0	5.5	5.4	3.4	4.7
<i>Scirpus burkei</i> C.B. Clarke	0.0	0.0	0.0	0.0	0.0	19.2	0.0	5.0	3.6	1.8	5.4	3.4	3.9
Dichapetalaceae (n = 1)													
<i>Dichapetalum cymosum</i> (Hook.) Engl.	0.0	0.0	0.0	0.0	2.1	1.9	0.0	0.0	1.4	3.6	0.0	0.0	0.8
Dipsacaceae (n = 1)													
<i>Scabiosa columbaria</i> L.	0.0	0.0	0.0	0.0	2.1	5.8	0.0	2.0	1.4	3.6	1.8	0.0	1.6
Ebenaceae (n = 4)													
<i>Diospyros lycioides</i> Desf. subsp. <i>guerkei</i> (Kuntze) De Winter	0.0	0.0	0.0	0.0	2.1	1.9	0.0	2.0	0.0	3.6	0.0	0.0	0.8
<i>Diospyros lycioides</i> Desf. subsp. <i>lycioides</i>	6.3	0.0	0.0	2.7	27.7	30.8	6.7	8.0	16.5	5.5	25.9	0.0	12.6
<i>Euclea crispa</i> (Thunb.) Guerke var. <i>crispa</i>	0.0	0.0	0.0	0.0	2.1	1.9	0.0	2.0	0.0	3.6	0.0	0.0	0.8
<i>Euclea undulata</i> Thunb. var. <i>myrtina</i> (Burch.) Hiern	0.0	0.0	0.0	0.0	2.1	5.8	0.0	1.0	2.2	0.0	3.6	0.0	1.6
Euphorbiaceae (n = 5)													
<i>Acalypha angustata</i> Sond. var. <i>glabra</i> Sond.	0.0	0.0	0.0	0.0	6.4	11.5	0.0	1.0	5.8	5.5	5.4	0.0	3.5
<i>Acalypha ecklonii</i> Baill.	0.0	0.0	0.0	0.0	2.1	5.8	0.0	1.0	2.2	1.8	2.7	0.0	1.6
<i>Acalypha peduncularis</i> E. Mey. ex Meisn.	0.0	6.3	0.0	0.0	2.1	1.9	0.0	3.0	0.0	5.5	0.0	0.0	1.2

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	Substrates						Vegetation			Region			Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom	
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87	254
Euphorbiaceae (cont.)													
<i>Clusia monticola</i> S.Moore	0.0	0.0	0.0	0.0	2.1	3.8	0.0	0.0	2.2	5.5	0.0	0.0	1.2
<i>Jatropha lagarinthoides</i> Sond.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.7	0.0	0.0	1.1	0.4
Fabaceae (n = 34)													
* <i>Acacia baileyana</i> F.Muell.	0.0	6.3	2.1	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.8	0.0	0.8
<i>Acacia caffra</i> (Thunb.) Willd.	0.0	0.0	0.0	0.0	2.1	1.9	0.0	1.0	0.7	0.0	1.8	0.0	0.8
* <i>Acacia cultriformis</i> A.Cunn. ex G. Don	0.0	18.8	0.0	2.7	4.3	3.8	0.0	9.0	0.0	16.4	0.0	0.0	3.5
* <i>Acacia dealbata</i> Link	0.0	6.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.9	0.0	0.4
+ <i>Acacia hebeclada</i> DC. subsp. hebeclada	0.0	0.0	0.0	1.3	6.4	7.7	0.0	4.0	2.9	0.0	7.1	0.0	3.1
+ <i>Acacia hereroensis</i> Engl.	0.0	0.0	0.0	0.0	6.4	7.7	0.0	4.0	2.2	0.0	6.3	0.0	2.8
+ <i>Acacia karroo</i> Hayne	6.3	12.5	0.0	12.0	34.0	42.3	20.0	23.0	17.3	23.6	24.1	11.5	19.7
* <i>Acacia longifolia</i> (Andr.) Willd.	0.0	6.3	0.0	0.0	0.0	1.9	0.0	2.0	0.0	1.8	0.9	0.0	0.8
* <i>Acacia meamsii</i> De Wild.	0.0	6.3	2.1	0.0	8.5	5.8	0.0	8.0	0.7	14.5	0.9	0.0	3.5
* <i>Acacia melanoxylon</i> R.Br.	0.0	6.3	0.0	0.0	2.1	1.9	0.0	3.0	0.0	5.5	0.0	0.0	1.2
* <i>Acacia podalyrifolia</i> A.Cunn. ex G.Don	0.0	6.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.9	0.0	0.4
<i>Acacia robusta</i> Burch. subsp. robusta	0.0	18.8	0.0	1.3	8.5	5.8	0.0	9.0	1.4	18.2	0.9	0.0	4.3
<i>Crotalaria spartioides</i> DC.	0.0	0.0	0.0	0.0	2.1	1.9	0.0	0.0	1.4	0.0	1.8	0.0	0.8
<i>Crotalaria sphaerocarpa</i> Perr. ex DC subsp. sphaerocarpa	0.0	0.0	0.0	1.3	2.1	1.9	0.0	0.0	2.2	0.0	2.7	0.0	1.2
<i>Elephantorrhiza elephantina</i> (Burch.) Skeels	6.3	0.0	0.0	0.0	0.0	21.2	6.7	1.0	7.2	5.5	8.0	0.0	4.7
<i>Indigofera adenoides</i> Baker f.	0.0	0.0	0.0	0.0	0.0	3.8	0.0	2.0	0.0	1.8	0.9	0.0	0.8
<i>Indigofera zeyheri</i> Spreng. ex Eckl. & Zeyh.	0.0	0.0	0.0	2.7	6.4	13.5	0.0	0.0	8.6	0.0	10.7	0.0	4.7
<i>Lotononis calycina</i> (E.Mey.) Benth.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.0	0.0	1.8	0.0	0.0	0.4
* <i>Medicago polymorpha</i> L.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.7	0.0	0.9	0.0	0.4
* <i>Medicago sativa</i> L. subsp. sativa	6.3	0.0	0.0	4.0	0.0	0.0	20.0	1.0	0.0	3.6	0.9	1.1	1.6
<i>Mundulea sericea</i> (Willd.) A.Chev.	6.3	0.0	2.1	1.3	2.1	1.9	0.0	0.0	3.6	9.1	0.0	0.0	2.0
<i>Neorautanenia ficifolius</i> (Benth.) C.A.Sm	0.0	0.0	0.0	0.0	8.5	13.5	0.0	0.0	7.9	0.0	9.8	0.0	4.3
<i>Prosopis glandulosa</i> Torr.	0.0	0.0	0.0	0.0	0.0	1.9	6.7	0.0	0.0	0.0	0.0	1.1	0.4
<i>Rhynchosia caribea</i> (Jacq.) DC.	0.0	0.0	0.0	4.0	6.4	1.9	6.7	2.0	2.9	0.0	6.3	0.0	2.8
<i>Rhynchosia totta</i> (Thunb.) DC. var. totta	0.0	0.0	0.0	0.0	2.1	3.8	0.0	0.0	2.2	0.0	0.0	3.4	1.2
<i>Sphenostylis angustifolia</i> Sond.	6.3	6.3	0.0	0.0	0.0	5.8	0.0	0.0	3.6	5.5	1.8	0.0	2.0
+ <i>Sutherlandia frutescens</i> (L.) R.Br.	0.0	6.3	0.0	1.3	4.3	3.8	0.0	4.0	1.4	0.0	5.4	0.0	2.4
<i>Tephrosia longipes</i> Meisn. subsp. longipes	0.0	0.0	0.0	0.0	2.1	1.9	0.0	2.0	0.0	3.6	0.0	0.0	0.8
<i>Tephrosia semiglabra</i> Sond.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	2.0	0.0	3.6	0.0	0.0	0.8
<i>Tipuana tipu</i> (Benth.) Kuntze	6.3	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.4	0.0	1.8	0.0	0.8
<i>Trifolium africanum</i> Ser. var. africanum	12.5	6.3	2.1	4.0	0.0	1.9	20.0	5.0	0.0	7.3	1.8	2.3	3.1
* <i>Trifolium repens</i> L.	6.3	0.0	0.0	0.0	0.0	1.9	6.7	1.0	0.0	1.8	0.9	0.0	0.8
* <i>Trifolium</i> sp.	0.0	6.3	0.0	0.0	0.0	1.9	0.0	2.0	0.0	0.0	1.8	0.0	0.8
<i>Vigna vexillata</i> (L.) A.Rich. var. vexillata	0.0	6.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.9	0.0	0.4

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	Substrates						Vegetation			Region		Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87
254												
Geraniaceae (n = 4)												
<i>Monsonia angustifolia</i> E.Mey. ex A.Rich.	0.0	0.0	0.0	1.3	4.3	9.6	0.0	4.0	2.9	1.8	6.3	0.0
<i>Monsonia attenuata</i> Harv.	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	1.4	1.8	0.9	0.0
<i>Monsonia burkeana</i> Planch. ex Harv.	0.0	0.0	0.0	0.0	6.4	1.9	0.0	0.0	2.9	0.0	2.7	1.1
<i>Pelargonium luridum</i> (Andrews) Sweet	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.0	0.0	1.8	0.0	0.0
Hyacinthaceae (n = 2)												
<i>Ledebouria ovatifolia</i> (Baker) Jessop	6.3	0.0	0.0	0.0	2.1	1.9	0.0	0.0	2.2	5.5	0.0	0.0
<i>Scilla nervosa</i> (Burch.) Jessop	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	1.4	0.0	1.8	0.0
Hypoxidaceae (n = 2)												
<i>Hypoxis hemerocallidea</i> Fisch. & C.A.Mey.	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	2.2	0.0	2.7	0.0
<i>Hypoxis</i> sp.	6.3	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.4	3.6	0.0	0.0
Illecebraceae (n = 1)												
<i>Pollichia campestris</i> Aiton	0.0	0.0	0.0	0.0	12.8	1.9	0.0	0.0	5.0	0.0	6.3	0.0
Juncaceae (n = 1)												
* <i>Juncus rigidus</i> Desf.	6.3	18.8	0.0	1.3	2.1	42.3	13.3	15.0	7.9	7.3	2.7	24.1
Lamiaceae (n = 6)												
<i>Becium grandiflorum</i> (Lam.) Pic.-Serm. var. obovatum (E.Mey. ex Benth.) Sebald	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.7	0.0	0.0	1.1
<i>Becium obovatum</i> (E.Mey. ex Benth.) N.E.Br. var. hians (Benth.) N.E.Br.	0.0	6.3	0.0	0.0	4.3	3.8	6.7	3.0	0.7	5.5	1.8	0.0
<i>Plectranthus madagascariensis</i> (Pers.) Benth. var. madagascariensis	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.7	0.0	0.9	0.0
<i>Salvia stenophylla</i> Burch. ex Benth.	0.0	6.3	0.0	0.0	2.1	1.9	0.0	3.0	0.0	5.5	0.0	0.0
<i>Salvia verbenaca</i> L.	0.0	6.3	0.0	1.3	4.3	5.8	0.0	4.0	2.2	0.0	5.4	1.1
<i>Teucrium trifidum</i> Retz.	0.0	0.0	2.1	4.0	8.5	9.6	20.0	5.0	3.6	0.0	11.6	0.0
Malvaceae (n = 3)												
<i>Hibiscus angolensis</i> Exell	0.0	0.0	0.0	0.0	4.3	5.8	0.0	4.0	0.7	0.0	4.5	0.0
<i>Pavonia burchellii</i> (DC.) R.A.Dyer	0.0	0.0	0.0	0.0	2.1	7.7	0.0	3.0	1.4	1.8	3.6	0.0
<i>Sida cordifolia</i> L.	0.0	6.3	0.0	0.0	2.1	0.0	0.0	1.0	0.7	0.0	1.8	0.0
Meliaceae (n = 1)												
* <i>Melia azedarach</i> L.	6.3	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.4	0.0	1.8	0.0
Menispermaceae (n = 1)												
<i>Antizoma angustifolia</i> (Burch.) Miers ex Harv.	0.0	0.0	0.0	5.3	12.8	15.4	0.0	7.0	7.9	0.0	16.1	0.0
7.1												

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	Substrates						Vegetation			Region		Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87
Mesembryanthemaceae (n = 8)												254
* <i>Carpobrotus edulis</i> (L.) L. <i>Bolus</i>	0.0	6.3	2.1	2.7	0.0	0.0	0.0	4.0	0.0	0.0	3.6	0.0
<i>Delosperma herbeum</i> (N.E.Br.) N.E.Br.	0.0	6.3	0.0	2.7	10.6	13.5	6.7	11.0	2.2	0.0	8.9	5.7
<i>Delosperma leendertziae</i> N.E.Br.	0.0	0.0	0.0	0.0	8.5	5.8	6.7	2.0	2.9	0.0	4.5	2.3
<i>Mesembryanthemaceae</i> sp. 1	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.1
<i>Mesembryanthemaceae</i> sp. 2	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.1
* <i>Ruschia</i> sp. 1	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.1
* <i>Ruschia</i> sp. 2	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.1
<i>Leipoldtia</i> sp.	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.1
Moraceae (n = 1)												
<i>Morus nigra</i> L.	0.0	0.0	0.0	0.0	2.1	0.0	6.7	0.0	0.0	0.0	0.9	0.0
Myrtaceae (n = 3)												
* <i>Eucalyptus camaldulensis</i> Dehnh.	0.0	0.0	0.0	1.3	0.0	5.8	0.0	4.0	0.0	0.0	2.7	1.1
* <i>Eucalyptus maculata</i> Hook.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	1.0	0.0	0.0	0.0	1.1
* <i>Eucalyptus melliodora</i> A.Cunn. ex Schauer	0.0	0.0	0.0	1.3	2.1	1.9	0.0	3.0	0.0	5.5	0.0	0.0
Oleaceae (n = 1)												
<i>Ligustrum lucidum</i> Ait. f.	0.0	6.3	0.0	0.0	2.1	0.0	0.0	2.0	0.0	3.6	0.0	0.0
Onagraceae (n = 1)												
<i>Oenothera stricta</i> Ledeb. ex Link subsp. <i>stricta</i>	0.0	6.3	0.0	0.0	2.1	0.0	0.0	1.0	0.7	0.0	0.9	1.1
Papaveraceae (n = 1)												
* <i>Argemone mexicana</i> L.	0.0	0.0	0.0	2.7	2.1	0.0	0.0	3.0	0.0	0.0	0.0	3.4
Pedaliaceae (n = 1)												
<i>Dicerocaryum eriocarpum</i> (Decne.) Abels	0.0	0.0	0.0	0.0	2.1	3.8	0.0	1.0	1.4	0.0	2.7	0.0
Phytolaccaceae (n = 1)												
* <i>Phytolacca octandra</i> L.	0.0	18.8	12.5	26.7	29.8	23.1	13.3	27.0	18.7	21.8	38.4	0.0
Poaceae (n = 64)												
* <i>Agrostis avenacea</i> C.Gmel	6.3	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	1.8	0.0	0.0
* <i>Agrostis tenuis</i> L.	6.3	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	1.8	0.0	0.0
<i>Anthephora pubescens</i> Nees	0.0	0.0	0.0	1.3	6.4	5.8	0.0	4.0	2.2	0.0	6.3	0.0
<i>Aristida adscensionis</i> L.	0.0	6.3	0.0	0.0	6.4	5.8	0.0	2.0	3.6	5.5	3.6	0.0
<i>Aristida congesta</i> Roem. & Schult.												
subsp. <i>barbicollis</i> (Trin. & Rupr.) De Winter	0.0	0.0	0.0	1.3	12.8	15.4	6.7	3.0	7.9	3.6	11.6	0.0
<i>Aristida congesta</i> Roem. & Schult. subsp. <i>congesta</i>	6.3	6.3	2.1	2.7	17.0	11.5	0.0	9.0	7.2	5.5	9.8	5.7

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	Substrates						Vegetation			Region			Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom	
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87	254
Poaceae (cont.)													
<i>Aristida diffusa</i> Trin. subsp. <i>burkei</i> (Stapf) Melderis	0.0	0.0	0.0	0.0	6.4	13.5	0.0	0.0	7.2	0.0	8.9	0.0	3.9
<i>Aristida junciformis</i> Trin. & Rupr. subsp. <i>junciformis</i>	0.0	0.0	0.0	2.7	14.9	1.9	0.0	4.0	4.3	0.0	5.4	4.6	3.9
<i>Aristida transvaalensis</i> Henrard	0.0	0.0	0.0	0.0	8.5	7.7	0.0	5.0	2.2	0.0	7.1	0.0	3.1
<i>Aristida vestita</i> Thunb.	0.0	0.0	0.0	1.3	2.1	1.9	0.0	0.0	2.2	0.0	0.0	3.4	1.2
<i>Arundo donax</i> L.	6.3	0.0	0.0	0.0	0.0	3.8	6.7	1.0	0.7	0.0	0.9	2.3	1.2
<i>Bothriochloa insculpta</i> (A.Rich.) A.Camus	0.0	0.0	0.0	0.0	8.5	11.5	6.7	4.0	3.6	0.0	8.9	0.0	3.9
* <i>Brachiaria serrata</i> (Thunb.) Stapf	0.0	0.0	0.0	1.3	2.1	3.8	0.0	2.0	1.4	0.0	1.8	2.3	1.6
* <i>Cenchrus ciliaris</i> L.	0.0	6.3	0.0	1.3	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.8
* <i>Chloris gayana</i> Kunth	12.5	25.0	2.1	14.7	14.9	3.8	46.7	18.0	1.4	10.9	9.8	11.5	10.6
<i>Chloris pycnothrix</i> Trin.	0.0	12.5	0.0	0.0	0.0	0.0	0.0	2.0	0.0	3.6	0.0	0.0	0.8
* <i>Chloris virgata</i> Sw.	0.0	6.3	2.1	1.3	10.6	7.7	0.0	6.0	4.3	0.0	8.0	3.4	4.7
* <i>Cortaderia jubata</i> (Lem.) Stapf and <i>C. selloana</i> (Schult.) Asch. & Graebn.	0.0	25.0	4.2	22.7	17.0	11.5	46.7	29.0	0.7	36.4	13.4	2.3	14.6
* <i>Cymbopogon excavatus</i> (Hochst.) Stapf ex Burtt Davy	6.3	0.0	0.0	0.0	2.1	9.6	6.7	2.0	2.9	7.3	2.7	0.0	2.8
+ <i>Cymbopogon plurinodis</i> (Stapf) Stapf ex Burtt Davy	18.8	62.5	12.5	45.3	87.2	88.5	80.0	75.0	38.1	52.7	57.1	54.0	4.3
* <i>Cynodon dactylon</i> (L.) Pers.	0.0	6.3	2.1	2.7	4.3	3.8	26.7	4.0	0.0	0.0	1.8	6.9	3.1
* <i>Cynodon nlemfuensis</i> Vanderyst	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.0	0.0	0.0	0.0	1.1	0.4
<i>Dichanthium aristatum</i> (Poir.) C.E.Hubb.	0.0	0.0	0.0	0.0	0.0	0.0	26.7	7.0	1.4	1.8	5.4	6.9	5.1
* <i>Digitaria eriantha</i> Steud.	0.0	6.3	0.0	5.3	4.3	11.5	26.7	7.0	1.4	1.8	5.4	6.9	5.1
<i>Diheteropogon amplexans</i> (Nees) Clayton	6.3	0.0	0.0	0.0	2.1	1.9	0.0	0.0	2.2	5.5	0.0	0.0	1.2
<i>Eleusine coracana</i> (L.) Gaertn. subsp. <i>africana</i> (Kenn.-O'Byrne) Hilu & De Wet	0.0	6.3	2.1	0.0	0.0	1.9	0.0	3.0	0.0	1.8	1.8	0.0	1.2
* <i>Elionurus muticus</i> (Spreng.) Kunth	0.0	6.3	0.0	1.3	4.3	1.9	0.0	5.0	0.0	5.5	0.0	2.3	2.0
<i>Enneapogon cenchroides</i> (Roem. & Schult.) C.E.Hubb.	6.3	6.3	0.0	1.3	4.3	3.8	20.0	4.0	0.0	0.0	0.0	8.0	2.8
<i>Eragrostis capensis</i> (Thunb.) Trin.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.0	0.0	1.8	0.0	0.0	0.4
<i>Eragrostis chloromelas</i> Steud.	0.0	31.3	2.1	13.3	46.8	28.8	0.0	25.0	20.1	18.2	33.0	6.9	20.9
* <i>Eragrostis curvula</i> (Schrad.) Nees	18.8	37.5	4.2	22.7	40.4	46.2	26.7	42.0	18.0	32.7	33.9	17.2	28.0
<i>Eragrostis gummiflua</i> Nees	0.0	0.0	0.0	0.0	0.0	3.8	0.0	2.0	0.0	0.0	0.9	1.1	0.8
<i>Eragrostis heteromera</i> Stapf	0.0	0.0	0.0	0.0	6.4	9.6	0.0	4.0	2.9	0.0	7.1	0.0	3.1
<i>Eragrostis lehmanniana</i> Nees var. <i>lehmanniana</i>	0.0	12.5	0.0	5.3	12.8	7.7	0.0	9.0	5.0	7.3	10.7	0.0	6.3
<i>Eragrostis racemosa</i> (Thunb.) Steud.	0.0	6.3	0.0	0.0	6.4	5.8	0.0	5.0	1.4	12.7	0.0	0.0	2.8
<i>Eragrostis superba</i> Peyr.	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.7	0.0	0.9	0.0	0.4
<i>Heteropogon contortus</i> (L.) Roem. & Schult.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.7	0.0	0.0	1.1	0.4
+ <i>Hyparrhenia gazensis</i> (Rendle) Stapf	0.0	0.0	0.0	0.0	4.3	3.8	0.0	1.0	2.2	1.8	2.7	0.0	1.6
* <i>Hyparrhenia hirta</i> (L.) Stapf	6.3	18.8	2.1	13.3	14.9	21.2	20.0	20.0	7.2	25.5	17.0	0.0	13.0
<i>Ischaemum fasciculatum</i> Brongn.	0.0	6.3	0.0	0.0	0.0	1.9	0.0	2.0	0.0	3.6	0.0	0.0	0.8
<i>Melinis repens</i> (Willd.) Zizka subsp. <i>repens</i>	0.0	18.8	0.0	0.0	14.9	11.5	0.0	11.0	3.6	20.0	4.5	0.0	6.3

*Taxa that were intentionally introduced at some stage during slimes dam vegetating attempts prior to survey in 1996.

+Taxa that were naturally present on slimes during this survey, and were also introduced to gold slimes dam trials subsequent to this survey (between 1996 and 2000).

APPENDIX 1.—Percentage frequency of species and subspecies within each substrate, vegetation class and region for plants found in the 100 m transects. Although 327 species and subspecies were identified, for the purposes of this frequency analysis the 5 *Tamarix* spp. and putative hybrids were combined due to difficulty in telling them apart in the field (i.e. n = 323) cont.

	Substrates						Vegetation			Region		Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87
Poaceae (cont.)												254
<i>Panicum deustum</i> Thunb.	0.0	6.3	0.0	2.7	6.4	3.8	0.0	4.0	2.9	1.8	4.5	2.3
<i>Panicum maximum</i> Jacq.	6.3	6.3	0.0	0.0	0.0	3.8	6.7	2.0	0.7	1.8	0.9	2.3
* <i>Paspalum dilatatum</i> Poir.	6.3	0.0	0.0	2.7	2.1	1.9	13.3	3.0	0.0	9.1	0.0	0.0
<i>Paspalum notatum</i> Flügge	0.0	6.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.9	0.0
* <i>Paspalum</i> sp.	0.0	0.0	0.0	1.3	0.0	1.9	6.7	1.0	0.0	0.0	0.0	2.3
<i>Paspalum urvillei</i> Steud.	0.0	18.8	0.0	0.0	4.3	3.8	0.0	6.0	0.7	12.7	0.0	0.0
* <i>Paspalum vaginatum</i> Sw.	0.0	6.3	0.0	0.0	0.0	7.7	0.0	2.0	2.2	3.6	2.7	0.0
* <i>Pennisetum clandestinum</i> Hochst. ex Chiov.	0.0	6.3	0.0	2.7	14.9	1.9	13.3	6.0	2.2	12.7	0.9	3.4
* <i>Pennisetum glaucum</i> (L.) R.Br.	0.0	12.5	0.0	0.0	0.0	0.0	0.0	1.0	0.7	3.6	0.0	0.8
* <i>Phragmites australis</i> (Cav.) Steud.	50.0	25.0	12.5	13.3	12.8	53.8	46.7	34.0	15.1	23.6	23.2	26.4
<i>Pogonarthria squarrosa</i> (Roem. & Schult.) Pilg.	0.0	0.0	0.0	0.0	2.1	9.6	0.0	2.0	2.9	0.0	5.4	0.0
<i>Setaria sphaelata</i> (Schumacher) Moss var. sphaelata	0.0	0.0	0.0	0.0	2.1	3.8	0.0	3.0	0.0	0.0	2.7	0.0
<i>Setaria sphaelata</i> (Schumacher) Moss var. sericea (Stapf) Clayton	0.0	12.5	0.0	1.3	4.3	17.3	0.0	9.0	3.6	18.2	3.6	0.0
<i>Setaria verticillata</i> (L.) P.Beauv.	0.0	6.3	0.0	1.3	4.3	3.8	6.7	5.0	0.0	0.0	1.8	4.6
<i>Sporobolus consimilis</i> Fresen.	0.0	6.3	0.0	4.0	4.3	3.8	0.0	5.0	2.2	5.5	4.5	0.0
<i>Sporobolus pectinatus</i> Hack.	0.0	0.0	0.0	1.3	6.4	5.8	0.0	5.0	1.4	0.0	6.3	0.0
<i>Sporobolus pyramidalis</i> P.Beauv.	0.0	0.0	0.0	0.0	0.0	5.8	6.7	1.0	0.7	1.8	1.8	0.0
<i>Sporobolus virginicus</i> (L.) Kunth	0.0	6.3	0.0	1.3	0.0	1.9	6.7	2.0	0.0	0.0	0.0	3.4
<i>Stipagrostis uniplumis</i> (Licht.) De Winter var. uniplumis	0.0	0.0	0.0	0.0	6.4	15.4	6.7	3.0	5.0	0.0	9.8	0.0
<i>Themeda triandra</i> Forsk.	0.0	0.0	0.0	0.0	0.0	19.2	13.3	5.0	2.2	5.5	4.5	2.3
<i>Tristachya leucothrix</i> Nees	6.3	0.0	0.0	0.0	2.1	1.9	0.0	0.0	2.2	5.5	0.0	0.0
+ <i>Vetiveria zizanioides</i> (L.) Nash	6.3	0.0	0.0	2.7	0.0	0.0	3.0	0.0	0.0	0.0	0.0	3.4
Polygalaceae (n = 1)												
<i>Polygala hottentotta</i> C.Presl	0.0	0.0	0.0	0.0	4.3	5.8	0.0	4.0	0.7	0.0	4.5	0.0
Polygonaceae (n = 1)												
<i>Oxygonum sinuatum</i> (Hochst. & Steud ex Meisn.) Damm.	0.0	0.0	0.0	1.3	6.4	1.9	0.0	3.0	1.4	0.0	3.6	1.1
Proteaceae (n = 1)												
<i>Protea caffra</i> Meisn. subsp. caffra	0.0	0.0	0.0	0.0	2.1	1.9	0.0	0.0	1.4	3.6	0.0	0.0
Ranunculaceae (n = 1)												
<i>Clematis brachiata</i> Thunb.	0.0	12.5	0.0	4.0	10.6	15.4	0.0	9.0	6.5	3.6	14.3	0.0
Resedaceae (n = 1)												
<i>Reseda lutea</i> L. subsp. lutea	0.0	0.0	2.1	1.3	0.0	5.8	0.0	3.0	1.4	0.0	4.5	0.0

*Taxa that were intentionally introduced at some stage during slimes dam vegetating attempts prior to survey in 1996.

+Taxa that were naturally present on slimes during this survey, and were also introduced to gold slimes dam trials subsequent to this survey (between 1996 and 2000).

APPENDIX 1.—Percentage frequency of species and subspecies within each substrate, vegetation class and region for plants found in the 100 m transects. Although 327 species and subspecies were identified, for the purposes of this frequency analysis the 5 *Tamarix* spp. and putative hybrids were combined due to difficulty in telling them apart in the field (i.e. n = 323) cont.

	Substrates						Vegetation			Region			Overall
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom	
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87	254
Rhamnaceae (n = 2) +Ziziphua mucronata Willd. subsp. mucronata Ziziphua zeyheriana Sond.	0.0 6.3	0.0 0.0	0.0 0.0	0.0 1.3	14.9 12.8	21.2 21.2	0.0 0.0	5.0 6.0	9.4 9.4	3.6 3.6	11.6 14.3	3.4 1.1	7.1 7.5
Rubiaceae (n = 6) Anthospermum hispidulum E.Mey. ex Sond. Anthospermum rigidum Eckl. & Zeyh. subsp. pumilum (Sond.) Puff	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	2.1 0.0	0.0 1.9	0.0 0.0	1.0 1.0	0.0 0.0	1.8 1.8	0.0 0.0	0.0 0.0	0.4 0.4
Galium spurius L. subsp. africanum Verdc. Gardenia volkensii K.Schum. subsp. volkensii Kohautia amatymbica Eckl. & Zeyh. Pavetta zeyheri Sond.	0.0 0.0	0.0 0.0	0.0 0.0	0.0 2.7	8.5 4.3	1.9 3.8	26.7 0.0	2.0 3.0	1.4 2.2	0.0 0.0	0.0 5.4	9.2 0.0	3.1 2.4
Santalaceae (n = 1) Osyris lanceolata Hochst. & Steud.	0.0	0.0	0.0	0.0	2.1	1.9	0.0	2.0	0.0	3.6	0.0	0.0	0.8
Scrophulariaceae (n = 1) Jamebrittenia atropurpurea (Benth.) Hilliard subsp. atropurpurea	0.0	6.3	0.0	0.0	4.3	1.9	0.0	2.0	1.4	0.0	3.6	0.0	1.6
Selaginaceae (n = 2) Walafrida densiflora (Rolfe) Rolfe Walafrida tenuifolia Rolfe	6.3 0.0	0.0 0.0	0.0 0.0	0.0 0.0	2.1 2.1	5.8 0.0	0.0 0.0	1.0 0.0	2.9 0.7	9.1 1.8	0.0 0.0	0.0 0.0	2.0 0.4
Solanaceae (n = 12) Datura sp. Datura stramonium L. Lycium cinereum Thunb. sens. lat. Lycium oxycarpum Dunal Nicotiana glauca Graham Solanum elaeagnifolium Cav. Solanum incanum L. Solanum mauritianum Scop. Solanum panduriforme E.Mey. Solanum retroflexum Dunal Solanum sisymbriifolium Lam. Withania somnifera (L.) Dunal	0.0 6.3 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 12.5 6.3 0.0 0.0 6.3 0.0 0.0 6.3 0.0	0.0 2.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 1.3 0.0 0.0 0.0 0.0 0.0 6.7 0.0 2.1	2.1 4.3 4.3 2.1 0.0 4.3 2.1 4.3 10.6 6.4	5.8 3.8 0.0 0.0 1.9 1.9 0.0 0.0 9.6 9.6	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 20.0	0.0 5.0 4.0 2.0 0.0 1.0 1.0 1.0 1.0 14.0 2.0 4.0	2.9 0.7 0.0 0.7 0.0 2.2 0.0 0.0 3.6 2.2 2.2	0.0 1.8 0.0 0.0 1.8 1.8 0.0 0.0 7.3 3.6 5.5	3.6 2.7 0.0 0.0 2.7 0.0 11.6 2.7 6.3	0.0 2.3 4.6 3.4 0.0 0.0 3.4 0.0 0.0 0.0	1.6 2.4 1.6 1.2 0.4 0.4 1.6 0.4 0.8 7.9 2.0 3.9
Sterculiaceae (n = 4) Hermannia coccocarpa (Eckl. & Zeyh.) Kuntze	0.0	0.0	0.0	0.0	6.4	3.8	0.0	0.0	3.6	0.0	4.5	0.0	2.0

*Taxa that were intentionally introduced at some stage during slimes dam vegetating attempts prior to survey in 1996.

+Taxa that were naturally present on slimes during this survey, and were also introduced to gold slimes dam trials subsequent to this survey (between 1996 and 2000).

APPENDIX 1.—Percentage frequency of species and subspecies within each substrate, vegetation class and region for plants found in the 100 m transects. Although 327 species and subspecies were identified, for the purposes of this frequency analysis the 5 *Tamarix* spp. and putative hybrids were combined due to difficulty in telling them apart in the field (i.e. n = 323) cont.

	Substrates						Vegetation			Region			Overall					
	Tops & berms pH ≥ 6.0	Tops & berms pH < 6.0	Slopes pH ≥ 6.0	Slopes pH < 6.0	Retaining walls pH < 6.0	Toe-paddocks pH < 6.0	Recently vegetated	Old-vegetated	Never-vegetated	Carletonville	Klerksdorp	Welkom						
Sample size (no. slopes)	16	16	48	75	47	52	15	100	139	55	112	87	254					
Sterculiaceae (cont.) <i>Hermannia geniculata</i> Eckl. & Zeyh. <i>Hermannia lancifolia</i> Syszyl. <i>Hermannia tomentosa</i> (Turcz.) Schinz ex Engl.	0.0	6.3	0.0	0.0	2.1	1.9	0.0	3.0	0.0	5.5	0.0	0.0	1.2					
	0.0	0.0	0.0	0.0	4.3	3.8	0.0	3.0	0.7	3.6	1.8	0.0	1.6					
	0.0	0.0	0.0	2.7	10.6	11.5	0.0	0.0	9.4	0.0	11.6	0.0	5.1					
	31.3	56.3	22.9	24.0	21.3	40.4	53.3	42.0	17.3	47.3	11.6	40.2	29.1					
Tamaricaceae (n = 5) * <i>Tamarix</i> spp. complex (T. usneoides E.Mey. ex Bunge, *T. gallica L., *T. aphylla (L.) Karst., *T. chinensis Lour., *T. ramosissima Ledeb. & hybrids)	0.0	6.3	0.0	1.3	19.1	21.2	0.0	4.0	12.9	0.0	19.6	0.0	8.7					
	6.3	0.0	0.0	6.7	34.0	38.5	20.0	8.0	22.3	3.6	35.7	0.0	16.5					
	0.0	0.0	0.0	0.0	4.3	11.5	13.3	0.0	4.3	0.0	7.1	0.0	3.1					
	0.0	0.0	2.1	2.7	19.1	25.0	13.3	9.0	10.1	0.0	22.3	0.0	9.8					
	6.3	0.0	0.0	0.0	0.0	3.8	6.7	0.0	1.4	0.0	2.7	0.0	1.2					
Ulmaceae (n = 2) + <i>Celtis africana</i> Burm. f. <i>Fraxinus excelsior</i> L.	0.0	12.5	0.0	0.0	6.4	7.7	0.0	5.0	2.9	10.9	2.7	0.0	3.5					
	0.0	0.0	0.0	0.0	8.5	3.8	0.0	3.0	2.2	0.0	5.4	0.0	2.4					
	0.0	6.3	2.1	1.3	4.3	0.0	0.0	5.0	0.0	1.8	0.9	3.4	2.0					
	0.0	6.3	0.0	0.0	2.1	0.0	0.0	2.0	0.0	1.8	0.9	0.0	0.8					
Total no. species and subspecies (5 <i>Tamarix</i> species combined) Basal area surveyed (ha) Species density (no. species ha-1)	53	128	47	139	242	255	86	260	231	168	216	120	323					
														765	1488	3611	5864	
														0.22	0.15	0.03	0.06	

*Taxa that were intentionally introduced at some stage during slimes dam vegetating attempts prior to survey in 1996.

+Taxa that were naturally present on slimes during this survey, and were also introduced to gold slimes dam trials subsequent to this survey (between 1996 and 2000).

APPENDIX 2.—List (in alphabetical order) of additional taxa (species, subspecies and varieties) present on gold slimes dams and adjacent slimes-polluted substrata between 1996 and 1997 ($n = 49$) and included in the general analysis (but for which frequency was not recorded). Species that were intentionally introduced during vegetation attempts are marked with an * ($n = 12$)

Anacardiaceae ($n = 1$)

Rhus undulata Jacq.

Asteraceae ($n = 4$)

Cotula nigellifolia (DC.) K.Bremer & Humphries var. *nigellifolia*

Gerbera piloselloides (L.) Cass.

Helichrysum nudifolium (L.) Less

Pentzia globosa Less.

Brassicaceae ($n = 1$)

* *Brassica* sp.

Chenopodiaceae ($n = 1$)

* *Atriplex nummularia* Lindl.

Ebenaceae ($n = 2$)

Diospyros austro-africana De Winter var. *microphylla* (Burch.) De Winter

Euclea crispa (Thunb.) Gürke var. *ovata* (Burch.) F.White

Euphorbiaceae ($n = 1$)

Clutia pulchella L. sens. lat.

Fabaceae ($n = 5$)

Acacia caffra (Thunb.) Willd.

Indigofera nigromontana Eckl. & Zeyh.

Lotononis divaricata (Eckl. & Zeyh.) Benth.

Rhynchosia nitens Benth.

Vigna vexillata (L.) A.Rich. var. *angustifolia* (Schumach. & Thonn.) Baker

Hyacinthaceae ($n = 1$)

Albuca sp.

Myrtaceae ($n = 1$)

* *Eucalyptus sideroxylon* A.Cunn.

Oleaceae ($n = 1$)

* *Olea europaea* L. subsp. *africana* (Mill.) P.S.Green

Poaceae ($n = 23$)

Andropogon chinensis (Nees) Merr.

Andropogon sp.

Bromus inermis Leyss.

Cymbopogon sp.

Eragrostis bicolor Nees.

Eragrostis nindensis Ficalho & Hiern

Eragrostis sp. 1

Eragrostis sp. 2

* *Festuca elatior* L.

* *Festuca rubra* L. var. *rubra*

* *Lolium perenne* L.

Melinis nerviglumis (Franch.) Zizka

Panicum coloratum L. var. *coloratum*

* *Pennisetum macrourum* Trin.

* *Pennisetum thunbergii* Kunth

* *Phalaris aquatica* L.

* *Poa annua* L.

* *Poa pratensis* L.

Setaria pallide-fusca (Schumach.) Stapf & C.E.Hubb.

Setaria sphacelata (Schumach.) Moss var. *torta* (Stapf) Clayton

Sporobolus centrifugus (Trin.) Nees

Sporobolus sp.

Urochloa mosambicensis (Hack.) Dandy

Rosaceae ($n = 1$)

Cotoneaster pannosus Franch.

Rubiaceae ($n = 2$)

Pentanisia angustifolia (Hochst.) Hochst.

Pygmaeothamnus zeyheri (Sond.) Robyns var. *zeyheri*

Sapindaceae ($n = 1$)

Pappea capensis Eckl. & Zeyh.

Solanaceae ($n = 1$)

Solanum nigrum L.

Typhaceae ($n = 1$)

Typha capensis (Rohrb.) N.E.Br.

Verbenaceae ($n = 1$)

Plexipus pinnatifidus (L.f.) R.Fern. var.

racemosa (Schinz ex Moldenke) R.Fern.

Zygophyllaceae ($n = 1$)

Tribulus terrestris L.

APPENDIX 3.—List (in alphabetical order) of additional taxa (species, subspecies and varieties) present on the gold slimes dams and adjacent slimes-polluted substrata subsequent to the survey (i.e. between 1998 and 2002, $n = 86$). Species that were intentionally introduced during vegetation attempts are also marked with an * ($n = 40$).

Agavaceae ($n = 1$)

* *Agave americana* L.

Anacardiaceae ($n = 2$)

Rhus erosa Thunb.

Schinus terebinthifolius Raddi

Asclepiadaceae ($n = 1$)

Araujia sericifera Brot.

Asteraceae ($n = 16$)

Arctotheca calendula (L.) Levyns

Bidens formosa (Bonato) Sch.Bip.

* *Cichorium intybus* L.

Dicoma macrocephala DC.

Euryops empetrifolius DC.

Gazania krebsiana Less. subsp. *krebsiana*

Helichrysum aureonitens Sch.Bip.

Helichrysum callicomum Harv.

Helichrysum cerastioides DC. var. *cerastioides*

Helichrysum setosum Harv.

Senecio glanduloso-pilosus Volkens & Muschl.

Senecio inornatus DC.

Senecio laevigatus Thunb.

Tragopogon porrifolius L.

Ursinia nana DC. subsp. *leptophylla* Prassler

Vernonia natalensis Oliv. & Hiern

Casuarinaceae ($n = 1$)

* *Casuarina equisetifolia* L.

Combretaceae ($n = 1$)

* *Combretum erythrophyllum* (Burch.) Sond.

Cyperaceae ($n = 3$)

Cyperus esculentus L.

Mariscus congestus (Vahl) C.B.Clarke

Schoenoplectus corymbosus (Roem. & Schult.) J.Raynal

Dipsacaceae ($n = 1$)

Cephalaria zeyheriana Szabó

Fabaceae ($n = 15$)

Acacia mellifera (Vahl) Benth. subsp. *detinens* (Burch.) Brenan

* *Alhagi maurorum* Medik.

Gleditsia triacanthos L.

Indigofera sp.

Indigofera alternans DC.

Lessertia sp.

Lotononis sp.

Sesbania punicea (Cav.) Benth.

* *Spartium junceum* L.

Sutherlandia microphylla Burch. ex DC.

* *Trifolium burchellianum* Ser.

* *Trifolium pratense* L.

* *Vicia sativa* L.

* *Vicia villosa* Roth

Vigna vexillata (L.) A.Rich. var. *davyi* (Bolos) B.J.Pienaar

Fagaceae ($n = 1$)

* *Quercus robur* L.

Flacourtiaceae ($n = 1$)

Dovyalis caffra (Hook. f. & Harv.) Hook. f.

Hyacinthaceae ($n = 1$)

Albuca setosa Jacq.

Juncaceae ($n = 2$)

Juncus effusus L.

Juncus punctatorius L.f.

Myrtaceae (n = 3)

- * Callistemon sp.
- * Callistemon viminalis (Sol. ex Gaertn.) Cheel.
- * Eucalyptus grandis W.Hill ex Maiden

Pinaceae (n = 2)

- * Pinus elliotii Engelm.
- * Pinus halepensis Mill.

Poaceae (n = 20)

- Avena sativa L.
- * Cynodon aethiopicus Clayton & Harlan
- * Dactylis glomerata L.
- Dichanthium sp.
- Digitaria abyssinica (A.Rich.) Stapf
- Echinochloa sp.
- * Eragrostis tef (Zucc.) Trotter
- Harpochoa falx (L.) Kuntze
- * Lolium multiflorum Lam.
- * Pennisetum setaceum (Forssk.) Chiov.
- * Pennisetum villosum R.Br. ex Fresen.
- * Phalaris arundinacea L.
- * Phalaris canariensis L.
- * Sorghum bicolor (L.) Moench subsp. drummondii (Steud.) de Wet
- * Sorghum halepense (L.) Pers.
- * Sorghum vulgare L.
- Stipagrostis sp.
- Trachypogon spicatus (L.f.) Kuntze

Tragus berteronianus Schult.

- * Triticum vulgare L.

Portulacaceae (n = 1)

Portulaca sp.

Rosaceae (n = 2)

- * Pyracantha angustifolia (Franch.) C.K.Schneid.
- * Pyracantha sp.

Salicaceae (n = 7)

- Populus alba L.
- Populus × canescens (Aiton) Sm.
- * Populus deltoides Marshall
- * Populus deltoides Marshall subsp. wislizenii (S.Wats.) Sarg.
- * Populus nigra L.
- * Populus simonii Carrière
- * Salix babylonica L.

Sapindaceae (n = 1)

- * Dodonaea angustifolia L.f.

Solanaceae (n = 1)

Lycium hirsutum Dunal

Ulmaceae (n = 1)

Celtis sinensis Pers.

Viscaceae (n = 1)

Viscum rotundifolium L.f.

OBITUARY

HELEN JOYCE VANDERPLANK (1919–2005)

Helen Joyce Vanderplank (Figure 1) was born on 28 July 1919 in Cheltenham, Gloucestershire in England and was educated at the Clifton High School for Girls in Bristol. After her training as a school teacher at the Froebel Educational Institute in Roehampton, London, she went on to become a junior lecturer in the natural history department there. At the insistence of her principal, Dr Frieda Howarth, she enrolled for night classes at Birkbeck College, London University where she qualified with a B.Sc. Hons in Botany and Zoology. Frieda Howarth had a great deal of influence on the young Helen and while working at the Institute they were jointly responsible for the publication by the University of London of the first six books of the *Natural History Series* in the 1950s, written by Dr Howarth and beautifully illustrated by Helen. They obviously had a close working relationship which was amusingly illustrated by Helen's recounting of Frieda's impatience with an importunate young man who asked too many questions and wasted her time: David Attenborough, later to become a world renowned naturalist, was at that time a young man hardly out of short pants and Helen was detailed on many occasions by Frieda to 'take him to the garden and amuse him while I get on with my work'!



FIGURE 1. —Helen Joyce Vanderplank (1919–2005).

Her father, Frederic James Vanderplank, owned a ladies outfitters and was a keen gardener at their home in Bristol and her love for flowers was instilled in her at an early age. She wryly remembered her first parental chastisement at the age of three years when she could not resist her father's exotic poppies.

Her mother was artistic too and was known for her fine leatherwork and Helen was encouraged early on to draw and paint the flowers she loved so well. As was common in upper middle class families of the time, she spent much of her time with her Nanny who nurtured her in her formative years. This bond of affection remained with her throughout her life and when her 'Nan' died, long after she had emigrated, her grief was as keen as for a beloved parent. She had an elder brother, Lionel and a sister, Betty who married and also emigrated to South Africa. The loss of her younger brother, John at the very early age of only 13 from diabetes was a great sadness to her, and her sister has told me that they were close companions and playmates. Their surname, Vanderplank, is Flemish in origin and the original forefathers emigrated to Britain during the time of the Huguenot persecution. She was always very particular about the spelling as one word and its English pronunciation and, until she took South African citizenship, never thought of herself as other than British.

The war years in Britain were not easy and during the 1st World War (before Helen was born), her father experienced a great deal of prejudice from the misconception that his name was German. This probably carried over to the 2nd World War as well and Helen must have experienced some of it too. After the war, life was pretty gloomy in a severely rationed Britain and to escape some of this depression, Helen undertook a trip to visit friends living in what was then Zululand.

She was enthralled by the wide open spaces and the colourful variety of wild flowers she saw. A second visit some years later confirmed her desire to live in South Africa and in 1963 she emigrated to take up a post as teacher in the pre-preparatory section of the Diocesan College, Bishops, in Cape Town. On board ship on her journey to Cape Town, she met Mary Maytham Kidd, wife of the principal of Bishops College, who was the author of *Wild flowers of the Cape Peninsula* (Maytham Kidd 1950). Their common interest in depicting the flowers they loved so well was an immediate bond which was to last throughout their lives. According to Helen, it was Mary Maytham Kidd's mentorship which set her on the path of botanical illustrator. She continued teaching at Bishops until 1971 when, after a short period at St Cyprian's School for Girls in Cape Town, she moved to Grahamstown to take up a post as lecturer in the Grahamstown Teachers Training College. Here she taught until the College closed down in 1975. All these years her art remained a favourite hobby and she earned her living teaching. Now, for the first time, this 'second string' would come in useful. She applied for the post



FIGURE 2. —Helen working on one of the displays at the Albany Museum, Grahamstown.

of Display Artist at the Albany Museum (Figure 2). Her qualifications in natural science and her ability as an artist made her eminently suited to the post and from 1971 to her retirement in 1984 she transformed gallery after gallery using her artistic talents in the widest possible way.

The Children's Gallery, three semi-circular spaces where specimens of wild animals are displayed in their natural habitats of seascape, temperate grassland and desert, was set up as an open 'touch and feel' gallery where children can experience close contact with the animals. Painting the scenic background on the concave walls was a challenge which extended her ability as a landscape artist far beyond the photographic depiction usual in landscape art and gave her many headaches. Next came the setting up of the Invertebrate Gallery where she used a variety of techniques from batik to etching to illustrate and decorate the many small dioramas of creatures on display. The backgrounds of a number of these cases where enlarged models of these microscopic creatures are displayed, bear delicate etchings on crayoned paper of a plethora of these minute animalcules in the finest detail. But the dioramas that are simply taken for granted as windows onto woodland scenes of flowers, mosses and a variety of insects, are the most stunning works of art. The flowers, leaves and insects, all made from silk, wax and wire, are so realistic that visitors assume that they were plucked and posed shortly before their arrival! With typical thoroughness, Helen had spent some weeks during one of her visits home to Britain learning the technique from the expert at the Cardiff Museum and was able on her return to model these specimens so well, that even now, almost 30 years later, the scenes are as fresh as when she had first made them.

In 1982 a new adjunct to the Albany Museum complex was opened. Called the Observatory Museum, it was a restoration of the Victorian home of watchmaker Henry Carter Galpin, one of the quartet of scientists, Atherstone, Rickards, MacOwan and Galpin who identified the Eureka diamond found near Hopetown in 1867. This was the first diamond found in South Africa and it intro-

duced a whole new mining industry. Some years earlier, Harry Oppenheimer's company, De Beers Consolidated, bought the building which was in disrepair and about to be demolished and set about restoring it. This included refurbishing all the living rooms and reworking the Camera Obscura (the only one of its kind in the southern hemisphere set up in 1882) and the Meridian Room with a north/south line on the floor which accurately measures Grahamstown time to be 14 minutes behind South African Standard Time. Helen was closely involved with refurbishing and embellishing the room used by Galpin's sons as a study and playroom. One of these sons was Ernest Galpin the botanist and botanical collector who had the privilege of growing up in this environment and went on to become famous in his own right as one of the founders of botany as a profession in this country. Nature study was a feature of the Galpin home life and in the room are collections of butterflies, plant presses and natural history books all put together by Helen. On the walls, a series of *Oxalis* prints from Jacquin's book (Jacquin 1794), was carefully photocopied onto old off-white typing sheets from the Selmar Schonland Herbarium and then faithfully water-coloured, each according to species, to brighten the room.

The opening ceremony was attended by the Oppenheimers and they were presented with a special gift of appreciation, a Victorian posy of Eastern Cape flowers under a glass dome which Helen made with great care and accuracy from silk, wax and wire (Figure 1). Harry Oppenheimer was so taken with this gift that he would not let it out of his sight and insisted on carrying it himself onto the aircraft when they left Grahamstown.

After her retirement in 1984 she busied herself with completing a set of greeting cards for the Department of Nature Conservation. In 1985 a set of six botanical paintings of trees which she made for the 1820 Settler's Memorial Foundation, was awarded a prize in an American competition. As she had never married, there was nothing that bound her to Grahamstown and, about a year after retiring, she decided to sell her house in Grahamstown and move to Port Elizabeth. Not long

after, in 1986, her good friend, Dr C.J. Skead moved to a retirement complex also in Summerstrand near Helen's home and their regular Sunday lunches were added to by day trips into the countryside. Jack Skead is an all-round naturalist with an abiding curiosity in all things natural. He was fully aware of the paucity of written material on the Eastern Cape flora and it was his prompting and subsequent support that moved Helen to embark on her two-volume opus, *Wildflowers of the Port Elizabeth area* (1998, 1999).

Their earliest forays were into the coastal bush and fynbos areas to the south and west of Port Elizabeth. She completed the first 96 plates which were ordered in families according to the calendar months in which they flowered. After unsuccessfully seeking sponsorship for publication from Kirstenbosch, she offered them to Oppenheimer's Brenthurst Library and Press in the hope that they would publish them. A visit in 1989 by the librarian representing Brenthurst confirmed their interest and although they did not see their way clear to publishing the collection in the near future, offered to buy the plates for their Africana collection. Helen agreed and sold the plates, hoping that they would eventually be published.

She and Jack then turned their sights to the dry, bushy country northeast of Port Elizabeth. By this time they had enlisted the help (and protection) of Pieter Coetzee, Director of the Western Districts Council of the Department of Nature Conservation, and William Massyn of the Van Staden's Wildflower Reserve, who helped them to penetrate into areas inaccessible either because of bad roads or the proliferation of urban informal settlements. Of this area, Helen completed 68 plates depicting 380 plants arranged in simple family order, and this time she was successful in getting a sponsor, Billiton Plc Mining Company, for publication. The book was duly published in 1998 and, after negotiating with Brenthurst Press, her previously completed 96 plates were loaned to her for publication in 1999.

Together the two books, in more than 1 000 illustrations, cover at least 900 different plant species. Helen identified most of these plants herself and made a number of trips to the Selmar Schonland Herbarium in Grahamstown. Although her demarcated areas are rela-

tively small, she collected intensively and many of the plants occur much wider afield.

This was also the year in which she turned 80 and she admitted that she was looking forward to a rest. One tends to forget that after the exertion of collecting, the work is far from over and upon return, the artist has to jump to it more or less immediately to capture the true colour and shape of the flowers before they fade.

We had all hoped that after a rest period she might turn her hand to documenting the *Oxalis* species of this area, many of which she cultivated successfully in her garden but beyond a delightful painting of a nosegay consisting entirely of different species of *Oxalis*, this project never got off the ground. After a short illness she died on the 7th of February 2005, leaving a rich legacy of floral art and having added handsomely to the documentation of the plants of the Eastern Cape.

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