

Bothalia

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CONTENTS

Bothalia 38,2

1. Systematics of the southern African genus <i>Ixia</i> (Iridaceae). 2. The filiform-leaved <i>I. capillaris</i> complex. P. GOLDBLATT and J.C. MANNING.	115
2. Asteraceae in <i>Strelitzia</i> 14 (2003) and <i>Southern African Botanical Diversity Network Report</i> No. 41 (2006): updates and corrections. P.P.J. HERMAN.	125
3. Developmental variation in a species of <i>Isoglossa</i> (Acanthaceae: Ruellioideae) over a season. D.L. PORIAZIS and K. BALKWILL.	131
4. Notes on African plants:	
Apocynaceae. Species delimitation in <i>Carvalhoa campanulata</i> (Rauvolfioideae). J.E. BURROWS.	147
Aponogetonaceae. <i>Aponogeton fugax</i> , a new species endemic to the Cape Floral Region, South Africa. J.C. MANNING, P. GOLDBLATT, E.J.J. SIEBEN & J.P. ROUX.	156
Begoniaceae. <i>Begonia sonderiana</i> , a new KwaZulu-Natal record from the southern Lebombo Range, Maputaland, South Africa. N.R. CROUCH and T. McLELLAN.	146
Celastraceae. A new species of <i>Gymnosporia</i> from South Africa and Swaziland. M. JORDAAN. ...	150
Droseraceae. <i>Drosera ericgreenii</i> , a new species from the fynbos of South Africa. A. FLEISCHMANN, R. GIBSON and F. RIVADAVIA.	141
Lamiaceae. A new combination in <i>Syncolostemon</i> . D.F. OTIENO and E. RETIEF.	144
Pteridophyta: Aspleniaceae. <i>Asplenium lobatum</i> var. <i>pseudo-abyssinicum</i> , a new record for South Africa. R.R. KLOPPER, J. NEL, A.W. KLOPPER and G.F. SMITH.	144
Selaginellaceae. <i>Selaginella nubigena</i> , a new species from the Drakensberg, South Africa. J.P. ROUX.	153
5. Diversity and species turnover on an altitudinal gradient in Western Cape, South Africa: baseline data for monitoring range shifts in response to climate change. L. AGENBAG, K.J. ESLER, G.F. MIDGLEY and C. BOUCHER.	161
6. Miscellaneous notes:	
A tribute to Prof. Kristo Pienaar (1922–1996), doyen of South African gardening. M. WALTERS and G.F. SMITH.	193
7. Obituary: Donald Joseph Boomer Killick (1926–2008). O.A. LEISTNER.	195
8. South African National Biodiversity Institute: administration and research staff 31 March 2008, publications 1 April 2007–31 March 2008. Compiler: B.A. MOMBERG.	203
9. Guide for authors to <i>Bothalia</i>	221
10. Change of policy for reprints of <i>Bothalia</i> articles.	233

New combination and species in *Bothalia* 38,2 (2008)

Aponogeton fugax *J.C.Manning & Goldblatt*, sp. nov., 156

Drosera ericgreenii *A.Fleischm., R.Gibson & F.Rivadavia*, sp. nov., 141

Gymnosporia hemipterocarpa *Jordaan*, sp. nov., 150

Ixia dieramoides *Goldblatt & J.C.Manning*, sp. nov., 120

Ixia exiliflora *Goldblatt & J.C.Manning*, sp. nov., 119

Ixia reclinata *Goldblatt & J.C.Manning*, sp. nov., 123

Selaginella nubigena *J.P.Roux*, sp. nov., 154

Syncolostemon cinereum (*Codd*) *D.F.Otieno & Retief*, comb. nov., 144



This issue is dedicated to
Donald Joseph Boomer Killick (1926–2008)
Deputy Director of the Botanical Research Insitute, Pretoria, 1973–1989
Editor of *Bothalia*, 1972–1985

Systematics of the southern African genus *Ixia* (Iridaceae). 2. The filiform-leaved *I. capillaris* complex

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

Keywords: *Ixia capillaris* group, leaf morphology, new species, southern Africa, taxonomy

ABSTRACT

Field study and associated examination of herbarium specimens of the filiform-leaved species of section *Morphixia* of the South African genus *Ixia* L. have resulted in an increase in the number of species with this derived leaf type. *Ixia capillaris* and *I. pauciflora* have until now been the only species with such leaves and they have not been regarded as immediately related in past accounts of the genus. The two foliage leaves, typically less than 2 mm wide, with a leathery to succulent texture, and lacking a raised central vein or margins, are specialized in the genus. Associated finely fibrous corm tunics, spikes of 1–3 flowers, and when present, short, thread-like lateral branches, usually bearing 1 or 2 flowers, provide supporting evidence that the group is monophyletic. *I. capillaris* as interpreted until now, comprises four species, three of them new and described here, and the large-flowered *I. pauciflora* includes two species, one of these described here. While *I. capillaris* has a branched stem, radially symmetric flowers with a perianth tube (4–)5–7(–8) mm long, tepals 11–15 mm long and thus substantially exceeding the tube, filaments typically exserted 1–2 mm, and anthers (3–)4–5 mm long, *I. exiliflora* has a tube 8–10 mm long and $\pm$ as long as the tepals, included filaments, and anthers 3.5–4.0 mm long. The new *I. dieramoides* also has included filaments but a perianth tube 13–18(–22) mm long and tepals 11–18 mm long. A third new species, *I. reclinata* has large flowers with a tube 13–15 mm long, tepals 16–21 mm long, and unilateral, declinate stamens with the filaments exserted 8–10 mm, and anthers 4–5 mm long. Typical *I. pauciflora* has flowers with unilateral stamens and filaments exserted 2–6 mm from the flower and anthers prominently displayed, but specimens until now included in that species with short, included filaments 3–5 mm long and anthers half included in the tube, are here regarded as *I. dieramoides*. The *I. capillaris* group as treated here, now includes five species.

INTRODUCTION

In a continuation of our studies of the systematics of *Ixia*, a genus of the winter rainfall zone of southern Africa and largely restricted to the Greater Cape floral region, we re-examine the taxonomy of *I. capillaris* [subgenus *Morphixia sensu* Goldblatt & Manning (1999), thus including Lewis's sections *Morphixia* and *Hyalis*] and allied species that share only two foliage leaves with distinctive narrow, leathery blades less than 2 mm wide, without a visible main vein, and with rounded, unthickened margins when fresh. We refer to the group for convenience as the *I. capillaris* complex, for the first and most widespread species with such leaves to be named. As revised by Lewis (1962), *Ixia* included 44 species, and since the publication of her account, a further 19 species have been added to the genus, one reduced to synonymy (Goldblatt & Manning 2008). With three more here as a result of our reappraisal of the *I. capillaris* complex, the current total in the genus is 66 species, of which 39 fall in subgenus *Morphixia*.

Plants assigned in herbaria to *Ixia capillaris* and *I. pauciflora*, which we consider to be closely related, share distinctive, derived leaf blades, and in addition, comparatively fine, netted corm tunics. Lateral branches, when present, are short, thin and wiry, and bear one or two, rarely three flowers. The leaf morphology, corm tunics and branching pattern all appear derived and we provisionally consider plants with these features to comprise a single lineage. The taxonomy of the group, however, is in need of revision: plant specimens cur-

rently placed under *I. capillaris* and *I. pauciflora* in herbaria seem on close examination to be more diverse than their respective circumscriptions. Plants with a perianth tube 5–7 mm long, filaments exserted 1–2 mm from the tube, anthers 4–5 mm long, and short style branches 1.0–1.8 mm long, match the type of *I. capillaris* according to Lewis's (1962) account of *Ixia*, which comprises the only modern monographic revision of *Ixia* [M.P. de Vos's (1999) account of *Ixia* for *Flora of southern Africa* follows Lewis's taxonomy exactly for the filiform-leaved species]. These plants occur widely across the Cape floral region (*sensu* Goldblatt & Manning 2000; Manning *et al.* 2002), usually on clay and loamy soils. Plants with the vegetative features described above but relatively small flowers with a funnel-shaped perianth tube, have until now been referred to *I. capillaris* by default. Our examination of floral variation in specimens that have accumulated in herbaria since Lewis's account of *Ixia*, however, shows that multiple undescribed species have now been assigned to *I. capillaris*.

Of the three sets of populations that stand out as diverging significantly from the above description, the first extends from Worcester eastward to Touws River, in the interior centre of the range of *Ixia capillaris*. These plants have a perianth tube 8–10 mm long, filaments included in the tube, and anthers 3–4 mm long, with the bases usually also included in the tube. Well-grown specimens stand out in having several 1–3-flowered lateral branches. A second set of populations includes tall plants from the Bonteberg and Voetpadsberg north and east of Touws River and locally in the Little Karoo, that have a perianth tube 13–17 mm long, filaments reaching the mouth of the tube, and 1 or 2 branchlets mostly with a single flower each. Lastly, plants from the Caledon District with larger flowers, a tube 13–15 mm long, unilateral stamens with filaments exserted 8–10 mm from

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the tube, and a style that divides below the level of the anthers into branches 4–5 mm long, appear intermediate between *I. capillaris* and *I. pauciflora*. Notably, none of the plants mentioned above has the chestnut brown cataphylls that are typical of both *I. capillaris* and *I. pauciflora*.

Ixia pauciflora has seemed fairly uniform in morphology but examination of all specimens available in southern African herbaria shows that the species comprises two sets of populations, the typical one with filaments 12–13 mm long, exserted 2–6 mm, and anthers (4–)5–6 mm long, and a second series with short filaments 2.5–5.0 mm long included in the tube, and short anthers 2.5–3.3 mm long, also partly included. These latter plants have a coherent range in the southern Cedarberg and although they occur within the range of *I. pauciflora*, we believe they represent a western series of populations of the plants mentioned above from the Bontebberg and Voetpadsberg.

MATERIALS AND METHODS

Using standard methods of taxonomic investigation, we examined the holdings of *Ixia* in herbaria with significant southern African collections, BOL, K, MO, NBG, PRE, and SAM (acronyms following Holmgren *et al.* 1990). We then assembled sets of measurements for taxonomically important features from well-preserved specimens, bearing in mind that floral features may shrink up to 20% of their original size, depending on the care with which specimens are prepared. We did not use Lewis's (1962) or De Vos's (1999) measures for any taxa because we apply some names in different ways. Leaf sections were made by hand from fresh material and stained with basic fuchsin.

Our herbarium studies were accompanied by field investigation throughout the geographic range of the *Ixia capillaris* complex to determine variation within populations and their ecology, especially soil, aspect, and altitudinal range.

RESULTS

Examination of living plants and anatomical sections of fresh leaves, confirmed the unique leaves of the *Ixia capillaris* complex, also present in *I. pauciflora*. Comparison of living and dried leaves revealed additional leaf details. The fresh leaf blades have a leathery to almost succulent texture and neither the central vein nor the margins are visible as raised portions of the surface. When dry, however, the leaf tissue surrounding the central vein shrinks to a greater degree than the vasculature and the margins. The blade can then be identified to have one main vein or pseudomidrib, now apparently raised above the surface. In addition, the main vein is always displaced toward the abaxial margin. The blade is thus divided into two unequal parts with the abaxial portion about half as wide as the adaxial portion. The blades sometimes have, in addition, one or a pair of secondary veins. Anatomically, the secondary bundles are surrounded by complete sclerenchymatous bundle sheaths and opposing bundles remain distinct (Figure

1C), in contrast to species with thin-textured blades in which opposing secondary bundles often merge at their xylem poles (compare also De Vos 1999: fig. 3i, fig. 7c). Species with such leaf blades, the *I. capillaris* complex, consistently have two foliage leaves with free blades, whereas a third leaf sheaths the stem for most or all of its length. The group is provisionally assumed to be monophyletic on the basis of the derived leaf morphology, branching pattern and finely fibrous corm tunics, which are also specialized in the genus.

Field studies conducted in August and September of 2006 and 2007 confirmed our preliminary hypotheses that *Ixia capillaris*, as treated in herbaria today, comprises four sets of populations. Plants conforming to the type are widespread, and always have a relatively short perianth tube, as described by Lewis (1962), exserted filaments, and frequently distinctive brown cataphylls. Flower colour is most often pale blue-mauve (also described as blue-grey), but white- and yellow-flowered populations have also been recorded.

The first set of divergent populations, from the Worcester District, both in the hills near Worcester and on the plateau at the top of Hex River Pass, consists of plants with the filaments always, and sometimes the bases of the anthers also, included in a tube 8–10 mm long, thus slightly longer than in *Ixia capillaris*, which has a tube (4–)5–7(–8) mm long and filaments mostly exserted 1–2 mm. These populations also have flowers with smaller tepals, 8–10 mm long and anthers 3.5–4.0 mm long, compared with tepals 11–15 mm long and anthers (3–)4–5 mm long in *I. capillaris*. Plants in these populations show no sign of variation for these features, and seen in the field, present a rather different appearance to *I. capillaris*, often having more branches per stem and thus more flowers. The flowers also have a light, sweet, rose-like scent, whereas those of *I. capillaris* that we examined, had a faint or no discernable scent. We conclude that these plants are most appropriately regarded as a separate taxon, which we call *I. exiliflora*. We include in *I. exiliflora*, a population of white-flowered plants from near Simonskloof west of Koo (Goldblatt & Porter 12936). These plants closely resemble the blue-flowered *I. exiliflora* except in colour and have the short stamens and partly included anthers that characterize the species. Plants were in full bloom in undisturbed renosterveld on clay ground.

The second set of divergent populations from the Touws River–Matjiesfontein area, mainly on the lower sandstone slopes of the Bontebberg and Voetpadsberg, and locally in the Little Karoo, consists of plants not only with a longer perianth tube, 13–18(–22) mm, but included filaments that reach just to the mouth of the tube, tepals 11–18 mm long, and anthers 2.5–3.5 mm long. Well-grown plants are also substantially taller than *Ixia capillaris*, up to 70 mm high, and have one or two short branchlets. Notably, at one locality in the Little Karoo, on Op-de-Tradouw Pass, these long-tubed plants grow parapatrically with typical *I. capillaris*, which at that site has a perianth tube 5–6 mm long and exserted filaments typical of the species. Ecological differences were evident between the two taxa at this site, and whereas the long-tubed plants grew in stony ground on ridge tops, *I. capillaris* occurred nearby on south-facing

clay slopes. We believe this set of populations with long-tubed flowers and included filaments also merits status as a separate species, which we call *I. dieramoides*.

The third divergent set of populations has a narrow range in the hills south of Theewaterskloof Dam between Caledon and Villiersdorp, where plants grow in heavy clay. The large flower with a perianth tube 13–15 mm long, tepals 16–21 mm long and filaments exerted up to 10 mm, cannot be accommodated in *Ixia capillaris* without radically expanding its circumscription. Additional collecting near the site of the first collection confirms that the corms match those of the *I. capillaris* complex but, surprisingly, reveal that its flowers are zygomorphic: the stamens are unilateral and are held horizontally, with the anthers abruptly flexed upward, and the style extended horizontally below the stamens, thus reclinate in orientation. The style divides below or opposite the anther bases, and the style branches are 4.5–5.0 mm long, exceptional for the complex. This plant evidently also merits recognition as a separate species, which we here name *I. reclinata*. As in the two other sets of populations, now to be treated as *I. exiliflora* and *I. dieramoides*, there is no evidence of significant morphological variation in *I. reclinata* despite the presence of typi-

cal *I. capillaris* growing a few kilometres to the south. *Ixia reclinata* is closer morphologically to *I. pauciflora* than to *I. capillaris* in flower size, tube length and in the declinate stamens. A species of the Cold Bokkeveld and Cedarberg, typical *I. pauciflora* has flowers with a perianth tube 15–18 mm long, filaments exerted 2–6 mm, a style typically dividing opposite the lower third of the anthers, and often an unbranched stem, occasionally with branchlets 10 mm long, each with one or two, rarely three flowers. In contrast, *I. reclinata* usually has two or three well-developed branchlets, each bearing up to three flowers.

During our examination of herbarium collections assigned to *Ixia pauciflora*, we found a small number of specimens from the southern Cedarberg with short filaments, up to 5 mm long, and anthers half included in the tube. These plants otherwise match *I. pauciflora* closely, so much so that despite the differences in floral features, Lewis (1962) and De Vos (1999) considered them part of the variation in *I. pauciflora*. The plants have symmetrically arranged stamens, the anthers only 3.0–3.3 mm long and a style with branches up to 1.3 mm long. This combination of features provides evidence for treating these plants as a western race of *I. dieramoides*.

Key to the *Ixia capillaris* complex of Subgenus *Morphixia*

- 1a Plants with blades leathery and linear-filiform, less than 2 mm wide when fresh; midvein lying closer to abaxial margin, not thickened or evident when fresh unless held to the light [when dry main vein and margins evident and appearing thickened due to collapse of mesophyll between them] *I. capillaris* complex
- 1b Plants with leaf blades linear to lanceolate or falcate but never leathery and filiform, mostly more than 2 mm wide in mature plants; midvein evident when fresh, and central or only slightly displaced toward abaxial margin (remaining species of subgenus *Morphixia*):
 - 2a Flowers relatively small with perianth tube 4–10 mm long; filaments included or exerted up to 2 mm from tube; anthers symmetrically arranged and enclosing style:
 - 3a Perianth tube (4)5–7(–8) mm long; tepals 11–15 mm long, $\pm$ twice as long as tube; filaments exerted 1–2 mm and anthers fully exerted; anthers (3)–4–5 mm long; cataphylls often chestnut-brown above ground, or green becoming membranous ... 1. *I. capillaris*
 - 3b Perianth tube 8–10 mm long; tepals 8–10 mm long, up to 1.5 times as long as tube; filaments always included and bases of anthers held within tube; anthers 3–4 mm long; cataphylls green with membranous margins or dry and turning light brown from tips 2. *I. exiliflora*
 - 2b Flowers larger with perianth 12–22 mm long; filaments included or well exerted from tube; anthers symmetrically arranged, or unilateral and facing upward and then style lying below anthers:
 - 4a Stamens symmetrically arranged; filaments included, 3–6 mm long; anthers 2.5–3.5 mm long, exerted or lower halves included in tube. 3. *I. dieramoides*
 - 4b Stamens usually (?always) unilateral and declinate; filaments 12–15 mm long, exerted 2–10 mm; anthers 4–5 mm long, fully exerted from tube:
 - 5a Filaments exerted 2–6 mm from tube; stem simple or 1 or 2(3) lateral branches, branches when present mostly 1- or 2(3)-flowered; cataphylls chestnut-brown above ground; stamens usually (?always) unilateral and extended horizontally 4. *I. pauciflora*
 - 5b Filaments exerted 8–10 mm from tube; stem with (1)2 or 3 lateral branches, branches (1)2- or 3-flowered; cataphylls green with $\pm$ membranous margins; stamens always unilateral and declinate with anthers abruptly flexed upward 5. *I. reclinata*

TAXONOMY

1. *Ixia capillaris* L.f., Supplementum plantarum: 92 (1782); Lewis: 68 (1962). Type: South Africa [Western Cape], without precise locality, collected circa 1773, C.P. Thunberg s.n. (UPS—Herb. Thunberg 935, 936, syn!).

I. capillaris var. *gracillima* Ker Gawl.: t. 570 (1802). Type: South Africa, without precise locality, illustration in Curtis's Botanical Magazine 16: t. 570 (1802).

I. gracilis Salisb.: 37 (1796), nom. illeg. superfl. pro *I. capillaris* L.f.

I. tenella Klatt: 396 (1882). Type: South Africa, without precise locality or date, Zeyher 557 (B—Herb. Lubeck, believed destroyed, drawing at S, not seen).

Plants 200–350(–500) mm high, usually with thin collar of fibres around stem base; cataphylls often chestnut-

brown, or green. *Corm* globose, 8–12(–15) mm diam.; tunics fine to medium-textured, netted fibres. *Stem* slender, usually with 1–3 lateral branches, rarely unbranched but then with 1 or more scale-like bracts on stem; branchlets mostly 8–15 mm long, filiform, curving outward, subtended by translucent, irregularly lobed, attenuate bracts and prophylls 2–3 mm long. *Leaves* three, lower two with linear blades 1.2–2.0 mm wide, one- to two-thirds as long as stem, central vein not raised when fresh, margins occasionally slightly raised, uppermost leaf sheathing stem, sometimes reaching base of spike. *Spike* drooping above, (1)2- or 3-flowered, lateral branchlets 1- or 2(3)-flowered; bracts translucent with dark veins, 7–10 mm long, outer 3-toothed, inner notched apically. *Flowers* held $\pm$ horizontally, pale blue to pale mauve or white, unscented in living plants examined; perianth tube funnel-shaped, (4)5–7(–8) mm long; tepals sub-

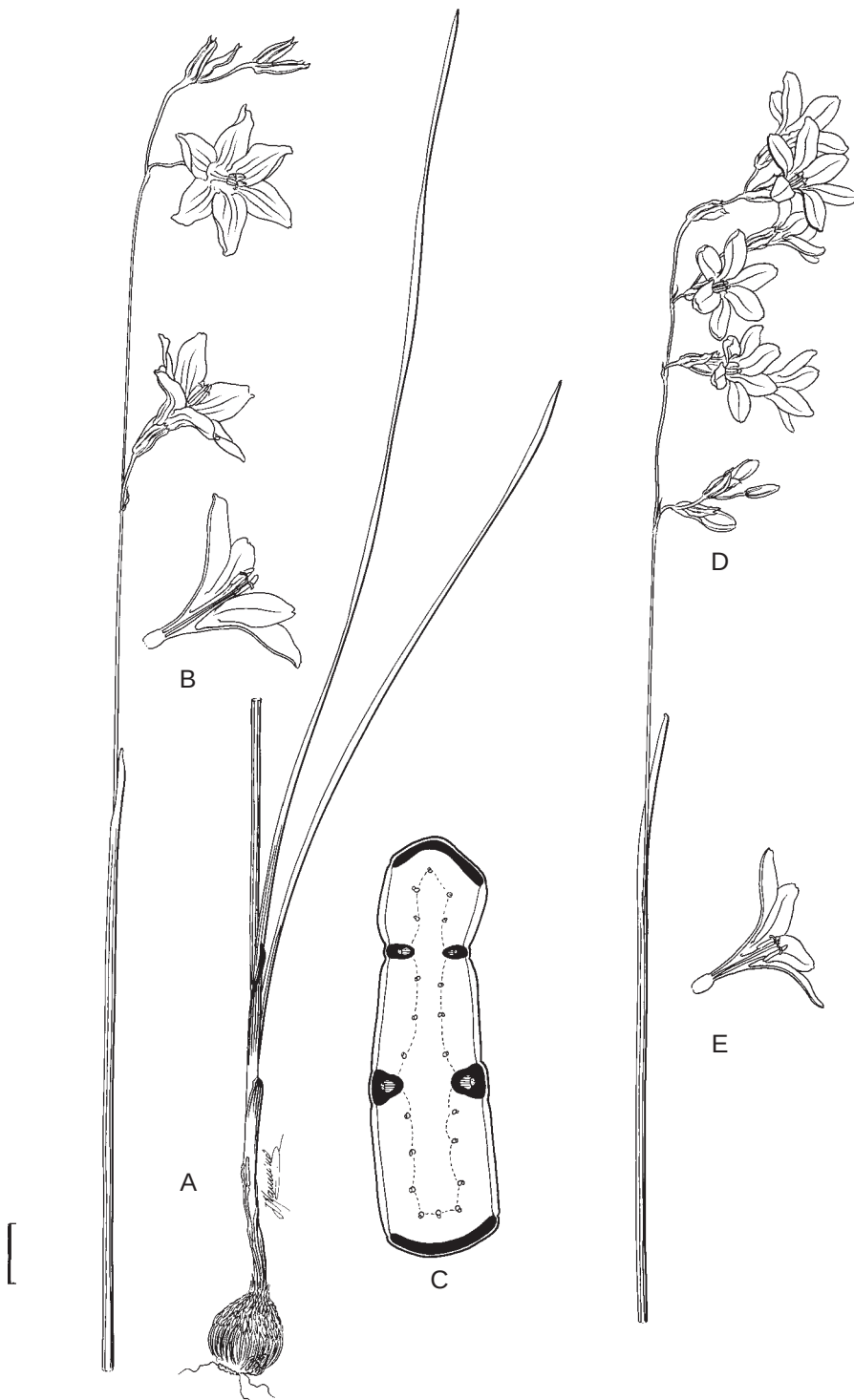


FIGURE 1.—A–C, *Ixia capillaris*, Goldblatt, Manning & Porter 12986 (MO, NBG): A, whole plant; B, 1/s flower; C, section of leaf blade. *Ixia exiliflora*, Goldblatt & Porter 12688 (MO, NBG): D, flowering stem; E, 1/s flower. Scale bar: 10 mm. Artist: J.C. Manning.

equal, $11-15 \times 4-7$ mm, spreading at right angles to tube. *Stamens*: filaments ± 5 mm long, usually exserted 1–2 mm from tube, rarely reaching only to mouth of tube; anthers (3–)4–5 mm long. *Style* usually dividing between middle and upper third of anthers, branches 1–2 mm long. *Flowering time*: mainly late July to late September. Figure 1A–C.

Distribution and habitat: with the widest range of any species of the complex, *Ixia capillaris* extends from the Piketberg and Cold Bokkeveld in the north to Bot River in the south and through the southern Cape to Riversdale (Figure 2). Plants favour clay slopes, usually in wetter sites, thus often on south-facing slopes.

Diagnosis and relationships: the type collection (or collections) of *Ixia capillaris* were made by C.P. Thunberg in the early 1770s (Linnaeus fil. 1782), probably in September 1773 when he was in the Cold Bokkeveld (Forbes 1986) where the species is common. Several specimens, on two sheets (*Thunberg Herbarium* 935, 936), show the typical attributes of the species, that is, narrow, linear leaves, corm tunics of fine, netted fibres, main spike of 1–3 flowers, branchlets when present very short and 1- or 2-flowered, and a perianth tube ± 5 mm long, enclosed by the translucent floral bracts, 6–8 mm long. The plants have a prominent dark cataphyll, a feature typical of the northern populations of the species. The flowers, excluding the ovary, are ± 20 mm long. The

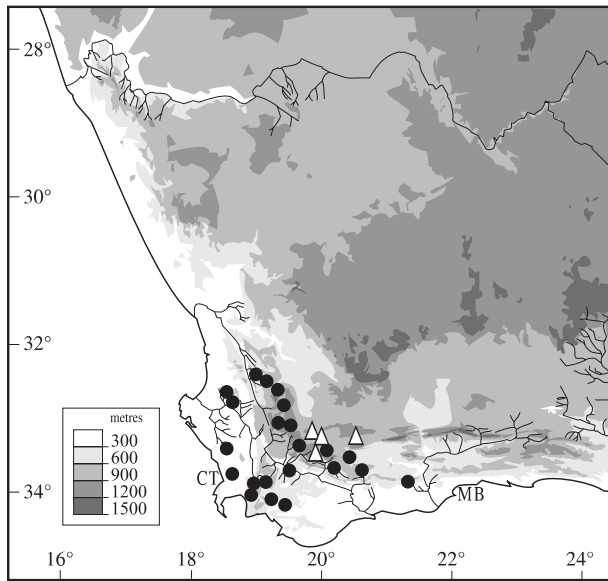


FIGURE 2.—Known distribution of *Ixia capillaris*, ●; and *I. exiliflora*, △.

distinctive pair of very slender basal leaves less than 2 mm wide and the upper leaf that sheaths the stem for $\pm$ half its length, are likewise present in all specimens, some of which have the fairly small corms, mostly $\pm$ 8 mm in diameter, and tunics of fine fibres that are characteristic of the group.

The type material is readily matched by plants from the mountains of Western Cape, long known by the name, and which also have filaments exerted 1–2 mm and anthers held in a column 4.0–4.5 mm long and a style dividing opposite the upper third of the anthers into short branches 1–2 mm long.

For many years in the early 20th century, *Ixia capillaris* was known as *I. linearis* L.f., a species described by Linnaeus fil. in 1782 at the same time as *I. capillaris*. Examination of the type by Brown (1928) showed this plant to be a species of *Gladiolus* with a radially symmetric perianth, the current name for which is *G. quadrangulus* (D.Delaroche) Barnard (Goldblatt & Manning 1998).

Plants included here in *Ixia capillaris* from the Breede River Valley south of Worcester (Goldblatt 2416) and in the hills around Bot River (Goldblatt & Manning 10674, 12685) in the south of its range, are more robust than usual for the species, some individuals more than 500 mm high, and some specimens of these collections have two or three flowers per spike. The short lateral branches and consistently narrow leaves, $\pm$ 1.5 mm wide, as well as the floral features match *Ixia capillaris* well, although the flowers are among the largest for the species, with the perianth tube exceptional in reaching 8 mm long.

Ixia capillaris is most likely to be confused with *I. exiliflora*, specimens of which have until now been included in the species. Whereas *I. capillaris* has flowers with a perianth tube 4–7, rarely 8 mm long, and tepals about twice as long as the tube, *I. exiliflora* has a perianth tube 8–10 mm long, and tepals about as long as the tube. The bases of the anthers of *I. exiliflora* are included

in the tube, whereas in *I. capillaris* the anthers are normally exerted 1–2 mm, or rarely barely exerted on included filaments.

Selected specimens

WESTERN CAPE.—3218 (Clanwilliam): Piketberg, near Berg River bridge, (–DC), 19 August 1932, *L. Bolus* s.n. (BOL20836, K, PRE); Piketberg, Versveld Pass, middle slopes on clay, (–DC), 1 September 1992, Goldblatt & Manning 9344 (MO, NBG). 3219 (Wuppertal): Elandsbloof, south slope of mountain, (–CA), 3 October 1940, Esterhuysen 3184 (BOL); Koue Bokkeveld, Skoongesig, stony sand, (–CC), 27 August 1968, Hanekom 1171 (PRE); Farm Houdenberg, $\pm$ 33 miles [53 km] NW of Ceres, deep sand, (–CD), 28 August, Boucher 3074 (NBG, PRE). 3318 (Cape Town): Waylands, Darling, (–AD), 29 August 1971, Axelson 473 (NBG); Tygerberg, south slopes, (–DC), August 1924, Pillans 4754 (BOL); Tygerberg Nature Reserve, (–DC), August 1976, Loubser 3027 (MO); Stellenbosch, (–DD), August 1924, Duthie 1507 (BOL); Simonsberg, (–DD), 22 August 1967, Strey 555 (PRE). 3319 (Worcester): Cold Bokkeveld, Elandsfontein, $\pm$ 6 miles [10 km] N of top of Gydo Pass, (–AB), 20 September 1952, Lewis 2662 (PRE); $\pm$ 19 miles [30.4 km] N of Ceres, (–AB), 11 September 1968, Marsh 763 (NBG, PRE), Mauve 4682 (PRE); flats near Ceres, 3600 ft [$\pm$ 1150 m], (–AD), September 1924, Levyns 1030 (BOL); Eselfontein, clay slopes, (–AD), 1 September 1952, Esterhuysen 20346 (BOL, PRE); Hex River Valley at Orchard, in sand at foot of mountains, (–BC), July 1944, Esterhuysen 10348 (BOL); stony flats between Worcester and the Breede River, (–CB), 24 August 1974, Goldblatt 2416 (MO, NBG, PRE); Groot Drakenstein, (–CC), 1914, Rogers s.n. (BOL10534); Stettynskloof, (–CD), 18 August 1961, Barker 9459 (K, NBG, PRE); Eendrag Pass, near the Koo, south slopes, (–DB), 23 September 1946, Levyns 7992 (BOL). 3320 (Montagu): south slopes of the Anysberg, 2000 ft [$\pm$ 660 m], (–BC), 2 August 1956, Wurts 1428 (NBG); Oudeberg, NE of Montagu, mountain renosterveld on S slopes, (–CA), 27 July 1959, Acocks 20535 (NBG, PRE); hill $\pm$ 5 miles [8 km] E of Montagu, (–CC), July 1918, Michell s.n. (BOL15566); upper slopes of Op-de-Tradouw Pass, clay ground in renosterveld, (–DC), 27 August 2006, Goldblatt & Porter 12718 (MO, NBG, PRE). 3418 (Simonstown): Vergelegen, Somerset West, (–BB), 20 August 1961, Johnson s.n. (NBG). 3419 (Caledon): Langhooft, E of Bot River, (–AA), 16 August 1997, Goldblatt & Manning 10674 (MO, NBG); clay slopes between Caledon and Riviersonderend, (–BA), 2 August 1976, Goldblatt 3712 (MO, PRE). 3420 (Swellendam): Hessaquaspoort, coastal renosterveld, (–AA), 20 July 1962, Acocks 22393 (K, PRE). 3421 (Riversdale): hill slopes near Riversdale show grounds, (–AB), August 1924, Muir 3248 (BOL, PRE).

2. *Ixia exiliflora* Goldblatt & J.C.Manning, sp. nov.

Plantae *Ixiae capillaris* similes sed floribus secundis pallide griseo-caeruleis vel albescentibus fauce pallide flava, tubo perianthii 8–10 mm longo anguste campanulato, tepalis subaequalibus ovatis 8–10 mm longis, filamentis 3–4 mm longis, antheris 3.5–4.0 mm longis partibus superis ex tubo exsertis, stylo prope apicem antherarum dividenti, ramis styli $\pm$ 1.3 mm longis.

TYPE.—Western Cape, 3319 (Worcester): $\pm$ 0.8 km S of turnoff to Montagu from N1, flat plateau, 3200 ft [$\pm$ 1050 m], (–BD), 25 August 2006, Goldblatt & Porter 12688 (NBG, holo.; K, MO, PRE, iso.).

Plants 250–700 mm high; cataphylls green with membranous margins, becoming dry distally. Corm subglobose, 8–12 mm diam., bearing small cormlets at base; tunics of fine fibres. Stem erect, sometimes nodding above, usually with 2 or 3 branchlets; bracts and prophylls subtending branchlets 3–4 mm long, acute to attenuate, translucent white. Leaves three, lower two with linear blades, reaching lower third to middle of stem, 1.0–1.7 mm wide, loosely twisted in upper half, midrib not evident when alive, slightly raised when dry. Spike with main axis (2)3- or 4-flowered, lateral spikes

(1)2- or 3-flowered; bracts translucent, 6–8 mm long, outer with 3 dark veins and 3-dentate, inner $\pm$ as long as outer, with 2 dark veins and 2-dentate. *Flowers* held horizontally, grey-blue to dingy white with creamy yellow cup, with faint rose scent; perianth tube narrowly funnel-shaped, 8–10 mm long; tepals ovate, 8–10 $\times$ 4–5 mm. *Stamens*: filaments 3–4 mm long, inserted 3–4 mm from base of tube; anthers 3.5–4.0 mm long, half included in tube and entirely within floral cup, yellow. *Style* dividing close to anther tips, style branches $\pm$ 1.3 mm long, when fully expanded often shortly exceeding anthers. *Capsules* and *seeds* unknown. *Flowering time*: July to mid-September. Figure 1D, E.

Distribution and habitat: *Ixia exiliflora* has a narrow range in the Worcester and Montagu Districts (Figure 2), where it has been collected in the hills north of Worcester, in the high country to the east of Keeromsberg, and beyond the top of Hex River Pass. Flowering is relatively early, in later July at lower elevations and from mid-August to mid-September at higher elevations. Plants favour loamy clay soils in stony ground, sometimes with sandstone bedrock.

Diagnosis and relationships: at first appearing to be a slightly smaller-flowered variant of the widespread, short-tubed *Ixia capillaris*, specimens here included in *I. exiliflora* differ in their longer perianth tube 8–10 mm [versus (4–)5–7(–8) mm in *I. capillaris*] and anthers partly included in the tube, whereas the filaments are always exerted $\pm$ 2 mm in *I. capillaris*. The partly included anthers recall the *I. rapunculoides* complex of species (Goldblatt & Manning 2008), but the very different, narrow leaves and small corms with finely fibrous tunics, as well as the smaller flowers, make it clear that the included filaments are convergent. A collection from near Simonskloof, west of Koo, with white flowers with a yellow cup, expands the known variation of the species. The flowers of these plants closely resemble blue-flowered *I. exiliflora* except in colour and have the short stamens and partly included anthers that characterize the species.

Selected specimens

WESTERN CAPE.—3319 (Worcester): Worcester, Karoo Garden, Veld Reserve, southwest slope, (–CB), July 1962, *Olivier* 28 (PRE); Matroosberg station turnoff, (–BD), 22 August 1967, *McMurry* 230 (PRE); N1 to Matroosberg station, flat plateau, 975 m, (–BD), 16 September 1974, *Mauve & Oliver* 186 (NBG, PRE); 2.5 km S of turn-off to Montagu from N1, flat plateau, 3200 ft [$\pm$ 1 050 m], (–BD), 25 August 2006, *Goldblatt & Porter* 12694 (MO); shale hills west of Koo near Simonskloof, renosterveld, (–DA), 30 August 2007, *Goldblatt & Porter* 12936 (MO, NBG, PRE). 3320 (Montagu): Witteberg, Bantams, 5000 ft [$\pm$ 1 660 m], (–BC), 27 October 1941, *Compton* 12243 (NBG).

3. *Ixia dieramoides* Goldblatt & J.C.Manning, sp. nov.

Plantae *Ixiae capillaris* similes sed caule ad 700 mm alto, floribus subnutantibus, tubo perianthii 13–18(–22) mm longo anguste campanulato, tepalis 11–18 $\times$ 5–9 mm, filamentis ad apicem tubi attingentibus, antheris 2.5–3.5 mm longis, stylo medium vel tertiam partem inferam antherarum adversus dividendi, ramis styli $\pm$ 1–2 mm longis.

TYPE.—Western Cape, 3320 (Montagu): north of N1 between Matjiesfontein and Touws River, sandstone out-

crop, (–BA), 27 August 2006, *Goldblatt & Porter* 12713 (NBG, holo., K, MO, PRE, BOL, iso.).

Plants 350–700 mm high, with a sparse collar of fibres around stem base; cataphylls green or brown, membranous at edges, becoming dry distally. *Corm* subglobose, 9–14 mm diam., bearing small cormlets at base; tunics of fine fibres. *Stem* erect or inclined, often nodding above, with 1–3 short lateral branchlets up to 10 mm long, occasionally unbranched; bracts and prophylls subtending branchlets, lanceolate to attenuate, 3–8 mm long, silvery translucent. *Leaves* three, lower two with linear, leathery blades reaching to between middle and upper third of stem, $\pm$ 1.2–2.0 mm wide, loosely twisted in upper half, main vein not evident when fresh, slightly raised when dry and lying closer to abaxial margin. *Spike* with main axis (1)2- or 3(4)-flowered, lateral branchlets 1- or 2-flowered; bracts translucent, (8–)9–11 mm long, outer with 3 dark veins and 3-dentate, inner $\pm$ as long as to slightly longer than outer, with 2 dark veins, 2-dentate. *Flowers* ascending, pale mauve-blue to watery lilac or $\pm$ violet with pale yellow cup, often sweetly scented; perianth tube 13–18(–22) mm long, widening $\pm$ uniformly from base to mouth, 5–6 mm diam. at mouth; tepals ovate, outer 13–18 $\times$ 7–9 mm, inner 11–14 $\times$ 5–8 mm, ascending below, spreading in upper two thirds. *Stamens* parallel; filaments 3–6 mm long, inserted 10–11 mm from base of tube, reaching to mouth of tube, rarely barely exerted $\pm$ 1 mm but held within floral cup; anthers 2.5–3.5 mm long, parallel, yellow, exerted or bases included in tube. *Style* dividing opposite lower to middle third of anthers, branches 1–2 mm long, when fully extended not reaching anther tips. *Capsules* and *seeds* unknown. *Flowering time*: early August to early October. Figure 3.

Distribution and habitat: fairly common on south-facing slopes of the Bonteberg and Voetpadsberg north and west of Touws River. *Ixia dieramoides* has, until now, seldom been collected but is locally quite frequent on the sandstone slopes of these mountains, and also occurs in a few sites to the southeast in the Little Karoo and in the southern Cedarberg between Wolfberg and Krom River (Figure 4).

Diagnosis and relationships: *Ixia dieramoides* has corms with fine, netted tunics and narrow, leathery leaves of the *I. capillaris* type, and differs from that species mainly in the larger flower with a tube 13–18(–22) mm long and in having the filaments and often the bases of the anthers included in the tube. The smaller flowers of *I. capillaris* have a tube (4–)5–7(–8) mm long, tepals spreading from the base and filaments typically exerted 1–2 mm. Unlike *I. capillaris*, the flowers are often faintly scented. Well-grown plants usually reach 600 mm high, thus extending substantially above the surrounding clumps of grass and low shrubs, which in open dry ground may be only 350 mm high. In dry and stony ground in poor soils, plants may be just 250 mm high, have just one or two flowers and may be unbranched. Seen from a distance, the flowering spikes nodding in the breeze resemble smaller-flowered species of *Dierama*. The immediate affinities of *I. dieramoides* may be with shorter-tubed *I. capillaris* or with the larger-flowered *I. pauciflora*, which though similar at first glance, has unilateral stamens, the filaments 12–13 mm long and

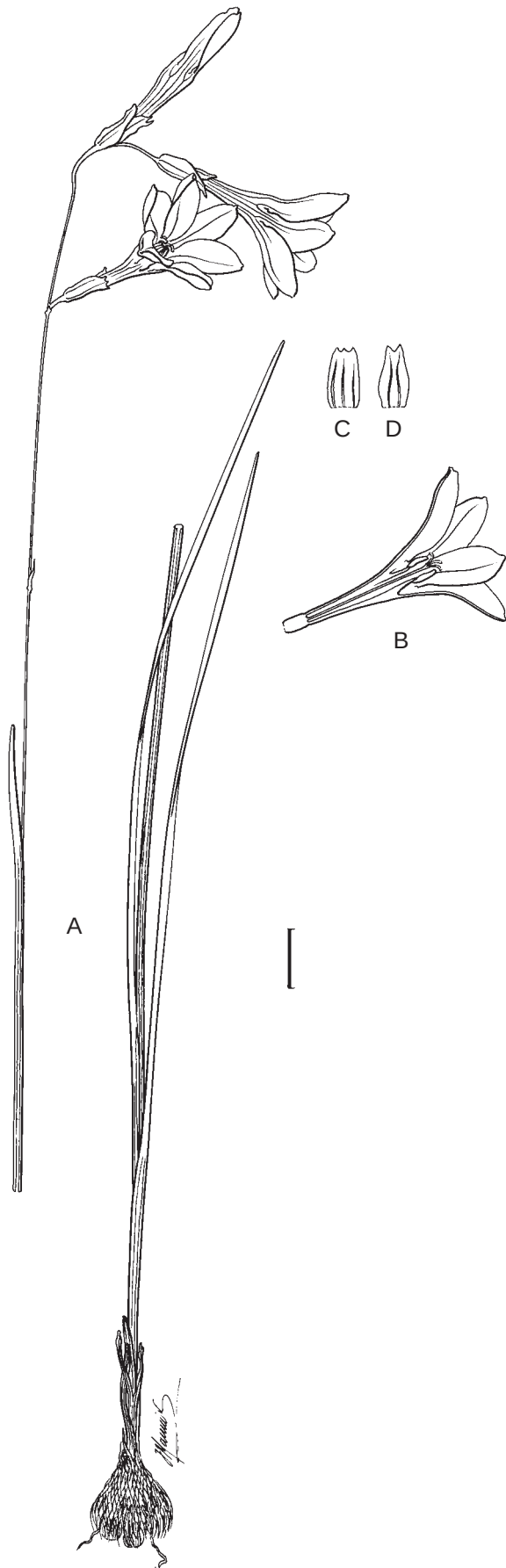


FIGURE 3.—*Ixia dieramoides*, Goldblatt & Porter 12713 (MO, NBG): A, whole plant; B, l/s flower; C, outer bract; D, inner bract. Scale bar: 10 mm. Artist: J.C. Manning.

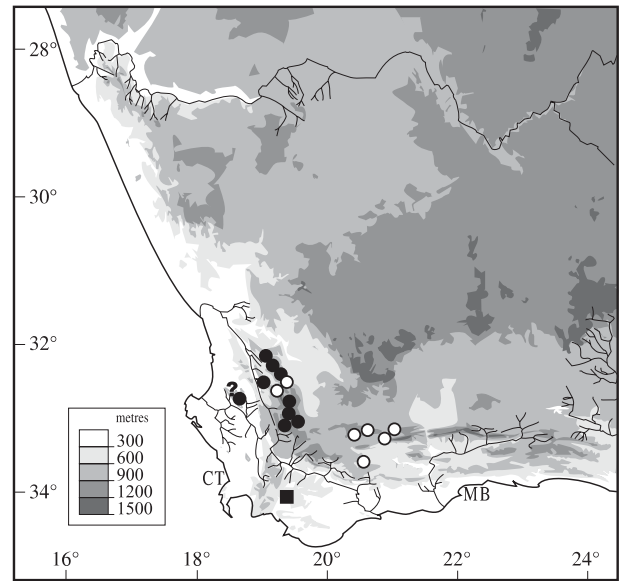


FIGURE 4.—Known distribution of *Ixia dieramoides*, ○; *Ixia pauciflora*, ●; and *I. reclinata*, ■.

exserted 2–6 mm from the perianth tube, anthers (4–)5–6 mm long and style branches 3.0–4.5 mm long.

The Cedarberg plants included here in *Ixia dieramoides* were treated by both Lewis (1962) and De Vos (1999) as *I. pauciflora* but cannot be accommodated within that species without expanding its circumscription to include plants with short, included filaments 2.5–5.0 mm long, as well as shorter anthers and style branches.

Selected specimens

WESTERN CAPE.—3219 (Wuppertal): South Cedarberg, Wolfberg, (–AD), 3 October 1952, *Esterhuysen* 20570 (BOL); Cedarberg, Matjiesrivier, (–CB), 8 September 1943, *Wagener* 140 (NBG); Cedarberg, Krom River, (–CA), August 1949, *Stokoe* s.n. (SAM60110, 2 sheets). 3320 (Montagu): Bonteberg, Pienaarskloof, in stony sandstone ground, (–AC), 31 August 2007, *Goldblatt & Porter* 12930 (MO, NBG); Pienaarskloof, western slopes of Voetpadsberg, among sandstone boulders, (–AC), 31 August 2007, *Goldblatt & Porter* 12926 (MO, NBG); lower south slopes of the Voetpadsberg east of Touws River, (–AC), 26 August 2006, *Goldblatt & Porter* 12700 (K, MO, NBG); valley west of Konstabel, sandy flats among restios along stream, (–AD), *Thompson* 1228 (NBG); Op-de-Tradouw Pass, burned renosterveld on shale slopes at top of pass, (–DC), 7 September 2002, *Goldblatt, Porter & Manning* 12178 (MO, NBG), 27 August 2006, *Goldblatt & Porter* 12719 (MO, NBG). Without precise locality: Cedarberg, shale band, September 1930, 5000 ft [$\pm$ 1 660 m], *Levyans* 2961 (BOL).

4. *Ixia pauciflora* G.J.Lewis, *Journal of South African Botany* 27: 88 (1962). Type: South Africa [Western Cape], Cold Bokkeveld, north of Waboomsriver, 2 September 1956, *W.F. Barker* 8635 (NBG, holo.!).

Plants 150–300(–400) mm high, with collar of fibres around stem base; cataphylls conspicuously chestnut-brown. *Corm* 9–14 mm diam.; tunics of fine, dark fibres. *Stem* usually unbranched, then often with a node bearing a short membranous scale, or with 1 or 2(–4) short branchlets up to 10 mm long, subtended by thread-like, attenuate bracts and prophylls 4–8 mm long. *Leaves* three, lower two with linear blades, leathery, $\pm$ 1.8 mm wide; uppermost leaf sheathing stem sometimes to base of spike. *Main spike* 1- or 2(3)-flowered, branchlets 1(2)-

flowered; bracts 9–14 mm long, outer 3-veined and 3-dentate, inner 2-veined and 2-dentate, $\pm$ as long as outer. Flowers facing to the side, zygomorphic (?or sometimes radially symmetric) with unilateral stamens, pale blue to blue mauve, whitish or palest yellow, pale yellow in throat, tepals spreading distally, proximal 3 mm directed forward and forming part of floral cup, odourless or faintly scented; perianth tube expanding uniformly from base to apex, 15–18 mm long; tepals subequal, 16–18 $\times$ 8–10 mm, ascending in lower third, spreading above. Stamens: filaments 12–13 mm long, exserted 2–6 mm; anthers (4–)5–6 mm long, fully exserted, unilateral and parallel. Style dividing opposite lower third of anthers, branches 3.0–4.5 mm long, extending between anthers. Flowering time: mid-August to mid-September. Figure 5.

Distribution and habitat: *Ixia pauciflora* is endemic to the mountains of Western Cape, where it extends from the Cedarberg near Algeria southward through the Cold Bokkeveld to Gydo Pass (Figure 4). There is also a single early record from Piketberg, Marloth 10563, which seems unlikely and requires confirmation. Plants favour seasonally moist sites on rocky sandstone slopes but may also be found on loamy clay.

Diagnosis and variation: well named for its few-flowered spikes, *Ixia pauciflora* typically has just one or two flowers on slender, often unbranched stems, or with one or two short branchlets. Robust plants may, however, occasionally have more branchlets, including an exceptional collection from Gydo Pass (Goldblatt & Porter 12987) that includes some plants with up to four branchlets, each bearing two flowers. The flowers are relatively large, having tepals 16–18 mm long, $\pm$ as long as the flared perianth tube, long filaments exserted 2–6 mm from the tube, and anthers 4–6 mm long. The stamens on fully open flowers are unilateral and are held horizontally with the anthers facing the dorsal tepal, a feature impossible to determine from pressed specimens. Vegetatively, the species is virtually identical to the more common *I. capillaris* in its two linear leaves, small corms with finely fibrous tunics, a collar of fine fibres around the underground part of the stem, and dry, chestnut-brown cataphylls, and differs mainly in the flower. Blooms of *I. capillaris* are radially symmetric and have a perianth tube 4–8 mm long, $\pm$ half as long as the tepals, and filaments $\pm$ 5 mm long, usually exserted 1–2 mm from the tube.

Ixia pauciflora also closely resembles the local Villiersdorp endemic, *I. reclinata*, in its flower, including the unilateral stamens, extended horizontally with declinate anthers but the latter has longer filaments, exserted 8–10 mm (vs 2–6 mm in *I. pauciflora*). *Ixia reclinata* also lacks the collar fibres around the stem base present in *I. pauciflora*, the stems typically have one or two branchlets, and the cataphylls are green or partly membranous when alive and not dry and chestnut-coloured. *Ixia reclinata* also differs in having the bracts and prophylls subtending the branchlets short and obtuse to subacute, quite different to the fine, thread-like bracts and prophylls of the remainder of the complex.

Collections from the southern Cedarberg assigned to *Ixia pauciflora* by Lewis (1962), e.g. Wagener 140 and Esterhuysen 20570, stand out in having shorter filaments

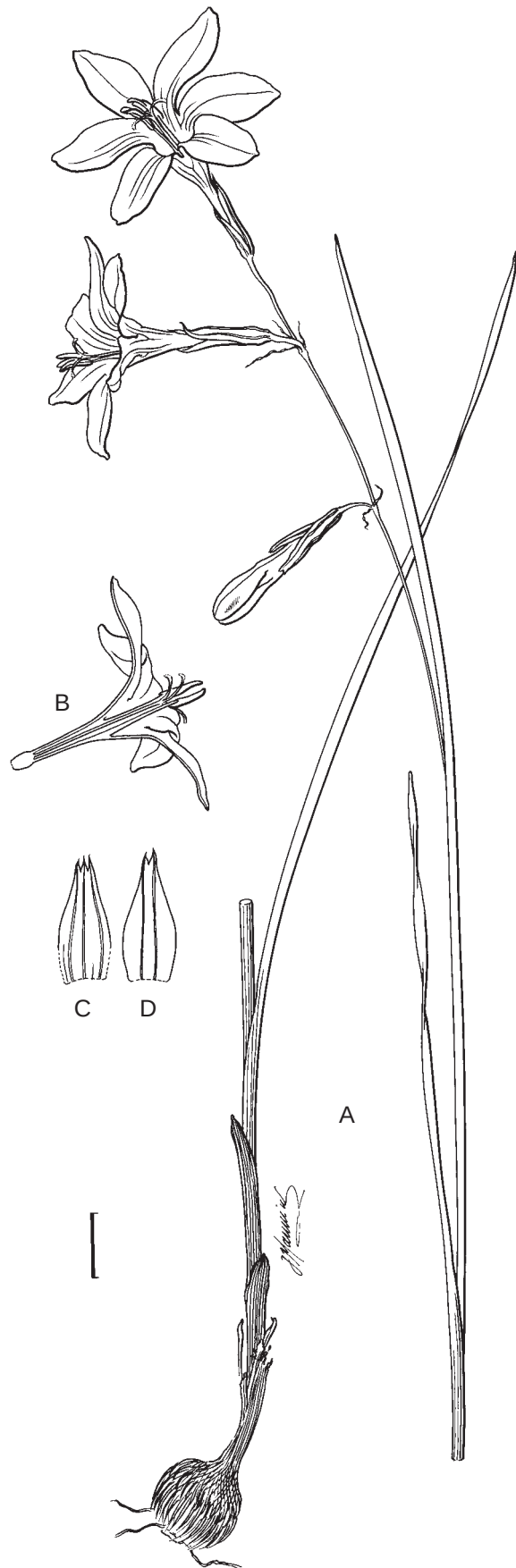


FIGURE 5.—*Ixia pauciflora*, Goldblatt & Porter 12987 (MO, NBG): A, whole plant; B, l/s flower; C, outer bract; D, inner bract. Scale bar: 10 mm. Artist: J.C. Manning.

2.5–5.0 mm long, included in the tube, and anthers 2.5–3.3 mm long, the bases of which are also included. Anthers of *I. pauciflora* are (4–)5–6 mm long and the filaments are 12–13 mm long. The style branches are also discordant with typical *I. pauciflora* in being 1.0–1.3 mm long; those of *I. pauciflora* are 3.0–4.5 mm long. These plants match *I. dieramoides* in all critical features and we include them in this species, which is centred to the east in the Bonteberg–Voetpadsberg complex.

Selected specimens

WESTERN CAPE.—3218 (Clanwilliam): Piketberg, (–DC), September 1921, *Marloth 10563* (PRE). 3219 (Wuppertal): Cedarberg, Algeria, De Rif, (–AC), 18 August 1982, *Viviers 470* (NBG, PRE); Cedarberg, Sederhoutkloof, NE base of Sneeuberg, 3000 ft [$\pm$ 960 m], (–AC), 3 September 1963, *Taylor 5114* (NBG); Welbedachtkloof, near Bushman Cave, $\pm$ 5500 ft [$\pm$ 1 780 m], (–AC), 23 September 1930, *Barnes s.n.* (BOL19322); Cedarberg, Scorpion Kloof, (–AC), September 1942, *Stokoe s.n.* SAM55669; Elandskloof Pass, (–CA), 8 September 1945, *Barker 3781* (NBG), August 1985, *De Vos 2589* (NBG); Cold Bokkeveld near Elandskloof, (–CA), 9 September 1945, *Leighton 1276* (BOL); Cold Bokkeveld near Waboomsriver, (–DC), 27 August 1954, *Lewis 4438* (SAM), 2 September 1956, *Lewis 5009* (SAM); Groenfontein, Zeekoegat west of Riet River, sandy ground, (–DC), 11 August 2001, *Stobie 3* (NBG). 3319 (Worcester): Cold Bokkeveld, 24 miles [$\pm$ 38.4 km] from Prince Alfred's Hamlet, marshy sandy ground, (–AB), 4 September 1947, *Story 3004* (PRE); top of Gydo Pass, on sandstone slope, (–AB), 11 September 2007, *Goldblatt & Porter 12987* (MO, NBG, PRE).

5. *Ixia reclinata* Goldblatt & J.C.Manning, sp. nov.

Plantae *Ixiae capillaris* et *I. pauciflorae* similes sed floribus grandioribus, albis, tubo perianthii 13–15 mm longo, tepalis 16–21 $\times$ 8.5–11 mm, filamentis 11–12 mm longis, unilateralibus, 8–10 mm ex tubo exsertis, antheris 4–5 mm longis, stylo infra usque ad partem tertiam inferiorem antherarum adversus dividenti, ramis styli 4.5–5.0 mm longis.

TYPE.—Western Cape, 3419 (Caledon): hills south of Theewaterskloof Dam, Farm Cranesfield, north of Draaiberg road, stony shale outcrops, (–AA), 24 August 2006, *Goldblatt, Manning & Porter 12686* (NBG, holo.; MO, PRE, iso.).

Plants 300–450 mm high, with green to $\pm$ membranous cataphylls. *Corm* 10–12 mm diam.; tunics fine to medium-textured. *Stem* with 1 or 2(3) short branchlets subtended by broad, obtuse to subacute bracts sometimes with a dark central vein, 2–3 mm long, exceeding prophylls. *Leaves* three, lower two with linear, leathery blades, $\pm$ 1.5 mm wide, central vein not evident when fresh, visible and close to abaxial margin when dry, margins hyaline when dry; uppermost leaf entirely sheathing, reaching to shortly below first branch or with a free tip reaching middle of spike. *Spike* (1)2- or 3-flowered; branchlets 1–3-flowered; bracts translucent brown, 8–13 mm long, outer bract shortly 3-toothed, inner $\pm$ as long as outer, forked at apex. *Flowers* borne horizontally, zygomorphic with declinate stamens, white suffused with blue-mauve, pale yellow in throat, with age veins becoming dark-coloured, faintly sweet-scented; perianth tube funnel-shaped, 13–15 mm long; tepals 16–21 $\times$ 8.5–11.0 mm, spreading, inner slightly wider than outer. *Stamens*: filaments 11–12 mm long, unilateral, exserted 8–10 mm from tube; anthers 4–5 mm long, well exserted from flower, parallel and facing upward. *Style* dividing just

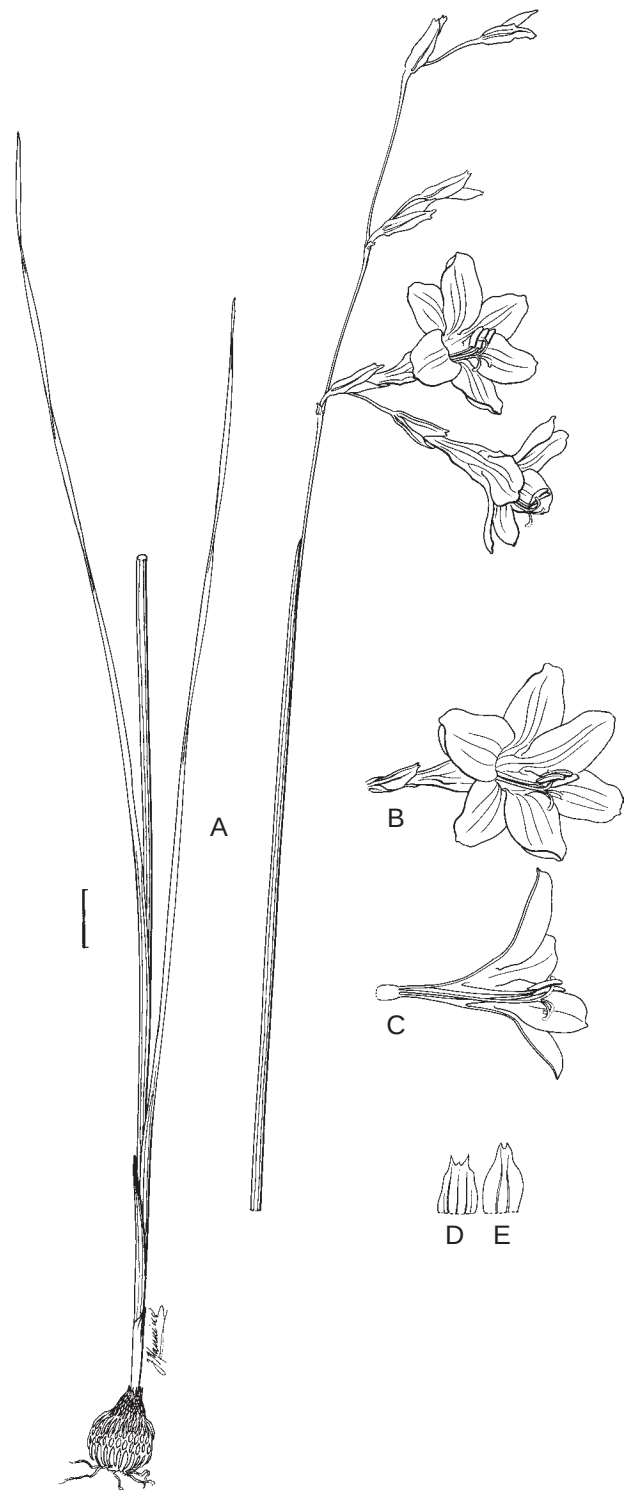


FIGURE 6.—*Ixia reclinata*, Goldblatt, Manning & Porter 12686 (MO, NBG): A, whole plant; B, front view of flower; C, l/s flower; D, outer bract; E, inner bract. Scale bar: 10 mm. Artist: J.C. Manning.

below to opposite lower third of anthers, branches 4.5–5.0 mm long. *Capsules* and *seeds* unknown. *Flowering time*: mid-August to early September. Figure 6.

Distribution and habitat: with a narrow range in the low hills south of Theewaterskloof Dam, *Ixia reclinata* ranks as one of the most threatened species in the genus (Figure 4). Populations we have seen are reduced today to narrow strips of native renosterveld in rough and rocky clay ground among ploughed land and pasture.

Diagnosis and relationships: *Ixia reclinata* was first collected in 1976 (Goldblatt 4001) and tentatively assigned to *I. capillaris*, largely because of the similar narrow leaves. When we began to investigate that species critically, the collection stood out in its very large flowers with a tube up to 15 mm long and spreading tepals forming a flower about 40 mm in diameter. In the one properly developed flower in the collection, the style divides just below the bases of the anthers into style branches $\pm$ 5 mm long, unusual for the complex. This contrasts with a tube up to 8 mm long, flower diameter of about 20 mm, style dividing opposite the upper third of the anthers and with branches less than 1.5 mm long in *I. capillaris*. After noting the discordance of this plant with all other collections of *I. capillaris*, we revisited the area where plants were first found. Flowering plants growing in fragmentary colonies confirmed our initial observations and yielded sufficient specimens for description, illustration, and preservation.

The flowers of *I. reclinata* are quite evidently zygomorphic, having unilateral stamens with parallel filaments extended horizontally, with the anthers held closely together and facing upward. The flowers are also faintly scented. Unilateral stamens are rare in *Ixia*, and are known in *I. pauciflora* and in some populations of *I. fucata*, the latter only distantly related to *I. reclinata*. We also confirmed the point of division of the style at or below the anthers, a distinctive feature unusual in the genus.

The large flower and unilateral stamens led us to consider whether *Ixia reclinata* might not be an isolated and somewhat divergent population of *I. pauciflora*. That species has similar corms and leaves, but usually an unbranched stem, pale blue-mauve, or sometimes white or pink flowers, occasionally with unilateral stamens, but the filaments are exerted only 2–5 mm, the anthers are usually symmetrically arranged and diverging, and the style usually divides opposite the lower third of the anthers. Equally significant, the stem is usually unbranched or has one or rarely two short branchlets, each with a single flower, and the underground part of the stem is sheathed by a collar of fibres, a feature uncommon in *Ixia*, but also present in the *I. capillaris* group in *I. dieramoides*.

Selected specimen

WESTERN CAPE.—3419 (Caledon): between Eseljacht Pass and Queen Anne, clay slope, (–AA), 31 August 1976, Goldblatt 4001 (MO, NBG).

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Asteraceae in *Strelitzia* 14 (2003) and Southern African Botanical Diversity Network Report No. 41 (2006): updates and corrections

P.P.J. HERMAN*

Keywords: Asteraceae, distribution, endemism, new combinations, new species, new tribes, southern Africa, updates

ABSTRACT

The distributions, endemism and tribal affiliations of taxa in the family Asteraceae in southern Africa are updated. New combinations and newly described species are added to the previously published lists.

INTRODUCTION

Since the publication of Herman *et al.* (2003) and Herman *et al.* (2006), a number of errors in the accounts of the family Asteraceae in southern Africa came to my attention. When the original work was started, the names and abbreviations for the new political provinces were still pliable and uncertain. Limpopo Province was originally known as the Northern Province, hence the letter N was sometimes erroneously used for Limpopo (LIM), but N was also used for Namibia. These discrepancies are corrected. Some additions to the distributions were necessary when the new political boundaries were made: often new distributions were added to the existing ones when it became clear that some plants occur just outside the previously recorded distribution ranges—plants do not comply to political boundaries! Following on these updated distributions, it was noted that the state of endemism of some species and genera had changed: these taxa are marked with an E (as in SABONET Report No. 41, 2006). Naturalized species are marked with an asterisk. The seven-digit numbers that follow the main genus entries are those used in the PRECIS database of SANBI. Publications are listed beneath the genus name and are numbered in brackets. A few newly described species and new combinations are added. Some spelling mistakes are corrected. In Herman *et al.* (2000) the tribes to which the genera belong, were noted. Based on continuous molecular studies, some genera were moved to new or different tribes. These are also indicated in this account. Some genera which are currently under revision, are not added to this account. Authors responsible for the different tribes have changed since the publication of *Strelitzia* 14. The tribe Senecioneae is now the sole responsibility of W.G. Welman, and any changes in this tribe are not accounted for in this publication. The format used in *Strelitzia* 14 is used here.

^E**ALATOSETA** Compton 9090010
^E**tenuis** Compton
 NC, WC

***ANTHEMIS** L. 9330000
cotula L.
 NW, G, M, FS, KZN, NC?, WC, EC

ARCTOTIS L. 9432000

(22) McKenzie *et al.* 2006. *Bothalia* 36: 171–173.

(23) McKenzie *et al.* 2006. *Botanical Journal of the Linnean Society* 151: 581–588.

^E**debensis** R.J.McKenzie

Perennial. Herb. Ht 0.1–0.2 m. Alt 0–600 m. EC

^E**decurrens** Jacq.

A. merxmuelleri Friedrich (22)

A. scullyi Dümmer (22)

Perennial. Dwarf shrub or suffrutesc. Ht up to 2 m. Alt 0–30 m. NC, WC

merxmuelleri Friedrich = **A. decurrens**

scullyi Dümmer = **A. decurrens**

ASTER L. 8900000

^E**anathocladus** Hilliard & B.L.Burt

KZN, EC

bakerianus Burt Davy ex C.A.Sm.

G, M, S, FS, KZN, L, WC, EC

erucifolius (Thell.) W.Lippert

non *A. pinnatifidus* (Hook.) Kuntze

ATHANASIA L. 9326000

^E**adenantha** (Harv.) Källersjö

NC, WC

^E**grandiceps** Hilliard & B.L.Burt

KZN, EC

^E**hirsuta** Thunb.

NC, WC

^E**linifolia** Burm.

WC, EC

^E**microphylla** DC.

NC, WC

^E**pachycephala** DC. subsp. **pachycephala**

WC, EC?

^E**pinnata** L.f.

WC, EC

^E**trifurcata** (L.) L.

NC, WC, EC

^E**vestita** (Thunb.) Druce

WC, EC

ATHRIXIA Ker Gawl. 9055000

^E**heterophylla** (Thunb.) Less. subsp. **heterophylla**

WC, EC?

BLUMEA DC. 8939000

dregeanoides Sch.Bip. ex A.Rich.

N, B, LIM, NW, G, M, S, KZN

* South African National Biodiversity Institute, Private Bag X101, 0001 Pretoria.

MS. received: 2008-04-08.

BRACHYLAENA R.Br. 8936000
discolor DC.
 LIM, M, S, KZN, EC
huillensis O.Hoffm.
 B, LIM, M, KZN
ilicifolia (Lam.) E.Phillips & Schweick.
 B, M, S, KZN, EC
^E**neriifolia** (L.) R.Br.
 NC, WC, EC
rotundata S.Moore
 B, LIM, NW, G, M, FS

***CALENDULA** L. 9423000
monstrosa Burm.f. = **Monoculus monstrosus**
tomentosa L.f. = **Inuloides tomentosa**

CHRYSANTHEMOIDES Fabr. 9427020
monilifera (L.) Norl. subsp. **canescens** (DC.) Norl.
 G, M, S, FS, KZN, L, EC
^E**monilifera** (L.) Norl. subsp. **monilifera**
 WC
monilifera (L.) Norl. subsp. **pisifera** (L.) Norl.
 N, NC, WC, EC
monilifera (L.) Norl. subsp. **rotundata** (DC.) Norl.
 KZN, WC, EC
monilifera (L.) Norl. subsp. **septentrionalis** Norl.
 LIM, M, S

CHRYSOCOMA L. 8930000
^E**oblongifolia** DC.
 NC, WC
obtusata (Thunb.) Ehr.Bayer
 N, B, LIM, NW, G, FS, NC, WC

CONYZA Less. 8926000
 (8) Pruski & Sancho. 2006. *Novon* 16: 96–101.
albida Willd. ex Spreng. = **C. sumatrensis** var. **sumatrensis**
floribunda Kunth = **C. sumatrensis** var. **leiotheca**, not
 FSA (8)
kraussii Sch.Bip. ex Walp. = **Pluchea dioscoridis**, not
 FSA (7)
pinnata (L.f.) Kuntze
 LIM, G, M, S, FS, KZN, L, NC, WC, EC
sumatrensis (Retz.) E.Walker var. **leiotheca**, not FSA (8)
C. floribunda Kunth
Erigeron floribundus (Kunth) Sch.Bip.
 ***sumatrensis** (Retz.) E.Walker var. **sumatrensis**
C. albida Willd. ex Spreng. (8)
Erigeron albidus (Willd. ex Spreng.) A.Gray (8)
Erigeron sumatrensis Retz. (8)
 Annual. Herb. Ht 0.2–2 m. Alt 2–1912 m. N, B, LIM,
 NW, G, M, S, FS, KZN, NC, WC, EC
ulmifolia (Burm.f.) Kuntze
 LIM, NW, G, M, S, FS, KZN, NC, WC, EC

^E**CORYMBIUM** L. 8764000
 Based on molecular studies, the genus *Corymbium* was
 put in its own subfamily and tribe: subfamily
 Corymbioideae, tribe Corymbieae (Panero & Funk
 2002. *Proceedings of the Biological Society of*
Washington 115,4: 909–922).
^E**glabrum** L. var. **glabrum**
 WC, EC

CREPIS L. 9605000
 ***capillaris** (L.) Wallr.
hypochaeridea (DC.) Thell.

DENEKIA Thunb. 8949000
capensis Thunb.
 N, B, LIM, NW, G, M, S, FS, KZN, L, NC, EC

DICOMA Cass. 9501000
 (16) Ortiz & Netnou. 2005. *Botanical Journal of the Linnean Society*
 147: 509–513.
 Based on molecular studies, the genus *Dicoma* was put
 in its own tribe together with *Macledium* and
Pleiotaaxis: the tribe Dicomeae (Panero & Funk
 2002. *Proceedings of the Biological Society of*
Washington 115,4: 909–922).

capensis Less.
 N, B, S, FS, NC, WC, EC
^E**galpinii** Wilson
 LIM, M
^E**kurumanii** S.Ortiz & Netnou
 Perennial. Dwarf Shrub. Ht? Alt? NC
macrocephala DC.
 N, B, LIM, NW, G, M, FS, KZN, NC, EC
^E**picta** (Thunb.) Druce
 NC, WC, EC
swazilandica S.Ortiz, Rodr.Oubina & Pulgar
 S

DIMORPHOTHECA Vaill. ex Moench 9425000
^E**acutifolia** Hutch.
 WC, EC
caulescens (Harv.) Harv.
 LIM, NW, G, M, S, FS, KZN, L, EC
^E**dregei** DC. var. **dregei**
 NC, WC
^E**nudicaulis** (L.) DC. var. **graminifolia** (DC.) Harv.
 NC, WC
^E**nudicaulis** (L.) DC. var. **nudicaulis**
 NC, WC
polyptera DC.
 N, NC, WC
zeyheri Sond.
 B, NW, FS, L, NC, WC, EC

***DITTRICHIA** Greuter 9061005
graveolens (L.) Greuter
 NC, WC

DOELLIA Sch.Bip. emended Anderb. 8939010
cafra (DC.) Anderb.
 N, B, LIM, NW, G, M, S, KZN, EC

***ERIGERON** L. 8901000
albidus (Willd. ex Spreng.) A.Gray = **Conyza suma-**
trensis var. **sumatrensis**
floribundus (Kunth) Sch.Bip. = **Conyza sumatrensis**
 var. **leiotheca**, not FSA
sumatrensis Retz. = **Conyza sumatrensis** var. **suma-**
trensis

ERIOCEPHALUS L. 9320000
^E**decussatus** Burch.
 FS, NC, WC

ERIOCEPHALUS L. (cont.)^E**glandulosus** M.A.N.Müll.
FS, NC, WC, EC^E**karooicus** M.A.N.Müll.
NW, FS, NC, EC**merxmuelleri** M.A.N.Müll.
N, FS, NC^E**tenuipes** C.A.Sm.
WC, EC***FACELIS** Cass. 8986000
retusa (Lam.) Sch.Bip.
KZN, WC, EC**FELICIA** Cass. 8919000
(7) Ortiz. 2007. *Botanical Journal of the Linnean Society* 154,4:
545–548.**clavipilosa** Grau subsp. **clavipilosa**
N, B, NW, NC^E**macrorrhiza** (Thunb.) DC.
NC, WC^E**martinsiana** S.Ortiz
Annual. Herb. Ht 0.05–0.12 m. Alt 600–700 m. NC,
WC^E**microcephala** Grau
WC, EC^E**minima** (Hutch.) Grau
NC, WC**petiolata** (Harv.) N.E.Br.
FS, KZN, L, EC**quinquenervia** (Klatt) Grau
M, FS, KZN, L, EC**rosulata** Yeo
LIM, M, S, FS, KZN, L, EC^E**tsitsikamae** Grau
EC***GAMOCHAETA** Wedd. 8992060
coarctata (Willd.) Kerguelen
LIM, G, M, S, KZN, WC, EC
spiciformis (Sch.Bip.) Cabrera
S, KZN, EC
subfalcata (Cabrera) Cabrera
LIM, G, M, S, FS, KZN, WC, EC**GARULEUM** Cass. 9426000
^E**pinnatifidum** (Thunb.) DC.
FS, NC, WC, EC^E**GIBBARIA** Cass. 9427010
ilicifolia (L.) Norl. = **Nephrotheca ilicifolia****GNAPHALIUM** L. 8992000
austroafricanum Hilliard
M, KZN, L, EC
confine Harv.
N, G, M, FS, KZN, L, NC, WC?, EC
***polycaulon** Pers.
N, B, LIM, M, KZN**HELICHRYSOPSIS** Kirp. 8992030
septrionalis (Vatke) Hilliard (not *septrionale*)^E**HETEROLEPIS** Cass. 9057000
^E**aliena** (L.f.) Druce
NC?, WC^E**HIPPIA** L. 9357000
^E**bolusae** Hutch.
WC
^E**pilosa** (P.J.Bergius) Druce
WC**INULANTHERA** Källersjö 9326010
calva (Hutch.) Källersjö
LIM, M, S, FS, KZN, EC^E**INULOIDES** B.Nord. 9428040
(1) Nordenstam. 2006. *Compositae Newsletter* 44: 44, 45.
^E**tomentosa** (L.f.) B.Nord.
Calendula tomentosa L.f. (1)
Osteospermum cuspidatum DC. (1)
Osteospermum tomentosum (L.f.) Norl. (1)
Tripteris tomentosa (L.f.) Less. (1)
Perennial. Herb. Ht 0.1–0.2 m. Alt 100–900 m. WC**LASIOPOGON** Cass. 8987000
^E**debilis** (Thunb.) Hilliard
NC, WC
micropoides DC.
N, NC, WC
muscoides (Desf.) DC.
N, B?, NW, FS, NC, WC, EC**MACLEDIUM** Cass. 9501010
Based on molecular studies, the genus *Macledium* was
put in the tribe Dicomeae together with *Dicoma*
and *Pleiotaxis* (Panero & Funk 2002. *Proceedings*
of the Biological Society of Washington 115,4:
909–922).
zeyheri (Sond.) S.Ortiz subsp. **zeyheri**
LIM, NW, G, M, S, KZN**MACOWANIA** Oliv. 9053000
pulvinaris N.E.Br.
L, EC^E**MAIRIA** Nees 8883000
^E**crenata** (Thunb.) Nees
WC, EC^E**MARASMODES** DC. 9370000
^E**dummeri** Bolus ex Hutch. (not *duemmeri*)**MICROGLOSSA** DC. 8921000
^E**mespilifolia** (Less.) B.L.Rob.
KZN, WC, EC**MONOCULUS** B.Nord. 9428020
(1) Nordenstam. 2006. *Compositae Newsletter* 44: 39–41.
^E**hyoseroides** (DC.) B.Nord.
Osteospermum hyoseroides (DC.) Norl. (1)
Tripteris hyoseroides DC. (1)
Annual. Herb. Ht 0.2–0.7 m. Alt 50–900 m. NC, WC
monstrosus (Burm.f.) B.Nord.
Calendula monstrosa Burm.f. (1)
Osteospermum clandestinum (Less.) Norl. (1)
Tripteris atropurpurea Turcz. (1)

MONOCULUS B.Nord. (cont.)**monstrosus** (Burm.f.) B.Nord. (cont.)*Tripteris clandestina* Less. (1)*Tripteris herbacea* E.Mey. ex DC. (1)*Tripteris hyoseroides* DC. var. *echinocarpa* DC. (1)*Tripteris scariosa* DC. (1)

Annual. Herb, succulent. Ht 0.2–0.5 m. Alt 15–900 m. N, NC, WC

^ENEPHROTHERCA B.Nord. & Källersjö 9427060(1) Nordenstam, Källersjö & Eldenäs. 2006. *Compositae Newsletter* 44: 32–37.**^Eilicifolia** (L.) B.Nord. & Källersjö*Gibbaria ilicifolia* (L.) Norl. (1)*Osteospermum ilicifolium* L. (1)

Perennial. Shrub. Ht 0.2–0.5 m. Alt 300–1115 m. WC

NIDORELLA Cass. 8925000**auriculata** DC.

B, LIM, NW, G, M, S, FS, KZN, L, WC, EC

^Efoetida (L.) DC.

WC

NOLLETIA Cass. 8929000**^Erarifolia** (Turcz.) Steetz

LIM, NW, G, M, FS, KZN, EC

NORLINDHIA B.Nord. 9428030(1) Nordenstam. 2006. *Compositae Newsletter* 44: 41–44, 49.**^Eamplectens** (Harv.) B.Nord.*Osteospermum amplexens* (Harv.) Norl. (1)*Tripteris amplexens* Harv. (1)*Tripteris amplexicaulis* acc. to DC. in part, not of (Thunb.) Less. (1)*Tripteris confusa* Bolus (1)*Tripteris gracilis* Hutch. (1)

Annual. Herb. Ht 0.3–1.2 m. Alt 90–900 m. NC, WC

aptera B.Nord.

Annual. Herb. Ht up to 1 m. Alt ? N

breviradiata (Norl.) B.Nord.*Osteospermum breviradiatum* Norl. (1)*Tripteris breviradiata* (Norl.) B.Nord. (1)

Annual. Herb. Ht 0.2–0.5 m. Alt 100–200 m. N, NC, WC

OLIGOCARPUS Less. 9424000(5) Nordenstam. 2006. *Compositae Newsletter* 44: 38, 45, 46.Delete **E** as this genus is no longer endemic to South Africa.A species of *Osteospermum* from St Helena was transferred to this genus.**OSTEOSPERMUM** L. 9427000*amplectens* (Harv.) Norl. = **Norlindhia amplexens***breviradiatum* Norl. = **Norlindhia breviradiata***clandestinum* (Less.) Norl. = **Monoculus monstrosus***cuspidatum* DC. = **Inuloides tomentosa****grandidentatum** DC.

M, S, KZN, EC

hyoseroides (DC.) Norl. = **Monoculus hyoseroides***ilicifolium* L. = **Nephrotheca ilicifolia****^Epolygaloides** L. var. **polygaloides**

WC, EC

^Erigidum Aiton var. **elegans** (Bolus) Norl.

NC, WC

^Erigidum Aiton var. **rigidum**

NC, WC

tomentosum (L.f.) Norl. = **Inuloides tomentosa****PEGOLETTIA** Cass.

9073000

senegalensis Cass.

N, B, LIM, NW, G, M, S, KZN, NC

PENTZIA Thunb.

9366000

^Epeduncularis B.Nord.

WC

^Equinquefida (Thunb.) Less.

NW, FS, NC, WC, EC

PLEIOTAXIS Steetz

9499000

Based on molecular studies, the genus *Pleiotaxis* was put in the tribe Dicomeae together with *Dicoma* and *Macleodium* (Panero & Funk 2002. *Proceedings of the Biological Society of Washington* 115,4: 909–922).**PLUCHEA** Cass.

8941000

dioscoridis (L.) DC, not *FSA**Conyza kraussii* Sch.Bip. ex Walp. (7)**dioscoridis** *sensu* Merxmüller (1967) and Hilliard (1977)was wrongly applied to southern African material. Material previously identified as this species actually belongs to **P. bojeri** (DC.) Humbert**PRINTZIA** Cass.

9059000

Based on molecular studies, the genus *Printzia* was moved from the tribe Gnaphalieae to the tribe Astereae (Bayer & Cross 2002. *Australian Journal of Botany* 50,6: 677–686.)**^Epolifolia** (L.) Hutch.

NC, WC, EC

PSEUDOGNAPHALIUM Kirp.

8992050

undulatum (L.) Hilliard & B.L.Burt

N, G, M, FS, KZN, L, NC, WC, EC

PTERONIA L.

8862000

^Ecamphorata (L.) L. var. **longifolia** Harv.

WC, EC

glauc Thunb.

N, B, NW, FS, NC, WC, EC

mucronata DC.

N, B, FS, NC, WC, EC

^Epunctata E.Phillips

FS, NC, WC, EC

^Eundulata DC.

NC, WC

SONCHUS L.

9595000

***asper** (L.) Hill subsp. **asper**

N, B, LIM, NW, G, M, S, FS, KZN, L, NC, WC, EC

***asper** (L.) Hill subsp. **glaucescens** (Jord.) Ball

FS, WC, EC

wilmsii R.E.Fr.

LIM, NW, G, M, S, FS, KZN, L, EC

^ESYNCARPHA DC.

9000010

^Eargentea (Thunb.) B.Nord.

WC, EC

^Eferruginea (Lam.) B.Nord.

WC, EC

^Estachelina (L.) B.Nord.

NC, WC

^E**SYNCARPHA** DC. (cont.)^E**striata** (Thunb.) B.Nord.

WC, EC

^E**vestita** (L.) B.Nord.

WC, EC

***TARAXACUM** F.H.Wigg. 9592000**officinale** Weber, aggregate species

N, LIM, NW, G, M, S, FS, KZN, L, WC, EC

serotinum (Waldst. & Kit.) Poir.

KZN, NC, EC

TENRHYNEA Hilliard & B.L. 8994000

Burt

phylicifolia (DC.) Hilliard & B.L.Burt

LIM, M, S, KZN, EC

***TRAGOPOGON** L. 9579000**dubius** Scop.

G, M, FS, KZN, L, EC

TRIPTERIS Less. 9428000*amplectens* Harv. = **Norlindhia amplectens***amplexicaulis* acc. to DC. in part, not of (Thunb.) Less.= **Norlindhia amplectens***atropurpurea* Turcz. = **Monoculus monstrosus***breviradiata* (Norl.) B.Nord. = **Norlindhia breviradiata***clandestina* Less. = **Monoculus monstrosus***confusa* Bolus = **Norlindhia amplectens***gracilis* Hutch. = **Norlindhia amplectens***herbacea* E.Mey. ex DC. = **Monoculus monstrosus***hyoseroides* DC. = **Monoculus hyoseroides***hyoseroides* DC. var. *echinocarpa* DC. = **Monoculus monstrosus***scariosa* DC. = **Monoculus monstrosus***sinuata* DC. var. **sinuata**

N, FS, NC, WC, EC

tomentosa (L.f.) Less. = **Inuloides tomentosa****TROGLOPHYTON** Hilliard & B.L. 8992020

Burt

capillaceum (Thunb.) Hilliard & B.L.Burt subsp. **capillaceum**

N, FS, KZN, NC, WC, EC

URSINIA Gaertn. 9431000**nana** DC. subsp. **nana**

N, LIM, NW, G, M, FS, KZN, L, NC, WC, EC

VELLEREOPHYTON Hilliard & 8992010

B.L.Burt

^E**niveum** Hilliard

NC, WC

VERNONIA Schreb. 8751000**poskeana** Vatke & Hildebr. subsp. **botswanaica** G.V.

Pope

N, B, LIM, NW, G, M, S, FS

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Developmental variation in a species of *Isoglossa* (Acanthaceae: Ruellioidae) over a season

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Keywords: Acanthaceae, character variation, identification, *Isoglossa* Oerst., monocarpy, morphology

ABSTRACT

In his appraisal of *Isoglossa* Oerst., Clarke (1901) placed major emphasis on the sizes of leaves and inflorescences in the key to species, but efforts to sort herbarium material have shown a great deal of variation in leaf size and inflorescence length that is very difficult to interpret. Specimens of a species of *Isoglossa* were collected from wild subpopulations from the Hartebeespoort Dam and Hartebeeshoek areas, at intervals over a season. Leaves and inflorescences were measured, and frequencies of hair types on bracts and calyces were recorded photographically. Results indicate that leaf size within a species increases over the vegetative phase of the plant and that inflorescence size within a species increases over the reproductive phase of the plant. Therefore, caution should be applied when these characters are used for species identification in *Isoglossa*. Bract and calyx indumenta also change over a season, thus making it necessary to use wisdom when applying this character taxonomically.

INTRODUCTION

Isoglossa Oerst. is a member of the pantropical family Acanthaceae, with about 50 species in the Old World tropics (Balkwill & Welman 2000). Most genera within the Acanthaceae include perennial herbs, subshrubs and shrubs but some members are monocarpic. Daniel (2006) has undertaken a review and provided references that record monocarpy in *Acanthopale* C.B.Clarke, *Aechmanthera* Nees, *Stenosiphonium* Nees, *Strobilanthes* Blume and *Mimulopsis* Schweinf. within the Acanthaceae. In the genus *Isoglossa*, monocarpy has been recorded for *I. woodii* C.B.Clarke (Clarke 1901; Van Steenis 1978), *I. substrobolina* C.B.Clarke and *I. oerstediana* Lindau (Tweedie 1976). Therefore, recording changes in leaf and inflorescence size of a wild subpopulation of a monocarpic species of *Isoglossa* over a season will provide an understanding of the nature of morphological variation and characters that are suitable for use in a re-appraisal of species circumscriptions in *Isoglossa*.

In general, perennial plants are morphologically relatively constant over a flowering season, so that herbarium specimens of perennials show consistency, even if collected at different periods over a season. In contrast, however, annuals, short-lived perennials and monocarpic species often show great morphological variation over a season because of the high level of translocation of nutrients from vegetative structures into the reproductive organs. Herbarium specimens of the same species may thus show considerable morphological differences depending on whether they were collected at the beginning or near the end of the flowering/fruiting season.

Indumenta of bracts and calyces are regarded as being taxonomically important within the Acanthaceae and are used in Clarke's (1901) key to species in the genus *Isoglossa*. In some cases, the difference in indumentum

may be genetically determined [e.g. *Isoglossa vulcanicola* Mildbr. has a variety that is characterized on the basis of being eglandular (Mildbraed 1943)], whereas in others the difference may be developmental or environmental. Observation of these characters within a subpopulation will clarify how they vary and whether or not the variation is genetically fixed and thus whether it is taxonomically useful.

Many more herbarium specimens of *Isoglossa* exist now than were available to Clarke and it is difficult to group them into Clarke's (1901) taxa because it seems that he did not take the probable morphological implications of monocarpy into account when delimiting species. So a vital step in establishing useful circumscriptions and ranges of measurements for species of *Isoglossa* is to determine how the developmental and translocational processes associated with monocarpy would influence the morphology expressed by a single genome over the course of a flowering season. This paper provides insight into meaningful ranges of measurements of structures in monocarpic taxa and thus for the evaluation of Clarke's species circumscriptions.

An annual or monocarpic plant will show several stages in its development with various nutrient balances and fluxes resulting in various morphological consequences. In the initial stage, nutrients will be translocated from the cotyledons to form the radicle and plumule. Very soon, the first leaves will begin to photosynthesize and in this vegetative phase photosynthate will be used in the elaboration of the root system to absorb water and minerals and the shoot system to provide a framework as well as leaves to photosynthesize. Over the course of this phase, the leaf size is likely to increase. When the plant enters the reproductive phase, new framework is produced to support the inflorescences and leaves are often associated with these new nodes. In addition, bracts, bracteoles and calyces are produced, which will usually complement the photosynthetic function of the leaves and will compete with the new leaves for photosynthate during the development of both reproductive and vegetative organs. Consequently, the leaves

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formed at this stage are smaller than those formed at the peak of the vegetative phase. Once anthesis begins, most of the structures that are produced (i.e. corollas, stamens, pollen, ovules) are not photosynthetic and are thus sinks for, rather than sources of, photosynthate. At this stage, the nutrients from the older leaves are often translocated into these sinks, especially once fruits and seeds are being produced. The older leaves (including the larger ones) will be abscised once they no longer provide nutrients and the plants will be left with the smaller leaves that were formed at the onset of the reproductive phase.

Many theories exist to explain leaf growth and although some may be inter-related, the debate remains unresolved (Inzé 2003). One such theory is the organismal one, which implies that there is a set number of cells per leaf and that leaf growth is accounted for by cell expansion (Beemster *et al.* 2003; Inzé 2003); i.e. by an increase of cell water content through vacuolation (Beemster *et al.* 2003). The behaviour of leaf cells is orchestrated at organ level and leaf size at whole plant level (Tsukaya 2003). In contrast, the cell theory proposes that leaf growth is due to an increase in cell number, with the size of the cells remaining constant (Tsukaya 2003; Cookson *et al.* 2006). Large mature leaves formed in the manner implied by the organismal theory would require less photosynthate to produce than leaves of similar size formed in accordance with the cell theory where there would be a considerably greater volume of cell wall. However, the organismal theory would not explain why smaller leaves are produced at the onset of the reproductive phase.

Since 'the number of chloroplasts per cell remains approximately constant' (Taitz *et al.* 1991), an increase in leaf size due to an increase in cell number will proportionately increase the number of chloroplasts and thus the amount of photosynthate produced per leaf. In contrast, an increase in leaf size attributed to an increase in cell size would reflect no increase in chloroplast number and correspondingly little or no increase in photosynthate production. Thus, leaf cell counts done at crucial developmental stages over a season may reflect on the interaction of photosynthate production and translocation as well as which theory explains leaf growth in this monocarpic species.

The species circumscription and nomenclature within southern African *Isoglossa* has not as yet been finalized. Most specimens of the species under study in this paper have been identified as *Isoglossa stipitata* C.B.Clarke. Clarke (1901) cites one synonym, two misapplied names and two specimens under his *I. stipitata*. His name should be typified on the type of the synonym, *Rhytiglossa glandulosa* Hochst. Hochstetter's (1845) type is *Krauss 302*, which would have been in Berlin and thus destroyed during World War II. Clarke (1901) assumed that the *Krauss 502* specimen of *Isoglossa* at Kew was Hochstetter's type, which had been mistakenly distributed with the number 502 instead of 302. We have obtained a *Krauss 302* specimen from Missouri (originally from The Bernhardt Herbarium) which is different from the *Krauss 502* that was annotated by Clarke, at least in having well-spaced nodes in the inflorescence, a feature captured in Hochstetter's description. Thus, Hochstetter's name, of which Clarke's *I. stipitata* is strictly a

later synonym, should be applied to an entity which is either closely allied to or conspecific with the well-known monocarpic understory shrub of the KwaZulu-Natal coast, *I. woodii* C.B.Clarke. Clarke's (1901) description of *I. stipitata* matches the *Krauss 502* specimen which he cites and we consider this to most likely be conspecific with *I. woodii*.

Flanagan 2322, the other specimen that Clarke cites, agrees with the species we have worked on, but differs from Hochstetter's and Clarke's descriptions of *Rhytiglossa glandulosa* and *Isoglossa stipitata* and *Krauss 302* and *502*, by having lanceolate rather than obovate, acuminate bracts. Our species also does not agree with the types of the two misapplied names that Clarke cites and we thus conclude that it has yet to be described and refer to it as *Isoglossa* sp. 1.

Clarke's specimens of *Isoglossa stipitata* occur only at the coast, whereas our specimens are found inland and at the coast. *Isoglossa* sp. 1 is the most widely distributed of the southern African members of *Isoglossa* (Figure 1), and occurs along the coast from the Eastern Cape Province to eastern KwaZulu-Natal, as well as inland from Barberton in Mpumalanga, through Gauteng to the North-West Province (Sebola 1994).

MATERIALS AND METHODS

Isoglossa subpopulations from two localities in the North-West Province (Sandspruit Farm, 2527DB, near Hartebeespoort Dam and Sugar Bush Mountain L49, 2527DD, near Hartebeeshoek) (Figure 1) were sampled at approximately three-week intervals, from January 2005 to August 2005. Due to the monocarpic nature of the plant, which dies after bearing fruit, no samples were taken in September or October 2005 (characteristically dry months). Sampling recommenced two weeks after the first rains in November 2005 and continued until March 2006 but these were specimens from a subsequent generation of plants.

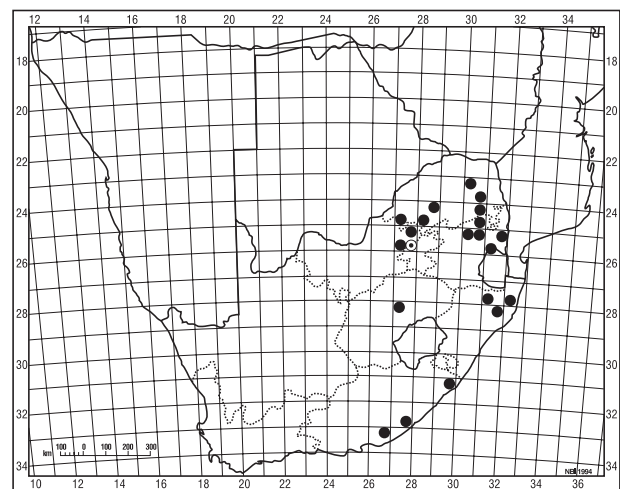


FIGURE 1.—Map showing distribution of *Isoglossa* sp. 1, ●; as well as sampling positions at Hartebeeshoek, Sugar Bush Mountain and Hartebeespoort Dam, Sandspruit Farm, North-West Province, ⊙.



FIGURE 2.—Specimens of branches of *Isoglossa* sp. 1 showing stages of development over a season: leaves subtending lower branches have dropped off in Dec. as in B, this process continues including leaves beginning to drop off axillary branches in May as in H, all leaves have dropped off by Aug. as in I. A, 19 Dec. 2005; B, 9 Jan. 2006; C, 16 Feb. 2006; D, 1 Mar. 2006; E, 6 Mar. 2005; F, 20 Mar. 2005; G, 8 Apr. 2005; H, 2 May 2005; I, 20 Aug. 2005. Scale bar: 55 mm.

It was extremely difficult to identify *Isoglossa* prior to flowering and field trips in November yielded no specimens of *Isoglossa*. The four neighbourhoods of *Isoglossa* at Hartebeeshoek did not re-appear after the first rains in November 2005. As a result, it was initially believed that *Isoglossa* may be locally extinct at this locality. However, an extensive search of the area in late

March 2006 revealed a single plant growing close to the skeletons of what must have been a previously undiscovered fifth neighbourhood. This plant was growing in denser shade on the opposite, eastern side of the dry stream bed. This may account for its survival. It is possible that the seedlings of the first four neighbourhoods died after germinating, as there was a dry spell between the first rains

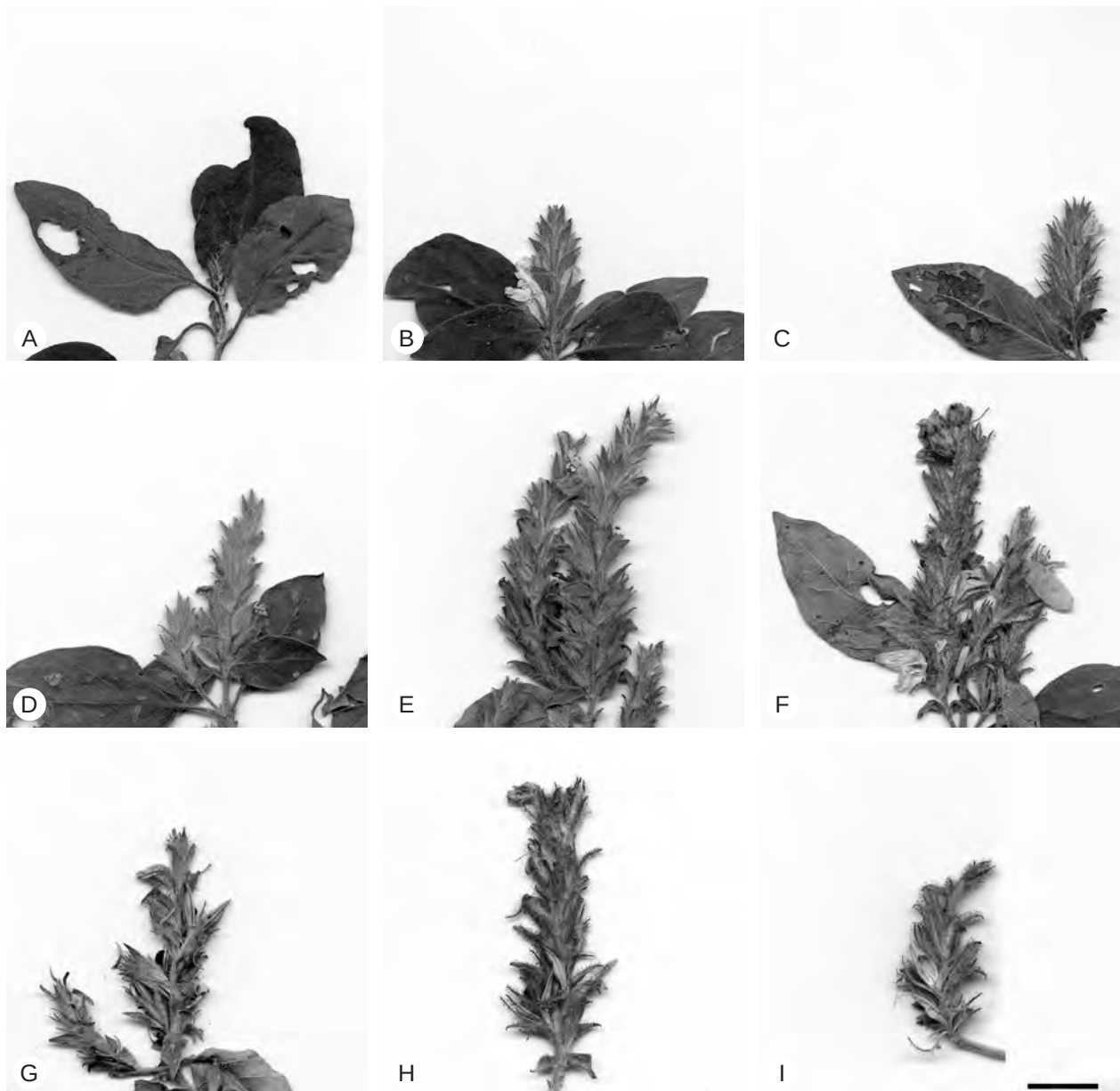


FIGURE 3.—Development of inflorescences over a season: A, 9 Jan.; B, 1 Feb.; C, 1 Mar.; D, 20 Mar.; E, 8 Apr.; F, 2 May; G, 20 May; H, 12 Jun.; I, 20 Aug. B, C, H, terminal inflorescences; D–G, inflorescences both terminal and lateral; I, lateral inflorescence. Inflorescence development begins in Jan. with length peaking in June. All to same scale. Scale bar: 10 mm.

and subsequent more frequent rains. This may not have affected the Hartebeespoort subpopulation, which experienced slightly later, frequent rain. As a result, only those specimens collected from the Hartebeespoort locality were used in the analyses. The loss of the four neighbourhoods from the second locality caused unintended limitations to the methodology, because it would have been preferable to have been able to study more than one subpopulation.

Where possible, two specimens per sampling period were cut from plants with the most developed branches within the subpopulation. Specimens were pressed in a plant press, dried at 37°C for a three-day period, then sterilized in a deep freeze for two days, before being brought into the herbarium where they were photographed and measured.

Specimens were scanned with an Epson Expression 1640XL scanner, using the same frame size and resolution each time to ensure consistent magnification. The

length of the six largest leaves and the longest lateral inflorescences were measured on each of the pairs of specimens collected over the sampling period. During the months of June to August, the number of leaves measured per specimen decreased, as the leaves are shed during these dry winter months and nutrients are translocated to the reproductive organs. Terminal inflorescence lengths were measured—the number of measurements varied depending on the number of terminal inflorescences on each specimen. Using the programme Statistica, the mean, minimum and maximum lengths together with the standard deviation were calculated for each sampling period (Figures 4–6). Leaf variation over a season was determined by comparing the mean of the shortest leaves produced to the mean of the largest leaves produced within a subpopulation in a season. Both terminal and lateral inflorescence variations over a season were calculated in the same way. Whereas the means in Figure 4 are based on up to six leaves from

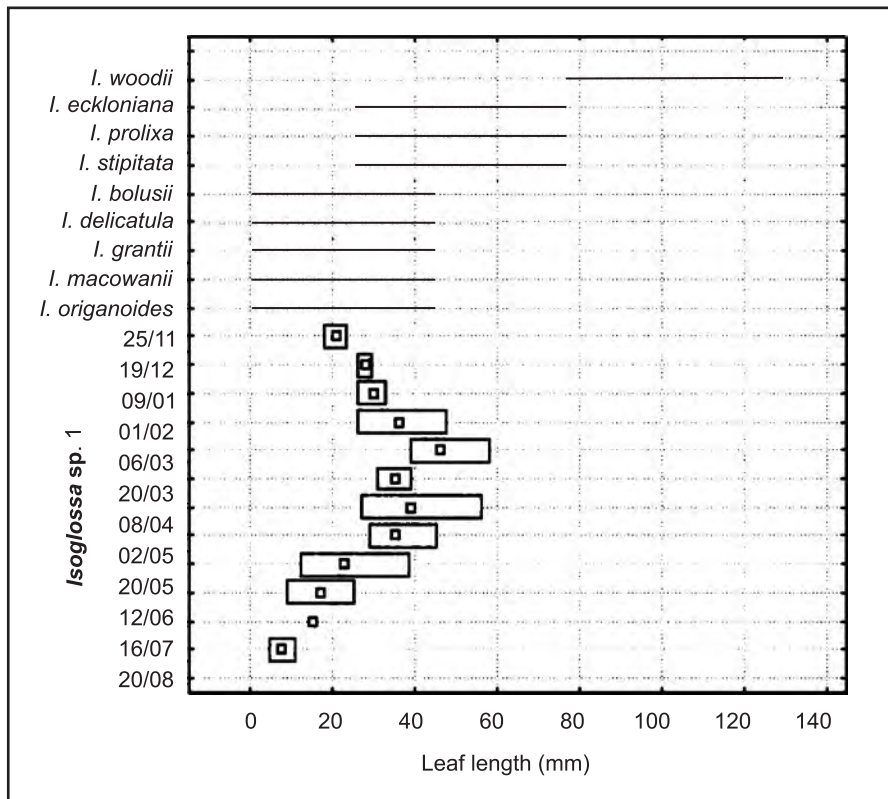


FIGURE 4.—Leaf length (mm) of *Isoglossa* sp. 1 measured over a season compared to leaf length ranges of Clarke's species mentioned in his key and descriptions. Single lines show ranges cited by Clarke (1901). Boxes are leaf length measurements in a natural subpopulation of *I. sp.1* on dates indicated ($n = 6$). Leaf length of *I. sp. 1* reaches a maximum in March. Leaf lengths of *I. sp. 1* straddle boundaries of leaf lengths of 2 of 3 groups of Clarke's species. $\square$, mean; $\square$, min.-max.; $\square$, SD.

two specimens, Figure 2 illustrates only one of the two specimens from any collecting period. A similar situation exists between Figures 5 and 6 and Figure 3.

Photographs to show the indumentum of the bracts and calyces at various stages of development (Figure 7) were taken using a Nikon SMZ 1500 dissecting Microscope and Nikon Digital Camera DXM 1200 attachment. Entire plants (Figure 8) were photographed using a Nikon E 990 digital camera to show morphological changes over a season as well as various habits.

Cell counts were calculated from four mature leaves sampled on the 9 January 2006 (representing leaves that were first produced), 6 March 2005 (representing the largest leaves produced) and 2 May 2005 (representing the smaller leaves that were produced later during inflorescence development) to determine whether the increase in leaf size over a season was attributable to an increase in leaf cell numbers (indicating greater production of photosynthate). Similarly, a decrease in total cell numbers in the smaller leaves that are produced later in the season, would indicate that the photosynthate initially produced by the larger leaves is utilized mainly for inflorescence development. Since only two specimens were collected per sampling date, only four leaves were used for the cell counts, corresponding to the two most mature leaves on each specimen collected. The specimens from 9 January 2006 were used for the leaf cell counts representing leaves that are first produced, as although specimens were collected in December 2005, leaf clearing did not produce consistently visible cells.

A modified leaf-clearing technique (O'Brien & von Teichman 1974) was devised to make cell counts possible. The instructions for normal specimens (O'Brien & von

Teichman 1974) were followed, with the exception that the leaves were placed in a 5 % potassium hydroxide (KOH) solution at room temperature following the 80 % ethanol autoclave procedure. The leaves used were from the dried samples, which may account for why initial experiments revealed that the leaves disintegrated or became unmanageable when autoclaved with 1 % KOH. Additionally, varying autoclave times of both the 80 % ethanol and 1 % KOH did not produce the required clearing results. Time durations for leaf submergence in the 5 % KOH varied, according to leaf size (leaf area 391 mm²—36 hours, 627 mm²—49 hours, and 140 mm²—30 hours). When a leaf looked clear it was removed from the KOH solution, subjected to several distilled water washes, mounted on a glass slide and observed under a compound microscope. If cells were not visible, the leaf was replaced in the KOH solution and the same procedure was repeated at regular intervals. Once cells were visible, the leaf was stained with basic fuchsin (O'Brien & von Teichman 1974).

Leaves and a ruler (for scale) were scanned with an Epson Expression 1640XL scanner, and the programme Simple PCI was used to calculate leaf areas. Three constant sites per abaxial leaf surface were viewed under an Olympus BH-2 compound microscope, linked to a Nikon Digital Camera DXM 1200 and computer viewing screen. A stage micrometer was used to determine the dimensions of the image and hence to calculate the area (0.04 mm²) projected on the computer screen. The same microscope magnification ($\times 20$) and resolution settings (Quick 3, 1280 $\times$ 1024) were used throughout, for each of the sites and for each of the leaves. Each site was positioned equidistant from the midrib and leaf edge, with one site positioned centrally on one half of the leaf. Each of the other sites was positioned on the opposite side of the midrib, halfway between the mid-

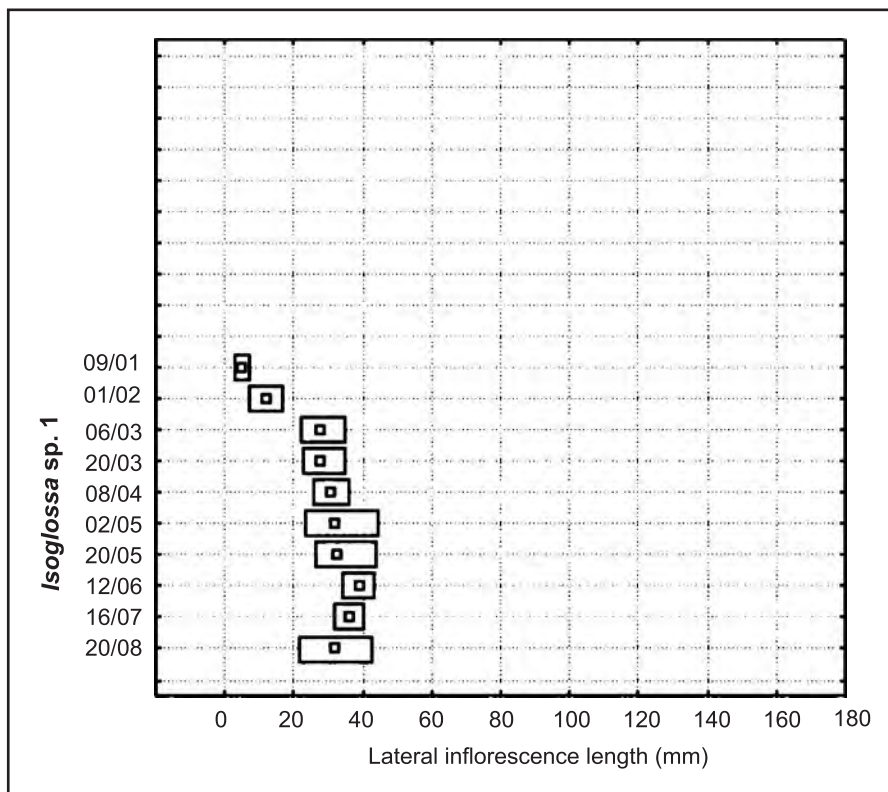


FIGURE 5.—Lateral inflorescence length (mm) of *Isoglossa* sp. 1 measured over a season. Boxes are measurements made in a natural subpopulation on dates indicated ($n = 6$). Inflorescence development begins in Jan. and reaches its peak in June. $\square$, mean; $\square$, min.-max.; — , SD.

point and the base or apex of the leaf. This sampling procedure standardizes cell size variation in different areas of the leaf (Horv  th *et al.* 2006). The programme Act 1 enabled photography and subsequent cell counting per site, with the counts based on Gundersen's 'unbiased two-dimensional sampling rule' (Kub  niov   1994; Gundersen 1997). Both epidermal and stomatal cells were included and since the variation in the cell numbers per site in each leaf was very slight, the numbers were averaged. The following equation rendered the total number of cells per leaf:

$$\frac{\text{leaf area}}{\text{site area}} \times \text{mean no. cells per three sites}$$

Since more than one leaf was cleared per sampling date, the mean and standard deviation for the total number of cells per leaf was calculated using the programme Quattro Pro (Table 1). Cell areas were calculated by dividing each of the three site areas (0.04 mm²) per leaf by the number of cells per site and the mean and standard deviation for the total cell area per four leaves sampled was calculated (Table 1). A t-test (using two tails and two sample variance) between the means of the cell areas for leaves sampled on the 9 January and the 6 March, and those on the 6 March and on the 2 May, was carried out using the programme Epistat.

RESULTS AND DISCUSSION

Isoglossa sp. 1 developed a tall (1–2 m high), scandent habit in the shade (Figure 8B). It had a softer stem and used woody branches from surrounding trees for support. This enabled it to obtain more light. Plants in the same subpopulations growing in brighter light were not as tall and had more sturdy stems (Figure 8C).

Four phenological trends were identified over the study period. In December the plants increased in size and branching (Figure 2), followed by the development of inflorescences in January (Figure 3). The first trend involved an increase in inflorescence length, which reached a maximum in June, together with the development of fruit (Figures 3A–H). Thereafter, there was a general waning of the subpopulations until August where senescence was prevalent. The bare brown branches were still in evidence the following season (Figure 8D).

The second trend was that leaves began to fall off the main stem as early as February (Figure 2C) and the plant continued to lose its leaves until May, when only the leaves below the spikes were evident. By August (Figure 2I), hardly any leaves were present. A caterpillar infestation was apparent in the leaves in February and was noted in both years at this time.

The third trend involved changes in bract indumentum. Observation of the inflorescences showed that the bracts of the young spikes were white-ciliate (Figure 7A). As the spikes increased in length and the bracts diverged, a combination of both eglandular and glandular trichomes became evident (Figure 7B, C). By April (Figure 7D) and the onset of fruit production, the gland tips were brown and stickier to the touch. By June (Figure 7F), they were extremely sticky. As the seed was dispersed, the bracts, calyces and trichomes senesced.

The fourth trend was that the leaves that were first produced (i.e. 9 January 2006) had a lower mean cell count per site area than those produced later, i.e. the cell area was slightly larger (Table 1). A t-test between the mean cell areas of the mature leaves that were first produced (9 January) and the largest leaves produced (6 March) showed a significant difference, with $t =$

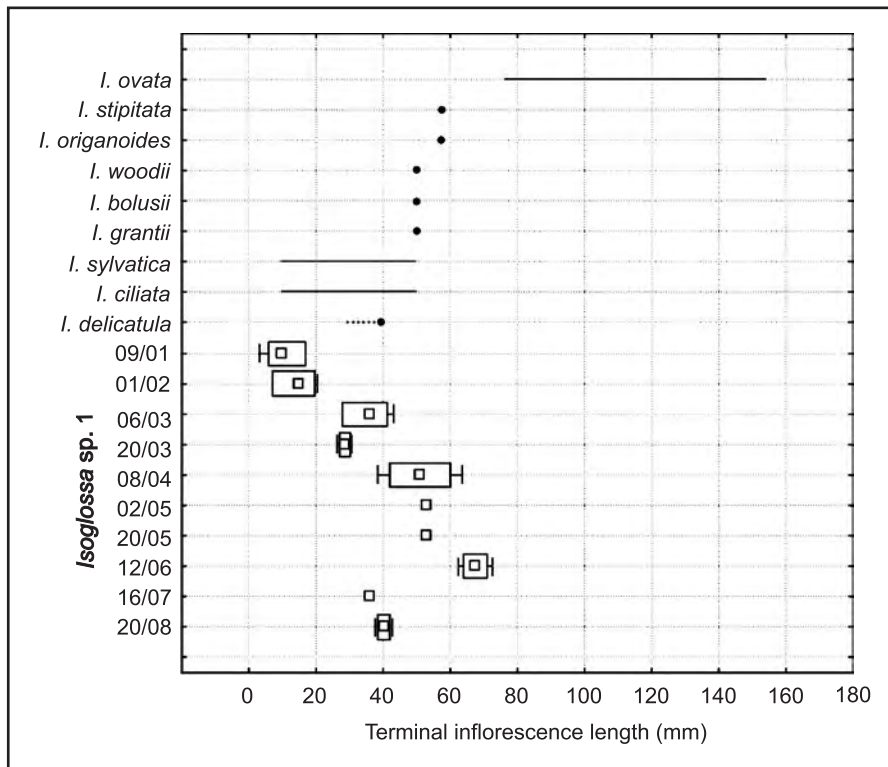


FIGURE 6.—Terminal inflorescence length (mm) of *Isoglossa* sp. 1 measured over a season, compared to inflorescence length ranges of Clarke's (1901) species. Single and dotted lines show ranges cited by Clarke: dotted line indicates mostly shorter than length cited; points are single lengths mentioned in Clarke's species descriptions. Box and whiskers are measurements made in a natural subpopulation of *I. sp. 1* on dates indicated. Inflorescence lengths of *I. sp. 1* straddle boundaries of inflorescence lengths of 3 out of 4 groups of Clarke's species. □, mean; □, min.-max.; ▤, SD.

8.903395 and $P < 10^{-6}$. However, these cells were not as definable as those in the later samples, and thus counts may be underestimated. Results of a t-test between the means of the cell areas for the largest leaves produced (6 March) and the smaller leaves produced later (2 May), with $t = 1.172771$ and $P = 0.2534304$, show no significant difference between these samples, which is consistent with the cell theory, where the cell size remains fairly constant.

Morphological development of leaves

The mean leaf length at the beginning of the season was 20.5 mm, peaking at 46 mm in March and was 6.5 mm at the end of the season, which gave a 39.50 mm variation (Figure 4).

The girth of the stem and the length of internodes appear to remain constant over the season, but leaf size varies considerably. Mean leaf length increases and

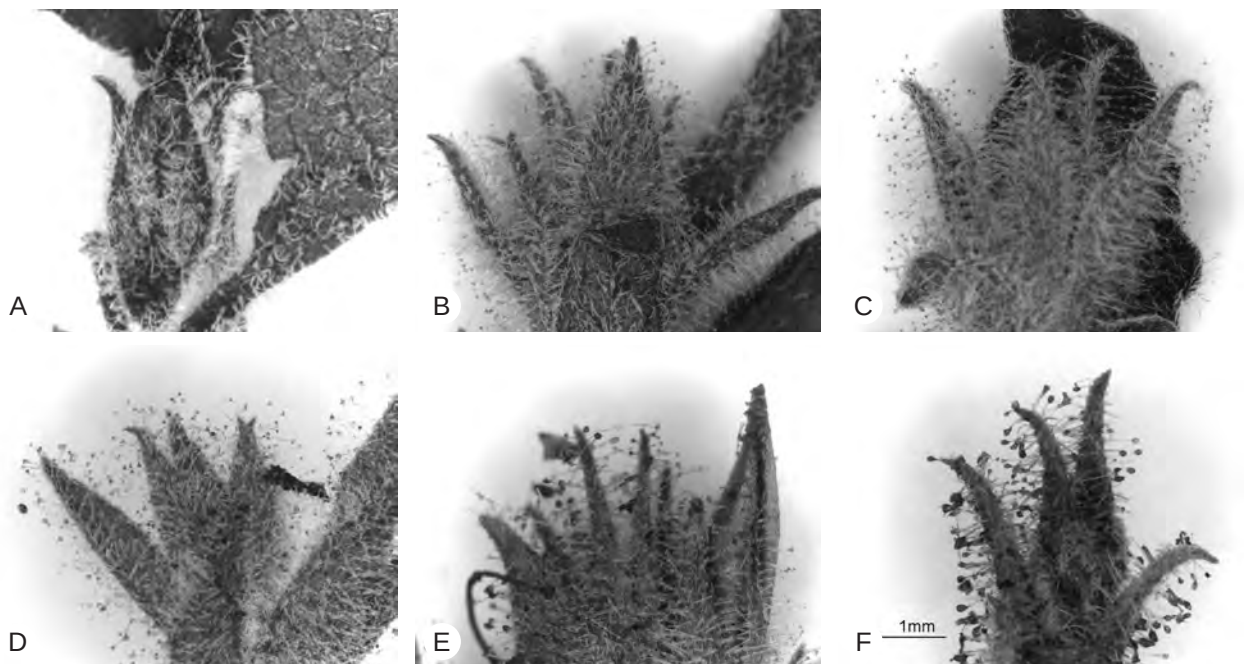


FIGURE 7.—Indumentum of bracts and calyx lobes over a season: A, Jan. 2006; B, Feb. 2006; C, Mar. 2006; D, Apr. 2005; E, May 2005; F, Jun. 2005. Closed bracts are white ciliate in Jan. Bracts diverge in Feb. revealing mix of translucent glandular and eglandular trichomes on bracts and calyces. Glandular trichomes become increasingly viscid from April until June. All to same scale. Scale bar: 1 mm.

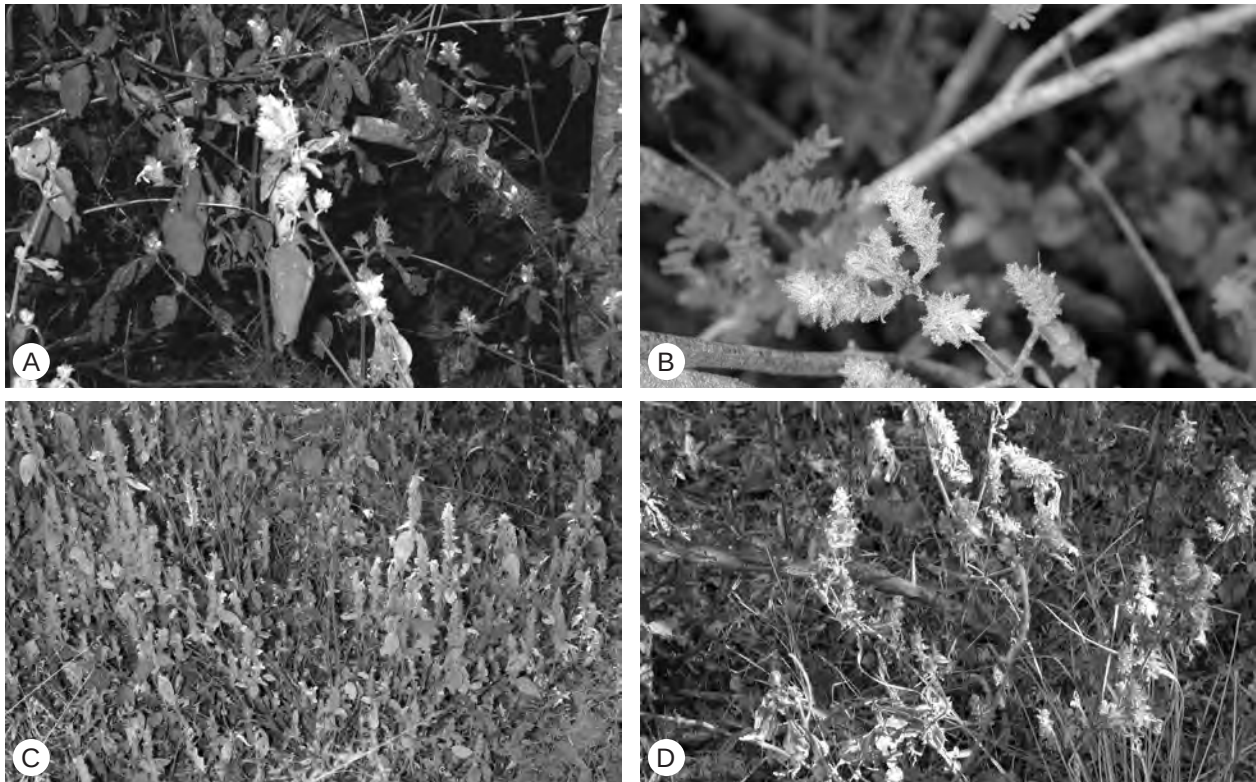


FIGURE 8.—Morphological changes over a season as well as various habits of *Isoglossa* sp. 1. A, April, 1–2 m tall, scandent habit in shade; B, April, extremely viscid inflorescence; C, May, growing in brighter light, not as tall, sturdier stem; D, Aug. inflorescence on dry, bare branches.

then decreases with time (Figure 4). The increase in the mean leaf length (Figure 2) is consistent with the suggestion that early in the season, photosynthate (initially produced by the cotyledons) is used for leaf production on the major branches. The leaf area for leaves that are first produced (9 December) is $359.75 \pm 9845 \text{ mm}^2$ and corresponding cell counts of 112355 ± 11225 (Table 1). Increasing numbers of leaves led to an increase in available photosynthate, and therefore more nutrients for the development of larger leaves, evidenced by the leaf area being $743.75 \pm 195.22 \text{ mm}^2$ with a cell count per leaf of 343323 ± 102779 on 6 March (Table 1). This increase in cell number per leaf indicates an increase in chloroplast numbers per leaf and thus an increase in photosynthate production. Although abaxial epidermal cells were counted, it is assumed that the number of palisade cells and thus the numbers of chloroplasts would be proportional to the number of epidermal cells. Later, during the reproductive phase, there is competition between the leaves and the reproductive structures for photosynthate (Meyer & Anderson 1949) resulting in the production

of smaller mature leaves, with the leaf area falling to $340.50 \pm 73.79 \text{ mm}^2$ and cell count to 264925 ± 125194 (2 May), (Table 1). Variance in leaf size for 6 March is accounted for by there being only two specimens per sampling period, which subsequently explains the relatively high standard deviation for the mean total leaf cell numbers calculated (Table 1). The same is true for leaves sampled on 2 May. In addition, the larger leaves that were formed in the vegetative phase are divested of nutrients and thus they senesce and are dropped (Figure 2). These changes in leaf size and their deciduous nature account for the apparent decrease in the mean leaf length (Figure 4). The cell numbers counted in mature leaves of different sizes support the cell theory (Tsukaya 2003) of leaf enlargement and of the hypothesis of competition for photosynthate resulting in smaller mature leaves being produced during the reproductive phase.

Measurements gleaned from Clarke's (1901) descriptions and key for *Isoglossa* (see below) produce three groups of species, with leaf sizes of *I. sp.1* in the field

TABLE 1.—Leaf area, cell counts and cell areas based on three measurements (from middle, base and apex) on each of four leaves (i.e. $n = 12$). Leaf cell counts increase during vegetative phase, reaching maximum in March

	Leaves produced		
	First–9 Jan.	Largest–6 March	Smaller–2 May
	Mean and standard deviation		
Cell count per 0.04 mm^2	11 ± 2	18 ± 4.8	18 ± 4
Cell area mm^2	0.0036 ± 0.0005	0.0022 ± 0.0002	0.0024 ± 0.0005
Leaf area mm^2	359.75 ± 89.45	743.75 ± 195.22	340.50 ± 73.79
Total leaf cell count	112355 ± 11225	343323 ± 102779	264925 ± 125194

straddling the boundary between two of the groups (Table 2, Figure 4). The field data can be more closely associated with the group with smaller leaves than with the group with leaves of intermediate size. In fact, Clarke's data for *I. stipitata* reflect a greater leaf length than the largest leaf size recorded in the field. Although it is likely that subpopulations of the species growing in more mesic climates would have larger leaves, no direct comparisons can be made as our *I. sp. 1* is not equivalent to Clarke's *I. stipitata*. Clarke differentiates *Isoglossa woodii* from other species in the key on the basis of its extremely long leaves (Figure 4) and in addition he quotes the maximum leaf lengths for *I. hypostiflora*, *I. sylvatica*, *I. ovata* and *I. cooperi* in the descriptions. The considerable variation observed in leaf length of *Isoglossa* over a season (Figure 4) suggests that leaf length alone should not be used for species determination within *Isoglossa* and other monocarpic species. Further, a comparison of leaf length measurements taken from Clarke's key with those taken from individual species descriptions (Figure 4) shows slight anomalies, in that Clarke states 'leaves up to $1\frac{3}{4}$ inches' in his species description for *Isoglossa delicatula*, whereas, in the key (see below) it is grouped with species with leaves 'attaining $1-1\frac{1}{2}$ inches' in length.

Clarke's (1901) key to species of *Isoglossa*

(Copyright protection has expired—in the Public Domain, 1957)

Subgenus 1. *Eu-Isoglossa*. Corolla $\frac{1}{3}-\frac{2}{3}$ in. long; tube cylindric:

Calyx with hairs none gland-headed:

Inflorescences $\frac{1}{2}-2$ in. long:

Bracteoles not white margined (1) *ciliata*

Bracteoles white-margined (2) *sylvatica*

Inflorescences 3–6 in. long (3) *ovata*

Calyx with numerous gland-headed hairs:

Leaves large, some up to 5 by 2–3 in. (4) *woodii*

Leaves medium-sized, some up to 3 by $1-1\frac{1}{2}$ in.:

Flowers very loosely paniculate, nearly all solitary. (5) *prolixa*

Flowers approximated:

Bracts linear-lanceolate (6) *eckloniana*

Bracts obovate, obtuse with a short acumination ... (7) *stipitata*

Leaves attaining $1-1\frac{1}{2}$ in. in length, mostly shorter:

Spikes slightly interrupted, manifestly viscid-hairy:

Bracts $\frac{1}{2}-\frac{2}{3}$ in. long, broadly lanceolate (8) *organoides*

Bracts $\frac{1}{4}-\frac{1}{3}$ in. long, spatulate-obovate (9) *grantii*

Bracts $\frac{1}{8}-\frac{1}{6}$ in. long, oblong (10) *bolusii*

Spikes interrupted, loose, sparingly hairy (except the calyx):

Corolla $\frac{3}{4}$ in. long, rather broad (11) *macowanii*

Corolla $\frac{1}{3}-\frac{1}{2}$ in. long, slender. (12) *delicatula*

Subgenus 2. *Ramusia*. Corolla $1\frac{1}{2}$ in. long; tube slender:

Bracteoles and calyx thinly hispid with white non-glandular

hairs (13) *hypostiflora*

Bracteoles and calyx viscid with many gland-headed hairs .. (14) *cooperi*

Morphological development of inflorescence

The mean lateral inflorescence length at the beginning of the season was 6.00 mm and increased to 39.8 mm showing a 33.8 mm variation over the season (Figure 5). Similarly, the mean terminal inflorescence length was initially 7.5 mm in January and reached a maximum mean length of 68 mm, showing a 60.5 mm increase over the season (Figure 6). Terminal inflorescences are generally longer than the lateral inflorescences (Figures 5, 6) with the anomalies probably accounted for by the low number of terminal inflorescences found on some specimens. It should be noted that *Isoglossa ovata* has predominantly terminal inflorescences which is characteristic of that species. Both terminal and lateral inflorescences show a decrease in length in July and August (Figures 5, 6). This may be attributed to variation found within a subpopulation, i.e. plants that have developed later in a season when conditions are less favourable produce smaller inflorescences, or to these specimens possibly having grown in sunnier conditions.

In monocarpic plants, leaf loss is associated with the nutrients being translocated for reproduction (Wareing & Phillips 1970). Our studies show that leaf loss begins in February and continues to May (Figure 2). Inflorescence development begins in January (Figure 5), with inflorescence length increasing over a season and reaching a peak in June. Thus, relatively late inflorescence development (Figures 2, 3) suggests that photosynthate is first used for leaf production, then production of larger leaves (supported by an 227144 increase in leaf cell numbers) (Table 1) and lastly as the leaves senesce, the photosynthate is translocated for inflorescence development. A comparison of inflorescence length over a season (Figure 6) with Clarke's inflorescence ranges shows that Clarke's species form four groups (Table 2). *Isoglossa ovata* is characterized by an extremely long inflorescence and is entirely separate from the other groups and from the field data. The second group of species includes *I. stipitata* and *I. organoides*. *I. bolusii*, *I. grantii*, *I. woodii*, *I. sylvatica* and *I. ciliata* form the third of Clarke's groups. This group, together with the fourth group, comprising *I. delicatula*, fall within the boundaries for the field data of *I. sp. 1*. Although it should be noted that Clarke (1901) only uses inflorescence length to diagnose *I. ovata* in the key, he does quote inflorescence lengths for the previously mentioned species in the descriptions. The variability in inflorescence length suggests that it should be used with caution as a taxonomic character for species delimitation within *Isoglossa* and in future studies of other monocarpic plants.

TABLE 2.—Conversion of imperial to metric measurements, for inflorescence and leaf lengths used in Clarke's (1901) key to and descriptions of species of *Isoglossa* and groups of species defined by these characters

Imperial	Metric	Clarke's (1901) <i>Isoglossa</i> spp.
Inflorescence		
$\frac{1}{2}-2$ inches	12.7–50.8 mm	<i>I. ciliata</i> , <i>I. sylvatica</i> , <i>I. bolusii</i> , <i>I. grantii</i> , <i>I. woodii</i>
$\frac{1}{2}-2\frac{1}{2}$ inches	12.7–63.5 mm	<i>I. organoides</i> , <i>I. stipitata</i>
3–6 inches	76.2–152.4 mm	<i>I. ovata</i>
Leaves		
Up to 5 inches	Up to 127 mm	<i>I. woodii</i>
Up to 3 inches	Up to 76.2 mm	<i>I. prolixa</i> , <i>I. eckloniana</i> , <i>I. stipitata</i>
Up to $1-1\frac{1}{2}$ inches	Up to 25.4–38.1 mm	<i>I. organoides</i> , <i>I. grantii</i> , <i>I. bolusii</i> , <i>I. macowanii</i> , <i>I. delicatula</i>

Micromorphological development of indumentum on bracts and calyces

A comparison of bracts over a season (Figures 7A–F) reveals that the proportion of glandular trichomes increases on individual bracts over a season. Further, the increase in degree of viscosity of the glandular trichomes may exist as a means of protection for the fruit against predation. Although the developmental variation in proportion of glandular hairs may question the taxonomic usefulness of the indumentum in Clarke's (1901) key to species of *Isoglossa*, he does use the indumentum in conjunction with other characters. Our findings suggest that it is important to compare the various kinds of trichomes in species at comparable developmental stages, especially when using the indumentum as a taxonomic character in monocarpic plants.

CONCLUSION

Results showed that the mature larger leaves had more cells than the mature smaller leaves which supports the cell theory (Tsukaya 2003; Cookson *et al.* 2006) as the process for leaf enlargement within this monocarpic species. Investigations showed considerable variation in leaf and inflorescence length over a season, and in addition, there was variation in the density of different kinds of hairs in the indumentums on the bracts and calyces over a season. Thus, it is suggested that this kind of study should be undertaken before using leaf size, inflorescence length and the indumentum as characters for taxonomic purposes, especially for monocarpic plants. This study does not necessarily suggest that the species described by Clarke are not worthy of recognition, but it brings the characters he has used in his key (i.e. the leaf and inflorescence length and possibly indumentuma of bracts and calyces) into some question.

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Notes on African plants

VARIOUS AUTHORS

DROSERACEAE

DROSERA ERICGREENII, A NEW SPECIES FROM THE FYNBOS OF SOUTH AFRICA

INTRODUCTION

The Western Cape region of South Africa is well known for the floral diversity of its fynbos vegetation. The genus *Drosera* L. (Droseraceae) includes ± 130 species distributed world-wide, of which ± 20 are known to occur in the Western Cape Province, 12 of them endemic to this area (Obermeyer 1970; Goldblatt & Manning 2000; Debbert 2002).

Drosera hilaris Cham. & Schlechtd. is a large, stem-forming species distributed along coastal mountains from Cape Town to Hermanus. A few collections were known from further inland, around the town of Franschhoek and from Du Toitskloof. Studying specimens and photographs (Miyamoto 2002) of plants from near Franschhoek, it was obvious that they differed from typical *D. hilaris*. When visiting this location in September 2006, it became clear that this population represents a new species, which is described below.

Drosera ericgreenii A.Fleischm., R.Gibson & F.Rivadavia, sp. nov., *Droserae hilaris* Cham. & Schlechtd. similis, sed caulibus brevibus, stipulis membranaceis, scapo e basi curvato adscendenti-erecto et ramis stigmaticis furcatis vel lobatis differt.

TYPE.—Western Cape, 3319 (Worcester): French Hoek [Franschhoek], alt. 2000' [610 m], (–CC), October 1913, *Phillips 1121* (NBG, holo.).

Perennial herb; stems short, at most 100 mm tall, usually much shorter; older part of stem densely covered with persistent leaf remains. *Stipules* triangular to oblong, ± 7 mm $\times$ 2 mm, irregularly lobed into 5–8 segments 2.0–3.5 mm long, white, drying brownish, papery, fused with base of petiole up to 1 mm. *Leaves* broadly obovate (in early growth season) to narrowly oblong, densely covered by carnivorous glands on abaxial surface; apical marginal tentacles with broadened base and enlarged, unifacial gland tip. *Petiole* 3–5 $\times$ 1.5–3.0 mm in early and late season's growth leaves, up to 25 mm in leaves produced in full growth and during flowering; densely covered by woolly indumentum of simple white hairs, ± 3 mm long on both abaxial and adaxial surface. *Scape* ascendant, reddish green to deep wine-red, curved at base, up to 300 mm long and with up to 8 flowers, lower $\frac{1}{3}$ densely covered with long simple white hairs which are deciduous with age, glandular in upper $\frac{2}{3}$; pedicels 5–10 mm long, glandular; bracts filiform, 2–3 $\times$ 0.2–0.3 mm, glandular. *Calyx* subcampanulate, glandular, ± 5 mm long; sepals 5, ovate, $\pm 4 \times 2$ mm, apex

acute, abaxial surface covered in short glandular hairs. *Petals* 5, cuneate with rounded margin, $\pm 10 \times 5$ mm, pink. *Stamens* 5, ± 2 mm long; filaments dilated towards apex; anthers and pollen yellow. *Styles* 3, 3–4 mm long, style arms divided near base, spreading, sometimes bifid, stigmatic apices swollen, lobulate or divided. *Ovary* subglobose, ± 2 mm diam. *Capsule* ovoid, 20–30 mm diam. *Seeds* fusiform. No ripe seed seen for exact measurements. Figure 1.

Distribution: *Drosera ericgreenii* is geographically very restricted, so far only known from the Franschhoek region of the inland mountains in the Western Cape. The related *D. hilaris*, in contrast, seems to be more widespread along coastal mountain ranges, such as Table Mountain, Tafelberg, Silverhill and Hermanus. One collection of *D. hilaris* (Esterhuysen 26463), however, was made further north, extending the range of that species. Figure 2.

Ecology: *Drosera ericgreenii* grows in short (< 0.5 m tall) ericoid fynbos in sandy soil with clay and scattered boulders over Table Mountain Sandstone, in a scree slope on south- to southeast-facing slopes near the town of Franschhoek in the Stellenbosch region of the Western Cape, at ± 600 –850 m. Associated vegetation at the site includes *Elegia filacea*, species of *Cannomois* and *Hypodiscus*, *Erica plukenetii*, *E. longiaristata*, *E. mammosa*, species of *Anaxeton*, *Brunia albiflora*, *Protea acaulis*, *P. speciosa*, *Leucadendron salignum*, *Drosera cistiflora*, species of *Gladiolus*, *Oxalis* and *Ixia*, *Gazania pectinata*, *Diastella divaricata* subsp. *montana* and *Aristea racemosa*. Like *Drosera hilaris*, *D. glabripes* (Harv.) Stein and *D. ramentacea* Burch. ex DC., it prefers rather dry soil with subsoil moisture. The plant grows in partial shade between rocks or beneath shrubby fynbos vegetation.

The evergreen chamaephyte, *Drosera ericgreenii* grows in close proximity to the summer dormant geophyte, *D. cistiflora* L. Like *D. hilaris* and *D. ramentacea*, which have evolved a similar chamaephytic habit, *D. ericgreenii* may stop growth during the driest summer months, forming a perennating, dense green apical bud well above ground level, while the persistent leaves desiccate. At the beginning of the cooler months of the rainy season, the plant resumes growth and produces flower scapes. It was collected in flower in November.

Taxonomy: *Drosera ericgreenii* is placed in subgenus *Drosera* section *Drosera* (sensu Diels 1906; Seine &

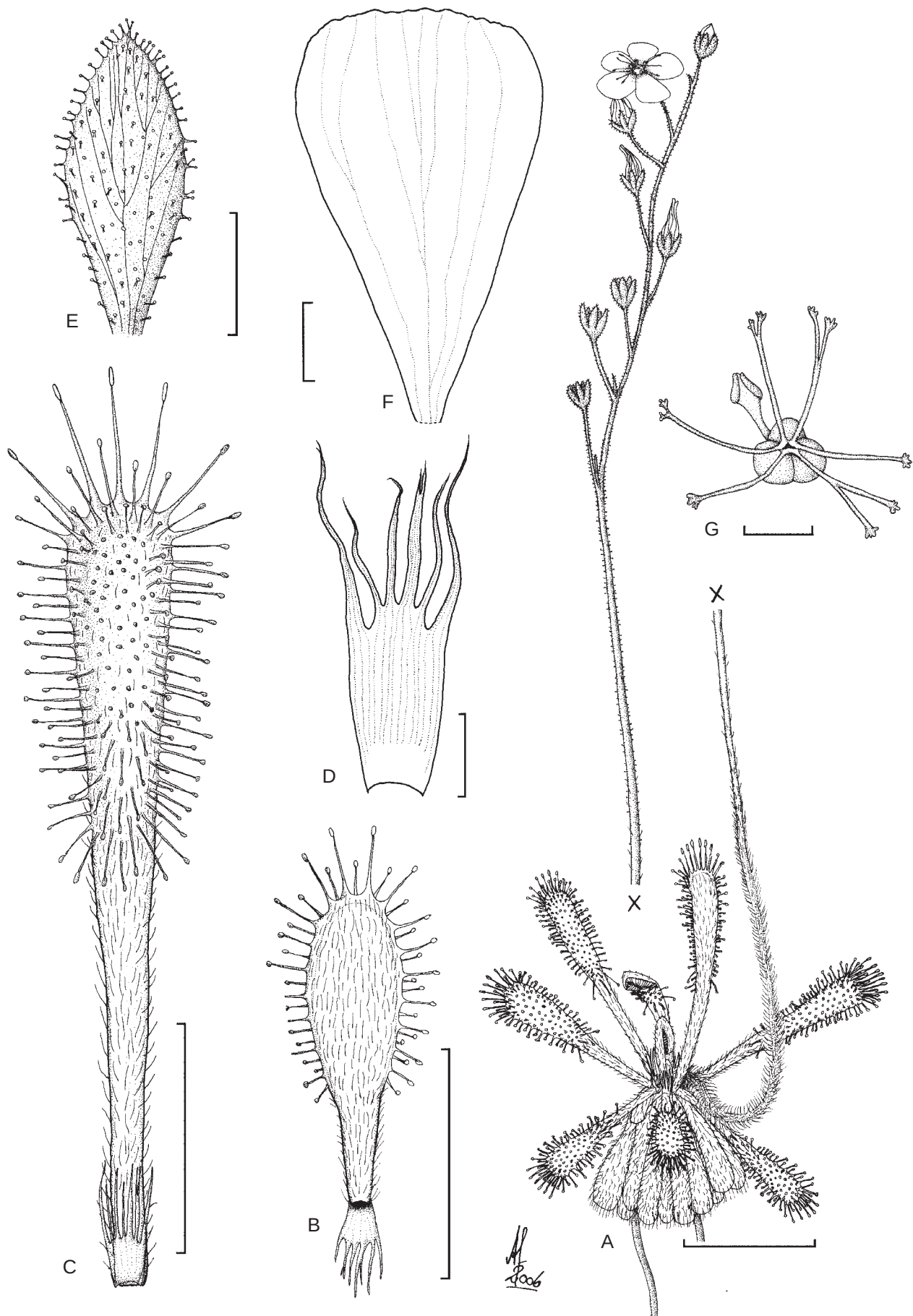


FIGURE 1.—*Drosera ericgreenii*. A, mature plant in flower; B, lower surface of early season leaf, with stipule; C, upper surface of leaf at anthesis, with stipule; D, stipule; E, sepal; F, petal; G, gynoecium with one of five anthers. Scale bars: A, 20 mm; B, C, 10 mm; D–G, 2 mm. A, drawn from type; B–G, W. Giess & S. Rehm 1368. Artist: Andreas Fleischmann.



FIGURE 2.—Known distribution of *Drosera ericgreenii*, ▲; and *D. hilaris*, ○; in the Western Cape.

Barthlott 1994). Table 1 gives a comparison with its closest relative, *D. hilaris*.

Etymology: *Drosera ericgreenii*, that has been formerly neglected or incorrectly identified as specimens of *D. hilaris* (Miyamoto 2002), is named in honour of Mr Eric Green, who over the past few decades has extensively explored the Western Cape Region for carnivorous plants, and in so doing has gathered priceless information about South African *Drosera* species (Gibson & Green 1999).

Additional material examined

Drosera ericgreenii

WESTERN CAPE.—3319 (Worcester): Franschhoek, (–CC), 17 November 1946, W. Giess & S. Rehm 1368 (M); French Hoek [Franschhoek], (–CC), Schlechter 9358 (PRE, photo!).

Drosera hilaris

WESTERN CAPE.—3318 (Cape Town): Table Mountain Summit, (–CD), Harvey s.n. (BM); Constantia Neck, (–CD), 29 October 1951, Salter s.n. (NBG); Orangetkloof, (–CD), 04 November 1955, Salter 9690 (BM), 20 October 1896, Wolley-Dod 262 (BM); Botmanskop, (–DD), 10 November 1946, Strey s.n. (M); Jakkalsvlei list 4, Jonkershoek, (–DD), 23 October 1963, Taylor 5479 (NBG); Stellenbosch, Swartsboskloof, (–DD), 13 October 1960, Van Rensburg 2083 (M). 3319 (Worcester): Du Toit's Kloof [Du Toitskloof], (–CA), 4 November 1956, Esterhuysen 26463 (BOL); De Hoop, kloof near Elandspad homestead, (–CD), 16 October 1984, Van Wyk 2040 (NBG). 3418 (Simonstown): Noordhoek, (–AB), October 1929, Godman 808 (BM); Steenberg Plateau, (–AB), November 1944, Lewis 988 (NBG); Glencairn Valley, (–AB), 20 October 1927, Salter 263/6 (BM); Silvermine, (–AB), 21 September 1958, Werdermann & Oberdieck 114 (B); Simon's Bay, (–AB), 09 December 1856, Wright s.n. (P); Smitswinkel Bay, (–AD), Marloth 338 (NBG); Kogelberg Forest Reserve, (–BB), 23 October 1969, Boucher 790 (NBG); quarry at southern end of Buffelstralberg, (–BD), 16 September 1969, Boucher 652 (NBG). 3419 (Caledon): near Villiersdorp, 9 miles [14.4 km] from Grabouw, (–AA), 30 October 1928, Gillett 1873 (NBG); Viljoen's Pass, (–AA), 30 October 1928, Hutchinson 1078 (BM), 22 September 1946, Strey s.n. (M); mountain slopes above estuarine vlei, Caledon, (–AB), 30 September 1928, Gillett 952 (NBG); Zwartberg [Swartberg], (–AB), October 1886, MacOwan 728 (BOL); Hermanus, (–AC), Barker 1690 (NBG); Palmietriviermond, Paardeberg, (–AC), 12 October 1962, Grobles 25258 (NBG); Riviera, Hermanus, (–AC), 2 October 1916, Purcell s.n. (NBG); Fernkloof Nature Reserve, (–AD), 18 October 1989, Greuter 21929 (B), 27 September 1980, Orchard 570 (NBG).

Key to stem-forming *Drosera* species of Western Cape

- 1a Summer dormant geophyte; stipules absent; seasonally emerging basal rosette of leaves (sometimes absent at time of flowering) forming annual stems covered with living, green leaves well spaced along stem; flower scape terminal, erect 1. *D. cistiflora* (s.l.)
- 1b Plant in growth year-round; stipules present (but reduced to inconspicuous setae in *D. hilaris*); stems perennial, ± woody, covered by remnants of dead leaves, green living leaves at growing tip only; flower scapes emerging laterally, ± ascending:
 - 2a Leaves with petiole graduating continuously into lamina:
 - 3a Stem glabrous and leaves with short, scattered white hairs only (in addition to tentacles) 2. *Drosera capensis* × *D. aliciae*
 - 3b Stem and leaves densely covered with woolly indumentum of short white hairs (in addition to tentacles):
 - 4a Stipules well developed, papery; stem short (< 100 mm); scapes ascending with curved base; flowers ± 20 mm diam. 3. *D. ericgreenii*
 - 4b Stipules reduced to tiny setae; stem > 100 mm (at least in flowering specimens); scapes erect with straight base; flowers more than 20 mm diam. (up to 40 mm) 4. *D. hilaris*
 - 2b Leaves with distinct petiole narrower than lamina:
 - 5a Stem and leaf lower surface covered with long white or brown hairs; inflorescence forked 5. *D. ramentacea*
 - 5b Stem glabrous and leaf lower surface only sparsely covered by short appressed hairs; inflorescence unbranched (only very rarely branched in robust plants):
 - 6a Lamina broadly linear, up to 150 mm long; stipules entire, triangular 6. *D. capensis*
 - 6b Lamina obovate to spatulate, up to 30 mm long; stipules lacinate:
 - 7a Petiole 1–2 mm wide; internodes > 2 mm 7. *D. glabripes*
 - 7b Petiole 3–4 mm wide; internodes < 2 mm 8. *D. × corinthiaca* (*D. aliciae* × *D. glabripes*)

TABLE 1.—Comparison of *Drosera ericgreenii* and *D. hilaris*

Character	<i>D. ericgreenii</i>	<i>D. hilaris</i>
Stem	short, < 100 mm	well developed in flowering plants, > 100 mm
internodes	short in both growth and dormant phase	long in active growth phase, short in dormant phase
Stipules	lacinate, triangular to rectangular, papery	inconspicuous, reduced to short setae and hidden in dense woolly indumentum of petiole
Scape	ascending, base curved	± erect, base straight
Leaves	narrowly oblong to broadly obovate, apex rounded	narrowly oblanceolate, apex acute
Leaf tip glands	long marginal glands with enlarged, non-mucilaginous, unifacial tips	marginal glands with knob-shaped mucus-secreting tips
Flowers	18–22 mm diam.	38–42 mm diam.

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LAMIACEAE

A NEW COMBINATION IN *SYNCOLOSTEMON*

A re-assessment of the relationship between *Syncolostemon* and *Hemizygia* based on molecular and morphological data (Otieno *et al.* 2006b), showed that neither genus as previously circumscribed, was monophyletic, and thus led to the merging of *Hemizygia* into *Syncolostemon*, the earliest name. Members of the genus, as newly circumscribed, are characterized by fused anterior stamens, a feature that sets them apart from other genera in the tribe Ocimeae (Paton 1998). In Otieno *et al.* (2006a, b), several name changes were made in the combined *Hemizygia* and *Syncolostemon* to conform to the new circumscription. However, *Hemizygia cinerea* Codd was inadvertently omitted. The new combination for this species is presented below.

***Syncolostemon cinereum* (Codd) D.F.Otieno & Retief, comb. nov.**

Hemizygia cinerea Codd in *Bothalia* 12: 6 (1976). Type: KwaZulu-Natal, Cathedral Peak Forest Research Station, *Killick 1644* (PRE, holotype).

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PTERIDOPHYTA: ASPLENIACEAE

ASPLENIUM LOBATUM VAR. *PSEUDO-ABYSSINICUM*, A NEW RECORD FOR SOUTH AFRICA

Asplenium lobatum Pappe & Rawson is a terrestrial fern with tufted, glabrous, narrowly lanceolate to elliptic fronds of up to 400 mm long. The stipe is dark matt brown, 45–230 mm long, glabrous or with a few hair-like scales and is sometimes vigorously proliferous. This fern is found on shaded floors of high-altitude, evergreen forests, often away from water,

where it can form dense stands. The species is very variable, especially in the degree of lamina dissection and the shape and proportions of the pinnules. In general, Zimbabwean material is more often 3-pinnate to 4-pinnatifid with narrowly linear ultimate lobes, whereas South African material is generally 2-pinnate to 3-pinnatifid, with broadly obtuse ultimate lobes.

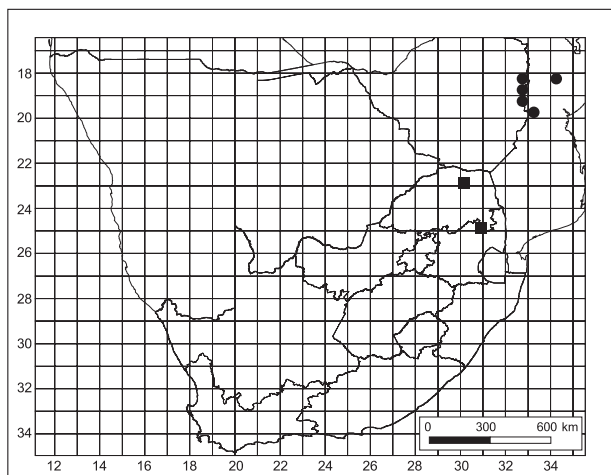


FIGURE 3.—Distribution of *Asplenium lobatum* var. *pseudo-abyssinicum*, adapted from Burrows (1990), with kind permission of the author, ●; new localities in South Africa, ■.

Furthermore, the more dissected fronds from north of the Limpopo River are sometimes proliferous at the base of the lamina, whereas the less dissected plants are not proliferous (Jacobsen 1983; Burrows 1990). Due to these differences, *A. lobatum* var. *pseudo-abyssinicum* Schelpe & N.C. Anthony was described in 1982 (Schelpe & Anthony 1982). Some authors still consider *A. lobatum* as a single extremely variable species and do not recognize the latter variety as a separate entity (Roux 2001).

Asplenium lobatum var. *lobatum* is widespread in the Eastern Cape, KwaZulu-Natal, along the eastern escarpment of Mpumalanga and Limpopo, in Swaziland, along the border of Zimbabwe and Mozambique, in Malawi and also on Madagascar. The much more dissected *A. lobatum* var. *pseudo-abyssinicum* has previously been recorded only on the highlands of Zimbabwe and Mozambique (Figure 3) (Jacobsen 1983; Burrows 1990; Roux 2001).

On a recent trip to the Entabeni State Forest near Levubu in the Soutpansberg, three plants of *A. lobatum* var. *pseudo-abyssinicum* were found next to the trail near Vera's Tears Waterfall. They grew on a moderately steep slope, well away from the stream. Fronds were 350–400 mm long and strongly 3-pinnate to 4-pinnatifid, with very narrow ultimate lobes. The plants were initially thought to be small specimens of the superficially similar *A. hypomelas* Kuhn, a widespread fern occurring from west tropical Africa and Ethiopia southwards to the Nyika Plateau in Malawi and the Zimbabwean highlands, with a disjunct collection from Woodbush in Limpopo, South Africa (Burrows 1990). *A. lobatum* var. *pseudo-abyssinicum* is easily distinguished from the latter species by the sori: *A. hypomelas* has a single, apparently marginal, cup-shaped sorus per lobe, whereas *A. lobatum* var. *pseudo-abyssinicum* has several oval, non-marginal sori per lobe. The fronds of *A. hypomelas* are, furthermore, usually longer than 1.5 m, whereas *A. lobatum* var. *pseudo-abyssinicum* is a smaller plant with fronds shorter than 0.5 m (Schelpe & Anthony 1986; Burrows 1990). On closer

inspection of the Entabeni plants, it was found that one had a fertile frond, and it was subsequently identified as *A. lobatum* var. *pseudo-abyssinicum*.

This is the first confirmed record of *A. lobatum* var. *pseudo-abyssinicum* in South Africa. However, on inspection of the *A. lobatum* collection at the National Herbarium, Pretoria (PRE), two collections from South Africa labelled as the 'tripinnatifid' form of the species were found. The first was collected by A.A. Obermeyer, also at Entabeni, Soutpansberg, in 1931, but no precise locality information is given. The second collection was from Kowyn's Pass near Graskop in Mpumalanga by J.P. Kluge in 1979 (Figure 3). The fronds of both these collections are strongly 3-pinnate to 4-pinnatifid and the ultimate lobes narrow and linear, making it *A. lobatum* var. *pseudo-abyssinicum*. Both localities fall within the Northern Mistbelt Forest vegetation type (Mucina & Rutherford 2006).

The Soutpansberg forms part of a centre of endemism with a very high biodiversity and with floristic links to several other such centres in southern Africa. Entabeni is situated at the intersection of the Drakensberg and Soutpansberg Mountain Ranges and has the highest annual rainfall recorded for the Soutpansberg (1 874 mm). The area also receives an additional average precipitation through mist of 1 366 mm per annum (Hahn 2002). These wetter areas of the Soutpansberg Centre of Endemism form part of the Afromontane region and show clear affinities with, amongst others, the Chimanimani-Nyanga Centre in the Eastern Highlands of Zimbabwe and the Wolkberg Centre of the northeastern Drakensberg Escarpment, of which the Graskop area forms the eastern border (Van Wyk & Smith 2001). It is therefore not surprising that *A. lobatum* var. *pseudo-abyssinicum*, previously known only from the Eastern Highlands of Zimbabwe, also occurs further south in the Soutpansberg and Wolkberg Centres of Endemism.

LIMPOPO.—2230 (Messina): Levubu, Entabeni State Forest, near Vera's Tears Waterfall, (–CC), R.R. Klopper & A.W. Klopper 218 (PRE); Zoutpansberg, Entabeni, (–CC), A.A. Obermeyer TM1919C (PRE).

MPUMALANGA.—2430 (Pilgrim's Rest): Kowyn's Pass, (–DD), J.P. Kluge 1699 (PRE).

ACKNOWLEDGEMENTS

Mr John Burrows is thanked for giving permission to use the distribution map of this species from his book *Southern African ferns and fern allies* (1990); Ms Hester Steyn, Data Management Unit, SANBI, Pretoria, for producing the distribution map; Ms Emsie du Plessis, of the Scientific Publications Section, SANBI, Pretoria, for comments on an earlier draft of this paper.

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BEGONIACEAE

BEGONIA SONDERIANA, A NEW KWAZULU-NATAL RECORD FROM THE SOUTHERN LEBOMBO RANGE, MAPUTALAND, SOUTH AFRICA

In the Begoniaceae account for the *Flora of southern Africa* (FSA), Hilliard (1976) treated only two regional taxa that possess bilamellate placentae, the naturalized *Begonia hirtella* Link, and the indigenous *B. sonderiana* Irmsch., with only the former reported by her from KwaZulu-Natal. However, subsequent regional checklists (Van Wyk 1993; Bredenkamp 2003, 2006) record *B. sonderiana* as occurring in KwaZulu-Natal, based, seemingly, on a misidentified specimen of *B. sutherlandii* Hook.f. collected in 1980 from Karkloof Falls (Hildyard 102 PRE). The previously documented occurrence of *B. sonderiana* falls within the Afromontane Archipelago-like Centre of Endemism (Van Wyk & Smith 2001), reported from the eastern highlands of Zimbabwe/western highlands of Mozambique through mountainous sites in the Limpopo and Mpumalanga Provinces of South Africa, to northwestern Swaziland (Figure 4). In the FSA region, the altitude range for *B. sonderiana* has been given as 1 000–1 850 m (Hilliard 1976), whereas in the *Flora zambesiaca* (FZ) region, plants have been found at expectedly higher elevations of between 1 650 and 2 000 m (Kupicha 1978). Herbarium records further reveal a single collection (J. Culverwell 789 PRE) from the Lebombo Mountains in Swaziland; plants were found growing in Chilobe Forest at an altitude of 600 m, in deep shade with very moist conditions.

During a recent search for *Begonia homonyma* Steud. in the vicinity of Gwalaweni (Hlatikulu) Forest in the southern Lebombo Mountains, KwaZulu-Natal, plants of *B. sonderiana* were unexpectedly encountered growing at a site overlooking the Jozini Dam, close to the border with Swaziland, at an altitude of 680 m. The exact locality is the head of Devil's Dive. Although found on a southern aspect, the habitat was xeric, very unlike the mesic one recorded previously for this species: Kupicha (1978) described its occurrence on rocks in the spray of waterfalls or on damp mossy boulders in kloof forest, whereas Hilliard (1976) recorded it from forest or forest margins in which sites it favours rockfalls or broken cliff faces. Hilliard (1976) also reported its presence amongst shady rock outcrops in steep grasslands. At the Devil's Dive site, *B. sonderiana* grows in shallow humic pockets overlying rhyolite, together with *Euphorbia evansii*, *Streptocarpus confusus* subsp. *lebomboensis*, *Cheilanthes*

hirta var. *nemorosa*, *Kalanchoe rotundifolia*, *Dracaena aletroformis*, *Plectranthus verticillatus* and *Dioscorea sylvatica*. The vegetation type corresponds to Southern Lebombo Bushveld (Rutherford *et al.* 2006).

Subsequent consideration of herbarium materials revealed that this gathering on the western edge of the southern Lebombo range was actually the second collection from this vicinity, the first (Vahrmeijer & Driehout 2002 PRE) having been made nearly 30 years earlier, but misidentified as *Begonia homonyma*. These two records are the first to authenticate the occurrence of *B. sonderiana* in KwaZulu-Natal as well as the Maputaland-Pondoland Region of Plant Endemism (Van Wyk & Smith 2001), extending its known distribution in a southerly direction by 95 km. The plants grow at a lower altitude than northern subpopulations of the Lebombo Mountains, and here receive less than 800 mm of rain per annum on average (Rutherford *et al.* 2006). The plants conform in most respects to typical *B. sonderiana*, possessing tubers and glabrous aerial parts, in contrast to the thinly villous and atuberosus *B. hirtella* which is known from the same general locality (Vahrmeijer 2000 PRE). Further, in contrast to *B. homonyma*, the *B. sonde-*

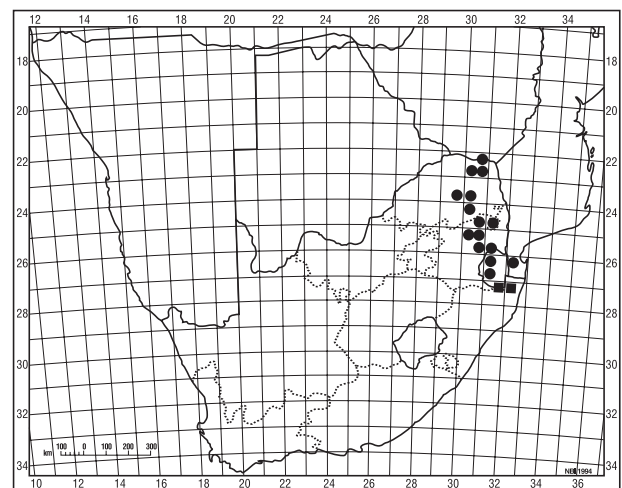


FIGURE 4.—Known distribution of *Begonia sonderiana* in FSA region based on specimens at J, NH, NU and PRE, ●; new provincial localities, ■.

riana plants presented female flowers with characteristic divided placentae, and ovate-acuminate leaves with lobed and toothed margins. However, tepal dimension differences warrant mention: the male flowers, which are white flushed pink, possess outer pairs up to 16×21 mm, and inner pairs up to 11×5 mm, relative to the respective dimensions of outer ($8\text{--}13 \times 11\text{--}17$ mm), and inner ($5\text{--}8 \times 3\text{--}4$ mm) pairs provided by Kupicha (1978). Hilliard (1976) described flowers as being up to 30 mm across, somewhat larger than tropical material (Kupicha 1978), but slightly smaller than the Lebombo form. In contrast to male flowers, tepals of female flowers from Devil's Dive were shorter than the maximum known from the tropics, attaining 12 mm rather than 17 mm (Kupicha 1978). Further, tubers of plants from the arid site were entire rather than presenting spaced swellings as noted for the mesic form (Hilliard & Burtt 5962 NU). Despite their dry habitat, flowering specimens still attained a height of 350 mm and remained turgid whereas the surrounding vegetation, with the exception of stem and leaf succulents, showed signs of drought stress. The drought tolerance of these begonias may be attributed to their succulent tubers, one measured 75×29 mm.

An unconfirmed sight record by the second author places *Begonia sonderiana* still further south, in the mistbelt component of Ngome Forest (2731 CD) at $\pm 1\ 200$ m elevation.

Specimens examined

Begonia hirtella

KWAZULU-NATAL.—2732 (Ubombo): Gwalaweni Forest, southern Lebombo Mountain range, (–AA), 08-01-1970, *J. Vahrmeijer 2000* (PRE).

Begonia sonderiana

MPUMALANGA.—2430 (Pilgrims Rest): cliffs on road to summit of Mariepskop, 1 830 m, (–DB), 16-01-1969, *Hilliard & Burtt 5962* (NU).

KWAZULU-NATAL.—2731 (Golela): in humus on rocky ledge of steep dry southern slope at head of Devil's Dive on crest of Lebombo range overlooking Jozini Dam, 680 m, S $27^{\circ}31'44''$, E $31^{\circ}9'77''$, (–BD), 05-02-2008, *N. Crouch, T. Edwards & I. Johnson 1166* (NH). 2732 (Ubombo): Gwalaweni Forest, (–AC), 1969, *Vahrmeijer & Drijhout 2002* (PRE).

SWAZILAND.—2632 (Bela Vista): Chilobe Forest, Lubombo Mountains south of Siteki, southeast of Jilobi, very close to Tikuba, climax wet canopy forest, 600 m, (–AC), 10-04-1977, *J. Culverwell 789* (PRE).

Begonia sutherlandii

KWAZULU-NATAL.—2930 (Pietermaritzburg): Karkloof Waterfalls, picnic spot in riverside forest remnant at waters edge, (–AD), 21-01-1980, *C.J. Hildyard 102* (PRE).

ACKNOWLEDGEMENTS

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APOCYNACEAE

SPECIES DELIMITATION IN *CARVALHOA CAMPANULATA* (RAUVOLFIOIDEAE)

INTRODUCTION

The genus *Carvalhoa*, typified by *C. campanulata* K.Schum., was established in 1897 by Karl Schumann based on a collection made by Manuel Rodrigues P. de Carvalho in 1884–1885 on the small island of Cabaceira Pequena ($15^{\circ}0'40''$ S, $40^{\circ}45'5''$ E), about 11 km ESE of Mossuril, a seaside settlement in Nampula Province of northern Mozambique. Despite Leeuwenberg's assertion

that all material within the genus belongs to a single species (Leeuwenberg 1985a), it is clear that there are two distinct taxa represented over its range: one a species of moist evergreen forest, and the other of dry coastal vegetation at low altitudes. In this contribution the morphology and ecology of the two taxa are examined and the younger name, *C. macrophylla* K.Schum., for the taxon that is widespread in the montane forests, is reinstated. The name *C. campanulata* is retained for the typical

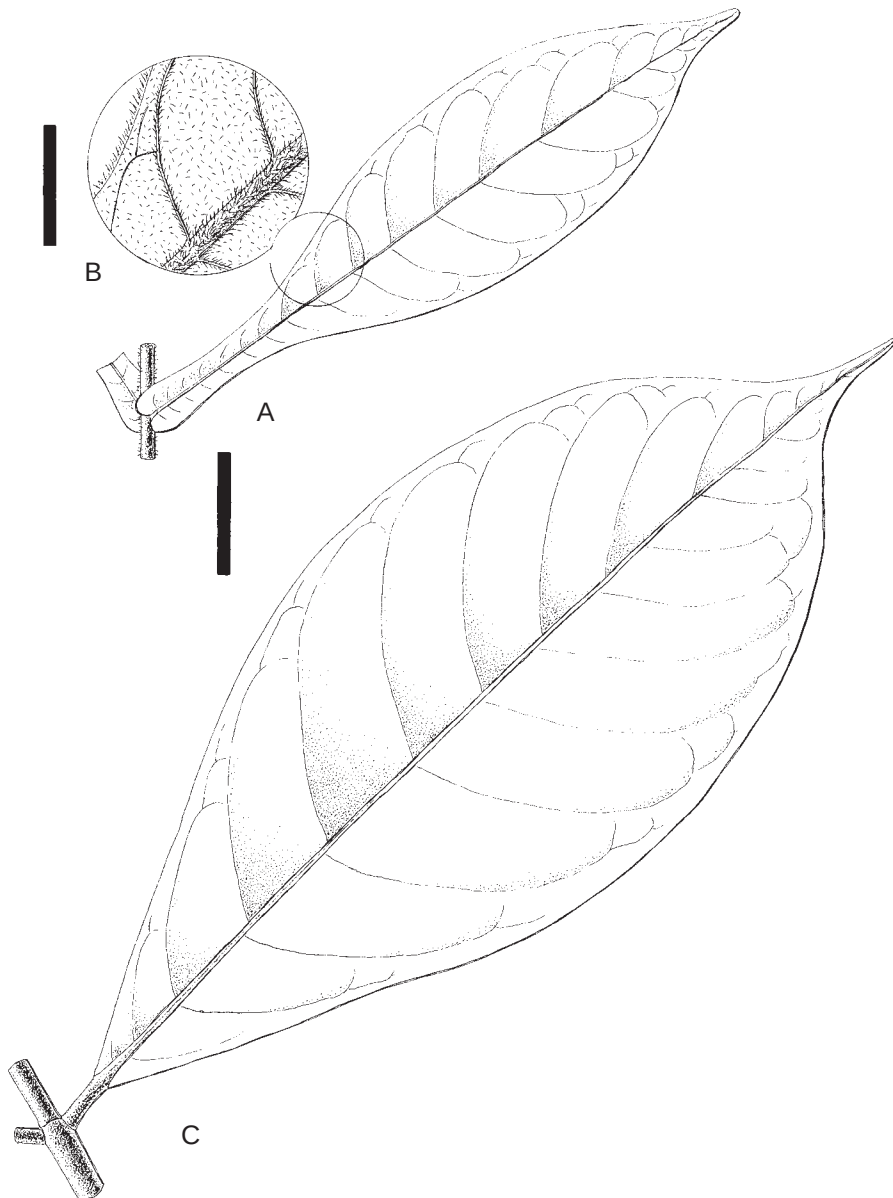


FIGURE 5.—*Carvalhoa campanulata*, Burrows & Burrows 9735 (BNRH): A, leaf; B, indumentum. *C. macrophylla*, Golding, Timberlake & Clarke 41 (BNRH, K, PRE): C, leaf. Scale bars: A, C, 20 mm; B, 5 mm. Artist: Sandra Burrows.

material which is confined to the coastal regions of northern Mozambique.

Until the Buffelskloof Herbarium, Lydenburg, is awarded an international acronym, the temporary acronym BNRH is used here.

DISCUSSION

Morphology: if *Carvalhoa* is regarded as a monotypic genus (Leeuwenberg 1985a, b; Omino 2002), the morphological variation in leaf size, leaf shape, leaf indumentum and petiole length over its range is, in the opinion of the author, unacceptably great. However, if the genus is divided into two species, the most striking and consistent differences between the two taxa are the shape and size of the leaf. In *C. campanulata sensu stricto* the leaves are narrowly elliptic to oblanceolate or narrowly obovate, with the base attenuating to a narrowly auriculate or truncate base (Figure 5A). Leaf size is 34–120 × 14–34 mm, with a width-to-length ratio of 1:(2.2–)2.8–4.0(–4.5). In *C. macrophylla*, the leaves measure 80–280

× 30–120 mm, with a width-to-length ratio of 1:1.9–2.5. The leaf base is always variously cuneate (Figure 5C).

In addition, the lateral venation of *Carvalhoa campanulata* is rather obscure, whereas those of *C. macrophylla* are always distinct, both in fresh and dried material. The leaves of *C. macrophylla* are almost always glabrous, although a single specimen from Namuli Mountain in Mozambique displayed a few sparse hairs. In contrast, the leaves of *C. campanulata* are always set on both surfaces with a very sparse indumentum of minute pale hairs, slightly more densely so along the margins, the midrib and the lateral veins (Figure 5B).

The author has been unable to detect any significant floral or fruit characters on which to differentiate the species, although it would appear that the paired carpels of *Carvalhoa campanulata* are smaller than those of *C. macrophylla* and are held at 180° to one another when ripe, whereas those of *C. macrophylla* are seldom spread as wide apart as 180°.

Ecology: the author has visited the type locality of *Carvalhoa campanulata* on two occasions: once in

October 2005 and once in December 2006. The area around Mossuril comprises a mosaic of open to closed woodland on coastal sands, interspersed with dense patches of coastal thicket, that are sometimes extensive and are dominated by emergent specimens of *Terminalia sambesiaca* (Combretaceae). In October, the area was extremely dry and the vegetation, with the exception of only a handful of species (notably *Ludia mauritiana*, Flacourtiaceae), was totally leafless and grey. Although not detected then, the *Carvalhoa* were almost certainly leafless at that time of year. In contrast, in mid-December the vegetation in the same area was fully in leaf, despite having had little, and late, rain. At this time *C. campanulata* was collected in flower and with immature fruit. This collection therefore represents topotypic material, close to where Carvalho originally collected the type specimen. Data from other collections of the same taxon indicate that the species occurs in coastal *Brachystegia/Julbernardia* ('miombo') woodland as well as on granite inselbergs where the plants are exposed to extreme heat and aridity during the dry season. Typical *C. campanulata* is therefore a species of seasonally arid deciduous woodland and deciduous thicket on coastal sands, or on rocky outcrops. Altitude ranges from sea level to 550 m.

In direct contrast, White *et al.* (2001) state that in Malawi, *Carvalhoa campanulata sensu lato* occurs 'in understorey of mid-altitude and montane rain forest', between altitudes of 750–2 000 m. Leeuwenberg (1985b) records that in the *Flora zambesiaca* region, *C. campanulata s.l.* occurs in 'montane rain forest and secondary forest; (300)800–1 900 m', whereas Omino (2002) states that in East Africa it grows in 'moist forest, riverine forest; 300–2 300 m.' The author has seen this taxon growing in moist undergrowth of evergreen lowland forest in the Great Ruo Gorge of Mt Mulanje, Malawi. While the altitudinal range of the montane taxon is commonly between 750 and 2 000 m, it does sometimes extend to altitudes of as low as 288 m in the moist lowland forests of coastal Kenya and Tanzania.

In his original description of the genus, Schumann (1897) mentions that *Carvalhoa campanulata* stretches from the inland highlands to the Mozambique coast, a view he was to change a few years later when he raised two predominantly montane species, *C. macrophylla* in 1902 and *C. petiolata* in 1904. However, it is puzzling that, although Leeuwenberg lists in his *Flora zambesiaca* treatment, numerous collections from coastal Mozambique, including the specimen *Gomes e Sousa 4559* which was collected near the sea at Pemba, and Carvalho's type collection gathered on an island, he does not recognize or indicate that it grows at or near sea level (Leeuwenberg 1985b). This gives the contemporary, but erroneous impression that *C. campanulata s.l.* is only a montane species.

Because of the foregoing, I propose the reinstatement of Schumann's *Carvalhoa macrophylla* which is a montane evergreen species with leaves cuneate at the base and almost entirely glabrous. In contrast, *C. campanulata* is a deciduous coastal species with smaller, sparsely pubescent leaves with a narrowly auriculate base. *C. petiolata*, while differing in some minor aspects (e.g. number of lateral veins), is regarded as synonymous with *C. macrophylla*.

Key to species of *Carvalhoa*

- 1a Plants deciduous; leaves narrowly elliptic to oblanceolate or narrowly obovate, attenuated into a very narrowly auriculate or truncate base; in deciduous coastal woodland and thicket; 0–550 m 1. *C. campanulata*
 1b Plants evergreen; leaves elliptic, subsessile or petiolate up to 7 mm long, base cuneate; in evergreen lowland or montane forests; (290–)750–2 000(–2 300) m 2. *C. macrophylla*

1. ***Carvalhoa campanulata* K.Schum.** in Engler & Prantl, Die Natürlichen Pflanzenfamilien, edn 1, 4,2: 189 (1897); Leeuwenberg: 50 (1985a), pro parte excl. *C. macrophylla* K.Schum. (1902) and *C. petiolata* K.Schum. (1904). Type: Mozambique, Nampula Province, Mossuril, Cabaceira Pequena, 1884–1885, *M.R.P. de Carvalho s.n.* (B, holo.†; COI, lecto.; K!, P, Z, islecto.).

Ecology: occurring in seasonally arid deciduous or semi-deciduous coastal forest, thicket or coastal miombo woodland, on sands and 'basaltic sands'. On the *Gomes e Sousa 4559* voucher, he states 'very common in Querimba Islands, where it forms dense communities'. It also grows on rocky granite outcrops with species of *Xerophyta*, *Myrothamnus*, *Aloe* and *Asparagus* on Monte Ancuabe. Altitude range from 0–550 m.

Distribution: endemic to the provinces of Cabo Delgado and Nampula in northern Mozambique; possibly yet to be discovered in the extreme southeast of Tanzania. Its entire distribution falls within White's (1983) Zanzibar-Inhambane undifferentiated forest of his Zanzibar-Inhambane regional mosaic (mapping unit 16a).

Conservation status: a status of Not Threatened, Least Concern is recommended. The species appears to be widespread within its area of occurrence and is, in places, still frequent.

Specimens examined

MOZAMBIQUE.—1139: Cabo Delgado Province, Mueda to Neganano road, Nambiti village, fl. & fr. 2 April 1960, *Gomes e Sousa 4561* (COI, K!, PRE!, SRGH). 1239: Ancuabe District, Monte Ancuabe, 550 m, de Koning & Groenendijk 9525 (K!, LMU). 1240: S of Porto Amelia (Pemba), road to Maringanha lighthouse, 2 April 1960, *Gomes e Sousa 4559* (COI, K!, PRE!). 1440: Nampula Province, Memba District, Memba, fl. & fr. 18 March 1961, *M.F. de Carvalho 468* (K!, LMU); Monapo District, Monapo, Monte Ndjidji, 250 m, 12 February 1984, Groenendijk, de Koning & Dungo 9598 (K!, LMU); Monapo District, Monapo, forest reserve of Sr Wolf, fr. 10 February 1984, Groenendijk, de Koning & Dungo 976 (K!, LMU); *ibid.*, Groenendijk, de Koning & Dungo 994 (K!, LMU); *ibid.*, 11 February 1984, de Koning, Groenendijk & Dungo 9344 (K!, LMU); Mossuril District, on road from Mossuril to Matibane, 60 m, fr. & fl. 22 December 2006, J.E. & S.M. Burrows 9735 (BNRH).

2. ***Carvalhoa macrophylla* K.Schum.** in Engler, Botanische Jahrbücher 30: 381 (1902); Beentje: 479 (1994); White *et al.*: 138 (2001), both as *C. campanulata*. Type: Tanzania, Rungwe District, Poroto Mts, Gurumbi (Ngurumbi) Mtn, 1 700 m, October 1899, Goetze 1343 (B, holo.†; BR, lecto.; E, K!, Z, islecto.).

C. petiolata K.Schum.: 317, 318 (1904). Type: Tanzania, Usambara Mtns, Derema, 800 m, 14 February 1900, Scheffler 219 (B, holo.†; PRE, lecto.).

Note: Leeuwenberg (1985a: 50) states that Schumann erroneously cites Goetze's collecting number as 1143. This is confirmed here; Goetze's correct number is 1343.

Ecology: an evergreen shrub in the understorey of moist evergreen montane or lowland forest, sometimes locally frequent, mostly at altitudes of 750–2 000 m but extending to much lower altitudes along the East African coast: 390 m (Shimba Hills, Kenya); 350 m (Lushoto, Tanzania); 400 m (Udzungwa Mountains, Tanzania); 288 m (Namatimbili Forest, Lindi District, Tanzania); 500 m (Mueda Plateau, Mozambique). At the upper limit of its range, *Carvalhoa macrophylla* is recorded growing at 2 300 m in 'bush often under *Hagenia*' (specimen data).

Distribution: coastal Kenya, Tanzania, Malawi, north-western Mozambique (as in Leeuwenberg 1985a, excluding specimens from coastal Mozambique).

Conservation status: a status of Not Threatened, Least Concern is recommended. This taxon is widespread in the moist evergreen forests of southeastern Africa and much of this habitat is legally protected.

Selected specimens examined

KENYA.—0439: Kwale District, Shimba Hills, Longomagandi, 390 m, 17 March 1991, Luke & Robertson 2727 (EA, K!); *ibid.*, Mwele Mdogo Forest, 400 m, 28 May 1987, Roberston 4673 (EA, K!, MO).

TANZANIA.—0637: Morogoro District, Uluguru Mts, 1 250 m, 16 January 1933, Schlieben 3253 (B, BM!, G, K!, LISC, M, MO, Z). 0933: Mbeya District, Rungwe, 'Station Kyimbila', 1 450 m, 29 November 1910, Stoltz 375 (BM!, BR, G, GH, HBG, K!, L, MO, S, US, W, WAG, Z).

MALAWI.—1133: Vipya Plateau, in Pamphala rainforest, 11 February 1956, J.D. Chapman 285 (BM!, FHO, K!). 1334: Nchisi Mtn, 1 450 m, 19 February 1959, Robson 1657 (BM!, K!, LISC, PRE!, SRGH).

MOZAMBIQUE.—1237: Niassa Province, Niassa Game Reserve, Simba Camp to Serra Mecula Peak, 1 000 m, 11 June 2003, Golding, Timberlake & Clarke 41 (BNRH!, K!, PRE!). 1636: Zambezia Province, Lugela District, Tacuane, Faulkner 124 (K!, S).

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CELASTRACEAE

A NEW SPECIES OF *GYMNOSPORIA* FROM SOUTH AFRICA AND SWAZILAND

***Gymnosporia hemipterocarpa* Jordaan, sp. nov.**, *G. buxifoliae* (L.) Szyszyl. affinis, sed ramis primo rubropurpureis; foliis caeruleo-griseis; capsulis sub-porcatis, laevigatis, flavis differt.

TYPE.—South Africa, KwaZulu-Natal, 2830 (Dundee): Weenen District, Farm Mkholumbe, 5 km E of Weenen, (–CC), 6 April 1987, Jordaan 1155 (PRE, holo.; NH, iso.).

Maytenus cymosus forma DE2507 sensu Edwards: 269 (1967) quoad specimens Edwards 2507, 2784, 2810.

Shrub up to 2 m high, rarely a small tree up to 4 m high, spinescent, glabrous. *Branches* terete, reddish brown when young, becoming grey with age. *Brachyblasts* short. *Thorns* robust, terete, up to 70 mm long, rarely floriferous. *Stipules* subulate, ± 1 mm long, margin fimbriate. *Leaves* fasciculate or alternate towards tips of branchlets, subcoriaceous, greyish green when fresh, greyish when dry; lamina ovate, obovate to oblanceolate, 15–40 × 10–20 mm, apex

acute to rounded, base cuneate, margin with incisions in distal half, venation not obvious below except for raised midrib in dry specimens; petiole ± 0.5 mm long. *Inflorescence* a dense dichasium, slightly shorter than or as long as leaves; peduncle 6–12 mm long, reddish purple; pedicels 1–2 mm long. *Flowers* unisexual, pentamerous, white or cream-coloured, 15–19 per cyme, sweetly scented. *Sepals* triangular, ± 0.8 mm long, margin lacinate. *Petals* oblong, 1–2 mm long, margin uneven. *Disc* ± 1.5 mm wide, 5-lobed. *Male flowers*: stamens slightly shorter than petals; filaments ± 1 mm long; pistillode short; style unbranched. *Female flowers*: staminodes shorter than stamens in male flowers; ovary 3-locular, half-ridged; style very short; stigma 3-branched, spreading. *Capsules* subglobose, 4–5 mm diam., 3-valved, each valve with outer surface ridged towards distal end, smooth, coriaceous, yellow to dark red to purplish. *Seeds* reddish brown, shiny; aril thin, yellow, partially covering the seed. Figures 6, 7.

Diagnostic characters and affinities: *Gymnosporia hemipterocarpa* is easily recognized by its leaves which

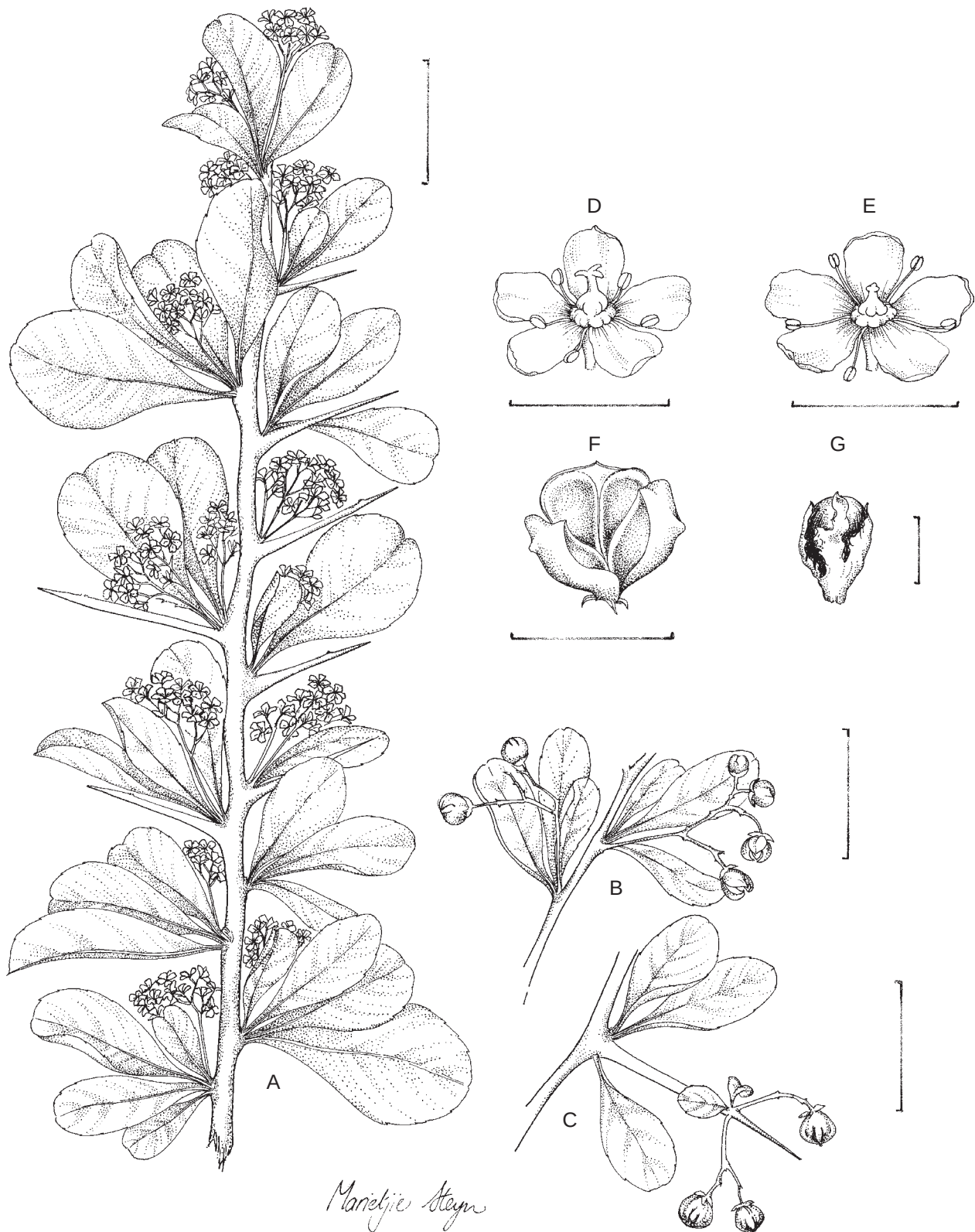


FIGURE 6.—*Gymnosporia hemipterocarpa*. A, flowering branch; B, C, fruiting branches; D, female flower; E, male flower; F, capsule, note wing-like ridges on upper half of valves; G, seed with aril. A, D, Edwards 2909 (PRE); B, F, G, Edwards 3299 (PRE); C, Edwards 2507 (NU); E, Compton 2640 (PRE). Scale bars: A, B, C, 20 mm; D, E, 4 mm; F, 5 mm; G, 2 mm. Artist: Marietjie Steyn.

are coriaceous and greyish green, giving the plant a greyish appearance. Furthermore, the inflorescences have dark reddish purple axes which contrast with the rest of the plant, and the capsules are small, dark red to purplish and half-ridged. It is related to species in what was previously referred to as the *Maytenus heterophylla*

complex (Robson 1965, 1966, 1994). Subsequently the complex has been resolved into several species, all now placed in the genus *Gymnosporia* (Wight & Arn.) Hook.f. (Jordaan 1995; Jordaan & Van Wyk 1999). The new species belongs to *Gymnosporia* section *Buxifoliae* Jordaan (Jordaan & Van Wyk 2006) by having seeds



FIGURE 7.—*Gymnosporia hemipterocarpa*. Leaves and fruit. Photograph: G. Nichols, taken from a plant growing in the Hluhluwe – iMfolozi Park.

with partially enclosed arils. It can be distinguished from the related and widespread *G. buxifolia* (L.) Szyszyl. in having subglobose, semi-ridged, smooth, dark red or purplish capsules (Figure 7). *G. buxifolia* has very small, globose, non-ridged, very rough, reddish or yellowish brown capsules. *G. hemipterocarpa* is also related to *G. devenishii* Jordaan, a species of Afromontane Forest with sulcate capsules from KwaZulu-Natal and the Transkei region of the Eastern Cape.

Gymnosporia hemipterocarpa can easily be confused with *G. glaucophylla* Jordaan which also has glaucous leaves. It can be distinguished from *G. glaucophylla* by having leaves which are always toothed in the distal part, whereas *G. glaucophylla* has often subentire leaves with only remnants of teeth on the margins. Both species have 3-valved capsules, but *G. glaucophylla* has smooth, subglobose, entire, reddish brown, non-ridged fruits.

Distribution and habitat: reported from the hot, arid, Mooi, Thukela, Mfolozi and Pongola River Valleys in KwaZulu-Natal and also from Swaziland (Figure 8). Plants grow on rocky hillsides in dense Valley Thicket (Lubke 1998: 16) in the Savanna Biome at altitudes of 0–600 m.

Etymology: the epithet is a compound of the Greek words, *hemipteron*, half-winged, and *carpos*, fruit, alluding to the half-winged pericarp of the capsule. Proposed

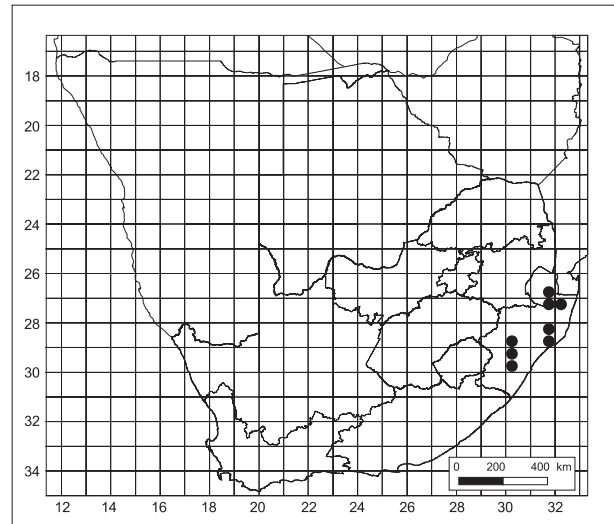


FIGURE 8.—Known distribution of *Gymnosporia hemipterocarpa*.

names for the species are: valley spikethorn and *val-leipendoring* in Afrikaans.

Other specimens examined

SWAZILAND.—2631 (Mbabane): Hlatikulu District, Sitobela, (–DC), Compton 26404 (NBG, PRE).

KWAZULU-NATAL.—2731 (Louwsburg): Ngotshe District, 6 miles [9.6 km] on Kosi-Pongola Weir road, (–BC), Edwards 3198 (PRE); Pongola Bosveldplaas, (–BC), Nel 41 (NH). 2732 (Ubombo): Ubombo District, 6 miles [9.6 km] W of Jozini Dam Village, (–AC), Edwards 2909 (NU, PRE). 2830 (Dundee): Thukela Ferry, (–CB), Galpin 14798 (PRE); Piet Retief Monument, Entonyaneni, (–CB), Gerstner 3580 (NH); Weenen Veld Reserve, (–CC), Acocks 10146 (NH, PRE); 1 km from Mudén, (–CC), Archer 350 (PRU); Blauwkrans River, (–CC), Pentz 214 (PRE); Umhlumbe Mountains, (–CC), West 1460 (PRE); Mudén Valley, (–CD), Edwards 2507 (NU, PRE); 4 miles [6.4 km] from Mudén to Greytown, (–CD), Edwards 2759 (PRE); 3 miles [4.8 km] from Mudén in Mooi River Valley, (–CD), Edwards 2784 (NU, PRE). 2831 (Nkandla): Umfolozi Game Reserve, (–BD), Edwards 3299 (PRE); 3 miles [4.8 km] W of Masimba, (–BD), Moll 5258 (NH, PRE); Umhlutzi Valley, (–DC), Lawn 567, 1470 (NH). 2930 (Pietermaritzburg): Umvoti District, Upper Huis River Valley, (–AB), Edwards 2810 (PRE); Richmond Road near Thornville, (–CB), Thompson 10 (NU). Without precise locality: bushveld of Black Umfolozi, Gerstner 3199 (NH).

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SELAGINELLACEAE

SELAGINELLA NUBIGENA, A NEW SPECIES FROM THE DRAKENSBERG, SOUTH AFRICA

In the southern African pteridophyte literature, the name *Selaginella imbricata* (Forssk.) Spring ex Decne. first appeared in the *Ferns of South Africa* (Sim 1915: 336, 337), but no collections were listed from South Africa. Alston & Schelpe (1952: 155) also list the species, but they too did not provide an indication or reference to any collections made in South Africa and/or Lesotho *per se*. The first supposed record of this plant south of the Zambezi River is a collection made on 12 December 1928 by E.E. Galpin at Devil's Hoek in the Royal Natal National Park, KwaZulu-Natal at $\pm 1\ 825$ m [6000'] (Letter by T.R. Sim to E.E. Galpin dated 26 December 1928 at PRE). Although the identity was [$\pm 1\ 825$ m] incorrect, the name for the Drakensberg plant was used by several authors (Jacobsen 1983; Schelpe & Anthony 1986; Burrows 1990; Roux 2001).

Jacobsen (1983: 145) found the high rainfall and disjunct distribution of the species in the Drakensberg puzzling, but never investigated the matter further.

The true *Selaginella imbricata* has a somewhat disjunct distribution, occurring in Arabia, Ethiopia, Eritrea, Somalia, Sudan, Kenya, Mozambique, Namibia, Zambia and Zimbabwe. Since the species occurs along the Namibian side of the Kunene River, it is expected that it may also occur in southern Angola. *S. imbricata* was erroneously reported for Swaziland by Roux (2003a, b). The unnumbered Chase collection listed in *Flora zambesiaca* (Jermy 1970: 26) reported to have come from the high-rainfall Vumba Mountains in eastern Zimbabwe, may be an erroneous location. Although occurring at altitudes ranging from 200 to 3 000 m, it is mostly associated with open woodland. In Eritrea and

TABLE 2.—Main morphological features distinguishing *Selaginella nubigena* from *S. imbricata*

Characters	<i>S. nubigena</i>	<i>S. imbricata</i>
Plant architecture	Primary and secondary stems creeping, unequally dichotomously branched	Primary stems erect, grouped along a creeping stolon, unequally dichotomously branched
Roots	Single root borne at each branching point along primary and secondary stems	Several roots borne at each branching point from stolon; primary stems rootless
Stolon leaves	Stolon absent	Radially arranged, isophyllous, brown
Primary stem leaves	Dorsolaterally arranged; leaves anisophyllous along entire length	Proximally isophyllous and radially arranged, higher up anisophyllous and dorsolaterally arranged
Lateral leaf shape and dimensions	Obliquely ovate, up to 2.2 x 1 mm	Broadly scimitar-shaped, erose, acroscopic convex half of leaf forms a broad wing, which is significantly thinner than basiscopic side of leaf, up to 3 x 1.8 mm
Distribution of stomata on lateral leaves	Adaxially with narrow band of stomata parallel to central vein in distal part of leaf; abaxially with narrow band of stomata parallel to vein extending from near leaf base to near leaf apex	Adaxially with narrow band of stomata parallel to central vein extending from leaf base to near apex; abaxially with narrow band of stomata parallel to vein extending from leaf base to near leaf apex
Median leaf shape and dimensions	Obliquely ovate, up to 2.3 x 0.9 mm	Inaequilaterally ovate to broadly scimitar-shaped, lacerate, up to 2.5 x 1.5 mm
Distribution of stomata on median leaves	Adaxially with narrow band of stomata along central vein extending from lower 1/3 of leaf to near apex; abaxially with broad central band of stomata extending from base to near apex	Adaxially with short and narrow band of stomata in upper 1/3 of leaf; abaxially with narrow central band of stomata extending from leaf base to near apex
Sporophyll shape and dimensions	Isophyllous, lanceolate to broadly ovate, weakly carinate, denticulate, up to 2 x 1.2 mm	Isophyllous, ovate, carinate, lacerate, up to 1.3 x 1 mm
Epidermal cell surface	Smooth	With 2 $\pm$ parallel rows of papillae

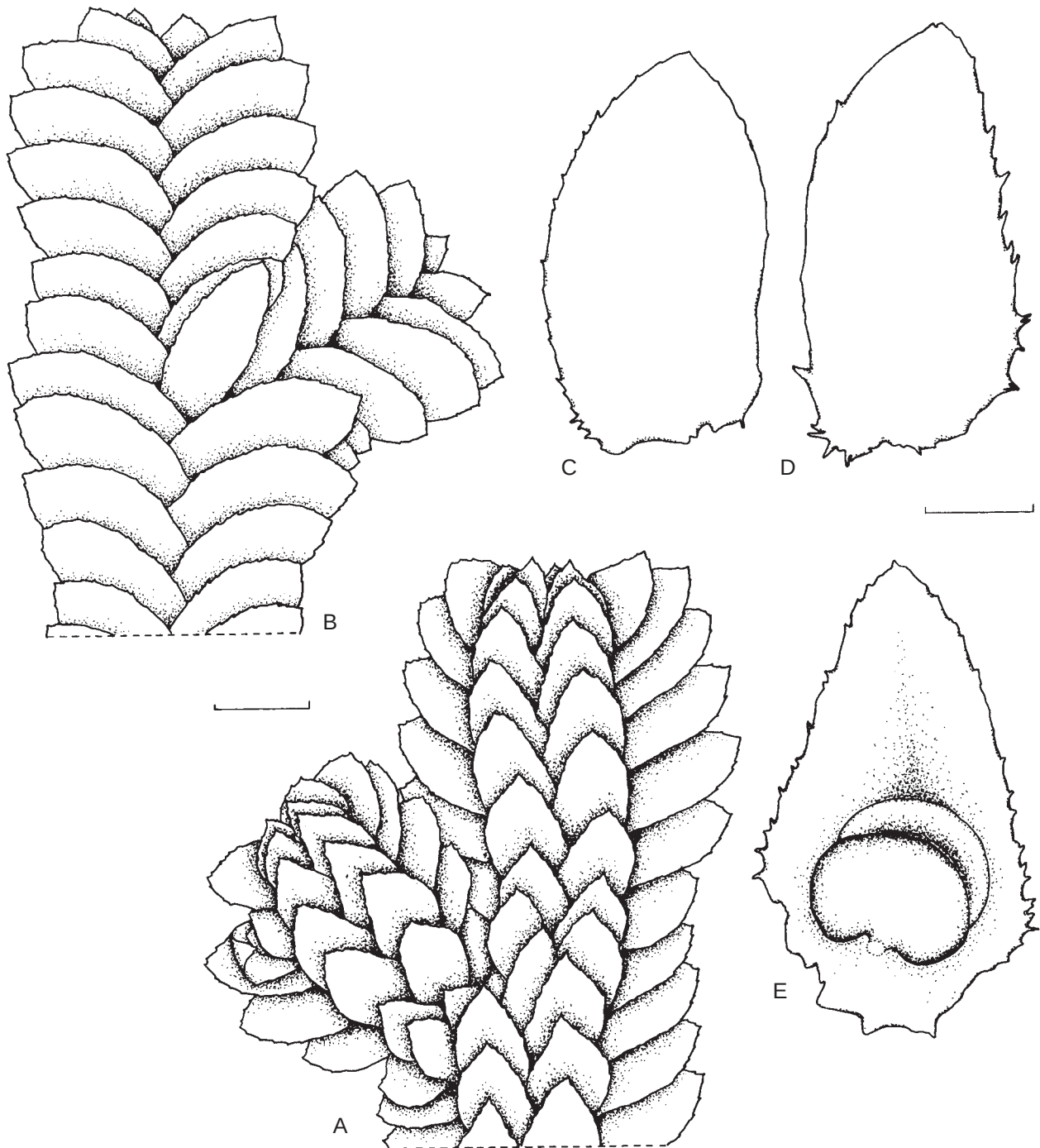


FIGURE 9.—*Selaginella nubigena*, Esterhuysen 30228. A, adaxial view of stem; B, abaxial view of stem; C, lateral leaf; D, median leaf; E, sporophyll. Scale bars: A, B, 1 mm; C–E, 0.5 mm. Artist: J.P. Roux.

Ethiopia it is chiefly associated with calcareous rocks, but elsewhere it appears to favour granite and basalt.

Selaginella imbricata is characterized by its miniature tree-like habit with 1–3 upright dorsoventrally flattened primary and lower order stems that are intermittently grouped along a creeping stolon, and roots that largely form at or near the branching points. The stolons and proximal stem parts are radially symmetric, and the appressed, scale-like leaves along the stolons and lower primary stem parts are without chlorophyll. These features are not exhibited by the Drakensberg plants and a close examination proved that it represents an as yet

undescribed *Selaginella* species, which until now, was erroneously ascribed to *S. imbricata*. This Drakensberg endemic is here described as *S. nubigena*, referring to its habitat which is regularly shrouded by clouds and mist. The distinguishing features separating *S. nubigena* from *S. imbricata* are listed in Table 2.

***Selaginella nubigena* J.P.Roux, sp. nov.**, a species aliis in regione caule repenti anisotomiter furcato foliis lateralibus medianisque imbricatis aliquantum obliquis ovatis coriaceis, foliorum medianorum margine proximali laciniato sed foliorum lateralium margine distali laciniato distinguitur.

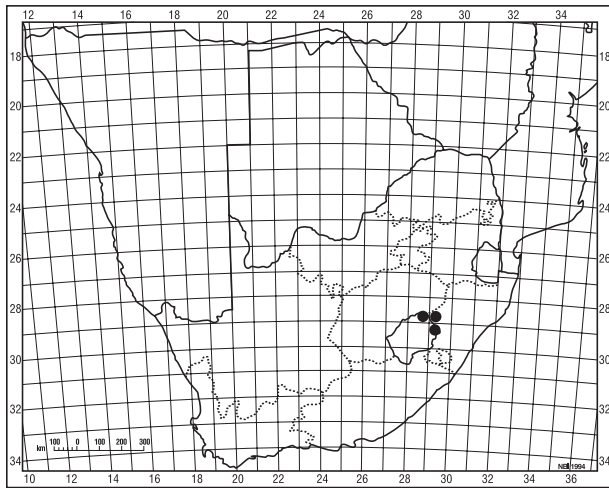


FIGURE 10.—Distribution of *Selaginella nubigena* in the Drakensberg.

The creeping, unequally dichotomously branched stem which has coriaceous, overlapping (imbricate), somewhat oblique ovate lateral and median leaves, separates *Selaginella nubigena* from other species in the region. The proximal margin of the median leaves is lacinate, whereas the distal margin of the lateral leaves is lacinate.

TYPE.—KwaZulu-Natal, 2828 (Bethlehem): Royal Natal National Park, on near vertical, much weathered, basalt cliff, NE aspect, along path up to ridge leading to The Sentinel, (–DB), 8000' [$\pm$ 2 430 m], 10 July 1963, *Esterhuysen* 30228 (BOL!, holo.; PRE!, iso.).

Plants epilithic. *Stems* creeping, terete, often slightly flattened adaxially, up to 1 mm diam., unequally dichotomously branched, anisophyllous, heterophyllous, a single root is borne laterally or abaxially at or near a branching point along stems. *Leaves* on older stems brown and often torn, closely imbricate and arranged in a dorsoventral plane; *lateral leaves* set at 30°–45° to stem axis, obliquely ovate to scimitar-shaped, up to 2.2 $\times$ 1 mm, basally truncate to near-truncate, forming a narrow erose collar, acute, bright green adaxially, drying matt green, greyish to greyish green abaxially, coriaceous, outer margin irregularly set with short outgrowths, often somewhat short-fimbriate near base, inner margin entire, but basally slightly folded inwards, clasping stem, and short-fimbriate, adaxially with a narrow band of stomata in distal part of leaf, parallel to central vein, abaxially with a narrow band of stomata parallel to vein extending from near leaf base to near leaf apex; *median leaves* set at 60° or more to stem axis, obliquely ovate, up to 2.3 $\times$ 0.9 mm, bright green adaxially, drying matt green, greyish green abaxially, coriaceous, basally truncate to near truncate, forming a narrow erose to short-fimbriate, acute, outer margin irregularly set with short outgrowths, proximal part infolded, clasping stem and short-fimbriate, inner margin irregularly short-fimbriate, adaxially with narrow band of stomata along central vein extending from lower $\frac{1}{3}$ of leaf to near apex, abaxially with broad central band of stomata extending from base to near apex; *ligule* near circular, erose. *Strobili* sessile, solitary at apex of secondary or lower order branches, up to 4 mm long, isophyllous; sporophylls in 4 ranks, coriaceous, peltate, weakly carinate, with narrow repand col-

lar proximally, irregularly serrulate, up to 2 $\times$ 1.2 mm. *Sporangia* sessile, isovalvate, reniform, up to 1 $\times$ 0.8 mm. *Megaspores* pale yellow, 4 per sporangium, colliculate. *Microspores* unknown. Figure 9.

Distribution and ecology: *Selaginella nubigena* is known from the northern parts of the Drakensberg escarpment only (Figure 10), growing in exposed or partially sheltered crevices and on narrow ledges of the predominant east-facing basalt cliffs at altitudes ranging between 1 825 and 3 100 m. The vegetation within this montane zone has been described as uKhahlamba Basalt Grassland (Mucina *et al.* 2006: 370). Precipitation within the zone measures $\pm$ 1 234 mm per annum and comes as summer rains (September to March), whereas several annual snowfalls may occur between April and August. The Drakensberg scarp is also regularly shrouded in mist and this contributes significantly to the annual precipitation. The mean annual day temperature within the region measures 11.6°C.

Conservation: plant populations occur along the high, mostly east-facing cliffs unaffected by human activity or pressure within well-managed nature reserves. The current IUCN classification recommended is Least Concerned.

Other material studied

KWAZULU-NATAL.—2828 (Bethlehem): Royal Natal National Park, Devil's Hoek, (–DB), 13-12-1928, *Galpin* CH3532 (PRE); Witsieshoek Reserve, near parking area, path to The Sentinel, (–DB), 15-01-1981, *Roux* 906 (NBG); Witsieshoek, on sheltered basalt ledges near summit, (–DB), *Schelpé* 7673 (BOL); Drakensberg, Inner Tower Ravine, (–DD), 16-07-1963, *Esterhuysen* 30234 (BOL, PRE); Royal Natal National Park, Devil's Tooth Gully, (–DD), 17-07-1963, *Esterhuysen* 30244 (BOL, PRE). 2829 (Harrismith): Bergville District, MnWeni area, outer MnWeni Needle, (–CC), 7-1962, *Esterhuysen* 29601 (BOL, PRE); Bergville, ridge leading to Cathedral Peak, (–CC), *Esterhuysen* 23028 (BOL); Bergville, Cathedral Peak area, north face of small peak next to The Bell, (–CC), *Esterhuysen* 29598 (BOL); Bergville, north ridge of Cathedral Peak overlooking Ntonjelane area, (–CC), 7-07-1974, *Esterhuysen* 33583 (PRE). 2929 (Underberg): Bergville District, The Turret and Amphlett, (–AB), 7-1957, *Esterhuysen* 26097 (BOL, NBG, PRE); Bergville, Umshlwazine, Cathedral area, (–AB), *Esterhuysen* 28510 (BOL).

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APONOGETONACEAE

APONOGETON FUGAX, A NEW SPECIES ENDEMIC TO THE CAPE FLORAL REGION, SOUTH AFRICA

The genus *Aponogeton* L.f. (Aponogetonaceae) comprises over 40 species of rhizomatous or tuberous, freshwater aquatics from Africa, Asia and Australia, nine of which are recorded in southern Africa (Van Bruggen 1998; Glen & Cook 2003; Cook 2005). For many years, just two species, the familiar *waterblommietjies* or pond blossoms, *A. angustifolius* Aiton and *A. distachyos* L.f., were known from the southwestern Cape, where they inhabit ponds, rivers and ditches at low and middle elevations. In 1983, however, Cape Town botanist Deidre Snijman collected an unidentified *Aponogeton* sp. from a vernal pool on the Bokkeveld Mountains in Northern Cape, South Africa. This attractive little species produces flowers with delicate, membranous tepals in dainty, floating inflorescences that bear a remarkable resemblance to those of *A. ranunculiflorus* Jacot Guill. & Marais, a species endemic to the Drakensberg of southern Lesotho and KwaZulu-Natal (Jacot Guillardmod & Marais 1972). This similarity in appearance led Goldblatt & Manning (2000) to identify the Bokkeveld material with *A. ranunculiflorus*, despite the significant disjunction between the two locations. Examination of fresh material of the Bokkeveld plants collected in the spring of 2007, however, revealed that the two are quite distinct.

Soon after the collection of fresh material from the Bokkeveld, a group of wetland ecologists working on biological monitoring in the southwestern Cape encountered an *Aponogeton* resembling *A. ranunculiflorus* in pools near Elim on the Agulhas Plain. These plants proved to match the Bokkeveld plants in all essential respects, thus extending the known range of the new species considerably. Subsequently, Cape Town botanist John Rourke mentioned that he had encountered what appeared to be the same species in a vernal pool on the West Coast near Philadelphia, some 20 km north of Cape Town, as long ago as 1976. A trip to this locality confirmed its occurrence there, and most recently biologist Nick Helme collected the species from a vernal pool near Darling.

This interesting new species is described here as *Aponogeton fugax*, in allusion to its delicate, short-lived flowers.

***Aponogeton fugax* J.C.Manning & Goldblatt, sp. nov.**

Geophyton aquaticum ex tubere globoso vel bilobo 10–15 mm diam., foliis 5 ad 8 submersis linearibus arcuatis vel sinuosis usque ad 600×0.8 –2.0 mm viridibus vel usitate aeneis, inflorescentia fluitanti bifida ex spicis binis utraque 4–5 mm longa 3(4)-flora, constante, spatha ampulliformi rostrata 10–12 mm longa, omnibus floribus fertilibus inodori, tepalis duobus inaequalibus albis ad basem colore ex carneo albis exteriore 5–7 mm diam., late ovato-cordato, interiore ± 1 mm diam., staminibus 4 suberectis, filamentis ± 2 mm longis ad basem connatis, antheris ± 1 mm longis, carpellis 2 subglobosis 2-ovulatis, stylo erecto vel suberecto ± 1.5 mm longo, folliculis anguste ellipsoideo-fusiformibus 5 – 7×2 mm, seminibus 2 in quoque folliculo fusiformibus 4.5–5.5 mm longis laevis nitidisque.

TYPE.—Western Cape, 3419 (Caledon): Farm Modderlei southwest of Elim, pond on southern edge of Bredasdorp road just west of Voëlvei homestead, (–DB), 28 September 2007, Manning & K. Roux 3114 (NBG, holo.; K, MO, PRE, iso.).

Aquatic geophyte. *Tuber* globular, or bilobed and testicular, 10–15 mm diam., pale brownish. *Leaves* 5–8, submerged, arching or sinuose, linear, elliptical in section, up to 600×0.8 –2.0 mm, leathery, aerenchymatous, pale green or more usually bronze-coloured. *Inflorescence* floating, forked, forming 2 opposed spikes, each 4–5 mm long, 3(4)-flowered; peduncle filiform, widening slightly below inflorescence, up to 800 mm long, elastic. *Spathe* flask-shaped with elongate beak, completely enclosing young inflorescence, 10–12 mm long, operculate, basally circumscissile, caducous. *Flowers* unscented, dorsal and subsecond, alternate, all fertile; tepals 2, very unequal, rotund or broadly ovate-cordate, cucullate, membranous, translucent white flushed pinkish at base, evanescent, outer tepal largest, 5–7 mm diam. in lowermost flower but decreasing in size acropetally and up to 4 mm diam. in uppermost flower, inner tepal scale-like, ± 1 mm diam. *Stamens* 4, suberect; filaments connate basally, subterete, ± 2 mm long, translucent white; anthers ± 1 mm long at dehiscence.



FIGURE 11.—*Aponogeton fugax*, Manning & Goldblatt 3105 (NBG). A, flowering and fruiting plant; B, spathe; C, inflorescence; D, flower; E, gynoecium; F, follicles; G, seed. Scale bar: A, 10 mm; B–D, F, 2 mm; E, 0.75 mm; G, 1 mm. Artist: J. Manning.

cence, brownish green; pollen yellow. *Carpels* 2, subglobose, 2-ovulate; style erect or suberect, ± 1.5 mm long. *Follicles* narrowly ellipsoid-fusiform, $5\text{--}7 \times 2$ mm with straight beak $1.5\text{--}2.0$ mm long, 2-seeded, thin-textured. *Seeds* fusiform, $4.5\text{--}5.5$ mm long, yellowish brown, smooth and shining. Flowering time: (late July) August–September. Figure 11.

Distribution and ecology: *Aponogeton fugax* is known from several scattered locations in the southwestern Cape

(Figure 12): from vernal pools on the Farms Avontuur and Willemsrivier on the Bokkeveld Mountains near Nieuwoudtville in Northern Cape; from two vernal pools on the West Coast north of Cape Town in Western Cape; and from several temporary and permanent waterbodies that form part of the drainage basin of the Uintjieskuil and Nieuwejaars Rivers on the Agulhas Plain southeast of Elim. Plants grow in silt or clay in shallow water, about 10 cm deep on the Bokkeveld but up to 120 cm deep on the West Coast and Agulhas Plain, with the leaves

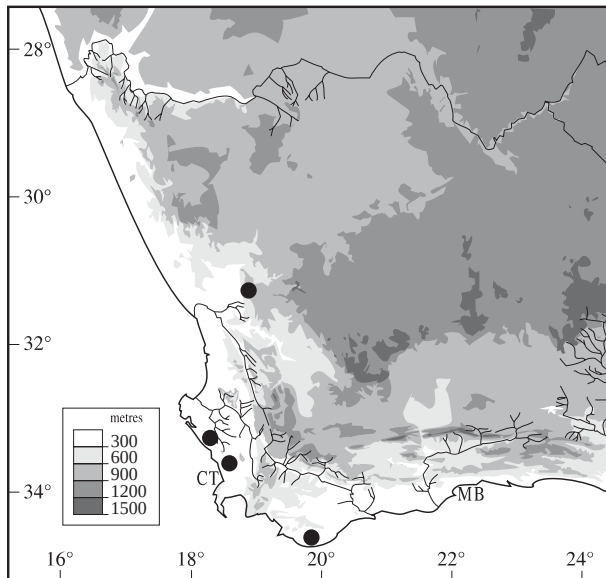


FIGURE 12.—Known distribution of *Aponogeton fugax*.

completely submerged and trailing. The Bokkeveld and West Coast plants, and those in Waskraalvlei near Elim grow in waterbodies that dry out completely as soon as two months after flowering, whereas in Uintjieskuil the plants form part of a permanent aquatic community in a deep waterbody over one metre deep. The scattered distribution of *A. fugax* is closely matched by the small, annual, hygrophilous grass genus *Prionanthium* Desv., with a single species each endemic to the Bokkeveld Escarpment, the West Coast, and the Cape Flats and Overberg (Davidse 1988).

The inflorescence of *Aponogeton fugax* floats on the surface of the water, with the outermost tepals of the lowermost flower on each of the paired spikes acting as buoyancy floats, one on each side. The tepals in the Bokkeveld population are especially delicate and surface tension spreads the lower two tepals out flat on the water surface, whereas in the southern populations all the tepals remain suberect and the inflorescence is thus $\pm$ cupped. The flimsy tepals do not persist in fruit and the infructescence sinks to the bottom as it matures.

Aponogeton fugax occurs in several different aquatic plant communities, in many instances in the company of other narrow Western Cape endemics. On the Bokkeveld it is found together with *Spiloxene aquatica* (Hypoxidaceae) and *Romulea multisulcata* (Iridaceae), and on the West Coast it occurs with *Cadiscus aquaticus* (Asteraceae) and *Crassula natans* (Crassulaceae). On the Agulhas Plain, *A. fugax* is known from at least four localities. At the type locality, the species grows together with *Crassula natans*, *Limosella grandiflora* (Plantaginaceae) and *Aponogeton distachyos*; further south in Waskraalvlei it grows in shallow water on clay in a dense population of the aquatic sedge *Isolepis striata*; on the Uintjieskuil farm it has been found in a small farm dam together with *Nymphoides thunbergiana* (Gentianaceae), species of *Potamogeton* (Potamogetonaceae) and *Oxalis natans* (Oxalidaceae), the latter a range extension for this rare species; and in the Melkbospan area it was found in temporary water between tussocks of *Chondropetalum tectorum*

(Restionaceae), *Eragrostis plana* (Poaceae) and *Eleocharis limosa* (Cyperaceae). It appears therefore that the species has a relatively wide ecological range, from temporary to permanent water, and on various substrates, from limestone to ferricrete to shales.

The delicate, short-lived flowers and submerged leaves raise the possibility that careful examination of other vernal pools along the West Coast, such as those around Hopefield, may reveal additional populations of *Aponogeton fugax*. We have, however, failed to locate any early collections of the species in BOL or SAM, where we would have expected to find evidence of the species from the Cape Peninsula and surrounding Cape Flats should it ever have occurred here in view of the extensive holdings in these herbaria of aquatics from Isoetesvlei and other vernal pools on the Flats. We therefore conclude that *A. fugax* did not grow on the Peninsula and surrounding Cape Flats in historical times.

Small differences between the known populations suggest that they have been isolated for some time. The Agulhas plants have narrower leaves, at most up to 1 mm wide, slightly firmer tepals that remain suberect, and styles that are erect and parallel. The leaves of the Bokkeveld plants are broader, up to 2 mm wide, the tepals are very membranous, such that the lowermost are drawn onto the water by surface tension, and the styles are divergent. The West Coast plants are similar to those from the Bokkeveld, with leaves up to 2 mm wide and flowers with slightly divergent styles. These morphological differences between the southern and western populations indicate that they have been isolated from one another long enough to have diverged genetically. The morphological differences between the populations are consistent with either long-distance dispersal or with vicariance events. Considerably greater areas of the coastal plains were exposed during lower sea levels during Pleistocene glaciations, and the concomitant cooler climates would almost certainly have resulted in more temporary pools than persist today, providing a greater number of suitable habitats for the species than currently available, as well as continuity between the western and southern populations.

Agricultural transformation of the Western Cape lowlands places this species at high risk and only some of the Bokkeveld locations are currently conserved.

Diagnosis and relationships: *Aponogeton fugax* is a very distinct species in the genus, characterized by its long, shoelace-like leaves and short, paired spikes bearing three (rarely four), subsecund flowers in two rows on the adaxial side. Each flower has two, very unequal, membranous tepals, four stamens, and two, bi-ovulate carpels. *A. fugax* is the only species of *Aponogeton* known in which this reduction in stamens and carpels has been observed (Cook 2005), and the reduced numbers of stamens and carpels, together with the anisopetalous perianth, are significant autapomorphies for the species.

The bifid spikes and second, distichous flowers with spreading tepals longer than the stamens are unusual in the genus but are shared with the other two southern African winter rainfall species, *Aponogeton angus-*

tifolius and *A. distachyos* (Obermeyer 1966), and the second flowers in particular suggest a relationship with them. Both of these species, however, have leaves with floating blades, $\pm$ fleshy tepals, and six or more stamens per flower. In addition, the seeds of these two species are characterized by a distinctive, spongy testa, whereas the seeds of *A. fugax* are smooth, like those of other species in the genus.

Although the dainty, floating inflorescence with membranous tepals of *Aponogeton fugax* bears a striking superficial resemblance to that of *A. ranunculiflorus* from tarns on sandstone in the high southern Drakensberg of KwaZulu-Natal and Lesotho, the two species differ in their vegetative morphology and in fundamental details of their inflorescence and flowers. The leaves of *A. ranunculiflorus* are fusiform, 3.5–4.0 mm in diameter and only 50–100 mm long; the simple, highly condensed spike comprises heteromorphic flowers, with the lower sterile and reduced to solitary tepals, the central flowers with paired, equal tepals, and the uppermost flowers lacking a perianth. The fertile flowers have 6 stamens and 3 carpels each, and the follicles are globose and $\pm$ 2 mm in diameter. The congested, heteroflorous spike of *A. ranunculiflorus* and the globose follicles are evidently autapomorphies for the species. The spirally inserted flowers of *A. ranunculiflorus* preclude any direct alliance with *A. fugax* and its relationships appear to lie rather among other species with spirally inserted flowers, notably *A. stuhlmannii* Engl. and *A. vallisnerioides* Baker (Jacot Guillarmod & Marais 1972). The congruence in the appearance of the inflorescence between *A. fugax* and *A. ranunculiflorus* is remarkable but the numerous fundamental differences in inflorescence form, floral insertion, and structure of the flowers themselves indicate that it is best interpreted as the result of convergent evolution and not as an indication of close affinity.

Additional specimens examined

Aponogeton fugax

NORTHERN CAPE.—3119 (Calvinia): Farm Meulsteenvlei [Willemsrivier], west of Nieuwoudtville, (–AC), 7 September 1983, *D. Snijman* 749 (NBG); Farm Willemsrivier, west of Nieuwoudtville, vernal pool alongside R27, 800 m, (–AC), 23 September 2007, *Manning, Goldblatt & L.J. Porter* 3105 (NBG, MO); northeastern edge of Kromvlei on Farm Avontuur 641, 15 km NW of Nieuwoudtville, (–AC), 5 August 2008, *Helme* 5520 (NBG); large pan on Farm Inhoek 637, (–AC), 5 August 2008, *Helme* 5521 (NBG).

WESTERN CAPE.—3318 (Cape Town): Darling, seasonal pan 0.3 km E of Darling Golf Course, (–AD), 22 July 2008, *N.A. Helme* 5517 (NBG); Philadelphia, Farm Tierhoogte, pool on western edge of N7 opposite farm entrance, (–DA), 2 October 2007 [sterile], *Manning & Rourke* 3115 (NBG).

Aponogeton ranunculiflorus

LESOTHO.—2929 (Underberg): Sehlabathebe National Park, Matsa a Mafikeng, 2 450 m, (–CC), *F.K. Hoener* 2150 (NU); Sehlabathebe National Park, 2 250 m, (–CC), 17 January 1983, *G.C. Matthews* 981 (NBG).

KWAZULU-NATAL.—2929 (Underberg): within $\frac{3}{4}$ km of Lesotho border at Sehlabathebe National Park, down from the Devil's Knuckles, (–CC), 14 January 1979, *F.K. Hoener* 2164 (NU); vicinity of Tarn Cave above Bushman's Neck, 8000 ft [2 400 m], (–CC), 21 November 1983, *Hilliard & Burt* 16824 (NU).

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Diversity and species turnover on an altitudinal gradient in Western Cape, South Africa: baseline data for monitoring range shifts in response to climate change

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Keywords: Fynbos-Succulent Karoo ecotone, long-term monitoring, Sandstone Fynbos, Shale Renosterveld, species-environment relationships

ABSTRACT

A temperature and moisture gradient on the equator-facing slope of Jonaskop on the Riviersonderend Mountain, Western Cape has been selected as an important gradient for monitoring the effects of climate change on fynbos and the Fynbos-Succulent Karoo ecotone. This study provides a description of plant diversity patterns, growth form composition and species turnover across the gradient and the results of four years of climate monitoring at selected points along the altitudinal gradient. The aim of this study is to provide data for a focused monitoring strategy for the early detection of climate change-related shifts in species' ranges, as well as gaining a better understanding of the role of climate variability in shaping species growth responses, their distributions, and other ecosystem processes.

INTRODUCTION

The vegetation of mountain ranges of the Cape Floristic Region (CFR) is characterized by gradients of high species turnover. These gradients are associated with increasing precipitation and lower temperatures with increasing elevation, as well as edaphic diversity (Goldblatt 1997). The vegetation of Cape mountain ranges within the CFR is dominated by fynbos (Mucina & Rutherford 2006). However, in inland intermontane valleys in the Western Cape interior, fynbos is replaced by Succulent Karoo, an arid shrubland, at lower elevations with an ecotonal zone in between, called renosterveld (Cowling & Holmes 1992).

Ecotones, or areas of transition between distinct biomes or vegetation types, have been pointed out as important areas for monitoring the effects of global climate change (Kupfer & Cairns 1996). Modelling of future climate scenarios for the Western Cape indicates that large areas of fynbos will be subjected to warmer and drier climate conditions similar to what is currently associated with Succulent Karoo, and that vegetation shifts might take place resulting in a loss of distribution area of fynbos due to a southward shift of Succulent Karoo (Rutherford *et al.* 2000). Therefore vegetation gradients incorporating transitions between fynbos and Succulent Karoo are important areas to monitor for the early detection of climate change-induced biome shifts.

The elevational gradient on the equator-facing slope of Jonaskop, one of the highest peaks in the Rivier-

sonderend Mountains, Western Cape, has been identified as a key site for monitoring the effects of climate change on fynbos and the Fynbos-Succulent Karoo boundary. On the equator-facing foothills of Jonaskop, fynbos vegetation type FFs13, North Sonderend Sandstone Fynbos, intersects with Succulent Karoo vegetation type SKv7, Robertson Karoo (Mucina & Rutherford 2006) through a renosterveld ecotone. The Jonaskop gradient has been described in terms of vegetation biomass turnover (Rutherford 1978), but no formal description of the plant communities or of species diversity turnover on the gradient has been done to date. Other studies conducted at the site include investigations into *Protea* species and classic rodent pollinator interactions (Rourke & Wiens 1977; Wiens *et al.* 1983; Fleming & Nicolson 2002a, b), including rodent diets and metabolism (Johnson *et al.* 1999; 2004; 2006); a comparative study between nectar qualities of Cape and Australian Proteaceae (Nicolson & Van Wyk 1998); seed dispersal by small mammals (Midgley & Anderson 2005); lizard foraging behaviour (Cooper *et al.* 1999); leaf functional classification of a number of species in a Mediterranean context (Vile *et al.* 2005); xylem traits in relation to water stress tolerance (Jacobsen *et al.* 2007); plant phenophase responses to climate (Agenbag *et al.* 2004a); how biome boundaries might respond to climate change (Agenbag *et al.* 2004b, c); and sampling for vegetation structural changes as part of a biome-wide study (Campbell 1985). These studies mark Jonaskop as an important site for ecological research that would benefit greatly from a formal description of the biotic and abiotic environment.

The aim of this paper, therefore, is to describe the Jonaskop gradient in terms of its vegetation changes, species turnover, soil chemistry and climate and to serve as a source of reference for future monitoring.

MATERIAL AND METHODS

Study area

The Riviersonderend Mountain is situated on the western end of a chain of east-west trending moun-

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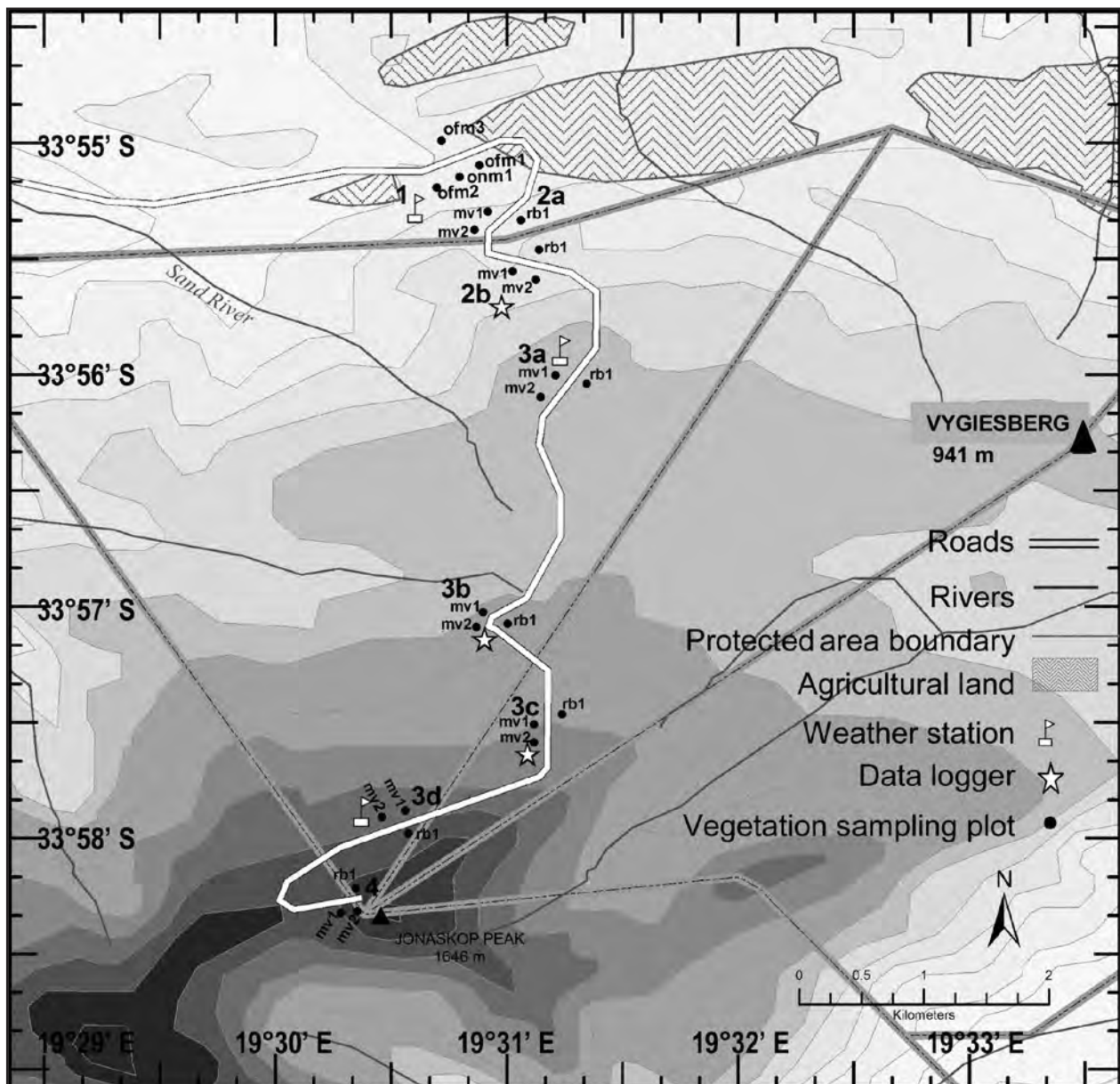


FIGURE 1.—Topographical map of study site indicating location of weather stations, data loggers and vegetation sampling plots. Contours represent 100 m intervals. 1, Karoo/ Renosterveld site, 545 m. 2, low-altitude fynbos sites: 2a, 690 m; 2b, 744 m. 3, mid-altitude fynbos sites: 3a, 953 m; 3b, 1 044 m; 3c, 1 196 m; 3d, 1 303 m. 4, high-altitude fynbos site, 1 576 m. Vegetation plot codes: onm, plot on *heuweltjie* or mima-like mound; ofm, plot in renosterveld/Karoo matrix vegetation; rb, plots in recently burnt fynbos vegetation; mv, plots in mature fynbos vegetation. GIS data provided by CapeNature, Department of Land Affairs: Surveys and Mapping, and the Department of Agriculture.

tain ranges at the southern edge of the Cape Fold Belt. Jonaskop, 33°58'00 S 19°30'00 E, altitude 1 646 m (Figure 1) is located within the Riviersonderend Mountain Catchment—a protected area that is managed by CapeNature as an important water source to the Riviersonderend River below the southern slopes and the Breede River towards the north. The protected area is bordered by privately owned agricultural land. A service road leading up to a Sentech radio mast on the mountain summit provides access to the equator-facing slope of Jonaskop.

The Jonaskop gradient spans a change of roughly 1 200 m in elevation between foothills in the Breede River Valley and Jonaskop Peak. Whereas the south-facing slope of Jonaskop is extremely steep, the equator-facing slope rises somewhat less rapidly, except for a flattened 'step' in the middle of the gradient, at ± 900 m.

Several drainage lines leading down from the northern slope converge in the Sand River, which at ± 400 m is the lowest point of the gradient. This small stream joins the Doorn River, a tributary of the Breede River, further down the valley.

Soils on the mountain are shallow and very rocky. The coarse, grey, sandy soils of the mountain slope are derived from quartzitic sandstone of the Table Mountain Group. At the foot of the mountain (below 600 m) soils are finer grained and less rocky compared to those of the Table Mountain Group. Here the geology is alternating bands of arenaceous shale and argillaceous sandstone from the Bokkeveld Group (Besaans 1966).

Vegetation changes from Succulent Karoo at the very lowest elevations (± 500 – 600 m) through an ecotonal area of renosterveld with succulent as well as fynbos ele-

ments (roughly around 600–800 m), to fynbos from 800 m upwards. The boundary between the Succulent Karoo and ecotone coincides with the transition from shale-derived to sandstone-derived soils.

Ecotonal and fynbos vegetation on either side of the road leading to the top of the mountain differs in fire history: with few exceptions, one side burned fairly recently (2000), whereas on the other side, mature vegetation has established after the last fire in 1992.

Climate monitoring

Climate change monitoring and experimental stations have thus far been placed at six sites along the length of the gradient (Figure 1). Weather stations (Watchdog Model 600 Weather Station 3325WD), recording air temperature, relative humidity, rainfall, soil moisture and wind speed and direction, are situated at the top (1 303 m), middle (953 m) and lowest (545 m) end of the gradient, whereas data loggers (Watchdog 450 Relative Humidity/Temperature Data Logger) record relative humidity, air temperature and soil moisture at the intermediate sites (1 196 m, 1 044 m, 744 m). Weather stations have been recording climate continuously since February 2002 (with some breaks at all stations from time to time due to equipment malfunction and damage, e.g. from rodent gnawing on exposed cables. Where such breaks occurred, data were interpolated from adjacent or nearby weather stations assuming average air temperature lapse rates or average annual altitude-related rainfall trends). Readings are taken automatically every 30 minutes. Climate data were analysed to show patterns in temperature, rainfall and wind conditions across the gradient.

Soil analysis

Soil samples were taken at each of the monitoring sites along the gradient and analysed for P, Ca, Mg, K, Na, N and pH according to standard methods: to analyse for P, a 5 g sample was added to 50 ml 1 % citric acid solution. To an aliquot of the clear and colourless extract was added an acidified ammonium molybdate solution. The phosphomolybdate complex was then reduced with stannous chloride and the absorbance of the resulting blue colour measured with a spectrophotometer and compared with the absorbances obtained from standard phosphorus. To analyse for N, a known mass of soil was digested with sulphuric acid using selenium as a catalyst. The resultant ammonia was distilled into a saturated boric acid solution and titrated with standard acid. Macro elements (Ca, Mg, Na, K) were determined by measuring a 1 mol dm⁻³ ammonium acetate extraction by atomic absorption against known standards.

Field sampling methods

For the vegetation analysis, two more sites were added to the existing climate monitoring stations: one on the lower sandstone slopes of the ecotonal zone (690 m), and another one near the mountain summit (1 576 m). Vegetation sampling was done in October and November 2003. Relevés of 10 × 10 m were used, with two relevés located in mature vegetation and one in recovering vegetation at each site. Species were scored following the Braun-Blanquet cover-abundance scale (Braun-Blanquet

1928). At the Succulent Karoo site, at the lowest end of the gradient (545 m), a relevé was added to include sampling of vegetation on nutrient-enriched *heuweltjies* or mima-like mounds usually found in association with termitaria in this region (Esler & Cowling 1995).

Environmental characteristics noted at each relevé included slope, aspect, percentage rock cover, soil type and soil depth. Soil depth was determined up to 0.5 m deep at 10 points at regular intervals across one diagonal of each relevé. Soil depth for each relevé was then expressed as a range from shallow to deep, with depths of more than 0.5 m indicated by 0.5 m+.

Data analysis

Species data were assembled into a phytosociological table and sorted according to constancy and affinity to determine plant communities and their characteristic species. Braun-Blanquet scores were then converted to percentage cover values for the calculation of species diversity (See Table 1 for conversion values). The diversity of each relevé was calculated according to the Shannon-Wiener Index (Kent & Coker 1994) with the formula:

$$\text{Diversity } H' = - \sum_{i=1}^s p_i \ln p_i$$

where *s* is the number of species, and *p_i* is the proportion of the *i*-th species to the total vegetation cover. Diversity values of the relevés of each site were then averaged to arrive at a diversity estimate for each site. Within-site comparisons of diversity between recently burned and mature vegetation were also done for all sites except the karoo site (545 m), which did not burn.

All sampled species were classified according to growth form. Growth forms were assigned according to a scheme adapted from Cowling *et al.* (1994) (Table 2). The contribution of each growth form to total vegetation cover in each relevé was calculated by summing converted percentage cover values of all species belonging to each growth form, and expressing it as a proportion of total vegetation cover. Site specific growth form composition was then calculated by averaging cover values of the relevés of each site. Comparisons of growth form composition between recently burnt and mature vegetation were done for all sites except the lowest karoo site (545 m). Relevés of mature vegetation of all sites were lumped, and the average growth form composition was

TABLE 1.—Conversion of Braun-Blanquet scores to percentage cover values

Braun-Blanquet	Converted % cover
O	
R	1
+	1
1	3
2M	4
2A	8.5
2B	19
3	39
4	63
5	88

TABLE 2.—Categorization of growth forms, adapted from Cowling *et al.* (1994)

Main groups	Code	Subgroups
Herbs	AH	Annual herb
	PH	Perennial herb
	HV	Herbaceous vine
	PHP	Perennial herb, parasite
Dwarf shrubs (< 0.25 m)	DES	Dwarf evergreen shrub
	DSP	Dwarf shrub, parasite
Low shrubs (0.25–1 m)	LES	Low evergreen shrub
	LSP	Low shrub, parasite
Mid-high shrubs (1–2 m)	MES	Mid-high evergreen shrub
Succulents	DSS	Dwarf succulent shrub, < 0.25 m
	LSS	Low succulent shrub, 0.25–1 m
	PHS	Perennial herb with succulent leaves
	SP	Succulent parasite
Geophytes	GEO	
Graminoids	GRA	Includes all grasses, sedges and restios

compared with the average composition of all recently burnt relevés across the gradient.

Similarity of species composition of different sites were compared using Jaccard's coefficient (Kent & Coker 1994). The formula is:

$$S_j = \frac{a}{a + b + c}$$

where S_j is the Jaccard similarity coefficient, a is the number of species common to both sites compared, b is the remaining number of species present at the first site, and c is the remaining number of species present at the second site. S_j was multiplied by 100 to arrive at a percentage similarity. The average turnover rate across the gradient was determined according to the methods of Itow (1991). Log percentage similarity between every pair of sites (on y-axis) was plotted against their difference in altitude (on x-axis). The slope of the regression line fitted is taken as the average turnover rate of species per 1 m altitudinal difference.

RESULTS AND DISCUSSION

Temperature

Temperatures decrease with increasing altitude (Barry 1992); however, the rate at which temperatures decrease can vary spatially as well as seasonally (Rolland 2003). On Jonaskop, there is an average difference of 4.4°C between the highest (1 303 m) and lowest site (545 m) on the gradient (Table 3). Temperatures along this gradient generally decrease by 0.58°C with every 100 m altitude gained, as indicated by the slope of a regression line fitted to mean annual temperatures recorded at each of the monitoring sites (not shown). However, diurnal and seasonal temperature lapse rates on the mountain slope vary between -0.40°C.100 m⁻¹ for winter minimum temperatures (April to September) and -0.77°C.100 m⁻¹ for summer maximum temperatures (October to March) (Figure 2). This is consistent with patterns found in mountainous regions elsewhere (Rolland 2003 and ref-

erences therein). Complex factors contribute to seasonal and diurnal variation in lapse rates. These include wind regime, cloud cover, amount of incoming solar radiation and the moisture content of the air (Barry 1992) and it is therefore difficult to explain the variations observed on Jonaskop without detailed analysis of other meteorological patterns.

It should be noted that the middle site (953 m) is somewhat colder than the site directly above it (1 044 m) (Table 3). This effect is particularly strong at night during winter (Figure 2), when mean minimum temperatures recorded at the site are on average 1.6°C colder than the expected trend. Such local temperature inversions are generally the result of cold air drainage, and are often observed in valley bottoms (O'Hare *et al.* 2005). The fact that the middle site is located on a plateau probably results in cold air flowing downwards from the steeper slopes above and collecting at this site during the long winter nights.

Monthly mean temperature summaries indicate that August is the coldest month at the site (Figure 3), with mean minimum temperatures ranging from 3.3–6.9°C between the highest and lowest monitoring points. Highest temperatures were recorded during February, when daily maximum temperatures are on average around 30°C at the karoo site (545 m) at the lowest end of the gradient.

Rainfall

During three years of climate recording (2002–2004), the highest site (1 303 m) received an average of 719.6 mm annual precipitation, the middle site (953 m) 411.3 mm and the bottom karoo site (545 m) 315.4 mm. The highest site receives on average a slightly lower proportion of its annual rainfall in winter (Table 3, Figure 4). Higher summer rainfall at the highest site is possibly due to orographic effects, with southerly winds pushing clouds over the mountaintop and bringing rain to the highest site but not to lower sites. According to Aschmann (1973), Mediterranean climates are defined by winter rainfall constituting at least 65 % of the annual rainfall. The proportions of winter rainfall recorded across the Jonaskop gradient, which ranges from 57–66 %, therefore indicates that the study site does not fall within the strictly winter rainfall zone of the CFR. Long-term rainfall data for the Riviersonderend Mountain confirm that many large rainfall events, associated with post-frontal cut-off lows occur in summer, resulting in the

TABLE 3.—Summary of temperatures and mean annual precipitation (MAP) recorded at different altitudes on Jonaskop elevational gradient

Altitude (m)	MAT (°C)	Tmin (°C)	Tmax (°C)	MAP (mm)	% Winter
545	16.5	6.9	30.2	315.4	62
744	15.7	6.7	29.3	nr	nr
953	13.6	3.6	27.4	411.3	66
1044	14.0	4.7	27.0	nr	nr
1196	12.9	4.1	25.2	nr	nr
1303	12.1	3.3	24.6	719.6	57

MAT, mean annual temperature; Tmin, mean minimum temperature of coldest month; Tmax, mean maximum temperature of warmest month; % Winter, proportion of total MAP recorded during winter (April–Sep.); nr, not recorded.

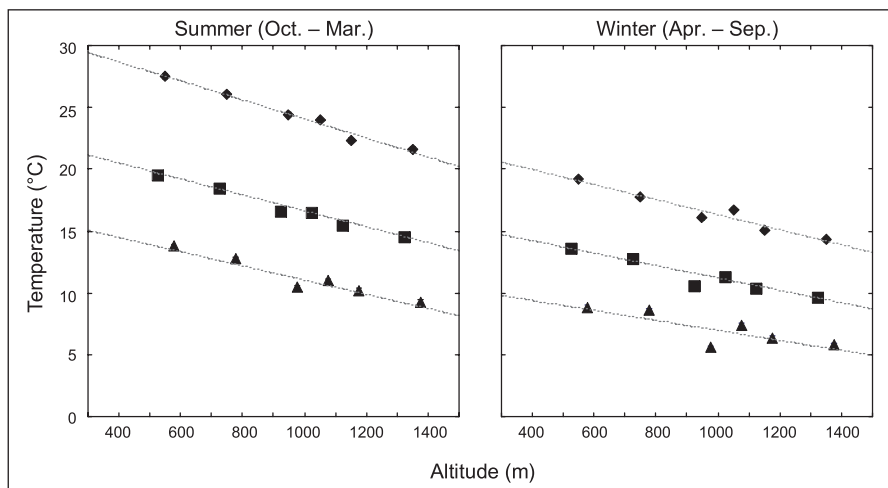


FIGURE 2.—Plot of mean daily temperatures, ■; mean daily maximum temperatures, ◆; and mean daily minimum temperatures, ▲, against altitude, showing seasonal variation in temperature decreases with increasing altitude.

area not being subjected to as severe summer droughts as elsewhere in the CFR (R.M. Cowling pers. comm.).

Monthly rainfall patterns recorded during three years of this study were very variable (Figure 5). The year 2002 had good winter rains and a relatively dry summer. The high monthly total precipitation of March 2003 was due to a single extreme rainfall event on 24 March when 174.5 mm was recorded at the highest site (1 303 m) and 103.9 mm at the lowest site (545 m). Year 2003 was an extremely dry year throughout the whole Western Cape, and the low rainfall, especially during the winter months, is reflected in the data from Jonaskop. Although 2004 had, in total, a much higher annual precipitation, it also had a very dry winter, with most of the annual precipitation recorded during October.

Cowling *et al.* (2005) highlighted the importance of rainfall reliability in terms of interannual variation in rainfall, as well as the size and structure of rainfall events, as a driver of plant traits in Mediterranean ecosystems. Rainfall data recorded at Jonaskop were, therefore, further analysed to explore seasonal pat-

terns in the size, duration and frequency of rainfall events. Whenever rain was recorded on a number of consecutive days, rainfall recorded over the period was added together as a single rainfall event. Cowling *et al.* (2005) also mentioned the importance of the regularity of rainfall events in Mediterranean climates, especially with regard to the germination of seedlings. Mustart & Cowling (1993) showed that the duration of dry periods between rainfall events is an important factor determining the successful germination of Proteaceae seeds, and that rainfall patterns during germination stages have a large impact on the distribution patterns of Proteaceae populations observed in the field. Therefore a frequency analysis of the number of days between rainfall events was also done.

At all sites, rainfall events occur most often as small (< 5 mm) events lasting only one day (Figure 6). This trend was observed during winter and summer. However, larger rainfall events (> 10 mm), and events lasting longer than two days occur much more frequently in winter than summer at all sites. In terms of the duration of dry periods between rainfall events, patterns are more diver-

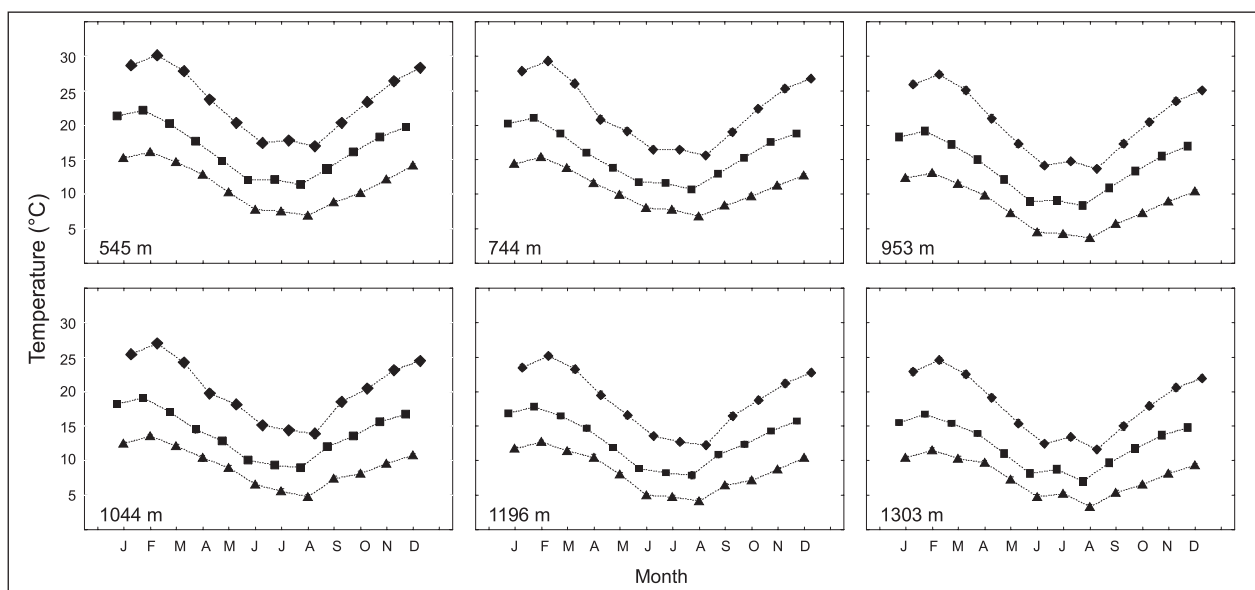


FIGURE 3.—Monthly mean daily, ■; mean daily maximum, ◆; and mean daily minimum, ▲, temperatures recorded at six sites across gradient. Numbers in lower left corner of graphs indicate altitude at which temperatures were recorded.

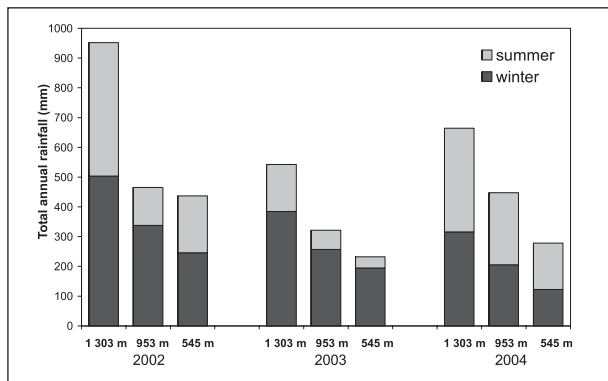


FIGURE 4.—Total annual rainfall (April to March) recorded at top (1 303 m), middle (953 m) and lower (545 m) monitoring points on Jonaskop gradient. Total annual rainfall is split into winter rainfall season (April to September) and summer growth rainfall season (October to March).

gent among sites and seasons. At the highest site (1 303 m), rainfall events were most often separated by less than four days during winter and summer. At the middle site (953 m), the winter rainfall events in contrast, are far more frequently within four days of each other than in the summer. Summer rainfall events show a larger frequency distribution towards longer dry intervals. At the lowest site (545 m), the winters tend to have longer dry intervals at low altitudes, indicating that even during winter, rainfall at this site can be very sporadic. At this site, dry intervals of longer than 14 days are also more common during winter and summer than at the higher sites.

Wind

An analysis of wind patterns at the top (1 303 m), middle (953 m) and lowest (545 m) sites (Figure 7) shows altitudinal as well as seasonal differences. All sites experience predominantly southerly winds during summer months (October to March). During winter (April–September) wind patterns shift to predominantly northwesterly at the top site and westerly at the middle site, whereas winter wind patterns at the lowest site are essentially the same as during summer conditions, with a slight shift towards more north and northwesterly winds and less easterly winds.

Wind speeds tend to increase with increasing altitude (Barry 1992), and can have an impact on plant growth. High wind speeds in combination with very low temperatures on exposed mountain peaks can cause stunted growth in plants, for example, in the prostrate cushion forms of pine trees found in the Krummholz zone of alpine regions (Körner 1999). However, mean seasonal wind speeds on Jonaskop do not indicate an increase of wind speed with increasing altitude (Figure 8).

When wind speeds are compared across the gradient, lowest mean wind speeds are recorded during both winter and summer at the middle site (953 m). The southerly winds of summer reach highest speeds (mean 11.8 km/h, maximum 28 km/h) at the lowest site. At the middle and lowest sites, winds are stronger during summer than in winter, but the predominantly northeasterly winds associated with advancing rain-bearing cold fronts are much

stronger during winter at the highest site. It is difficult to place wind speed data recorded on Jonaskop into context, as windspeed data for mountain slopes elsewhere in the CFR are not readily available. According to Barry (1992), mean wind speeds of around 25 km/h are typical for mountain peaks in the mid-latitudes of the northern hemisphere, which is much higher than wind speeds recorded on Jonaskop. Whether wind on Jonaskop is likely to affect the vegetation is also not certain. Controlled experimental studies have indicated that wind speeds higher than 10 km/h negatively affects the growth of herbaceous annuals and grasses (Whitehead 1962; Woodward 1993). On Jonaskop, mean wind speeds during the growth season (summer) are higher than 10 km/h only at the lowest site, but it is unlikely to affect growth in the sturdy perennial shrubs of the site, except when associated with high temperatures and low relative humidity, as under berg wind conditions.

Soil characteristics

Soils on the gradient are generally very shallow and rocky, the rockiness increasing with increasing altitude (Table 4). This has an effect on soil moisture, as soils at

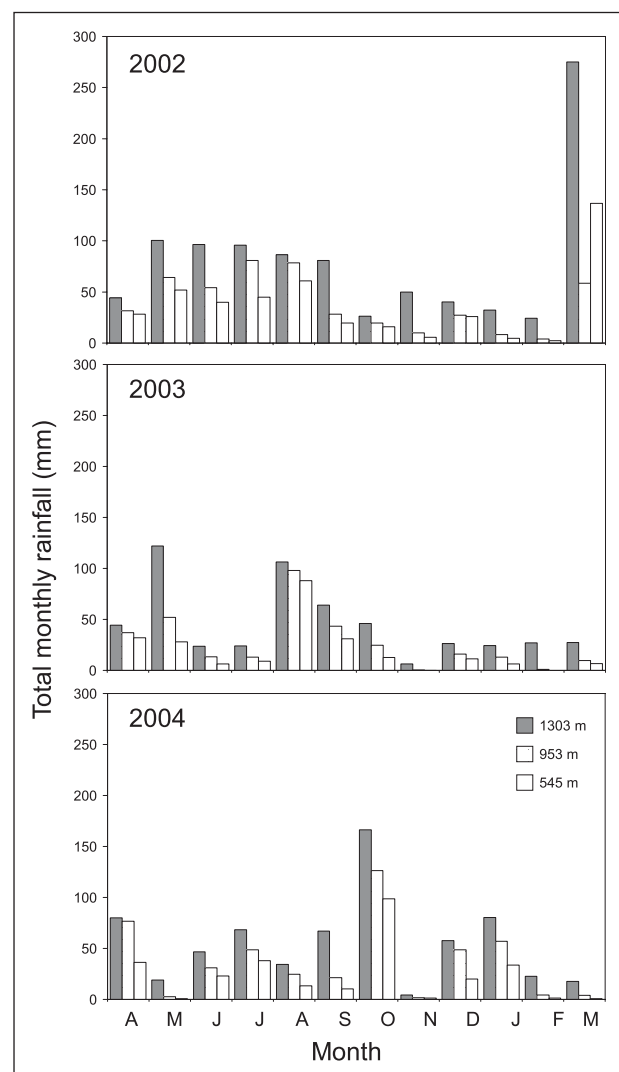


FIGURE 5.—Monthly rainfall recorded from April 2002 to March 2004 at the top (1 303 m), middle (953 m) and lower (545 m) monitoring points on the Jonaskop gradient.

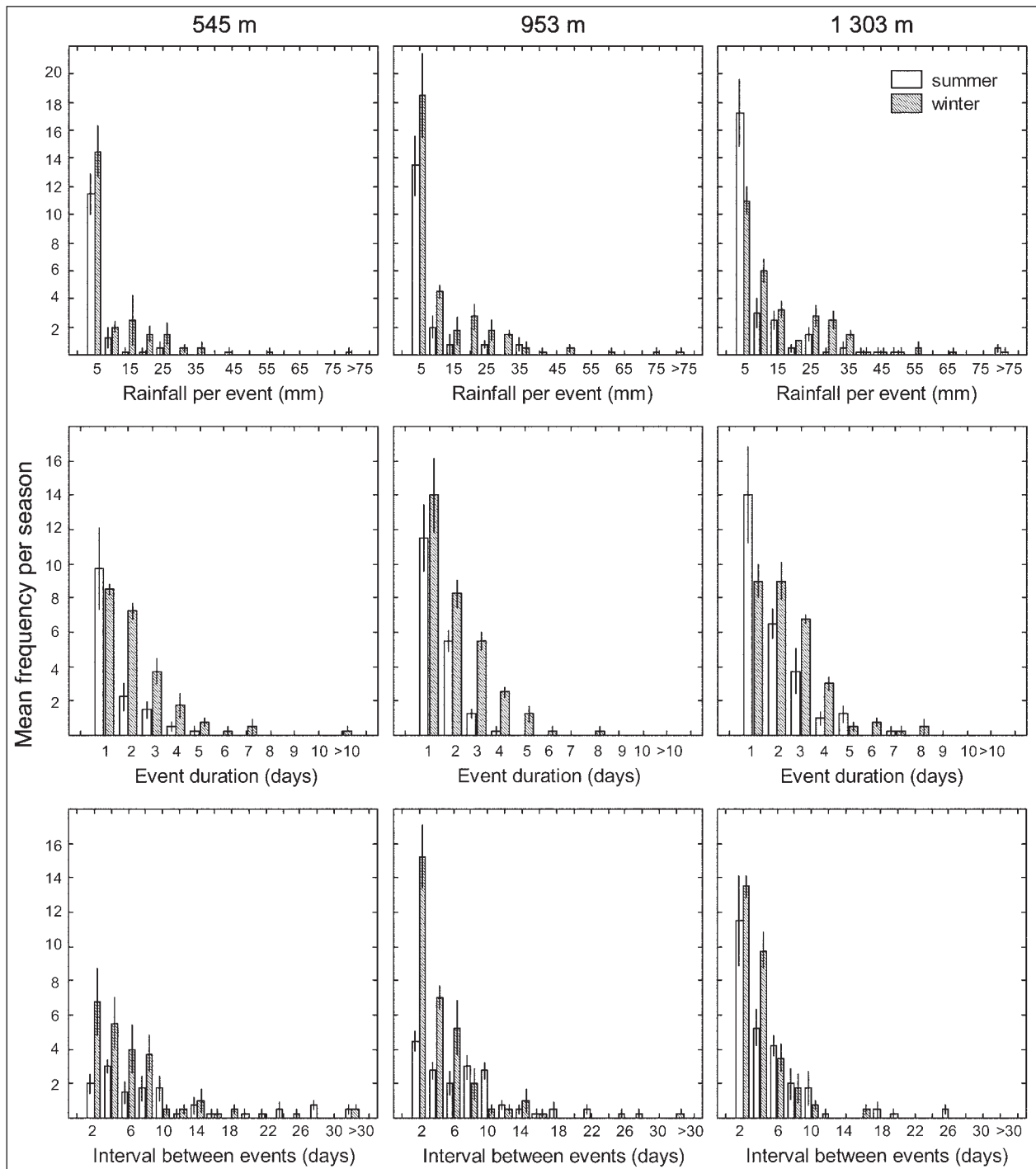


FIGURE 6.—Amount of rain per rainfall event, duration of rainfall events, and duration of dry intervals between rainfall events summarized as mean frequencies per season. Altitude where rainfall was recorded on gradient is indicated above each column. Error bars indicate 1 standard error.

the highest site (1 303 m) are generally drier than the site just below (1 196 m) (data available on request). At the 1 303 m site, slopes are steeper, and the soil is shallower and rockier than at the 1 196 m site (Table 4). These factors imply that faster drainage and runoff of rainfall occurs at the highest site, resulting in soils being drier. It is important to note that the soil moisture sensors did not record values drier than 100 kPa, and thus indicate when water was freely available, and then only in shallow surface layers of the soil. The calibrated range of the sensors was not wide enough to record the onset of stressful soil moisture conditions, which are generally associated

with soil water tensions lower than -1500 kPa (Miller & Gardiner 1998). Soil moisture values do not give an indication of water availability to deep-rooted species. However, our data (available on request) does illustrate that there is a trend toward different soil moisture dynamics at different altitudes that is related to rainfall.

The main differences in soil chemistry between shale-derived soils at the karoo site (545 m) and the sandstone-derived soils of the rest of the mountain was in terms of P, Ca and Mg, which were much higher in the shale-derived soils. Soil on the mounds (*heuweltjies*) was very

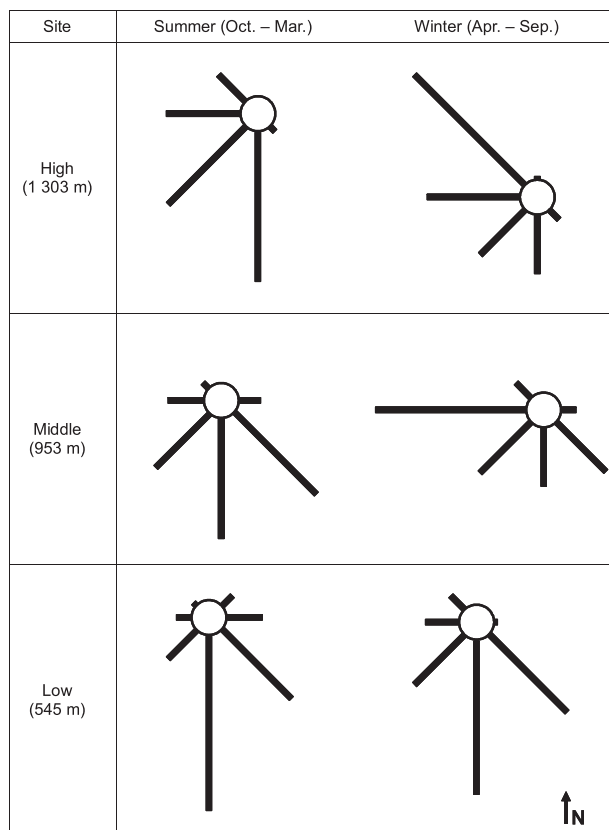


FIGURE 7.—Seasonal wind patterns recorded at top, middle and lower monitoring points on Jonaskop gradient. Lengths of bars indicate no. days.

different from that in the sandstone-derived soils, as well as from off-mound shale-derived soils (see also Ellis 2002). *Heuveltyje* soils have much higher Ca, K and N content than either sandstone or off-mound shale. Off-mound shale has roughly double the Na content of either *heuveltyje* or sandstone-derived soils.

Vegetation

A total of 286 species were recorded at sampling sites along the gradient. The highest number of species recorded in a single 10×10 m relevé was 50 species at the middle site (953 m) (Appendix 1 & 2). Species accumulation curves, calculated for each site, revealed that vegetation sampling did not approach complete sampling of communities (data not shown). Typically, the vegetation of the Fynbos Biome has three strata and is a mid-tall to tall shrubland (Campbell 1985). The vegetation recorded in this study differed only at the summit where extreme subalpine conditions have resulted in dwarf shrubland vegetation, less than 0.5 m tall.

Karoo site (545 m)

Out of a total of 56 species recorded at this site, 45 (80 %) occurred at no other sites on the gradient. A number of species were specific to *heuveltyjes* alone (Group II, Appendix 1), namely *Galenia africana*, *Schismus barbatus* and *Galium tomentosum*. The off-mound communities are defined by the presence of *Dicerotheramnus rhinocerotis*, *Oedera squarrosa* and *Pteronia paniculata* (Group III, Appendix 1). General species typifying the vegetation at this site are *Euphorbia burmannii*,

Pteronia incana and *Ruschia lineolata*. These species are found in high abundances on *heuveltyjes*, and to a lesser extent elsewhere at the site (Group I, Appendix 1). Four species found frequently at the karoo site, that are able to successfully cross the soil barrier between the karoo and ecotonal site are *Anthospermum aethiopicum*, *Drosanthemum speciosum*, *Montinia caryophyllacea* and *Passerina obtusifolia* (Group VII, Appendix 1). Eight other species were found on both sandstone and shale-derived soils, but these were rare and had low cover values.

Dicerotheramnus rhinocerotis (*renosterbos*) and *Oedera genistifolia*, which both have fairly high cover values in relevés 6B & 6C (Appendix 1), are generally associated with renosterveld (Mustart *et al.* 1997; Goldblatt & Manning 2000), a vegetation type of the Fynbos Biome which is found on more nutrient-rich soils (Rebello 1998). According to Mucina & Rutherford (2006), the vegetation on the lower eastern slope of Jonaskop, which is quite close to the karoo site, is classified as Breede Shale Renosterveld (FRs8). This is probably a function of mapping scale as Holmes (2002), in an environmental impact study on the vegetation of the Breede River Valley northeast of Jonaskop, found that in this area, Succulent Karoo is found on the foothills of equator-facing slopes, whereas renosterveld is found on pole-facing slopes. The karoo site is located between the foot of the equator-facing slope of Jonaskop and the south-facing slope of a low hill, with relevés 6B & 6C (plot OFM3 in Figure 1) located on the south-facing hillslope. The species composition of this site, considered in combination with the topography, points either to an altitudinal banding of the vegetation types, or to transitional vegetation, or to a mosaic of adjacent Succulent Karoo and renosterveld, which has resulted in an inevitable mix of species from both vegetation types found in the sampling plots. The substrate, in conjunction with the local climate, appears to be the main driving force determining the vegetation found here (Boucher & Moll 1981), but it is still unclear whether this is due to soil nutritional or soil water retention constraints.

The site also has a relatively high incidence of unpalatable asteraceous shrubs such as *Chrysocoma ciliata* (bitterbos), *Galenia africana* (kraalbos) and species of *Pteronia*, which may indicate that the vegetation at this

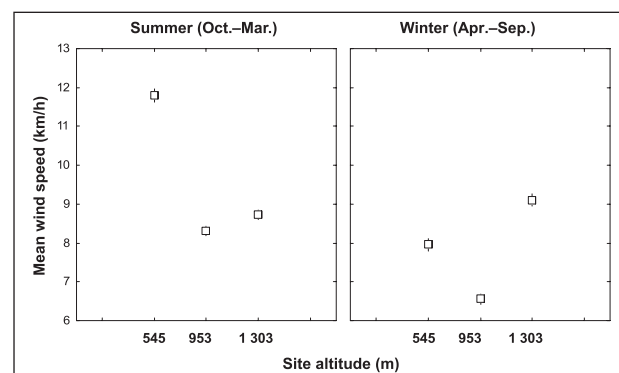


FIGURE 8.—Mean seasonal wind speeds recorded at top (1 303 m), middle (953 m) and lowest (545 m) end of Jonaskop gradient. Wind speeds measured at 1 m above soil surface. Error bars indicate 1 standard error.

site has been somewhat degraded by overgrazing in the recent past.

Ecotone (690–744 m)

In all, 105 species were recorded at the two sites located at low altitude sandstone sites. Fifty five species were found nowhere else on the gradient. Species typical of the low altitude sandstones are *Cannomois scirpoides*, *Ficinia oligantha*, *Protea humiflora* and *Ruschia* sp. (L. Agenbag 5A09, Group IV, Appendix 1). The lower site (690 m) has a number of highly abundant species occurring only at this site, which defines it as supporting a subcommunity within the ecotonal Low-altitude Inland Sandstone Fynbos (Group V, Appendix 1). They are *Cliffortia crenata*, *Ischyrolepis sieberi*, *Lachnospermum fasciculatum* and *Polygala fruticosa*. A number of species were also found unique to the higher ecotonal site (744 m), namely, *Hermannia rudis*, *Othonna ramulosa* and *Phylla* sp. (L. Agenbag 5A03) (Group VI, Appendix 1).

The vegetation of the ecotonal Low-altitude Inland Sandstone Fynbos recorded here is very similar in species composition and physical aspects to the *Cannomois parviflora*–*Passerina obtusifolia* Shrublands described by McDonald (1993), which occurs on the lower northern slopes of the nearby Langeberg. These arid Sandstone Fynbos shrublands are also found near the transition between Table Mountain Sandstone and Bokkeveld Shales, which support Little Karoo vegetation.

Mid-altitude Sandstone Fynbos (953–1 303 m)

Although there were a number of species characteristic of different sites within the Mid-altitude Sandstone Fynbos (Groups IX, X, XI and XII, Appendix 1), as a whole, these sites seem to represent variations within a specific community (*Protea repens*–*Phaenocoma prolifera* Closed Tall Mid-altitude Sandstone Fynbos) characterized by *Edmondia sesamoides*, *Hypodiscus aristatus*, *Leucadendron laureolum*, *Phaenocoma prolifera*, *Protea amplexicaulis* and *Protea magnifica* (Group VIII, Appendix 1).

Site 4: *Protea repens*–*Tetraria flexuosa* Closed Tall Mid-altitude Sandstone Fynbos, which is located in the middle of the gradient (953 m), has by far the highest species number on the gradient, with 85 species recorded at this site alone. It has a high number of rare species which were recorded in low abundances and low fre-

quencies. *Tetraria flexuosa* and *Wahlenbergia neorigida* (Group IX, Appendix 1), typify this community.

Sites 1–3: *Protea repens*–*Tetraria ustulata* Closed Tall Mid-altitude Sandstone Fynbos, is typified by *Tetraria ustulata* and the other less frequent species listed in Group X (Appendix 1). The sites at 1 196 m and 1 303 m, however, do have characteristic species, but in both cases, these species were not found in the recently burned vegetation. These latter communities are therefore given lower ranking.

The *Elegia filacea* Subcommunity, recorded at an altitude of 1 196 m, is characterized by the following species: *Elegia filacea*, *Erica* sp. (L. Agenbag 2A02) and *Nebelia laevis* (Group XI, Appendix 1). The *Elegia racemosa* Subcommunity was recorded at 1 303 m and is characterized by *Erica longifolia*, *Elegia racemosa*, *Tetraria fasciata* and *Diosma* sp. (L. Agenbag 1A08) (Group XII, Appendix 1).

Ehrharta ramosa–*Restio triticeus* High Altitude Sandstone Dwarf Fynbos (1 576 m):

Structurally, vegetation at the mountain summit is very low compared to the rest of the gradient (less than 0.25 m tall). Some species found at this site, that also occur elsewhere on the gradient, such as *Helichrysum swartbergense*, are found near the summit as dwarfed growth forms, compared to taller individuals lower down. Soils are extremely shallow (surface rock to pockets of soil not often more than 10 cm deep) and very rocky, with an average of 75 % rock cover. Species numbers at this site are very low, with only 26 species recorded in the plots. The vegetation at this site is dominated by grasses, sedges and restios, although dwarf shrubs are present throughout. Species characteristic of this high-altitude summit vegetation include *Ehrharta ramosa*, *Metalsia* sp. (L. Agenbag 0B02), *Restio triticeus* and *Stoebe* sp. (L. Agenbag 0C04) (Group XV, Appendix 1).

Diversity

Shannon diversity indices showed highest diversity at the low to middle altitudes (690–953 m) and sites on a sandstone substrate (Figure 9A). When diversity was compared within sites between recently burned and mature vegetation, burned relevés had higher diversity in all fynbos sites (953, 1 044, 1 196 and 1 303 m) as well as at the summit (1 576 m, Figure 9B). Low-altitude inland sandstone fynbos sites (690 and 744 m)

TABLE 4.—Soil characteristics of selected sites along Jonaskop gradient

Monitoring site	Geology	Mean rock cover (%)	Soil depth range (cm)	pH	P (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Na (mg/kg)	N (mg/kg)
545 m on	Bokkeveld Group	0	14–31	6.3	45.7	3 206.3	854.0	165.0	22.0	3 446.9
545 m off	Bokkeveld Group		5–32	4.2	36.3	651.7	620.7	87.7	53.3	1 390.5
744 m	Table Mtn Group	15	0–38	4.9	2.3	394.3	87.3	74.7	19.7	1 245.2
953 m	Table Mtn Group	13	0–50+	4.3	3.3	417.3	85.3	56.0	15.7	1 120.7
1 044 m	Table Mtn Group	22	0–50+	4.1	2.0	148.3	71.0	79.0	18.0	694.3
1 196 m	Table Mtn Group	19	4–50+	3.6	3.7	133.3	55.7	41.7	12.0	888.6
1 303 m	Table Mtn Group	43	0–34	4.0	2.0	190.7	65.7	52.7	24.7	632.3

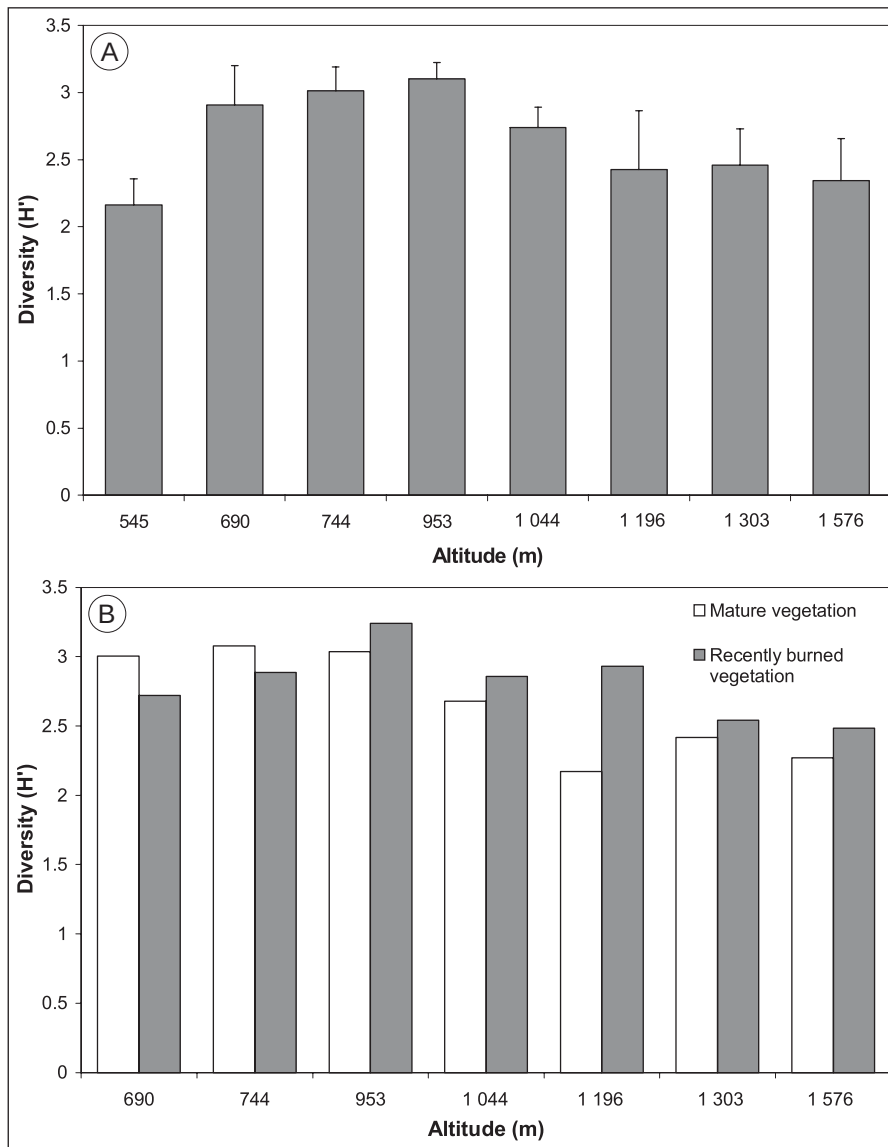


FIGURE 9.—A, Shannon-Wiener diversity indices (H') recorded across gradient. H' values for each altitude is mean of three 10×10 m relevés; B, comparative diversity indices (H') between recently burned and mature vegetation at selected altitudes along Jonaskop gradient. Diversity values for mature vegetation is mean of two 10×10 m relevés, whereas only one relevé was sampled in recently burned vegetation at each altitude. Error bars in A indicate 1 standard error.

have lower diversity in recently burned relevés. Other studies in fynbos have also found that richness is highest in the first few years after fires, due to the presence of ephemeral species (Bond & Van Wilgen 1996; Holmes & Cowling 1997).

Growth form composition

A comparison of the relative contribution of various growth forms to vegetation cover shows clear shifts in dominant growth forms across the gradient (Figure 10A). From the karoo site (545 m) up to the lowest fynbos site (953 m), vegetation is dominated by low shrubs. At the karoo site, succulents are also a significant contributor to vegetation cover, but not at any of the other sites. Above 953 m, the dominant growth form shifts to graminoids, which includes grasses, sedges and restios. The low vegetation at the summit site (1 576 m) is reflected in a high proportion of vegetation cover represented by dwarf shrubs, with heights lower than 0.25 m. At this site, herbs also represent a larger proportion of the vegetation cover than at other sites.

When growth form composition between recently burned and mature vegetation is compared, ecotonal low-alti-

tude inland sandstone sites show very similar composition (Figure 10B). In mid to high-altitude fynbos sites, however, recently burned vegetation has higher cover in herbs, succulents and graminoids, whereas mature vegetation consists largely of long-lived low and mid-high shrubs, as well as graminoids.

Taking a closer look at the relative contribution of the families Cyperaceae, Poaceae and Restionaceae to graminoid cover across the gradient, more interesting patterns are revealed (Figure 11A, Appendix 3). Grasses are more common at the karoo site (545 m), and are found only in very low proportions elsewhere on the gradient, except again for the summit (1 576 m), where grasses, sedges and restios make roughly equal contributions to total graminoid cover. Restionaceae show increasing dominance from the low-altitude sandstone sites upwards to 953 m, after which sedges become slightly more important. Comparing graminoid cover between recently burned and mature vegetation reveals that in fynbos, Cyperaceae dominate recently burned vegetation, whereas Restionaceae are dominant in mature vegetation (Figure 11B). In the low-altitude sandstone sites, grasses are slightly more abundant in recently burned than mature vegetation.

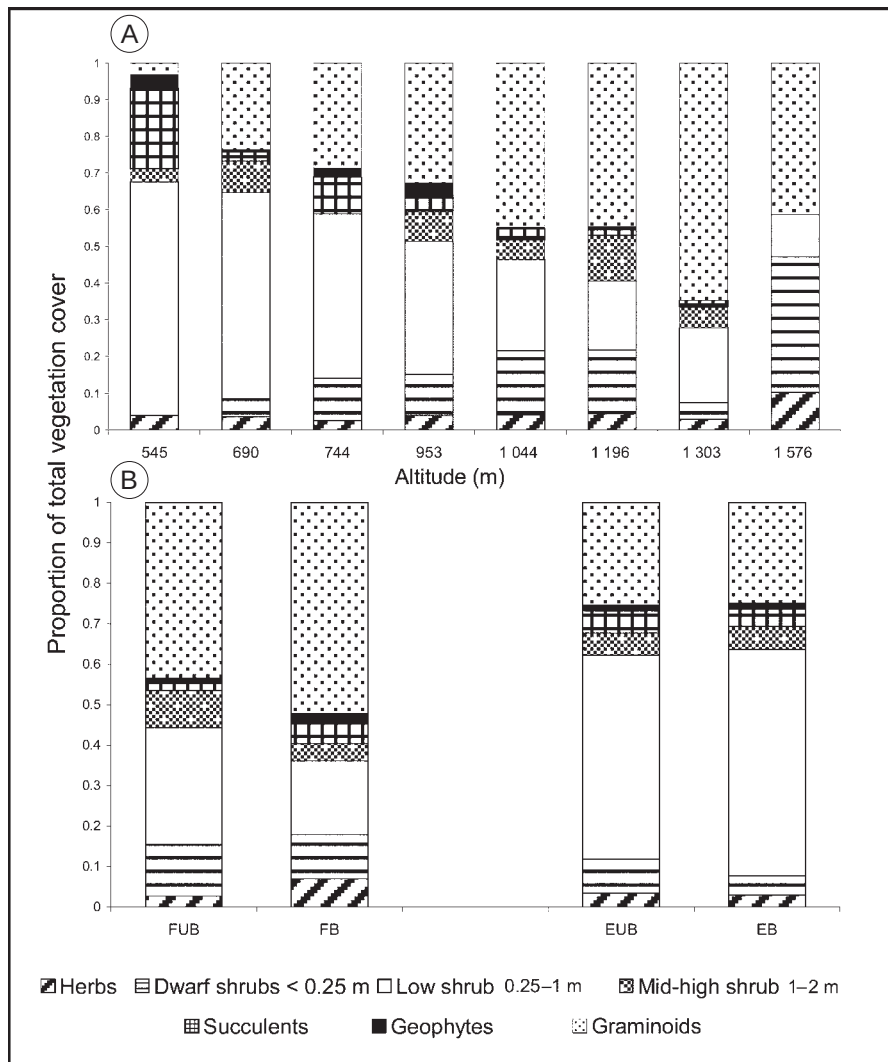


FIGURE 10.—A, comparative contributions of various growth forms to total vegetation cover at selected altitudes along gradient; B, comparative growth form composition between recently burned and mature vegetation in fynbos sites. FUB, fynbos mature vegetation; FB, recently burned fynbos; EUB, ecotone mature vegetation; EB, recently burned ecotone vegetation.

Similarity and turnover rates

Similarity between all sites is relatively low, suggesting high species turnover even between sites with similar vegetation. Similarity between the karoo site and the rest of the gradient, as well as between the summit and the rest of the gradient is the lowest (Table 5), suggesting that strong climatic and/or soil factors are limiting species distributions between these and other areas on the gradient. Highest similarities were found among the ecotonal low-altitude sandstone sites (25.6 %) and among fynbos sites (15.7–25.5 %). Similarities of 11.3 %, 17.1 % and 16.2 % between the (low-altitude sandstone) ecotone and lower mid-altitude fynbos sites (953 and 1 044 m) suggests that the low-altitude sandstone ecotonal vegetation is more closely related to fynbos than karoo, as similarities between the latter two sites are only 7.5 % (690 m) and 2.7 % (744 m). Mean turnover rate for the gradient was determined as -0.0014 , with the equation fitted to the plot of difference in altitude against similarity being $\text{Log } \% \text{ similarity} = -0.0014 \times \text{difference in altitude} + 1.41$, $r^2 = 0.52$ (Figure 12). Similarity values between the karoo site and other sites were generally much lower than predicted by the regression line for similar changes in altitude elsewhere along the gradient, again suggesting that the area between 545 and 690 m is governed by strong environmental factors affecting species distributions.

CONCLUSION

Climate change studies report increasing evidence that species' ranges shift higher on mountain slopes as a result of climate warming, and that high altitude species are therefore particularly vulnerable to extinction as they reach the limits of mountain summits (Grabherr *et al.* 1994; Parmesan & Yohe 2003). Therefore the summit community on the Jonaskop gradient, with its very restricted range, is almost certainly vulnerable to the warmer and drier conditions predicted for the Western Cape.

However, monitoring species for population mortality, extinctions and shifts in ranges across the entire gradient will provide valuable insights into the responses of fynbos, renosterveld and Succulent Karoo vegetation dynamics to climate change. Anecdotal evidence suggests that *Protea* species (mainly genus *Leucadendron*) may be vulnerable to drought stress on Jonaskop (Hannah *et al.* 2007). Jacobsen *et al.* (2007) studied 19 species from nine angiosperm families along the Jonaskop gradient, and found significant variation in their water stress tolerance. Species studied were not as tolerant of water stress as chaparral shrubs occurring in climatically similar California, USA. They suggested that the measurement of xylem density may be a useful tool to assess drought tolerance of large numbers of species.

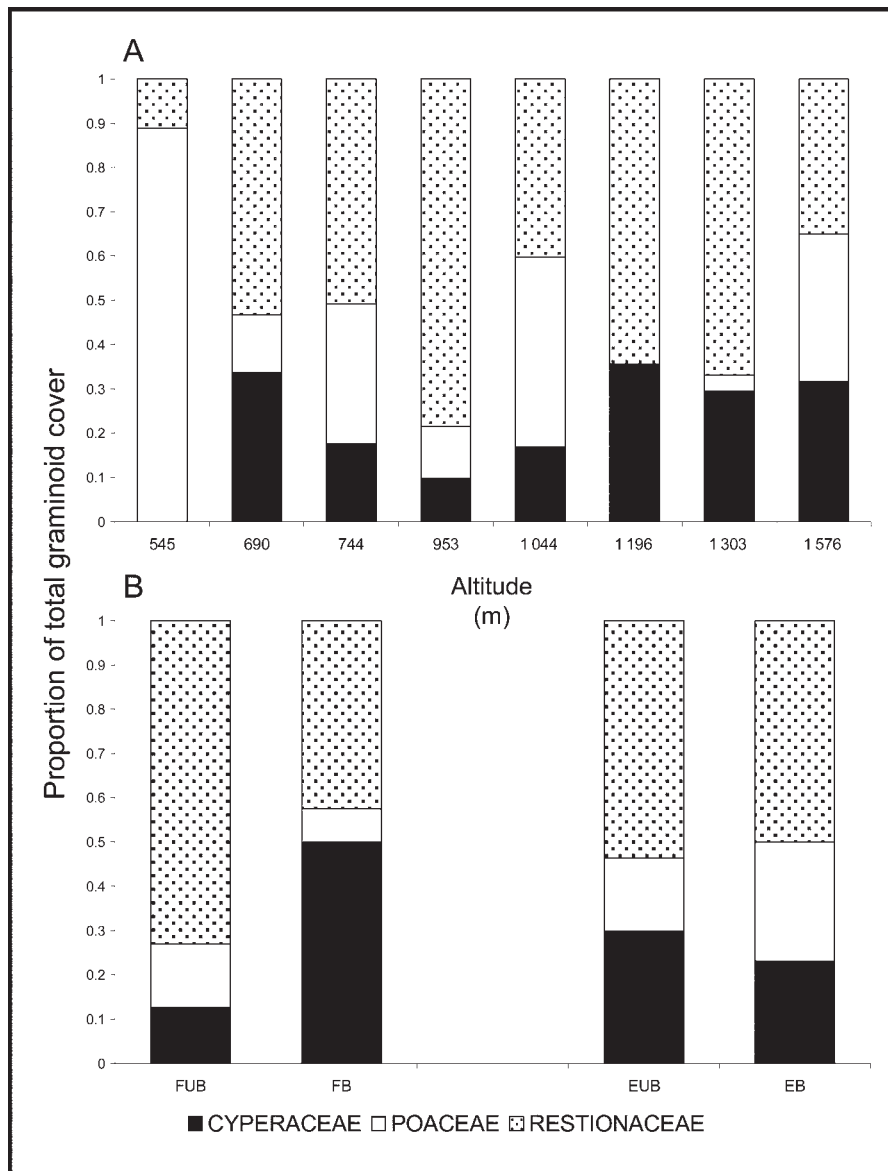


FIGURE 11.—A, relative contribution of sedges (Cyperaceae), grasses (Poaceae) and restios (Restionaceae) to total graminoid cover at selected altitudes across Jonaskop gradient; B, comparative contribution of sedges (Cyperaceae), grasses (Poaceae) and restios (Restionaceae) to total graminoid cover between recently burned and mature vegetation. FUB, fynbos mature vegetation; FB, recently burned fynbos; EUB, ecotone mature vegetation; EB, recently burned ecotone vegetation.

The area around the lower ecotonal site (550–700 m) is the most important to monitor for the first signs of shifts in species and growth form composition as indication of an upward shift of Succulent Karoo into renosterveld-fynbos territory. Since karoo vegetation is known to be distinct from the vegetation recorded in this study through analysis of species similarity, diversity and growth form composition, changes should be detected relatively easily.

Monitoring efforts should not only focus on upward shifts in species ranges, but also on contraction of ranges at the lower elevational limits of species (Hampe *et al.* 2005). Data collected in this study revealed clearly defined upper and lower altitudinal limits on the gradient for many species sampled, and thus, focusing monitoring on changes in abundance of these species at their upper and lower limits, along with continued climate data

TABLE 5.—Total no. species and no. species with single site occurrences recorded at selected sites along Jonaskop gradient, including percentage similarity values for all sites compared. Shaded diagonal represents similarity values between adjacent sites

		Karoo		Fynbos				
		Low altitude		Mid-altitude			High alt.	
Total no. spp.		56	73	59	85	56	62	53
No. single spp.		45	25	11	30	11	26	14
Altitude (m)		545	690	744	953	1044	1196	1303
Karoo	545							
Ecotone	690	7.5						
	744	2.7	25.7					
Fynbos	953	1.4	11.3	17.1				
	1044	0.9	7.5	16.2	24.8			
	1196	0	3.8	7.1	15.7	25.5		
	1303	0	5.9	5.7	18.0	23.9	22.3	
Summit	1576	0	2.1	1.2	5.7	3.8	8.6	12.9

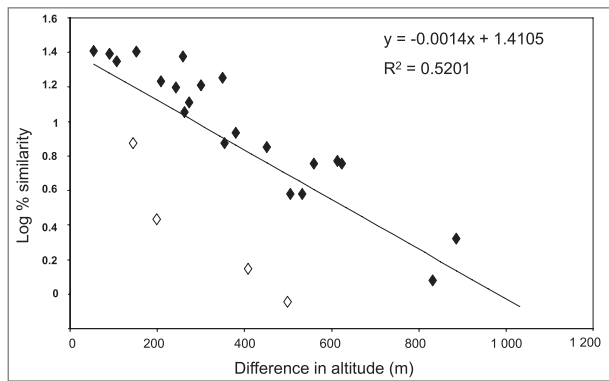


FIGURE 12.—Difference in altitude against log percentage similarity between pairs of all sites sampled, ♦. Slope of fitted regression line represents mean turnover rate across gradient. Karoo sites, ◇; closed symbols indicate sites elsewhere on the gradient, ♦.

recording, could reveal much about the climatic controls of species' ranges.

It is of course necessary to investigate the importance of the change in soil type between 545 m and 690 m as a potential barrier to climate change-induced shifts in species' ranges, and this is possibly best achieved through experimental studies. As Dunne *et al.* (2004) have indicated, a combination of gradient monitoring and experimental investigation strategies provide the best insights into complex ecosystem responses to climate change. We submit that this study will provide useful baseline data for a future focused and directed monitoring effort leading to a better understanding of the potential effects of climate change on fynbos and the fynbos-renosterveld-succulent karoo boundary.

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APPENDIX 1.—Structured relevé table for Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Data were collected in October 2003. See Appendix 2 for species with low frequency occurrences (cont.)

VEGETATION TYPE	SUCULENT KAROO- RENOSTERVELD MOSAIC	SANDSTONE FYNBOS															
		LOW ALTITUDE INLAND								MID-ALTITUDE							
		2.1				2.2				3.1				3.2.1			
Community no.	1.1	5.5A	5.5B	5.5C	5A	5B	5C	4A	4B	4C	3A	3B	3C	2A	2B	2C	3.2.3
Releve no.	6A	6B	6C					953	953	953	1044	1044	1044	1196	1196	1196	1303
Altitude (m)	545	545	545	690	690	744	744	953	953	953	1044	1044	1044	1196	1196	1303	1303
Aspect (°)	325	320	320	3	355	255	332	195	140	10	320	20	35	335	325	45	15
Slope (°)	11	16	12	24	16	14	18	4	3	4	25	14	4	3.5	2	4.5	13
Latitude South°	33.55.053	33.55.059	33.55.068	33.55.222	33.55.235	33.55.312	33.55.314	33.56.061	33.56.097	33.56.128	33.56.563	33.56.560	33.56.589	33.57.283	33.57.287	33.57.287	33.58.130
Longitude East°	19.30.421	19.30.417	19.30.407	19.31.041	19.31.057	19.30.599	19.30.592	19.31.228	19.31.183	19.31.294	19.30.539	19.30.525	19.31.000	19.31.007	19.31.011	19.31.106	19.30.249
Rock cover (%)	0	0	0	25	50	30	35	35	1	2	5	40	20	2	1	55	70
Vegetation cover (%)	80	50	40	75	50	70	60	60	95	68	80	60	30	85	90	30	30
Soil type (SH, shale; SHM, shale, heuweltjie; SA, sandstone)	SHM	SH	SH	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Soil depth range (cm)	14-31	5-23	13-32	0-33	0-7	0-12	3-38	0-37	4-53	0-37	0-39	4-30	5-50+	12-50+	4-50+	10-50+	0-16
2. <i>Protea humiflora</i> – <i>Ficinia oligantha</i> Medium-tall Mid-dense Low-altitude Sandstone Fynbos																	
<i>Ficinia oligantha</i>	.	.	.	2A	1	R	R	R	.	.	.	.	.	.	.	.	.
<i>Ruschia</i> sp. (L. Agenbag 5A09)	.	.	.	R	+	1	2A	R	1	.	.	.	.	.	.	.	.
<i>Protea humiflora</i>	.	.	.	+	R	3	+	R	R	.	.	.	.	.	.	.	.
<i>Cannomois scirpoides</i>	.	.	.	+	+	1	1	1	.	.	.	.	.	.	.	.	.
<i>Agathosma glandulosa</i>	.	.	.	R	.	1	R	+	1	.	.	.	.	.	.	.	.
<i>Seriphium incanum</i>	.	.	.	R	.	.	2A	+	O	.	.	.	.	.	.	.	.
<i>Syncarpha paniculata</i>	.	.	.	1	R	.	1	1	.	.	.	.	.	.	.	.	.
<i>Searsia dissecta</i>	.	.	.	R	O	.	.	.	2A	.	.	.	.	.	.	.	.
<i>Felicia filifolia</i>	.	.	.	+	.	R	.	R	.	.	.	.	.	.	.	.	.
<i>Lobostemon fruticosus</i>	.	.	.	1	2B	.	.	.	R	.	.	.	.	.	.	.	.
<i>Aspalathus biflora</i>	.	.	.	+	.	2A	.	.	.	.	.	.	.	.	.	.	.
<i>Centella triloba</i>	.	.	.	.	R	.	R	+	.	.	.	.	.	.	.	.	.
<i>Aspalathus spicata</i>	.	.	.	.	2A	.	R	R	.	.	.	.	.	.	.	.	.
<i>Searsia rosmarinifolia</i>	.	.	.	.	.	+	O	O	.	.	.	.	.	.	.	.	.
<i>Arctotis</i> sp. (L. Agenbag 5C03)	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.
<i>Aspalathus pachyloba</i> subsp. <i>macroclada</i>	.	.	.	3	.	.	2A	.	.	.	.	.	.	.	.	.	.
<i>Cymbopogon pospischilii</i>	.	.	.	R	+	.	.	.	.	.	.	.	.	.	.	.	.
<i>Oxalis engleriana</i>	.	.	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.
<i>Hermannia angularis</i>	.	.	.	.	+	.	R	.	.	.	.	.	.	.	.	.	.

APPENDIX 1.—Structured relevé table for Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Data were collected in October 2003. See Appendix 2 for species with low frequency occurrences (cont.)

	VEGETATION TYPE	SUCCULENT KAROO- RENOSTERVELD MOSAIC		SANDSTONE FYNBOS																							
				LOW ALTITUDE INLAND						MID-ALTITUDE						HIGH-ALTITUDE											
				2.1			2.2			3.1			3.2.1			3.2.2			3.2.3			4					
		1.1	1.2	5.5A	5.5B	5.5C	5A	5B	5C	4A	4B	4C	3A	3B	3C	2A	2B	2C	1A	1B	1C	0A	0B	0C			
	Community no.	6A	6B	6C	690	690	690	744	744	744	953	953	953	1044	1044	1044	1196	1196	1196	1303	1303	1303	1576	1576	1576		
	Releve no.	545	545	545	690	690	690	744	744	744	953	953	953	1044	1044	1044	1196	1196	1196	1303	1303	1303	1576	1576	1576		
	Altitude (m)	325	320	320	3	355	355	332	330	330	195	140	10	320	20	35	335	325	45	355	10	15	25	0	10		
	Aspect (°)	11	16	12	24	16	23	14	18	12	4	3	4	25	14	4	3.5	2	4.5	6	18	13	18	22	22		
	Slope (°)																										
	Latitude South°	33.55.053	33.55.059	33.55.068	33.55.222	33.55.235	33.55.234	33.55.312	33.55.314	33.55.272	33.56.061	33.56.097	33.56.128	33.56.563	33.56.560	33.56.589	33.57.283	33.57.287	33.57.287	33.57.691	33.57.694	33.57.743	33.58.224	33.58.203	33.58.130		
	Longitude East°	19.30.421	19.30.417	19.30.407	19.31.041	19.31.057	19.31.057	19.30.599	19.30.592	19.31.035	19.31.228	19.31.183	19.31.294	19.30.539	19.30.525	19.31.000	19.31.007	19.31.011		19.30.800	19.30.777	19.30.823	19.30.306	19.30.266	19.30.249		
	Rock cover (%)	0	0	0	25	50	30	5	35	5	35	1	2	5	40	20	2	1	55	40	20	70	80	75	70		
	Vegetation cover (%)	80	50	40	75	50	70	70	60	55	60	95	68	80	60	30	85	90	30	60	80	30	20	25	30		
	Soil type (SH, shale; SHM, shale, heuweltjie; SA, sandstone)	SHM	SH	SH	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA		
	Soil depth range (cm)	14–31	5–23	13–32	0–33	0–7	0–12	3–38	0–37	0–36	0–10	4–53	0–37	0–39	4–30	5–50+	12–50+	4–50+	10–50+	0–23	0–34	0–23	0–49	0–46	0–16		
3. Protea repens–Phaenocoma prolifera Closed Tall Mid-altitude Sandstone Fynbos (cont.)																											
XI	Zyphelis microcephala	.	.	.	.	.	.	.	.	.	R	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Thesium spicatum	.	.	.	.	.	.	.	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Aspalathus leucophylla	.	.	.	.	.	.	.	.	.	.	+	O	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Ischyrolepis curviramis	.	.	.	.	.	.	.	.	.	2A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Tetraria ustulata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
X	Hypodiscus laevigatus	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	2A	+	2B	2A	2A	2B	.	.	.	.	
	Leucadendron nervosum	.	.	.	.	.	.	.	.	.	.	.	.	O	.	.	O	.	1	.	.	.	.	.	.	.	
	Hypodiscus squamosus	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	+	2A	.	.	.	.	.	.	.	
	Restio filiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	
	Erica fastigiata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	
	Anthospermum galioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	+	+	.	.	.	.	
	Clutia polygonoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	R	+	.	.	.	
	Erica sessiliflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	O	+	.	.	.	.	
IX	Cannomois nitida	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	
	Elegia filacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2A	2A	.	.	.	.	.	.	.	.	
	Erica sp. (L. Agenbag 2A02)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2B	1	.	.	.	.	.	.	.	.	
	Hypodiscus albo-aristatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	
	Nebelia laevis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	O	R	.	.	.	.	.	.	.	.	
	Euryvum abrotanifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	O	.	.	.	.	.	.	.	.	.	

APPENDIX 1.—Structured relevé table for Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Data were collected in October 2003. See Appendix 2 for species with low frequency occurrences (cont.)

VEGETATION TYPE	SUCCULENT KAROO- RENOSTERVELD MOSAIC	SANDSTONE FYNBOS															
		LOW ALTITUDE INLAND								MID-ALTITUDE							
		2.1				2.2				3.1				3.2.1			
Community no.	1.1	5.5A	5.5B	5.5C	5A	5B	5C	4A	4B	4C	3A	3B	3C	2A	2B	2C	3.2.3
Releve no.	6A	6B	6C														1C
Altitude (m)	545	545	545	690	744	744	744	953	953	953	1044	1044	1044	1196	1196	1196	1303
Aspect (°)	325	320	320	3	355	355	330	195	140	10	320	20	35	335	325	45	15
Slope (°)	11	16	12	24	16	23	18	4	3	4	25	14	4	3.5	2	4.5	18
Latitude South°	33.55.053	33.55.059	33.55.068	33.55.222	33.55.235	33.55.234	33.55.312	33.55.314	33.55.272	33.56.097	33.56.563	33.56.560	33.56.589	33.57.283	33.57.287	33.57.287	33.58.224
Longitude East°	19.30.421	19.30.417	19.30.407	19.31.041	19.31.057	19.31.057	19.30.599	19.30.592	19.31.035	19.31.183	19.31.294	19.30.525	19.31.000	19.31.007	19.31.011	19.31.106	19.30.266
Rock cover (%)	0	0	0	25	50	30	5	35	5	1	2	5	40	2	1	55	70
Vegetation cover (%)	80	50	40	75	50	70	70	60	55	95	68	80	60	85	90	30	30
Soil type (SH, shale; SHM, shale, heuweltjie; SA, sandstone)	SHM	SH	SH	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Soil depth range (cm)	14-31	5-23	13-32	0-33	0-7	0-12	3-38	0-37	0-36	4-53	0-37	0-39	4-30	5-50+	4-50+	10-50+	0-46
3. Protea repens-Phaenocoma prolifera Closed Tall Mid-altitude Sandstone Fynbos (cont.)																	
<i>Elegia racemosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Erica longifolia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Tetraria fasciata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Diosma</i> sp. (L. Agenbag 1A08)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Adenandra villosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Erica equisetifolia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Erica axillaris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species common to Communities 2, 3.1 and 3.2.1																	
<i>Ehrharta capensis</i>	R	R	R	R	R	R	R	R	R	+	1	2M	+	.	.	.	.
<i>Erica anguliger</i>	+	+	+	R	1	2A	+	R	1	O	2A	2A	O	.	.	.	.
<i>Muraltia heisteria</i>	+	+	+	R	1	+	R	+	+	R	.	.	.	.	.	.	.
<i>Osteospermum polygaloides</i> var. <i>polygaloides</i>	.	.	.	R	R	R	R	R	R	+	.	.	.	.	.	.	.
<i>Pentstemonis eriostoma</i>	1	.	1	1	+	+	+	+	2A	+	.	.	.	.	.	.	.
<i>Hypodiscus striatus</i>	+	.	+	+	+	+	+	+	1	+	.	.	.	.	.	.	.
<i>Aspalathus juniperina</i>	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.
<i>Thesium</i> sp. (L. Agenbag 5B05)	.	.	.	.	.	.	.	.	1	+	O	2A	O	.	.	.	.
<i>Microdon dubius</i>	.	.	.	.	R	.	.	R	+	+	.	.	.	.	.	.	.
<i>Serruria gremialis</i>	.	.	.	.	.	.	O	O	O	1	.	.	.	.	.	.	.

APPENDIX 1.—Structured relevé table for Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Data were collected in October 2003. See Appendix 2 for species with low frequency occurrences (cont.)

VEGETATION TYPE	SUCCULENT KAROO- RENOSTERVELD MOSAIC	SANDSTONE FYNBOS															
		LOW ALTITUDE INLAND								MID-ALTITUDE							
		2.1				2.2				3.1				3.2.1			
Community no.	1.1	5.5A	5.5B	5.5C	5A	5B	5C	4A	4B	4C	3A	3B	3C	2A	2B	2C	3.2.3
Releve no.	6A	6B	6C					953	953	953	1044	1044	1044	1196	1196	1196	1303
Altitude (m)	545	545	545	690	744	744	744	195	140	10	320	20	35	335	325	45	1576
Aspect (°)	325	320	320	3	355	355	330	330	140	10	320	20	35	335	325	45	1576
Slope (°)	11	16	12	24	16	23	18	12	3	4	25	14	4	3.5	2	4.5	10
Latitude South°	33.55.053	33.55.059	33.55.068	33.55.222	33.55.235	33.55.234	33.55.312	33.55.272	33.56.097	33.56.128	33.56.563	33.56.560	33.56.589	33.57.283	33.57.287	33.57.287	33.58.130
Longitude East°	19.30.421	19.30.417	19.30.407	19.31.041	19.31.057	19.31.057	19.30.599	19.31.035	19.31.183	19.31.294	19.30.539	19.30.525	19.31.000	19.31.007	19.31.011	19.31.106	19.30.249
Rock cover (%)	0	0	0	25	50	30	5	5	1	2	5	40	20	2	1	55	70
Vegetation cover (%)	80	50	40	75	50	70	60	55	95	68	80	60	30	85	90	30	30
Soil type (SH, shale; SHM, shale, heuweltjie; SA, sandstone)	SHM	SH	SH	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Soil depth range (cm)	14–31	5–23	13–32	0–33	0–7	0–12	3–38	0–37	4–53	0–37	0–39	4–30	5–50+	12–50+	4–50+	10–50+	0–16
Species common to communities 3 and 4																	
IAX	<i>Hypodiscus argenteus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R
	<i>Thesium carinatum</i>	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	R
	<i>Elegia grandis</i>	.	.	.	.	.	.	.	.	.	.	.	.	O	.	.	2A
	<i>Stoebe capitata</i>	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	O
	<i>Ursinia</i> sp.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
	<i>Ficinia monticola</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	<i>Cliffortia pungens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	<i>Pentameris macrocalycina</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2M
	<i>Arctotis acaulis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2A
	<i>Tetradlea bromoides</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	<i>Aristea racemosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R
	<i>Nebelia sphaerocephala</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R
Widespread species occurring through study area																	
IIAX	<i>Helichrysum swartbergense</i>	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	2B
	<i>Seriphium plumosum</i>	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	R
	<i>Erica vestita</i>	.	.	.	.	.	O	.	1	O	.	O	.	.	+	.	R
	<i>Ursinia anthemoides</i>	.	.	.	.	.	.	O	+	.	.	.	.	.	.	.	.
	<i>Zygophyllum fulvum</i>	O	.	.	.	.	.	R	O	O	.	.	R	.	.	.	.

APPENDIX 2.—List of species occurring only once in Appendix 1. Symbols in parentheses represent cover-abundance categories and address (original relevé number) for each record

<i>Acrosanthes teretifolia</i> Eckl. & Zeyh. (R, 4B)	<i>Geissorhiza confusa</i> Goldblatt (R, 5.5B)
<i>Adenandra uniflora</i> (L.) Willd. R (3B)	<i>Gladiolus debilis</i> Sims (R, 2C)
<i>Adenocline pauciflora</i> Turcz. (R, 5.5B)	<i>Haplocarpha lanata</i> (Thunb.) Less. (+, 2B), (R, 2C)
<i>Agathosma stipitata</i> Pillans (O, 4C)	<i>Heliophila subulata</i> Burch. ex DC. (R, 4C)
<i>Anthospermum</i> sp. (L. Agenbag 2C06) (+, 2C)	<i>Lachnaea pudens</i> Beyers (R, 4A)
<i>Antimima hamatilis</i> (L.Bolus) H.E.K.Hartmann (O, 6C)	<i>Linum acuticarpum</i> C.M.Rogers (+, 5.5B)
<i>Arctotis flaccida</i> Jacq. (R, 2C)	<i>Lobelia capillifolia</i> (C.Presl) A.DC. (R, 5.5C)
<i>Arctotis incisa</i> Thunb. (R, 4B)	<i>Lobelia jasionoides</i> (A.DC.) E.Wimm. (R, 0A)
<i>Aristea africana</i> (L.) Hoffmanns (+, 5.5B)	<i>Lobelia pinifolia</i> L. (1, 2C)
<i>Aristea juncifolia</i> Baker (R, 2C)	<i>Merxmüllera arundinacea</i> (P.J.Bergius) Conert (O, 6C)
<i>Askidiosperma paniculata</i> (Rottb.) Desv. (1, 1A)	<i>Merxmüllera stricta</i> (Schrud.) Conert (O, 5.5A)
<i>Aspalathus alpestris</i> (Benth.) R.Dahlgren (O, 6C)	<i>Metalasia montana</i> P.O.Karis (O, 0B)
<i>Aspalathus fusca</i> Thunb. (+, 3B)	<i>Muraltia muraltioides</i> (Eckl. & Zeyh.) Levyns (O, 6C)
<i>Aspalathus hirta</i> E.Mey. (+, 5.5A)	<i>Paranomus dispersus</i> Levyns (R, 5B)
<i>Aspalathus linearis</i> (Burm.f.) R.Dahlgren (+, 5A)	<i>Pelargonium alchemilloides</i> (L.) L'Hér. (O, 5.5B)
<i>Aspalathus tridentata</i> L. (R, 5A)	<i>Pelargonium caucalifolium</i> Jacq. subsp. <i>convulvulifolium</i> (R, 5.5B)
<i>Cassytha ciliolata</i> Nees (1, 5.5C)	<i>Pelargonium elegans</i> (Andrews) Willd. (O, 1C)
<i>Cheilanthes contracta</i> (Kuntze) Mett. ex Kuhn (R, 5.5A)	<i>Pelargonium hermanniifolium</i> (P.J.Bergius) Jacq. (O, 2C)
<i>Cliffortia juniperina</i> L.f. (R, 1B)	<i>Pelargonium longifolium</i> (Burm.f.) Jacq. (R, 4A)
<i>Cliffortia ruscifolia</i> L. (+, 4B)	<i>Pelargonium rapaceum</i> (L.) L'Hér. (R, 5.5A)
<i>Cliffortia sericea</i> Eckl. & Zeyh. (R, 4A)	<i>Pelargonium</i> sp. (L. Agenbag 2C15) (R, 2C)
<i>Clutia alaternoides</i> L. (R, 4C)	<i>Pentastichis colorata</i> (Steud.) Staff (O, 2C)
<i>Clutia laxa</i> Eckl. ex Sond. (R, 2C)	<i>Polygala scabra</i> L. (O, 6C)
<i>Clutia polifolia</i> Jacq. (+, 2C)	<i>Protea lorifolia</i> (Salisb. ex Knight) Fourc. (1, 3A)
<i>Corymbium</i> sp. (L. Agenbag 2C13) (R, 2C)	<i>Protea neriifolia</i> R.Br. (O, 4C)
<i>Crassula capensis</i> (L.) Baill. (R, 6C)	<i>Pseudoselago serrata</i> (P.J.Bergius) Hilliard (R, 2C)
<i>Crassula nudicaulis</i> L. (O, 6C)	<i>Rafnia acuminata</i> (E.Mey.) G.J.Campbell & B-E.van Wyk (R, 5C)
<i>Crassula pubescens</i> Thunb. (R, 4A)	<i>Satyrium odoratum</i> Sond. (+, 4A)
<i>Crassula</i> sp. (L. Agenbag 6D04) (O, 6C)	<i>Sebaea exacoides</i> (L.) Schinz (R, 4C)
<i>Cullumia sulcata</i> (Thunb.) Less. (+, 5.5C)	<i>Senecio acaulis</i> (L.f.) Sch.Bip. (R, 3B)
<i>Cyphia volubilis</i> (Burm.f.) Willd. (O, 2C)	<i>Senecio burchellii</i> DC. (R, 4B)
<i>Dicerothamnus</i> sp. (L. Agenbag 3C09) (O, 3C)	<i>Stipagrostis zeyheri</i> (Nees) De Winter (+, 1C)
<i>Dilatrix ixioides</i> Lam. (O, 3C)	<i>Stoebe nervigera</i> (DC.) Sch.Bip. (R, 5.5A)
<i>Drosanthemum flammeum</i> L.Bolus (O, 5C)	<i>Struthiola myrsinites</i> Lam. (+, 4A)
<i>Drosanthemum</i> sp. (L. Agenbag 6D11) (O, 6C)	<i>Syncarpha flava</i> (Compton) B.Nord. (O, 3C)
<i>Ehrharta ottonis</i> Kunth ex Nees (O, 2C)	<i>Syncarpha gnaphaloides</i> (L.) DC. (R, 4C)
<i>Ehrharta rehmannii</i> Stapf subsp. <i>rehmannii</i> (O, 2C)	<i>Syncarpha variegata</i> (P.J.Bergius) B.Nord. (O, 1A)
<i>Ehrharta rupestris</i> Nees ex Trin. (+, 3C)	<i>Tetragonia spicata</i> L.f. (O, 6B)
<i>Erica coccinea</i> L. (O, 2A)	<i>Tritoniopsis lata</i> (L.Bolus) G.J.Lewis (R, 2B)
<i>Erica embothriifolia</i> Salisb. (O, 0C)	<i>Ursinia paleacea</i> (L.) Moench. (O, 5A)
<i>Erica lateralis</i> Willd. (+, 1A)	<i>Ursinia rigidula</i> (DC.) N.E.Br. (+, 5.5B)
<i>Erica taxifolia</i> Bauer (+, 1B)	<i>Viscum</i> sp. (O, 6C)
<i>Eriocephalus</i> sp. (1, 5A)	<i>Wahlenbergia</i> cf. <i>anerea</i> (L. Agenbag 5.5C06) (R, 5.5C)
<i>Ficinia deusta</i> (P.J.Bergius) Levyns (+, 3C)	<i>Willdenowia</i> sp. (L. Agenbag 2B06) (R, 2B)
<i>Gazania ciliaris</i> DC. (+, 4C)	<i>Willdenowia teres</i> Thunb. (R, 2A)
<i>Gazania rigida</i> (Burm.f.) Roessler (O, 2C)	

APPENDIX 3.—Checklist of species occurring on Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Growth form codes (GFC) are provided in Table 2

Species	Family	GFC
<i>Acrosanthes teretifolia</i> Eckl. & Zeyh.	Aizoaceae	LSS
<i>Adenandra uniflora</i> (L.) Willd.	Rutaceae	LES
<i>Adenandra villosa</i> (P.J.Bergius) Licht. ex Roem. & Schult.	Rutaceae	LES
<i>Adenocline pauciflora</i> Turcz.	Euphorbiaceae	AH
<i>Agathosma glandulosa</i> (Thunb.) Sond.	Rutaceae	LES
<i>Agathosma serphyllacea</i> Licht. ex Roem. & Schult.	Rutaceae	LES
<i>Agathosma stipitata</i> Pillans	Rutaceae	LES
<i>Aloe microstigma</i> Salm-Dyck	Asphodelaceae	LSS
<i>Anaxeton asperum</i> (Thunb.) DC. subsp. <i>pauciflorum</i> Lundgren	Asteraceae	DES
<i>Anthospermum aethiopicum</i> L.	Rubiaceae	LES
<i>Anthospermum galioides</i> Rchb.f.	Rubiaceae	DES
<i>Anthospermum</i> sp. (L. Agenbag 2C06)	Rubiaceae	DES
<i>Antimima hamatilis</i> (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	DSS
<i>Arctotis acaulis</i> L.	Asteraceae	PH
<i>Arctotis flaccida</i> Jacq.	Asteraceae	PH
<i>Arctotis incisa</i> Thunb.	Asteraceae	PH
<i>Arctotis</i> sp. (L. Agenbag 5C03)	Asteraceae	PH
<i>Aristea africana</i> (L.) Hoffmanns	Iridaceae	PH
<i>Aristea juncifolia</i> Baker	Iridaceae	PH

APPENDIX 3.—Checklist for species occurring on Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Growth form codes (GFC) are provided in Table 2 (cont.)

Species	Family	GFC
<i>Aristea racemosa</i> Baker	Iridaceae	PH
<i>Aristida diffusa</i> Trin.	Poaceae	GRA
<i>Askidiosperma paniculata</i> (Rottb.) Desv.	Restionaceae	GRA
<i>Aspalathus alpestris</i> (Benth.) R.Dahlgren	Fabaceae	LES
<i>Aspalathus biflora</i> E.Mey.	Fabaceae	LES
<i>Aspalathus cordata</i> (L.) R.Dahlgren	Fabaceae	LES
<i>Aspalathus fusca</i> Thunb.	Fabaceae	LES
<i>Aspalathus hirta</i> E.Mey.	Fabaceae	LES
<i>Aspalathus juniperina</i> Thunb.	Fabaceae	LES
<i>Aspalathus leucophylla</i> R.Dahlgren	Fabaceae	LES
<i>Aspalathus linearis</i> (Burm.f.) R.Dahlgren	Fabaceae	LES
<i>Aspalathus pachyloba</i> Benth. subsp. <i>macroclada</i> R.Dahlgren	Fabaceae	LES
<i>Aspalathus</i> sp. (L. Agenbag 6B06)	Fabaceae	LES
<i>Aspalathus spicata</i> Thunb.	Fabaceae	DES
<i>Aspalathus tridentata</i> L.	Fabaceae	LES
<i>Bromus hordeaceus</i> L. subsp. <i>molliformis</i> (J.Lloyd) Maire & Weiller	Poaceae	GRA
<i>Cannomois nitida</i> (Mast.) Pillans	Restionaceae	GRA
<i>Cannomois scirpoides</i> (Kunth) Mast.	Restionaceae	GRA
<i>Cassytha ciliolata</i> Nees	Lauraceae	HV
<i>Centella</i> sp. (L. Agenbag 5.5B02)	Apiaceae	PH
<i>Centella triloba</i> (Thunb.) Drude	Apiaceae	HV
<i>Ceratocaryum argenteum</i> Kunth	Restionaceae	GRA
<i>Cheilanthes contracta</i> (Kuntze) Mett. ex Kuhn	Pteridaceae	PH
<i>Chrysocoma ciliata</i> L.	Asteraceae	LES
<i>Cliffortia crenata</i> L.f.	Rosaceae	MES
<i>Cliffortia juniperina</i> L.f.	Rosaceae	LES
<i>Cliffortia pungens</i> C.Presl	Rosaceae	LES
<i>Cliffortia ruscifolia</i> L.	Rosaceae	LES
<i>Cliffortia sericea</i> Eckl. & Zeyh.	Rosaceae	LES
<i>Clutia alaternoides</i> L.	Euphorbiaceae	LES
<i>Clutia laxa</i> Eckl. ex Sond.	Euphorbiaceae	LES
<i>Clutia polifolia</i> Jacq.	Euphorbiaceae	LES
<i>Clutia polygonoides</i> L.	Euphorbiaceae	DES
<i>Corymbium glabrum</i> L.	Asteraceae	PH
<i>Corymbium</i> sp. (L. Agenbag 2C13)	Asteraceae	PH
<i>Crassula atropurpurea</i> (Haw.) D.Dietr. var. <i>atropurpurea</i>	Crassulaceae	LSS
<i>Crassula capensis</i> (L.) Baill.	Crassulaceae	PHS
<i>Crassula fascicularis</i> Lam.	Crassulaceae	PHS
<i>Crassula nudicaulis</i> L.	Crassulaceae	PHS
<i>Crassula pubescens</i> Thunb.	Crassulaceae	DSS
<i>Crassula</i> sp. (L. Agenbag 6D04)	Crassulaceae	DSS
<i>Crassula subaphylla</i> (Eckl. & Zeyh.) Harv.	Crassulaceae	LSS
<i>Cullumia sulcata</i> (Thunb.) Less.	Asteraceae	LES
<i>Cymbopogon pospischilii</i> (K.Schum.) C.E. Hubb.	Poaceae	GRA
<i>Cyphia volubilis</i> (Burm.f) Willd.	Lobeliaceae	HV
<i>Dicerothamnus rhinocerotis</i> (L.f.) Koekemoer	Asteraceae	LES
<i>Dilatris ixiioides</i> Lam.	Haemodoraceae	GEO
<i>Diosma</i> sp. (L. Agenbag 1A08)	Rutaceae	DES
<i>Dodonea viscosa</i> Jacq.	Sapindaceae	MES
<i>Drosanthemum flammeum</i> L.Bolus	Mesembryanthemaceae	DSS
<i>Drosanthemum</i> sp. (L. Agenbag 6D11)	Mesembryanthemaceae	LSS
<i>Drosanthemum speciosum</i> (Haw.) Schwantes	Mesembryanthemaceae	LSS
<i>Edmondia sesamoides</i> (L.) Hilliard	Asteraceae	PH
<i>Ehrharta capensis</i> Thunb.	Poaceae	GRA
<i>Ehrharta delicatula</i> (Nees) Stapf	Poaceae	GRA
<i>Ehrharta ottonis</i> Kunth ex Nees	Poaceae	GRA
<i>Ehrharta ramosa</i> (Thunb.) Thunb.	Poaceae	GRA
<i>Ehrharta rehmannii</i> Stapf subsp. <i>rehmannii</i>	Poaceae	GRA
<i>Ehrharta rupestris</i> Nees ex Trin.	Poaceae	GRA
<i>Ehrharta thunbergii</i> Gibbs Russ.	Poaceae	GRA

APPENDIX 3.—Checklist for species occurring on Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Growth form codes (GFC) are provided in Table 2 (cont.)

Species	Family	GFC
<i>Elegia filacea</i> Mast.	Restionaceae	GRA
<i>Elegia grandis</i> (Nees) Kunth	Restionaceae	GRA
<i>Elegia racemosa</i> (Poir.) Pers.	Restionaceae	GRA
<i>Elegia stokoei</i> Pillans	Restionaceae	GRA
<i>Elytropappus</i> sp. (L. Agenbag 3C09)	Asteraceae	MES
<i>Erepsia gracilis</i> (Haw.) L.Bolus	Mesembryanthemaceae	LSS
<i>Erica anguliger</i> (N.E.Br.) E.G.H.Oliv.	Ericaceae	DES
<i>Erica axillaris</i> Thunb.	Ericaceae	LES
<i>Erica cerinthoides</i> L.	Ericaceae	LES
<i>Erica coccinea</i> L.	Ericaceae	LES
<i>Erica corifolia</i> L.	Ericaceae	LES
<i>Erica embothriifolia</i> Salisb.	Ericaceae	LES
<i>Erica equisetifolia</i> Salisb.	Ericaceae	LES
<i>Erica fastigiata</i> L.	Ericaceae	LES
<i>Erica lateralis</i> Willd.	Ericaceae	LES
<i>Erica longifolia</i> Bauer	Ericaceae	MES
<i>Erica monsoniana</i> L.f.	Ericaceae	MES
<i>Erica plukenetii</i> L.	Ericaceae	LES
<i>Erica sessiliflora</i> L.f.	Ericaceae	LES
<i>Erica setacea</i> Andrews	Ericaceae	DES
<i>Erica</i> sp. (L. Agenbag 2A02)	Ericaceae	DES
<i>Erica taxifolia</i> Bauer	Ericaceae	LES
<i>Erica vestita</i> Thunb.	Ericaceae	LES
<i>Eriocephalus africanus</i> L.	Asteraceae	LES
<i>Eriocephalus</i> sp.	Asteraceae	LES
<i>Euclea undulata</i> Thunb.	Ebenaceae	MES
<i>Euphorbia burmannii</i> E.Mey. ex Boiss.	Euphorbiaceae	LSS
<i>Euryops abrotanifolius</i> (L.) DC.	Asteraceae	MES
<i>Felicia filifolia</i> (Vent.) Burtt Davy	Asteraceae	LES
<i>Ficinia deusta</i> (P.J.Bergius) Levyns	Cyperaceae	GRA
<i>Ficinia monticola</i> Kunth	Cyperaceae	GRA
<i>Ficinia nigrescens</i> (Schrad.) J.Raynal	Cyperaceae	GRA
<i>Ficinia oligantha</i> (Steud.) J.Raynal	Cyperaceae	GRA
<i>Ficinia</i> sp. (L. Agenbag 0B01)	Cyperaceae	GRA
<i>Ficinia stolonifera</i> Boeck.	Cyperaceae	GRA
<i>Galenia africana</i> L.	Aizoaceae	LES
<i>Galium tomentosum</i> Thunb.	Rubiaceae	LES
<i>Gazania ciliaris</i> DC.	Asteraceae	PH
<i>Gazania rigida</i> (Burm.f.) Roessler	Asteraceae	PH
<i>Geissorhiza confusa</i> Goldblatt	Iridaceae	GEO
<i>Geranium incanum</i> Burm.f.	Geraniaceae	PH
<i>Gladiolus debilis</i> Sims	Iridaceae	GEO
<i>Haplocarpha lanata</i> (Thunb.) Less.	Asteraceae	PH
<i>Harveya bolusii</i> Kuntze	Orobanchaceae	PH
<i>Helichrysum revolutum</i> (Thunb.) Less.	Asteraceae	LES
<i>Helichrysum zwartbergense</i> Bolus	Asteraceae	DES
<i>Heliophila scoparia</i> Burch. ex DC.	Brassicaceae	LES
<i>Heliophila subulata</i> Burch. ex DC.	Brassicaceae	PH
<i>Hermannia angularis</i> Jacq.	Sterculiaceae	LES
<i>Hermannia aspera</i> J.C.Wendl.	Sterculiaceae	LES
<i>Hermannia rudis</i> N.E.Br.	Sterculiaceae	LES
<i>Hypodiscus albo-aristatus</i> (Nees) Mast.	Restionaceae	GRA
<i>Hypodiscus aristatus</i> (Thunb.) C.Krauss	Restionaceae	GRA
<i>Hypodiscus laevigatus</i> (Kunth) H.P.Linder	Restionaceae	GRA
<i>Hypodiscus squamosus</i> Esterh.	Restionaceae	GRA
<i>Hypodiscus striatus</i> (Kunth) Mast.	Restionaceae	GRA
<i>Indigofera depressa</i> Harv.	Fabaceae	LES
<i>Indigofera porrecta</i> Eckl. & Zeyh.	Fabaceae	LES
<i>Ischyrolepis capensis</i> (L.) H.P.Linder	Restionaceae	GRA
<i>Ischyrolepis curviramis</i> (Kunth) H.P.Linder	Restionaceae	GRA

APPENDIX 3.—Checklist for species occurring on Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Growth form codes (GFC) are provided in Table 2 (cont.)

Species	Family	GFC
<i>Ischyrolepis gaudichaudiana</i> (Kunth) H.P.Linder	Restionaceae	GRA
<i>Ischyrolepis sieberi</i> (Kunth) H.P.Linder	Restionaceae	GRA
<i>Ixia longituba</i> N.E.Br. var. <i>bellendenii</i> (R.C.Foster) M.P.de Vos	Iridaceae	GEO
<i>Lachnaea pudens</i> Beyers	Thymeleaceae	LES
<i>Lachnospermum fasciculatum</i> (Thunb.) Baillon	Asteraceae	LES
<i>Lampranthus</i> sp. (L. Agenbag 5.5A19)	Mesembryanthemaceae	LSS
<i>Leucadendron laureolum</i> (Lam.) Fourc.	Proteaceae	MES
<i>Leucadendron nervosum</i> E.Phillips & Hutch	Proteaceae	MES
<i>Leucadendron salignum</i> P.J.Bergius	Proteaceae	LES
<i>Leucospermum calligerum</i> (Salisb. ex Knight) Rourke	Proteaceae	LES
<i>Linum acuticarpum</i> C.M.Rogers	Linaceae	PH
<i>Lobelia capillifolia</i> (C.Presl) A.DC.	Lobeliaceae	LES
<i>Lobelia coronopifolia</i> L.	Lobeliaceae	PH
<i>Lobelia jasionoides</i> (A.DC.) E.Wimm.	Lobeliaceae	PH
<i>Lobelia pinifolia</i> L.	Lobeliaceae	DES
<i>Lobostemon fruticosus</i> (L.) H.Buek	Boraginaceae	LES
<i>Lobostemon gracilis</i> Levyns	Boraginaceae	LES
<i>Merxmüllera arundinacea</i> (P.J.Bergius) Conert	Poaceae	GRA
<i>Merxmüllera stricta</i> (Schrad.) Conert	Poaceae	GRA
<i>Metalasia densa</i> (Lam.) P.O.Karis	Asteraceae	LES
<i>Metalasia montana</i> P.O.Karis	Asteraceae	DES
<i>Metalasia</i> sp. (L. Agenbag 0B02)	Asteraceae	DES
<i>Microdon dubius</i> (L.) Hilliard	Scrophulariaceae	LES
<i>Montinia caryophyllacea</i> Thunb.	Montiniaceae	MES
<i>Muraltia heisteria</i> (L.) DC.	Polygalaceae	LES
<i>Muraltia muraltioides</i> (Eckl. & Zeyh.) Levyns	Polygalaceae	DES
<i>Nebelia laevis</i> (E.Mey.) Kuntze	Bruniaceae	MES
<i>Nebelia sphaerocephala</i> (Sond.) Kuntze	Bruniaceae	MES
<i>Oedera genistifolia</i> (L.) Anderb. & K.Bremer	Asteraceae	LES
<i>Oedera squarrosa</i> (L.) Anderb. & K.Bremer	Asteraceae	LES
<i>Oligocarpus calendulaceus</i> (L.f.) Less.	Asteraceae	AH
<i>Ornithogalum dubium</i> Houtt.	Hyacinthaceae	GEO
<i>Osteospermum polygaloides</i> L.	Asteraceae	DES
<i>Osteospermum polygaloides</i> L. var. <i>polygaloides</i>	Asteraceae	DES
<i>Othonna quinqueidentata</i> Thunb.	Asteraceae	MES
<i>Othonna ramulosa</i> DC.	Asteraceae	LSS
<i>Oxalis depressa</i> Eckl. & Zeyh.	Oxalidaceae	GEO
<i>Oxalis engleriana</i> Schltr.	Oxalidaceae	GEO
<i>Oxalis pes-caprae</i> L.	Oxalidaceae	GEO
<i>Paranomus dispersus</i> Levyns	Proteaceae	LES
<i>Passerina obtusifolia</i> Thoday	Thymeleaceae	LES
<i>Pelargonium alchemilloides</i> (L.) L'Hér.	Geraniaceae	DES
<i>Pelargonium caucalifolium</i> Jacq. subsp. <i>convulvulifolium</i>	Geraniaceae	LES
<i>Pelargonium elegans</i> (Andrews) Willd.	Geraniaceae	DES
<i>Pelargonium hermanniifolium</i> (P.J.Bergius) Jacq.	Geraniaceae	LES
<i>Pelargonium incarnatum</i> (L'Hér.) Moench	Geraniaceae	DES
<i>Pelargonium longifolium</i> (Burm.f.) Jacq.	Geraniaceae	GEO
<i>Pelargonium ovale</i> (Burm.f.) L'Hér.	Geraniaceae	DES
<i>Pelargonium rapaceum</i> (L.) L'Hér.	Geraniaceae	GEO
<i>Pelargonium</i> sp. (L. Agenbag 2C15)	Geraniaceae	DES
<i>Pelargonium</i> sp. cf. section <i>Hoarea</i> (L. Agenbag 6B07)	Geraniaceae	GEO
<i>Pentameris macrocalycina</i> (Steud.) Schweick.	Poaceae	GRA
<i>Pentaschistis colorata</i> (Steud.) Stapf	Poaceae	GRA
<i>Pentaschistis curvifolia</i> (Schrad.) Stapf	Poaceae	GRA
<i>Pentaschistis eriotoma</i> (Nees) Stapf	Poaceae	GRA
<i>Phaenocoma prolifera</i> (L.) D.Don	Asteraceae	LES
<i>Phylica</i> sp. (L. Agenbag 5.5A08)	Rhamnaceae	LES
<i>Phylica</i> sp. (L. Agenbag 5A03)	Rhamnaceae	LES
<i>Phylica vulgaris</i> Pillans var. <i>major</i> Pillans	Rhamnaceae	DES
<i>Phyllobolus splendens</i> (L.) Gerbaulet subsp. <i>splendens</i>	Mesembryanthemaceae	LSS

APPENDIX 3.—Checklist for species occurring on Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Growth form codes (GFC) are provided in Table 2 (cont.)

Species	Family	GFC
<i>Podalyria</i> sp. (L. Agenbag 2C14)	Fabaceae	LES
<i>Polygala fruticosa</i> P.J.Bergius	Polygalaceae	LES
<i>Polygala scabra</i> L.	Polygalaceae	LES
<i>Protea amplexicaulis</i> (Salisb.) R.Br.	Proteaceae	LES
<i>Protea humiflora</i> Andrews	Proteaceae	LES
<i>Protea laurifolia</i> Thunb.	Proteaceae	MES
<i>Protea lorifolia</i> (Salisb. ex Knight) Fourc.	Proteaceae	LES
<i>Protea magnifica</i> Link	Proteaceae	LES
<i>Protea neriifolia</i> R.Br.	Proteaceae	MES
<i>Protea repens</i> (L.) L.	Proteaceae	MES
<i>Pseudopentameris macrantha</i> (Schrad.) Conert	Poaceae	GRA
<i>Pseudoselago serrata</i> (P.J.Bergius) Hilliard	Scrophulariaceae	LES
<i>Pteronia fasciculata</i> L.f.	Asteraceae	LES
<i>Pteronia incana</i> (Burm.) DC.	Asteraceae	LES
<i>Pteronia paniculata</i> Thunb.	Asteraceae	LES
<i>Rafnia acuminata</i> (E.Mey.) G.J.Campbell & B.-E.van Wyk	Fabaceae	DES
<i>Restio bolusii</i> Pillans	Restionaceae	GRA
<i>Restio filiformis</i> Poir.	Restionaceae	GRA
<i>Restio triticeus</i> Rottb.	Restionaceae	GRA
<i>Ruschia caroli</i> (L.Bolus) Schwantes	Mesembryanthemaceae	DSS
<i>Ruschia lineolata</i> (Haw.) Schwantes	Mesembryanthemaceae	DSS
<i>Ruschia</i> sp. (L. Agenbag 5A09)	Mesembryanthemaceae	LSS
<i>Satyrium odorum</i> Sond.	Orchidaceae	GEO
<i>Schismus barbatus</i> (Loefl. ex L.) Thell.	Poaceae	GRA
<i>Searsia dissecta</i> (Thunb.) Moffett	Anacardiaceae	LES
<i>Searsia lucida</i> (L.) F.A.Barkley	Anacardiaceae	LES
<i>Searsia rosmarinifolia</i> (Vahl) F.A.Barkley	Anacardiaceae	LES
<i>Searsia undulata</i> (Jacq.) T.S.Yi, A.J.Mill. & J.Wen	Anacardiaceae	MES
<i>Sebaea exacoides</i> (L.) Schinz	Gentianaceae	AH
<i>Selago parvibractea</i> Hilliard	Scrophulariaceae	LES
<i>Senecio acaulis</i> (L.f.) Sch.Bip.	Asteraceae	PHS
<i>Senecio burchellii</i> DC.	Asteraceae	DES
<i>Senecio paniculatus</i> P.J.Bergius	Asteraceae	PH
<i>Seriphium incanum</i> (Thunb.) Pers.	Asteraceae	LES
<i>Seriphium plumosum</i> L.	Asteraceae	LES
<i>Serruria gremialis</i> Rourke	Proteaceae	DES
<i>Stipagrostis zeyheri</i> (Nees) De Winter	Poaceae	GRA
<i>Stoebe aethiopica</i> L.	Asteraceae	LES
<i>Stoebe capitata</i> P.J.Bergius	Asteraceae	LES
<i>Stoebe montana</i> Schltr. ex Levyns	Asteraceae	DES
<i>Stoebe nervigera</i> (DC.) Sch.Bip.	Asteraceae	DES
<i>Stoebe</i> sp. (L. Agenbag 0C04)	Asteraceae	PH
<i>Struthiola myrsinites</i> Lam.	Thymeleaceae	LES
<i>Sutera caerulea</i> (L.f.) Hiern	Scrophulariaceae	AH
<i>Sutera uncinata</i> (Desr.) Hilliard	Scrophulariaceae	LES
<i>Syncarpha flava</i> (Compton) B.Nord.	Asteraceae	DES
<i>Syncarpha gnaphaloides</i> (L.) DC.	Asteraceae	DES
<i>Syncarpha paniculata</i> (L.) B.Nord.	Asteraceae	LES
<i>Syncarpha variegata</i> (P.J.Bergius) B.Nord.	Asteraceae	DES
<i>Tetragonia spicata</i> L.f.	Aizoaceae	LES
<i>Tetragonia bromoides</i> (Lam.) Pfeiff.	Cyperaceae	GRA
<i>Tetragonia fasciata</i> (Rottb.) C.B.Clarke	Cyperaceae	GRA
<i>Tetragonia flexuosa</i> (Thunb.) C.B.Clarke	Cyperaceae	GRA
<i>Tetragonia sylvatica</i> (Nees) C.B.Clarke	Cyperaceae	GRA
<i>Tetragonia ustulata</i> (L.) C.B.Clarke	Cyperaceae	GRA
<i>Thamnochortus fruticosus</i> P.J.Bergius	Restionaceae	GRA
<i>Thamnochortus lucens</i> (Poir.) H.P.Linder	Restionaceae	GRA
<i>Thesium carinatum</i> A.DC.	Santalaceae	DS,P
<i>Thesium commutatum</i> Sond.	Santalaceae	DS,P
<i>Thesium patulum</i> A.W.Hill	Santalaceae	PH,P

APPENDIX 3.—Checklist for species occurring on Jonaskop altitudinal gradient in Riviersonderend Mountain Catchment of Western Cape, South Africa. Growth form codes (GFC) are provided in Table 2 (cont.)

Species	Family	GFC
<i>Thesium</i> sp. (L. Agenbag 5B05)	Santalaceae	LS,P
<i>Thesium spicatum</i> L.	Santalaceae	DS,P
<i>Thesium strictum</i> P.J.Bergius	Santalaceae	LS,P
<i>Trachyandra muricata</i> (L.f.) Kunth.	Asphodelaceae	GEO
<i>Tribolium hispidum</i> (Thunb.) Desv.	Poaceae	GRA
<i>Tritoniopsis lata</i> (L.Bolus) G.J.Lewis	Iridaceae	GEO
<i>Tylecodon paniculatus</i> (L.f.) Toelken	Crassulaceae	LSS
<i>Ursinia anthemoides</i> (L.) Poir. subsp. <i>anthemoides</i>	Asteraceae	AH
<i>Ursinia paleacea</i> (L.) Moench.	Asteraceae	LES
<i>Ursinia rigidula</i> (DC.) N.E.Br.	Asteraceae	DES
<i>Ursinia</i> sp.	Asteraceae	DES
<i>Vellereophyton dealbatum</i> (Thunb.) Hilliard & B.L.Burt	Asteraceae	PH
<i>Viscum</i> sp.	Viscaceae	S,P
<i>Wachendorfia</i> sp.	Haemodoraceae	GEO
<i>Wahlenbergia</i> cf. <i>anerea</i> (L. Agenbag 5.5C06)	Campanulaceae	LES
<i>Wahlenbergia neorigida</i> Lammers	Campanulaceae	LES
<i>Willdenowia</i> sp. (L. Agenbag 2B06)	Restionaceae	GRA
<i>Willdenowia teres</i> Thunb.	Restionaceae	GRA
<i>Zygophyllum fulvum</i> L.	Zygophyllaceae	LES
<i>Zyrphelis lasiocarpa</i> (DC.) Kuntze	Asteraceae	DES
<i>Zyrphelis microcephala</i> (Less.) Nees	Asteraceae	DES

Miscellaneous notes

VARIOUS AUTHORS

A TRIBUTE TO PROF. KRISTO PIENAAR (1922–1996), DOYEN OF SOUTH AFRICAN GARDENING

Few people have made a greater contribution to popularizing gardening and an appreciation of nature in South Africa than Prof. Kristo Pienaar (Figure 1). Through the printed media and as a television personality, Kristo became nothing short of a gardening and environmental celebrity. If, on any particular evening in his gardening programme, he suggested that a certain plant should be eradicated from the South African gardening landscape, the gardeners of the country rallied behind him and started chopping out the plants the very next morning. It would be fair to say that, during the 1970s and 1980s, Kristo was truly Mr Gardening in South Africa. Kristo sadly passed away on the 6th of April 1996 at the age of 73, after a long battle with prostate cancer.

Kristo Johannes Pienaar (always with great emphasis on the Kristo with a K) was born in Bokfontein near Rustenburg on 4 July 1922 to parents Jan Leon Cachet Pienaar and Hendrina Johanna van der Merwe. He had two brothers and two sisters, and grew up on the slopes of the Magaliesberg. Kristo started his school career at the age of four, sitting quietly under his mother's desk, while she taught her class at the local school. He subsequently skipped some grades and matriculated from the *Höer Volksskool* in Heidelberg at the age of 16. He achieved an M.Sc. in Botany from



the University of Pretoria. His Ph.D. was done at the University of Stellenbosch and dealt with the Liliaceae. He then became a teacher at Monument High School in Klerksdorp where he remained from 1944–1960. In 1962 he joined the Department of Botany at the University of the Western Cape as senior lecturer, and he later became the head of the department.

Kristo married Christina Wilhelmina van Rooyen, the love of his life, on 15 December 1945 at the Dutch Reformed Students Church in Pretoria East. It was love at first sight when on the first day he saw Christina, he turned to his friend and said 'There is the woman I'm going to marry.' Kristo and Christina had four daughters (Ronel, Riana, Christa and Adri) who between them gave them four granddaughters, five grandsons and four great-grandchildren. One of his granddaughters aspires to walk in her grandfather's footsteps and wants to become a great botanist one day.

His hobbies included gardening (of course!) and rugby which he played for Northern Transvaal. He supported the team for many years until loyalty to his province of residence made him change sides to Western Province. This caused a major fallout with Prof. Anna Neethling-Pohl who was of Blue Bull blood, and they did not speak for many years! He also enjoyed staying abreast of new scientific literature, caring for his wild birds and listening to Pavarotti. He loved westerns/cowboy movies, old musicals and love stories, and never missed the antics of JR on *Dallas* nor an episode of *Haasdas se nuuskas* on TV!

Most of us will remember Kristo as the kindly gentleman of *VeldFocus* in the 50/50 nature programme on TV, which he presented for six years. Or perhaps you are one of those who remembers him as the kindly grandfather in a television shoe polish commercial. Kristo enjoyed acting and appeared in a number of films namely, *Fratse in die vloot*, *Rip van Winkel*, *'n Seder val in Waterkloof* and *Herfsland*.

His talents were not limited to television and he was once a presenter for *Radio Good Hope*. He was the first programme presenter to do an interview with Prof. Chris Barnard after the first heart transplant in 1967, and he wrote and presented a series called *Goue gedagtes* on Springbok Radio, which was later published as a book. Other programmes included *Ons en die wetenskap* and *Vra vir Kristo*. He also wrote a story for the children's radio programme *Siembamba*, in honour of his first grandchild Klippie, which he read to the children himself.

He is also the author of more than thirty books and other publications of which some of the most popular is undoubtedly the *South African What flower is that?* and *Everyone's guide to gardening*.

During his reign as the king of gardening, he was also on the Board of the National Botanic Gardens, a member of the then Western Cape Regional Council for Cultural Affairs, and Chairman of the Bellville Amateur Acting Society. He was the head elder of his church and from time to time involved in the Heart Foundation of South Africa. He judged the national police stations' gardens and was involved with the African Violet Society. He was city councillor and mayor of Bellville as well as magazine and newspaper columnist for *Die Burger* and *Sarie*. His weekly gardening column *Vra vir Kristo* in *Die Burger* was immensely popular.

In 1996, the Professor Kristo Pienaar Floating Trophy for Environmental Education and Awareness was created by the then SA Army in his honour and is bestowed on units within the South African National Defence Force (SANDF) in recognition of the best contribution with respect to environmental education.

Many have felt the need to bestow honour on him. There is for instance a hybrid tea rose (which he personally selected from a group of potential candidates) named after him in recognition of his efforts in creating an awareness of indigenous plants in South Africa. There are also disa hybrids named after both him and his wife, Christina.

He was the recipient of a Laureatus Award in 1987, which is the highest award of the Alumni Association of the University of Pretoria (Tukkies). In 1989 he was given the freedom of the city of Bellville when he was named *Die Burger* Resident of the Year. In 1992 he was made Honorary Colonel in the Police Force. In 1997, a posthumous award was made to him, in memory of his contribution towards environmental education in the SANDF, which was received by his daughter. He has received the Nederburg Prize for the arts and the SABC Artes award for the best television programme, *VeldFocus*. He was also awarded the gold Order for Excellence in Service to the Country by the president, which is the highest award that a country can bestow on a citizen.

Above all, Kristo was a family man. He considered his home to be his castle and his wife his refuge. Affectionately known by his daughters as 'Tito', he used to call them *peervoël* whenever they did something silly.

The family travelled the country extensively, as Kristo believed that you had to see your own country before travelling abroad. The Kruger National Park was his personal favourite and travel was always accompanied with a strict programme of what had to be achieved on each day.

At a time when very few people flew, Kristo took his daughters flying on Saturdays, first in a small plane and later in a Dakota, so that they could experience flight. When asked to sum up his character in three words, three of his daughters each said the following: 'larger than life', 'diligence, exuberance (for life) and warmth' and 'faith, family and nature.'

A fellow botanist gave his impression of Kristo as a person with a 'passionate urge to broadcast his knowledge as a teacher', 'a person with infectious enthusiasm' and on meeting him at a botanical gathering 'you had the feeling that you were talking to a reporter, a communicator, a person focused on the spreading of information'.

It was the city of Bellville's habit to name streets after their mayors. Kristo, however, requested that the Tygerberg Nature Reserve's Environmental Education Centre be named after him instead. Thanks to the legacy of this great man, the Tygerberg region now has an outdoor classroom in the form of the Kristo Pienaar Environmental Education Centre, which is a place where children (and their parents) can learn about nature and hopefully gain some respect for the beauty of our country, thus, fittingly paying tribute to a man who dedicated his life to the (environmental) education of others.

'Die meetsnoere het vir my in lieflike plekke geval, ja, my erfenis is vir my mooi—The lines have fallen for me in pleasant places; indeed I have a beautiful inheritance'

Psalm 16: 6

Inscription on Prof. Kristo Pienaar's tombstone

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OBITUARY

DONALD JOSEPH BOOMER KILLICK (1926–2008)

Fortiter in re, suaviter in modo—strong in deed,
gentle in manner

‘Mountains the world over attract not only mountaineers and climbers, but also botanists. The Natal Drakensberg is no exception’ (Figure 1). With these words Donald opens the chapter *Plant exploration* in his *A field guide to the flora of the Natal Drakensberg* (Killick 1990), his last major publication and the one that was perhaps closest to his heart. Visualise a forester’s cottage among the sweeping, tawny-red *Themeda triandra* grassland on the Little Berg where he spent many lonely (Figure 2) but highly productive hours studying and preserving plant specimens, overlooking winter-brown communities of *Pteridium aquilinum*, cliff scrub with red-flowered *Greyia sutherlandii* and *Aloe arborescens*, dark green patches of kloof forest with *Podocarpus latifolius* and *Scolopia mundii*, and on the summit plateau the bleak and apparently barren afro-alpine heath, at an altitude of about 2 900 m, with species of *Erica* and *Helichrysum*: life against the magnificent backdrop of Cathedral Peak, the Bell, Outer and Inner Horn, the Chessmen, Mitre and Elephant, to name but a few—these last five words Donald would have detested: he had an intense dislike for sloppy lingo, well balanced by his passion for concise, correct language, English as well as Latin. He would also have said that this paragraph is too flowery, or gushy, as he would have put it [for readers without *The Oxford dictionary*: displaying excessive sentimentality], and that the sentences are much too long [see section Style in his *Guide to science writing* (Killick 1981b)], and too full of brackets.

Donald Killick (Figure 3) was born in Pietermaritzburg, KwaZulu-Natal, on the 6th of May 1926, the son

of a Methodist minister. He attended Maritzburg College from 1940 until matriculation in 1943. From 1945 to 1950 he studied at the Natal University College which became the University of Natal in 1948. He graduated with a B.Sc. in Zoology and Botany (with distinction). The following year he graduated B.Sc. Hons in Botany, and in 1950 he was awarded an M.Sc. degree for the thesis entitled *An account of the plant ecology of the Table Mountain area of Pietermaritzburg, Natal*. For this he won the Junior Captain Scott Memorial Medal of the South African Biological Society in 1954 for the best M.Sc. thesis in botany. The work was published in *Memoirs of the Botanical Survey of South Africa* No. 32 (Killick 1959b).

In 1950 Donald joined the Botanical Research Institute of the Department of Agriculture in the Botanical Survey Section. In September of the same year he was given the task of surveying the Cathedral Peak area of the KwaZulu-Natal Drakensberg for the Department of Forestry. During the survey period, he alternated between Cathedral Peak for the field work, and the National Herbarium in Pretoria for identifying the collected specimens. At the time, he worked under the guidance of L.E.W. (Les) Codd, J.P.H. (John) Acocks and R. (Bob) Story. From 1954 to 1957 he served as South African Liaison Officer at the Royal Botanic Gardens, Kew in London. Here he gained valuable taxonomic experience, and he had the opportunity to compare and identify many of his own collections.

After his return to South Africa in 1957, he completed his field work at Cathedral Peak and wrote up the research results as a Ph.D. thesis, *An account of the plant ecology of the Cathedral Peak area of the Natal*



FIGURE 1.—Forestry cottages (with no electricity) on the Little Berg where Donald spent many months studying the Drakensberg flora.



FIGURE 2.—Donald resting against a house of the Mountain Club during a hike across the highest peaks of the Drakensberg.

Drakensberg which was published in *Memoirs of the Botanical Survey of South Africa* No. 34 (Killick 1963a). Donald also undertook *ad hoc* ecological investigations of poisonous plants and of burrgrass. He started editing the Institute series *Memoirs of the Botanical Survey of South Africa* and assisted B. (Bernard) de Winter, then Officer in Charge of the Botanical Survey Section. As Officer in Charge of the Botanical Survey Section from 1963 to 1966, he directed the research of the Section and was largely responsible for an important change in ecological approach—from descriptive (qualitative) to quantitative methodology. Methods such as association analysis and plotless sampling were introduced, as well as ordination techniques. He took a personal interest in each project and visited the researchers on site. Among them were H.C. (Hugh) Taylor, J.W. (Jeff) Morris, E.J. (Eugene) Moll, M.J. (Mike) Wells, C.J. (Chris) Scheepers and J.P.H. (John) Acocks.

In 1963 he was placed in charge of the administration of all research projects of the Institute and was responsible for the registration and termination of facets and for seeing that project applications, annual project reports and final reports were scientifically acceptable. On the occasion of the 1966 Republic Festival, he joined B. (Bernard) de Winter and his wife Mayda to produce *Sixty-six Transvaal trees* (De Winter, De Winter & Killick 1966) which sparked wide interest in indigenous trees and was the first publication in which numbers were assigned to all known South African trees. In response to public demand, *Readers Digest* commissioned the same

authors to produce a booklet dealing in an abbreviated manner with 55 of the original 66 trees *simply to whet the appetite of the South African public and to show what fun and interest can be derived from an awareness of the trees which one passes on the roadside and in the veld* (De Winter, De Winter & Killick 1974).

From 1966 to 1969 Donald was Officer in Charge of the Flora Section. He directed the research of the Section and also undertook personal taxonomic research. Volume 13 of the *Flora of southern Africa* was the first volume to be written entirely by members of the Flora Section. They were W. (Wessel) Marais, L.E.W. (Leslie) Codd, L.E. (Lars) Kers, H.R. (Hellmut) Toelken, J.A. (Judy) Marsh, O.A. (Otto) Leistner, A.A. (Amelia) Obermeyer-Mauve and Donald himself. During this period, as aids to taxonomic practice, he prepared standard lists of literature abbreviations, author abbreviations and a card index to location of type specimens.

Donald served for a second time as South African Liaison Officer at Kew from 1969 to 1971, a task which he accomplished with distinction. On his return he was appointed Assistant Director. He continued as Officer in Charge of the Flora Section from 1971 to 1973, deputising for J.H. (Jim) Ross who was Liaison Officer at Kew at the time. Donald also became involved with editing, in particular of the Institute series, *Memoirs of the Botanical Survey of South Africa*.

In 1973 he was promoted to Deputy Director and assumed growing responsibility for three of the publications of the Institute, *Memoirs of the Botanical Survey*

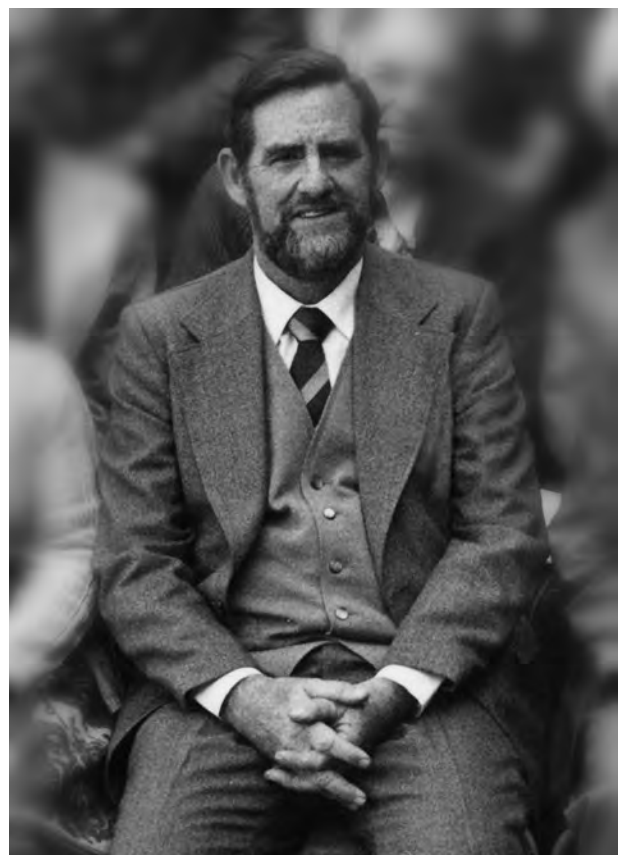


FIGURE 3.—Donald Joseph Boomer Killick (1926–2008).



FIGURE 4.—Presentation of Long-service Awards at the Botanical Research Institute, 13 January 1981. Back row, left to right, horticultural staff, L.C. Steenkamp, A. Pilusa, J. Makena, Stuurman Makena, S. Makena and J. Ehrens. Front row, left to right, herbarium staff, Dr D.J.B. Killick, Dr R.A. Dyer, Ms M.D. Gunn, Dr L.E.W. Codd, and Ms I.C. Verdoorn.

of South Africa, *The Flowering Plants of Africa* and *Bothalia*. He was editor of *Bothalia* from 1972–1985. After his thirtieth year with the Institute he received a Long-service Award together with several other colleagues (Figure 4). When D. (Denzil) Edwards, Assistant Director in charge of the Botanical Survey Section, left the Institute in 1982, he took over the administration of the Institute's research programme. This included the annual evaluation of the 85 research facets in progress at the time. In 1985 he relinquished most of the editorial responsibility for the Institute journals, with the exception of *The Flowering Plants of Africa*. He then took up many administrative tasks, amongst others control of finances and annual reports. On the 31st of March 1989 he retired (Figure 5). A few months later he submitted the final report on his taxonomic studies as part of the Drakensberg-Maluti Mountain Catchment Conservation Programme. In the following year Donald published his *A field guide to the flora of the Natal Drakensberg* (Killick 1990). He continued to answer nomenclatural queries and lectured part-time in plant nomenclature to post-graduate students at the University of Pretoria. He wrote and checked Latin descriptions, refereed articles and wrote up plates for *The Flowering Plants of Africa*. During his last months, which he spent in a retirement village, his health deteriorated gradually and he grew ever weaker, but to the end he was able to attend to his small garden and to read widely, preferably novels. On 16 April 2008 he died suddenly due to failing circulation. He is survived by his wife, Berenice, neé Boegman, whom he met when she was employed at the Institute. From this family union which formed an extremely important part of Donald's life, two sons were born: Stephen, a chartered accountant, and Michael, a civil engineer.

Donald had a considerable impact on botanical science through his furtherance and editing of three of the Institute's publications for many years. The series *Memoirs of the Botanical Survey of South Africa* was under his editorship for 27 years, *Flowering Plants of Africa* for 15 years, and *Bothalia*, the house journal of

the Institute, for 13 years. In addition he was a member of the editorial board of the *Journal of South African Botany*. He gave the journals of the Institute a new look and helped build up their international status. He vetted hundreds of research papers, and rewrote many either partly or completely. Over a period of 36 years he also refereed many articles for the *Journal of South African Botany* and the *South African Journal of Botany*. Authors were continually encouraged to improve the standard of



FIGURE 5.—Donald paging through the commemorative album presented to him on the occasion of his retirement on 31 March 1989.

their research papers. In so doing he has helped to launch numerous botanists on their publishing careers. Donald was promotor or co-promotor of several M.Sc. and Ph.D theses dealing with various branches of botany. He gave lectures on science writing at the Institute and at the University of Cape Town and in 1981 he published his acclaimed and widely consulted *Guide to science writing* (Killick 1981b) dealing with the do's and don'ts in this field. The guide starts with the sentence: 'I believe, and I am sure many other editors of scientific journals will agree, that there has been a steady decline in the standard of science writing in recent years'. He then discusses three possible causes: 'the teaching of grammar has been largely thrown out of the window; instead functional English' is taught at schools. Secondly, 'few universities, if any, teach their students how to write a scientific paper'. The increasing use of multiple-choice examinations at universities is given as a third possible cause. Instead of expressing themselves in writing, students simply have to put a tick in the appropriate box. Reading further in his *Guide to science writing* one not only acquires a deeper knowledge of the subject but one also learns more about the author, a man of great integrity, diligent, meticulous and methodical. And as he writes: 'Another important essential is brevity....Remember that words cost money'. Donald was a man of few, well considered words, both in speech and in writing: 'Write to express—not to impress'. A man not given to bursts of laughter but with a fine sense of humour expressed in a dry manner. An example of a cited cliché as they should not be used by self-respecting authors: *she's as happy as a lark in the knowledge that her husband is slightly musclebound above his 19-inch collar, making his cranial area simply an anatomical device to separate his ears*. Concerning the perceived decline in the standard of science writing: the teaching of grammar will remain on the red data list and multi-choice exams will become ever more popular with professors and lecturers, but there appears to be a marked improvement in the way students at local universities are taught how to write scientific papers, partly, I am convinced, due to Donald's efforts.

In the words of Bernard de Winter, Director of the Institute during the last 16 years of Donald's term of office: 'His retiring nature, matched with a tall frame, neat beard and conservative dress made him seem unapproachable. In all situations he remained the English gentleman who strictly adhered to correct behaviour, and deeply valued the underlying code of conduct this implied. He was a professional in the real sense of the word and a dedicated botanist. A pragmatist, he nevertheless dissuaded his sons from following him in his profession, advising them to choose more lucrative careers. He made enduring friendships but remained a somewhat solitary person to the end'.

Donald has published 80 papers in taxonomy varying from one-page descriptions of new species to full-scale revisions of families running to 39 pages. On the whole, his taxonomic revisions have stood the test of time. His account of *Satureja* (Killick 1961a) was accepted *in toto* by L.E. Codd in his treatment of Lamiaceae in the *Flora of southern Africa*. A revision of the difficult genus *Myrica* (Killick 1969a) was used by N. Grobelaar of the University of Pretoria in research on nitrogen-

fixation and was found to be reliable and in agreement with physiological findings. His paper on the use of the disc as a diagnostic character in *Maerua* (Killick 1969c) created wide interest locally and overseas. He revised several genera of Capparidaceae for the *Flora of southern Africa* (Killick 1970d–g). The revision of Clusiaceae was done in joint authorship with Norman Robson of the Natural History Museum, London (Killick & Robson 1976), and his Flacourtiaceae account, also for the *Flora of southern Africa*, in collaboration with Hermann Sleumer, then with the Rijksherbarium, Leiden (Killick 1976c). In the same volume of the *Flora* he published an account of the Achariaceae (Killick 1976d). During his retirement, he published the name change from *Myrica* to *Morella* together with Roger Polhill & Bernard Verdcourt (Killick, Polhill & Verdcourt 1998).

In volume 52,1 of *The Flowering Plants of Africa*, which is dedicated to him, Donald is described as a *leading light and a refuge to taxonomists lost in the thorny field of botanical nomenclature*. His first nomenclatural 'case' published in 1957 is cited as an example in the *International Code of Botanical Nomenclature* and two of his proposals for change of the Code were accepted by the 1981 International Botanical Congress in Sydney (Killick 1981a). Some of his nomenclatural 'cases' were cited in Kew's *Nomenclatural Forum*. Through his work as an editor he was well aware that the general standard of knowledge of plant nomenclature among South African taxonomists left much to be desired. Therefore he presented 2-day courses in the Institute in Pretoria and at the University of Cape Town. They included a lengthy quiz comprising a number of interesting and tricky problems which had to be solved and which tested many of the delegates to, if not well beyond, their limit. His knowledge of plant nomenclature was recognised internationally and he was elected to the Committee for Spermatophyta of the International Association for Plant Taxonomy in 1975, and he was actively involved in the affairs of the Committee until 1981. At the time he was the only South African to have achieved this distinction.

His published account of the plant ecology of the Cathedral Peak area of the Natal Drakensberg is still the definitive work on the vegetation of that region. Prof. Eugene Moll, at the time at the University of Cape Town, described it 'as the best published account of the vegetation of the Natal Drakensberg', and Prof. O.T. Solbrig, former President of the International Union of Biological Sciences, commented: 'it seems to be the last word and little more needs to be done'. Since the account appeared in 1963, Donald had maintained an interest in mountain ecology and had continued to publish on the subject well into his retirement. This includes in-depth discussions of the then poorly known climate of the Alpine Vegetation of eastern Lesotho, the region you enter once you have scaled the Natal Drakensberg from the South African side (Killick 1978d). He was invited to contribute substantive review chapters to four important books (Killick 1978a, 1979a, 1994b, 1997). These reviews were based very largely on his own researches in the Drakensberg and eastern Lesotho. Donald's researches have formed a botanical foundation for much of the management practice and research in the Drakensberg by the Department of Forestry and the KwaZulu-Natal Parks Board.



FIGURE 6.—Donald and Otto Leistner at Katima Mulilo in the Caprivi Strip, 1958/1959, where they collected plants for the *Flora zambesiaca*, *Prodromus einer Flora von Südwestafrika* and *Flora of southern Africa*.

His work on the Drakensberg attracted the attention of a number of prominent botanists who specialised in high-altitude vegetation, such as Prof. and Mrs O. Hedberg (Sweden), Prof. C.G.G.J. van Steenis (Netherlands), Prof. O. Stocker (Germany), Prof. K. Faegri (Norway) and Dr E. Weinert (Germany). All except Dr Weinert visited the Drakensberg in Donald's company. Dr Weinert commented on the reprints of his papers: 'they are of great value to me and I agree with him concerning the definition of the sub-alpine and alpine zones in Africa (and around the world)'.

Donald had a great love for botanical art, and his editing of *The Flowering Plants of Africa*, the Institute's journal devoted to this exquisite art form, gave him particular pleasure. It was the last of the Institute's publications from which he could tear himself away to hand it over to his successor. Not only was he an excellent judge of botanical art but he was equally adept at judging botanical artists. Among several artists who served under him, two deserve special mention: Rosemary Holcroft worked in the Institute from 1975 to 1985. She produced the line drawings for his *A field guide to the flora of the Natal Drakensberg* and executed almost 100 colour plates for *The Flowering Plants of Africa*. Gillian Condy joined the Institute in 1983 and has played a prominent role in the field of botanical art ever since. Donald nominated her for the Jill Smythies Award of the Linnean Society of London and it was presented to her in 1990.

The lectures he gave, most of them by invitation, dealt mainly with the vegetation and flora of the Drakensberg,

including eastern Lesotho, as well as plant nomenclature, science writing and the recording of ecological literature. Lectures were given at the University of Natal, the Museum of Science, Pretoria, the Royal Botanic Gardens, Kew, the Royal Horticultural Society, London, the University of Uppsala, the Rijksherbarium, Leiden, congresses of AETFAT in Uppsala, Munich and Pretoria, congresses of SAAB and the 13th International Botanical Congress, Sydney in 1981 where he was invited to defend three of his proposals at the Nomenclature Session. The Presidential address he delivered to the South African Biological Society in 1966 was entitled *Fifty years of plant ecology in South Africa* (Killick 1968c).

He was a member of the following societies: South African Association of Botanists, the Association pour l'étude taxonomique d'Afrique tropicale (AETFAT), the International Association for Plant Taxonomy (IAPT) and the National Committee and the Taxonomy Subcommittee of IUBS. From 1982 to 1985 he was a member of the Professional Advisory Committee for Plant Sciences of the South African Council for Natural Scientists. Donald was also member of advisory committees of the then Department of Agriculture under which the Institute fell at the time. He was a Fellow of the Linnean Society of London since 1956. From 1959 to 1963 he served as Honorary Secretary of the South African Biological Society and he was President of the Society in 1966.

Donald did most of his collecting in KwaZulu-Natal, particularly in the mountains, from Table Mountain in the south, the study area for his M.Sc., to the Cathedral Peak area in the central Drakensberg, the subject of his Ph.D. thesis. Duplicates of his collections from this region are housed in the Donald Killick Herbarium (CPF) in Pietermaritzburg. It falls under the Department of Environmental Affairs and Tourism and comprises about 6 000 vascular plants, mainly of the Drakensberg Mountains and the KwaZulu-Natal coast, collected by employees of the former Department of Forestry. In 1958/1959 he undertook a collecting expedition to the Caprivi Strip (Figure 6) in northern Namibia accompanied by me. There were no mountains to climb but lots of wetlands to be traversed and myriads of mosquitos to be deterred/endured. The collections made during this venture proved valuable in the compilation of three regional floras covering this area: *Flora zambesiaca*, *Prodromus einer Flora von Südwestafrika* and *Flora of southern Africa*. Between 1966 and 1969 he undertook several collecting expeditions to the southern Drakensberg together with Johannes Vahrmeijer. During 1977 he led an expedition to central Lesotho which included several staff members of the Institute and R.E. (Bob) Magill, bryologist and TROPICOS-fundi of the Missouri Botanical Garden. In February 1984, together with Bob Magill and J. (Jacques) van Rooy, bryologist of the Institute, he visited some of his former collecting sites and inspected relevés he had laid out in the Drakensberg and on Table Mountain near Pietermaritzburg (Figure 7), and they collected on top of Sani Pass. In December of the same year he returned to the Cathedral Peak area in the company of Rosemary Holcroft, who prepared drawings for the proposed *Guide to the Drakensberg*



FIGURE 7.—Donald with R.E. (Bob) Magill on a collecting visit to Table Mountain, Pietermaritzburg in 1984.

flora, and Jacques van Rooy, who collected mosses. Shortly before his retirement he undertook an expedition to the highlands of Lesotho in the company of officers of the Institute as well as B.J. (Bruce) Hargreaves, then of Roma University, and an official of the Lesotho Department of Agriculture. In 1994 he visited central Lesotho for the last time accompanied by his wife Berenice and S.M. (Sarie) Perold, hepaticologist of the Institute, who was looking for a new liverwort known to grow near the Oxbow Dam. During that expedition they met Prof. J.G. Duckett of the Queen Mary and Westfield College, London who eventually was the lucky person to find the elusive “mountain nymph” in a rather inaccessible spot. The specific epithet of *Cryptomitrium oreades*, as Sarie Perold named it, is derived from the Greek word for such a delicate creature of the highlands.

Altogether, Donald described 24 new species, published 11 new combinations and collected about 5 000 numbers, mostly with several duplicates. Three species were named in his honour: *Carex killickii* Nelmes and

Festuca killickii Kenn.-O’Byrne and recently a fossil fern, *Asterotheca killickii* H.M.And. & J.M.And.

Among the many plant collectors in the Drakensberg that he discusses in his *A field guide to the flora of the Natal Drakensberg*, the place of honour belongs undoubtedly to Hans Justus Thode, a little known pioneer of the High Berg and a man in whom Donald could surely see something of himself. He went to great lengths to trace Thode’s life history and he succeeded in finding and interviewing four persons who had been taught by him (Killick 1977f). ‘If Thode had one ‘magnificent obsession’, Donald writes (Killick 1990), ‘it was the Drakensberg and its flora’. And he quotes Thode admiring ...‘the majestic range of the Kathlambe or Drakensberg which has irresistibly attracted and again and again induced me to climb its lofty heights....What an inexpressible incentive to be the first explorer of this terra incognita, to open this veiled enchanted country to investigating science and to return with trophies of its interesting flora in the form of many a plant still undescribed’.

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Driver, Ms A.L. B.Soc.Sci.(Hons), M.A., M.B.A. Deputy Director. Planning, monitoring and advice

Bhengu, S. B.Soc.Sc.(Hons), Monitoring and Reporting Officer	Manganye, Ms J.H. B.Sc.(Hons). Monitoring and Reporting Intern
Grobler, Ms J.K. M.Sc. Monitoring and Reporting Manager	Mashua, Ms T. B.Sc.(Microbial Biotechnol.). Threatened ecosystems Officer
	Smith, Ms T.J. Ph.D. Bioregional Projects Officer

INFORMATION MANAGEMENT, KRC—CAPE TOWN (DBIO/IM)

Willoughby, S.W. M.A.(Geogr. Sci.), H.D.E., Manager (contract worker)

Khatieb, Ms S. B.Sc.(Hons). GIS Technician (contract worker)	Roberts, R.D. B.Sc.(Hons). SIBIS Manager (contract worker)
Parker-Allie, Ms F. M.Sc.(Botany). SABIF Node Manager (contract worker)	Terrapon, Ms H.M.E. M.A.(GIS). Biodiversity Information Systems Analyst

SANBI WEBSITES (AMWS)

Reynolds, Ms P.Y. B.Bib.(Hons), M.A.(Info.Sci.), B.Proc., Dip.(Datamet.). Website Manager

MARINE PROGRAMME—CAPE TOWN (YDBR/OMPA)

Sink, Dr K.J. Ph.D.(Zool.). Marine Programme Manager (contract worker)
Lawrence, Ms C. M.Sc.(Cons. Biol. Zool.). Marine Biodiversity Co-ordinator (contract worker)
Majiedt, Ms P. B.Sc.(Hons) Marine Projects Officer (contract worker)

BIODIVERSITY PLANNING—PRETORIA (DBIO/PL)

Jonas, Ms Z.R. M.Sc.(Conserv. & GIS). Conservation Planner
 Wistebaar, Ms P.N. B.Sc.(Hons)(Applied remote sensing & GIS). Conservation Planner

EASTERN CAPE CO-ORDINATION UNIT—PORT ELIZABETH (DBIO/EC)

Hartmann, N.R. B.Sc.(Hons)(GIS). Intern Project Officer (contract worker)

THREATENED SPECIES PROGRAMME—PRETORIA (DBIO/TS)

Nkoana, Mr L.S. M.Sc. (Syst. and Cons. Evaluation).Threatened Species Programme Manager
 Parbhoo, Ms S. B.Sc.(Microbial Biotechnology). Co-ordinator

THREATENED PLANT PROJECT (DBIO/FLOR)
CUSTODIANS OF RARE AND ENDANGERED WILD FLOWERS (CREW)

Raimondo, Ms D.C. M.Sc.(Cons. Biol.). Threatened Plant Manager (Pretoria)

Agenbag, Ms L. B.Sc.(Hons). Red List Officer (contract worker)	Rogers, Ms I.M. Supervisor: data encoding and georeferencing (contract worker)
Ebrahim, I. N.Dip.(Hort.). CREW Project Manager (Cape Town)	Von Witt, Ms C.G. B.Sc. CREW Cape Floristic Region. Project Co-ordinator (contract worker)
Koopman, R. B.Sc. Cape Nature Botanist (contract worker)	Zikishe, Ms V.S. Learnership for Cape CREW Project Assistant (contract worker)
Manyama, P.A. B.Sc.(Hons). Red List Officer	

SUCCULENT KAROO ECOSYSTEM PROGRAMME (SKEP)—CAPE TOWN (YDBR/SK)

Johnson, Ms M. M.Admin. Programme Manager (contract worker)
 Mathys, Ms C.L. N.Dip.(Journ.).Communications Officer (contract worker)
 Ndita-Mphande, Ms B.A. Control Provis. Admin. Clerk. Education Programme Administrator (contract worker)
 Ntsholo, L. B.Tech. Environmental Management (contract worker)

NATIONAL GRASSLANDS BIODIVERSITY PROGRAMME—PRETORIA (YDBR/GG)

Stephens, Ms A.C. M.Sc. Grasslands Programme Manager
 Ngobeni, N. Grasslands Programme Administrative Officer
 Tau, M. M.Sc.(Agric.). Grasslands Programme Officer
 Manaka, Ms B. Grasslands Programme Urban Co-ordinator
 Mgwadlamba, Ms N. B.A.(Communication), Dip.(Advanced Business Managem.). Grasslands Programme Communications Co-ordinator

CAPE ACTION PLAN FOR PEOPLE (CAPE) PROJECT—CAPE TOWN (YCAP)

Barnett, M. Ph.D. Programme Developer
 Damons, Ms M.H. B.A.(Dev. & Env.). Project Officer (contract worker)
 Manuel, J.J. B.Sc.(Hons). Land Use Advisor (contract worker based at DEA & DP)
 Martin, Ms F. Provisioning Admin. Clerk I (contract worker)
 Parker, Mrs A. B.A.(Hons). Project Developer (contract worker)
 Petersen, Ms C.A. M.Phil.(Adult Ed.), M.Sc.(Econ.), Postgrad.Cert.Ed. Learning Network Manager (contract worker)
 Raven, G. Ph.D. Capacity Development Co-ordinator (contract worker)

GARDENS DIRECTORATE—ADMIN STAFF (GDIR)**PRETORIA**

Willis, C.K. M.Sc.(Cons. Biol.). Chief Director: Gardens and Horticultural Services
 Bagus, Mrs J. N.Dip.(Account.). Senior State Accountant. Poverty Relief Projects (contract worker)
 Els, Ms L. N.Dip.(Sec.). Office Manager
 Ribeiro, Ms S. Senior Secretary IV

URBAN CONSERVATION UNIT—CAPE TOWN (APRJ/UC)

Davis, G.W. Ph.D. Deputy Director: Urban ecology. Communications

Goldman, Ms T. B.Soc.Sci.(Hons). Project Manager.
Programme development

Hathorn, Ms P.M. B.A.(Hons), N.Dip.(Hort.). Capacity
building Manager. Cape Flats Nature Project

Martin, Ms M. Cert.Masters Business Serv.(CMBS).
Control Provincial Admin. Clerk. Cape Flats
Nature Project

Paulse, Mrs D.W.S. Dip.(Bookkeep.), Dip.(Sec.).
Control Provisioning Admin. Clerk

Peter, L.M. N.Dip.(Hort.). Principal Communications
Officer. Communications Manager. Edith Stevens
Reserve. Cape Flats Nature Project

Phoswayo, Ms V. Cert. Office Admin. Senior
Provisioning Admin. Clerk II. Admin. support
(contract worker)

INTERPRETATION—PRETORIA (GINN)

Ferreira, Ms L. B.A.(Fine Art), N.Dip.(Nature Cons.). Chief Auxiliary Services Officer. Information

BUILDING PLANNING, MAINTENANCE & DEVELOPMENT—CAPE TOWN (BPMD)

Linde, D.C. N.T.C.III(Civil & Structural: Building), N.T.C.III (Inspector of Works: Building),
M.S.A.I.D, Cert. Estate Agency. Control Works Inspector

Abrahams, P. Senior Factotum. Building maintenance
Manasse, S.P. Dip.(Masonry). Artisan Superintendent.
Building maintenance

Peck, W.I. Senior Factotum. Building maintenance
Tomlinson E.C. Factotum. Building maintenance

CURATORS

Behr, Ms C.M. Curator: Pretoria NBG
Britz, R.M. Curator: Lowveld NBG (Nelspruit)
Gavhi, M.P. Curator: Free State NBG (Bloemfontein)
Le Roux, P.H. Deputy Director. Curator: Kirstenbosch NBG (Cape Town)
Marinus, E.M. Curator: Hantam NBG (Nieuwoudtville)
Mutshinyalo, T. Curator: Walter Sisulu NBG (Roodepoort/Mogale City)
Oliver, I.B. Curator: Karoo Desert NBG (Worcester)
Tarr, B.B. Curator: KwaZulu-Natal NBG (Pietermaritzburg)
Voigt, W.E. Curator: Harold Porter NBG (Betty's Bay)

HANTAM NBG—NIEUWOUDTVILLE (GNEU)

Marinus, E.M. N.Cert.(Buildg & Struct. Engin.) Control Agricultural Technician. Curator
Rust, Ms C. Senior Provisional Admin. Clerk III. Admin., financial and HR

HAROLD PORTER NBG—BETTY'S BAY (GHPG)

Voigt, W.E. N.Dip.(Hort.), Control Agricultural Technician. Curator

Carolus, Ms B.J. B.Tech.(Hort.). Chief Agricultural
Development Technician. Garden management

Arendse, L.P. Senior Provisioning Clerk I.

Bebe, Ms N. Cleaner I

Bezuidenhout, Mrs H.M. Chief Provisioning Admin.
Officer

Floris, Ms C. Auxiliary Services Officer II. Access control

Forrester, Ms J.A. N.T.C.III(Hort.). Chief Agricultural
Development Technician. Garden management

Fredericks, Mrs C.J. Auxiliary Services Officer II.
Access control

Malgas, E.K. Senior Foreman. Garden maintenance and
development

October, Ms R.P. Dip.(Ed.). Senior Auxiliary Services
Officer. Plant records and admin. support

Smith, E.J. Senior Foreman. Estate maintenance and
development

Van Wyk, A.B. Artisan. General maintenance

KAROO DESERT NBG—WORCESTER (GKAR)

Oliver, I.B. N.Dip.(Hort.), N.Dip.(Parks & Recrea. Admin.), N.Parks Dip. (Parks & Recrea. Managem.).
Control Agricultural Technician. Curator

Harris, Ms S. N.Dip.(Hort.). Chief Agricultural
Development Technician. Scientific collections

Kwayimani, P. N.Dip.(Hort.). Chief Agricultural
Development Technician. Garden management

Makubalo, F.N. Principal Foreman. Nursery
 Mpeke, Ms E.N. Specialist Cleaner
 Sibozo, N.E. Driver II. Plant sales
 Simani, D.K. Principal Foreman. Plant collections

Van der Westhuizen, Ms M. Specialist Cleaner
 Viljoen, D.M. N.Dip.(Hort.). Chief Agricultural
 Development Technician. Records Officer

KIRSTENBOSCH NBG—CAPE TOWN (GKBC)

Le Roux, P.H. Dip.(Forestry), N.Dip.(Hort.), N.Dip.(Parks & Recrea. Managem.), Cert. Turf Management.
 Director: Garden Management. Curator
 Poole, Ms F.Y. N.Dip.(Public Managem. & Admin.). Assistant Director: HR management

Adams, T.D. B.Tech.(Hort.). Chief Agricultural
 Development Technician. Supervisor: Greenhouse
 Hitchcock, A.N. N.H.Dip.(Hort.). Control Agricultural
 Development Technician. Nursery Manager
 Morkel, A.T. N.Dip.(Nature Cons.). Control Agricultural
 Development Technician. Estate Manager
 Notten, Ms A.L. B.Sc., N.Dip.(Hort.). Chief Agricultural
 Development Technician. Interpretive Officer
 Van Wyk, F. Artisan. Supervisor: Workshop
 Adonis, A. Principal Foreman. Dell & ericas
 Adonis, S.J. Senior Foreman. Alien vegetation control
 Arends, Ms S.J. Principal Auxiliary Services Officer.
 Plant records
 Brown, B.M. N.Dip.(Hort.). Agricultural Development
 Technician. Seed room
 Duncan, G.D. M.Sc., N.Dip.(Hort.). Control Agricultural
 Development Technician. Bulbs, systematics of
Lachenalia
 Engelbrecht, F. Senior Provisioning Admin. Clerk II.
 Stores
 Engelbrecht, Mrs L.D. Control Auxiliary Services
 Officer. Plant records
 Grace, T. Senior Provisioning Admin. Clerk III. Stores
 & admin. support
 Harrower, A.D. B.Sc.(Bot. & Zoo.) Ball Agreement.
 Project Manager
 Haynie, R.D. Senior Handyman. Workshop
 Hope, C.F. Senior Handyman. Construction
 Jacobs, H.C. Principal Foreman. Plant production
 Jansen, K.J. Principal Foreman. Drivers
 Julie, V. Control Specialist Groundsman. Proteas
 Kayster, G.J. Principal Foreman. Construction
 Kuscus, G.W. Principal Foreman. General maintenance

Lucas (née Jodamus) Mrs N.L. N.Dip.(Hort.). Chief
 Agricultural Development Technician. Annuals,
 Rutaceae, alpine and Cape endemics
 Mathys, Mrs S.S.B. Senior Accounting Clerk III.
 Revenue and garden statistics
 Mbambezeli, N.G. N.Dip.(Hort.). Agricultural
 Development Technician. Trees & shrubs
 McQuillan, (née Twine) Mrs M. N.Dip.(Hort.). Chief
 Agricultural Development Technician. Proteas and
 restios
 Mitchells, G. Control Specialist Groundsman. Senior
 Foreman. Casual staff projects
 Newman, W. Artisan. Mechanical workshop
 Petersen, A.D. Control Specialist Groundsman. Cycads
 Picane, Ms S. Auxiliary Services Officer II. Tissue cul-
 ture
 Prins, F.B. Security Officer III
 Rudolph, A. Security Officer III
 Shanks, G.R. Ball Agreement. Glass House Assistant
 (contract worker)
 Skepe, M.M. Senior Foreman. Proteas
 Smith, Mrs A. Senior Provisioning Admin. Clerk II.
 Admin. support
 Smith, D. Accounting Clerk II. Seed room
 Solomons, T.C. Senior Security Officer II
 Tamboer, J.S. Principal Foreman. Index nursery
 Van Gusling, E.J. Principal Foreman. Mowers
 Van Jaarsveld, E.J. M.Sc., N.Dip.(Hort.). Control
 Agricultural Technician. Succulents
 Van Reenen, D.B. Principal Auxiliary Services Officer.
 Label maker
 Viljoen, Ms C.C. N.Dip.(Hort.). Chief Agricultural
 Development Technician. Plant production
 Wall, Ms K.E. (student)

VISITORS CENTRE—CAPE TOWN (GKBC/VC)

Struys, Ms S. B.A.(Hons)(Directing), Postgrad.Dip.(Market. Manag.). Assistant Director: Communi-
 cation. Events & Centre Manager

Fredericks, Ms N.C.E. Senior Auxiliary Services Officer.
 Information services
 Jacobs, A.P. Chief Auxiliary Services Officer.
 Information services
 Pekeur, Ms A.B. Control Provisioning Administration
 Clerk II: Events Co-ordinator

Phillips, R. Senior Provisioning Admin. Clerk. Facilities
 Officer
 Williams, G.C. Senior Auxiliary Services Officer.
 Information

LOWVELD NBG—NELSPRUIT (GLOW)

Britz, R.M. N.Dip.(Forestry). Control Agricultural Technican. Curator

Froneman, W.C.F. N.T.C.III(Hort.), N.Dip.(Nature Cons.
 & Man.), N.Dip.(Parks & Rec. Admin.). Control
 Agricultural Technician. Nursery management &
 garden development

Khoza, Ms P.K. Senior Auxiliary Officer. Front line
 Officer
 Le Roux, Ms L. N.H.Dip.(Nature Cons.). Control
 Auxiliary Services Officer. Interpretation

Mathebula, Ms N.R. Senior Provisioning Administrative Clerk III. Admin. Support
 Mathebula, Ms I.N. Senior Auxiliary Services Officer. Front line Officer
 Matsebula, Ms J.E. Cleaner II
 Mbhele, Ms S.N. Senior Accounting Clerk I. Admin. Support
 Ndlovu, L.D. Principal Foreman. Artisan

Ngwenya, P.S. Senior Auxiliary Services Officer II. Front line reliever
 Nyathikazi, Ms T.P. Senior Auxiliary Services Officer. Admin.
 Sibanyoni, Ms S.M. Specialist Cleaner II
 Van der Walt, Ms K. N.Dip.(Nature Cons.). Horticulturist. Threatened Plants Project
 Xozumti, M.M. Principal Foreman. Supervisor. Garden

KWAZULU-NATAL NBG—PIETERMARITZBURG (GKZN)

Tarr, B.B. N.Dip.(Parks & Recrea. Admin.), Advanced Dip.(Adult Educ.). Control Agricultural Technician. Curator

Dlungwane, T.R. Principal Foreman. Development & maintenance
 Johnson, Ms I. HED, M.Sc. Control Agricultural Development Technician
 Khanyile, P.S. Cert.(Basic IT concepts, MSWord, Excell & PowerPoint). Interpretation

Nonjinge, S.H.B. N.T.C.III(Hort.). Chief Agricultural Development Technician
 Sibiya, Ms C.P.T. Cleaner II
 Van der Merwe, Mrs M.E.H. Senior Provisioning Admin. Clerk III
 Zimu, M.J. Principal Foreman. Horticulture maintenance

FREE STATE NBG—BLOEMFONTEIN (GFSG)

Gavhi, M.P. N.Dip.(Hort.). Control Agricultural Technician. Curator

Lepitla, M.H. Senior Foreman. Garden
 May, T.S. Foreman. Garden
 Ngalo, Ms M.J. Cleaner I.
 Ngalo, M.S. Senior Auxiliary Services Officer. Interpretation

Nyuleka, Ms N.A. Senior Accounting Clerk I
 Raditlhare, Mrs E.M. Specialist Cleaner
 Rambuwani, L.D. N.Dip.(Hort.). Chief Agricultural Development Technician. Nursery
 Sebolai, Ms C.L. Specialist Cleaner

PRETORIA NBG (GPTA)

Behr, Ms C.M. B.Sc.(Hons). Control Agricultural Development Technician. Curator

Baloyi, K.J. Senior Auxiliary Services Officer II. Information Officer. Garden records
 Keyter, B.A. Senior Security Officer II
 Kutama, B.T. Principal Foreman. Garden: hard landscape development and maintenance
 Lithudza, E.F. Dip.(Hort.). Chief Agricultural Development Technician
 Mabapa, Ms K.I. Cleaner II
 Mahlangu, J.F. Senior Foreman. Garden: machine operators and irrigation

Makgobola, Ms M.R. Auxiliary Services Officer II. Reception & admin. Support
 Modisha, M.D. Cleaner II
 Mukondeleli, T.E. Senior Provisioning Admin. Officer
 Naidoo, D.A. N.Dip.(Hort.), Dip.(Fund & Managem.). Control Agricultural Development Technician
 Sibiya, Ms T.R. Cleaner II
 Solomons, Ms C.V. Principal Auxiliary Services Officer. Plant records clerk

WALTER SISULU NBG—ROODEPOORT (GSIS)

Mutshinyalo, T.T. Control Agricultural Development Technician. Curator

Aubrey, Mrs A.E. B.Tech.(Hort.). Chief Agricultural Development Technician. Plant records, interpretation, information (part time)
 Baloyi, S.J. Handyman. Stores
 Hankey, A.J. N.Dip.(Hort.), B.Tech.(Hort.). Control Agricultural Development Technician. Garden, estate, collections, nursery
 Head, Mrs S.E. Dip.(Shorthand & Typing). Provisioning Admin. Officer
 Mabela, H.L. B.Tech.(Hort.). Agricultural Development Technician. Nursery, collections
 Mamosebo, M.A. Factotum
 Manyikana, T.M. Factotum

Mmola, Mrs B.E. Cleaner II
 Mtsweni, P. N.Dip.(Hort.). Senior Agricultural Development Technician. Support services, estate
 Ndou, A.P. Senior Auxiliary Services Officer II. Information services
 Ndzondo, Ms N.L. Senior Provisioning Admin. Clerk I
 Ndzondo, Mrs P.G. Cleaner II
 Nedambale, M.P. Senior Foreman. Garden and nursery
 Nenalili, M.E. Senior Foreman. Machines and vehicles
 Nene, A.G. N.Dip.(Hort.). Agricultural Development Technician. Garden management
 Nenungwi, M.S. Senior Foreman. Nursery

BIOSYSTEMATICS RESEARCH AND BIODIVERSITY COLLECTIONS DIRECTORATE (RDIR)

PRETORIA

Smith, Prof. G.F. Ph.D., F.L.S. Chief Director
Senior Provisioning Admin. Officer. Personal Assistant—vacant

Arnold, T.H. Head: Data Management
Crouch, Prof. N.R. Head: Ethnobotany Unit (Durban)
Donaldson, Dr J.S. Director: Kirstenbosch Research Centre (Cape Town)
Klopper, Mrs R.R. M.Sc. Senior Plant Taxonomist. Taxonomy of Asphodelaceae and Pteridophyta
Koekemoer, Dr M. Curator: National Herbarium
Meyer, Mrs N.L. B.Sc.(Hons). Agricultural Development Technician (contract worker)
Roux, Dr J.P. Curator: Compton Herbarium (Cape Town)
Singh, Ms Y. Curator: Natal Herbarium (Durban)
Walters, Ms M. M.Sc.(Cons.Ecol.). Scientific Officer. (contract worker)

Wolfson, Mrs M.M. Ph.D. Director. HDE Policy and Legislation related to Access and Benefit-sharing,
Bioprospecting and Intellectual Property
Mutizhe, Ms S.L. Cert.(Secr.), Cert.(Bus. Studies), Dip. (PR). Senior Secretary IV. Personal Assistant

Liebenberg, Mrs E.J.L. Head: Research Support Services, Publications
Potgieter, Mrs E. Principal Librarian
Van Wyk, E. Project manager, Millenium Seed Bank Project

KWAZULU-NATAL HERBARIUM—DURBAN (RHED)

Singh, Ms Y. HED, M.Sc. Deputy Director. Taxonomy of Araceae, Hypoxidaceae. Curator

Apollos, Mrs C.E. Senior Provisioning Admin. Clerk II. Marketing Glen, H.F. Ph.D. Specialist Scientist. Taxonomy of trees, cultivated plants; botanical history Hlongwane, Mrs N.C. Specialist Cleaner & messenger	Ngwenya, M.A. Chief Agricultural Development Technician. Herbarium Officer. Plant identifica- tion and information, Zulu Botanical Knowledge Project Mazibuko, J.V.G. Senior Auxiliary Services Officer. Herbarium Assistant
---	---

ETHNOBOTANY UNIT—DURBAN (RETH)

Crouch, Prof. N.R. Ph.D. Deputy Director. Ethnobotany of southern African flora, bioprospecting

NATIONAL HERBARIUM—PRETORIA (RHEN)

Koekemoer, Ms M. Ph.D. Deputy Director. Herbarium management. Taxonomy of Asteraceae:
Gnaphalieae

Rampho, Ms E.T. B.Sc. Deputy Curator

Brendenkamp, Mrs C.L. Ph.D. Control Agricultural Scientist. Assistant Curator: Public relations.
Taxonomy of *Vitex*, *Passerina*, Malvaceae, Sterculiaceae, and other related families

Fish, Mrs L. B.Sc. Principal Agricultural Scientist. Assistant Curator: Collections Manager.
Taxonomy of Poaceae

Herman, P.P.J. M.Sc. Control Agricultural Scientist. Assistant Curator: Personnel. Taxonomy of
Asteraceae

Mothogoane, M.S. Chief Auxiliary Services Officer. Assistant Curator: Herbarium assistants. Wing C
Sebothoma, P.N. Cert.Sec. Principal Auxiliary Services Officer. Assistant Curator: Service room.

Plant identifications co-ordinator

Van Rooy, J. Ph.D. Control Agricultural Scientist. Assistant Curator: Technical staff. Taxonomy and
biogeography of mosses

Anderson, J.M. Ph.D. Specialist Scientist. Molteno
Palaeoflora, Gondwana Alive
Archer Mrs C. M.Sc. Principal Agricultural Scientist.
Taxonomy of Cyperaceae, monocotyledons (gen-
eral)
Archer, R.H. Ph.D. Control Agricultural Scientist.
Taxonomy of mainly Celastraceae, Euphorbiaceae

Bester, S.P. M.Sc. Principal Agricultural Scientist.
Taxonomy of Apocynaceae, Ericaceae, Rutaceae
Burgoyne, Ms P.M. M.Sc. Control Agricultural Scientist.
Mesembryanthemaceae and Crassulaceae
Götzl, Ms A. Senior Provisioning Admin. Clerk III
Govender, Ms M. B.Sc. Senior Agricultural Develop-
ment Technician. Curation and plant ID in Wing C

Grobler (née Krige), Mrs A. B.Sc. Principal Agricultural Scientist. Fabaceae
 Hölscher (née Sachse), Mrs B. B.Sc.(Hons). Senior Agricultural Development Technician. Herbarium information
 Johannsmeier, Ms A.E. B.Sc.(Hons). Scientist
 Jordaan, Mrs M. M.Sc. Principal Agricultural Scientist. Taxonomy of Celastraceae: Celastroideae, interactive key to the trees of southern Africa
 Kgaditsi, T.W. Senior Auxiliary Services Officer. Specimen mounter, general assistant
 Makgakga, M.C. B.Sc. Agricultural Development Technician. Curation and plant ID in Wing B
 Mashua, Ms T.J. B.Sc.(Microb.Biotechnol.). Scientific Officer. Gondwana Programme (contract worker)
 Meyer, J.J. HED. Chief Agricultural Development Technician. Bioprospecting Project
 Mothapo, M.A. H.Cert.Off.Admin.(DMS). Herbarium Assistant: Principal Auxiliary Services Officer. Data Capturer, encoding, plant loans & gift exchanges
 Mothapo, Ms N. B.Sc.(Hons)(Zool.). Scientific Officer. Gondwana Programme (contract worker)
 Mashau, Mrs A.C. B.(Envir.Sci.). Scientific Officer (contract worker)
 Nkoane, Ms G.K. Principal Auxiliary Services Officer. Loans, exchanges, gifts, parcelling, stores
 Phahla, T.J. Senior Auxiliary Services Officer. Specimen mounter of cryptogams, packer, general assistance

Phephu, Ms N. B.Sc.(Hons). Senior Agricultural Development Technician. Mosses
 Ready, Mrs J.A. N.Dip.(Hort.). Principal Auxiliary Services Officer. Plant identifications, *Helichrysum*. Curation of Wing D
 Retief, Ms E. Ph.D. Principal Agricultural Scientist. Taxonomy of Boraginaceae, Verbenaceae, Lamiaceae, Asteraceae, Rubiaceae, Geraniaceae, Oxalidaceae, Vitaceae
 Smithies, Mrs S.J. M.Sc., Dip.Ed.(Moray House). Chief Agricultural Development Technician. Taxonomy of Scrophulariaceae *sens. lat.*, Pedaliaceae, Bignoniaceae, Lentibulariaceae, Gesneriaceae, Martyniaceae, Orobanchaceae
 Steyn, Ms C.C. Principal Auxiliary Services Officer. Scientific support
 Swelankomo, Ms N. B.Sc.(Hons). Senior Agricultural Development Technician. Curation and plant ID in Wing D
 Victor, Ms J.E. M.Sc.(Plant Syst.), H.Dip.(Journ.). Control Agricultural Scientist. Red List Scientist. Taxonomy of Rutaceae, Asclepiadaceae
 Welman, Ms W.G. M.Sc. Principal Agricultural Scientist. Taxonomy of Dipsacaceae, Solanaceae, Cucurbitaceae, Asteraceae: *Helichrysum*, Senecioneae
 Winter, P.J.D. M.Sc. Principal Agricultural Scientist. Taxonomy of mainly Apiaceae

DATA MANAGEMENT—PRETORIA (RPDC)

Arnold, T.H. M.Sc. Principal Data Technologist. Assistant Director. Computer database application especially in taxonomy

Boman, Ms M.J. PRECIS data typist
 Botha, Mrs A.G. Chief Auxiliary Services Officer. Administrative Assistant
 Mogodi, P. B.Sc.(Biol. & Chem.). Scientific Officer (Intern)
 Nkonki, Mrs T. Information Officer

Snyman, Mrs E.E. B.Sc. N.Dip.(Comp. Data Proc.). Senior Agricultural Development Technician. PRECIS Information Officer
 Steenkamp, Ms Y. M.Sc. Principal Agricultural Scientist. PRECIS Information Co-ordinator
 Steyn, Ms H.M. Senior Agricultural Scientist. PRECIS Information Officer

PUBLICATIONS—PRETORIA (RPUB)

Liebenberg, Mrs E.J.L. M.Sc. Control Agricultural Technician. Cytotaxonomy. Manager

Condy, Ms G.S. M.A. Chief Industrial Technician. Botanical artist
 Du Plessis, Mrs E. B.Sc.(Hons), S.E.D. Chief Language Practitioner. Technical editor. Editing, translating, layout
 Fouche, Ms E. M.A.(Corporate Communication & Graphic Design). Graphic design
 Germishuizen, G. M.Sc. Assistant Director. Scientific Editor
 Leistner, O.A. D.Sc. F.L.S. Agricultural Scientist (contract worker)

Mapheza, T.P. Senior Provisioning Admin. Clerk III. Bookshop Manager
 Momberg, Mrs B.A. B.Sc.(Entomol. & Zoo.). Principal Language Practitioner. Technical editor. Editing, layout (part time)
 Maree, Ms D.J. HED. Senior Computer Operator.
 Sithole, A.M. Provisioning Admin. Clerk II. Bookstore
 Turck, Mrs S. B.A.(Information Design). Control Industrial Technician. Graphic design

MARY GUNN LIBRARY—PRETORIA (RLBP)

Potgieter, Ms E. B.Libr. Principal Librarian
 Fourie, Mrs A. H.Dip.(Libr.Sci.). Principal Librarian (part time)

MILLENNIUM SEEDBANK PROJECT

PRETORIA (YRDR/MS)

Van Wyk, E. M.Sc.(Plant Ecol.). Principal Agricultural Scientist. Project manager

Mabatha, F.W. B.Envir.Sc. Chief Auxiliary Services Officer. Project Assistant (contract worker)

Nkuna, L.A. B.Envir.Sc. Senior Agricultural Development Technician. Pretoria Collecting Team Co-ordinator (contract worker)

KIRSTENBOSCH (YKBG/MS)

Cowell, Ms C.R. B.Tech.(Hort.). Senior Agricultural Development Technician. Cape Collecting Team Co-ordinator (contract worker)

Pekeur, Ms O.R. N.Dip.(Nature Cons.). Chief Auxiliary Services Officer. Project Assistant (contract worker)

**KIRSTENBOSCH RESEARCH CENTRE
CONSERVATION SCIENCE AND SUSTAINABLE USE DIRECTORATE (RREL)**

CAPE TOWN

Donaldson, J.S. Ph.D.(Zoo.). Chief Director

Van Aswegen, Ms G. Personal Assistant to Chief Director

Conrad, Ms F. M.Sc. Deputy Director. Research Operations

Oliver, Ms T.A. BIOTA Project. Liaison Officer (contract worker)

Parenzee, Ms H.A. Dip.(Ed). Senior Provisioning Admin. Clerk III

COMPTON HERBARIUM—CAPE TOWN (RHEC)

Roux, J.P. N.T.C.III(Hort.), Ph.D., F.L.S. Deputy Director. Curator. Systematics of Lycopodiophyta and Peridophyta

Manning, J.C. Ph.D. Senior Specialist Scientist.
Research Leader, Systematics. Systematics of
Iridaceae and Hyacinthaceae; anatomyBergh, Ms N.G. B.Sc.(Hons). Senior Agricultural
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1 April 2007–31 March 2008

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- WELMAN, W.G. & CONDY, G. (Artist). 2007. *Coccinia palmata*. *Flowering Plants of Africa* 60: 118–122, t. 2238.
- WELMAN, W.G. & CONDY, G. (Artist). 2007. *Momordica foetida*. *Flowering Plants of Africa* 60: 112–116, t. 2237.
- WIGGET, J. & NOTTEN, A. 2008-1. *Diosma oppositifolia* L. (Rutaceae). Internet 3 pp. <http://www.plantzafrica.com/plantcd/diosmaopposit.htm>.
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- XABA, P. 2007-08. *Struthiola argentea* Lehm. (Thymelaeaceae). <http://www.plantzafrica.com/plantqrs/struthargent.htm>.
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- ZELANGA, M. & NOTTEN, A. 2008-1. *Salvia africana-caerulea* L. (Lamiaceae). Internet 4 pp. <http://www.plantzafrica.com/plantqrs/salviaafricaerul.htm>.

Guide for authors to *Bothalia*

This guide is updated when necessary and includes an index. **Important points and latest additions appear in bold type.**

Bothalia is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the South African National Biodiversity Institute (SANBI), Pretoria, is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

1 Editorial policy

1.1 *Bothalia* welcomes original papers dealing with flora and vegetation of southern Africa and related subjects. Full-length papers and short notes, as well as book reviews and obituaries of botanists, are accepted. The editor should be notified that an article is part of a series of manuscripts; please submit a list of the parts of a series; all parts should preferably be published in one journal.

1.2 Submission of a manuscript to *Bothalia* implies that it has not been published previously and is not being considered for publication elsewhere.

1.3 Authors whose first language is not English are requested to have their MS edited by an English speaker before submission.

1.4 Articles are assessed by referees, both local and overseas. Authors are welcome to suggest possible referees to judge their work. Authors are responsible for the factual correctness of their contributions. *Bothalia* maintains an editorial board (see title page) to ensure that international standards are upheld.

1.5 **Page charges:** as stated in our notification included in volume 23,1 (May 1993), MSS submitted for publication in *Bothalia* are subject to payment of page charges of R125,00 per printed page, VAT included. The following are exempt from these charges: 1, SANBI members; 2, persons/institutions who have been granted exemption by the Executive Committee of the SANBI; 3, authors of contributions requested by the Editor; 4, contributors to the column 'FSA contributions'. The Editor's decision on the number of pages is final. An invoice will be sent to the author, who must arrange for payment as soon as possible to SANBI, Publications Section, Private Bag X101, Pretoria 0001.

1.6 Deadline dates for submission of MS: for possible inclusion of the MS for the May issue—**July** of the previous year, and for the October issue—**February** of the same year.

2 Requirements for a manuscript

2.1 The original manuscript should be typed on one side of A4-size paper, double line spacing throughout (including abstract, tables, captions of figures, literature references, and have a margin of at least 30 mm

all round. **Tables should be typed in single line spacing on a separate page at the end of the article.** Three photocopies (all pages photocopied on both sides of the paper, including figures, to reduce weight for postage) of all items, including text, line drawings, tables and lists should be submitted, and the author should retain a complete set of copies. Three photographs (or high quality photocopies) of each figure should be submitted for review purposes. The electronic version of the text should be submitted with the manuscript.

2.2 Papers should conform to the general style and layout of recent issues of *Bothalia* (from volume 26 onwards).

2.3 Material should be presented in the following sequence: title page with title, name(s) of author(s), keywords, abstract (and information that should be placed in a footnote on the title page, such as address(es) of author(s) and mention of granting agencies).

2.4 The sequence continues with Introduction and aims, Contents (see 8), Material and methods, Results, Interpretation (Discussion), Specimens examined (in revisions and monographs), Acknowledgements, References, Index of names (recommended for revisions dealing with more than about 15 species), Tables, Captions of figures and figures. In the case of short notes, obituaries and book reviews, keywords and an abstract are superfluous.

2.5 All pages must be numbered consecutively beginning with the title page to those with references, tables, captions of figures and figures.

2.6 Special characters: use your own word or code that is unique and self-explanatory, enclosed between ANGLE BRACKETS, e.g. <mu>m for µm. Please supply us with a list of the codes.

2.7 Use a non-breaking space (in MS Word—Ctrl, shift, space) to keep two elements together on the same line, e.g. 3 500.

2.8 DO NOT JUSTIFY LINES.

2.9 Do not break words, except hyphenated words.

2.10 A **hyphen** is designated as one dash, with no space between the letter and the dash, e.g. ovate-lanceolate. See also 17.6.

2.11 An **N-dash** is typed in MS Word code (alt + 0150) or as **three** hyphens with no space between the letter and the hyphen, e.g. 2- -5 mm (typeset, it looks like this, 2–5 mm). See also 17.6.

2.12 An **M-dash** is typed in MS Word code (alt + 0151) or as **two** hyphens with no space between the letter and the hyphen, e.g. computers- -what a blessing! (typeset, it looks like this: computers—what). See also 17.6.

2.13 **Do not use a double space anywhere** between words, after commas, full stops, colons, semicolons or exclamation marks.

2.14 Use lower case x as times sign, with one space on either side of the x, e.g. 2 x 3 mm.

2.15 Use single (not double) opening and closing quotes, e.g. the so-called 'stiffy' refers to a rigid diskette. In MSWord the codes are alt + 0145 and alt + 0146.

2.16 Keys—put only three leader dots before number of taxon (with one space before and after each dot), regardless of how far or near the word is from the right margin, e.g. . . . 1. *R. ovata* (see 13.18).

3 Requirements for electronic files

3.1 USE NORMAL STYLE ONLY.

3.2 **Provide electronic files on CD or send** via the e-mail to momberg@sanbi.org or germishuizen@sanbi.org.

3.3 Data must be in **MSWord**. An rtf file is preferable because it retains the formatting.

3.4 All lines, headings, keys, etc., should start flush at the margin, therefore NO INDENTATIONS, FOOTNOTES, TABS OR STYLES of any kind.

3.5 In MS Word, italics and bold should be used where necessary.

3.6 Paragraphs and headings are delineated by a carriage return (ENTER) but **no indentation**.

3.7 **Graphics i.e. drawings, graphs or photographs: submit in a separate file, do not include it in the text.**

3.8 Image files with a bigger file size than **2MB** cannot be e-mailed as the SANBI has a **2MB** limitation on the network's firewall at Head Office. Files smaller than 2MB can be emailed to: **momberg@sanbi.org**. **Image files bigger than 2 MB should be provided on a CD or can be copied to the SANBI ftp site by using the following link: <ftp://ftp.sanbi.org/incoming/>. Permission needs to be obtained to copy material to the FTP site. Please contact the editor for details.**

3.9 If any image file was originated in **CorelDraw** up to version 12 or Adobe Illustrator **up to version CS2 (AI)**, please provide the image file as a CDR file (please include fonts). The conversion to TIF or other file extensions will be accommodated by the SANBI (see 12.2–12.4).

3.10 If extensive changes to image files are proposed by the editor, the author will be contacted and the specific image file will have to be re-submitted after the indicated corrections have been implemented.

3.11 **Tracked changes must NOT be included when submitting a MS on a CD or electronically.**

4 Author(s)

When there are several authors, the covering letter should indicate clearly which of them is responsible for correspondence and, if possible, telephonically available while the article is being processed. The contact address, telephone number and email address should be mentioned if they differ from those given on the letterhead.

5 Title

The title should be as concise and as informative as possible. In articles dealing with taxonomy or closely related subjects, the family of the taxon under discussion (see also 13.2) should be mentioned in brackets but author citations should be omitted from plant names (see also 13.6).

6 Keywords

Up to 10 keywords (or index terms) should be provided in English in alphabetical sequence. The following points should be borne in mind when selecting keywords:

6.1 Keywords should be unambiguous, internationally acceptable words and not recently coined little-known words.

6.2 They should be in a noun form and verbs should be avoided.

6.3 They should not consist of an adjective alone; adjectives should be combined with nouns.

6.4 They should not contain prepositions.

6.5 The singular form should be used for processes and properties, e.g. evaporation.

6.6 The plural form should be used for physical objects, e.g. augers.

6.7 **Location** (province and/or country); taxa (species, genus, family) and vegetation type (community, veld type, biome) should be used as keywords.

6.8 Keywords should be selected hierarchically where possible, e.g. both family and species should be included.

6.9 They should include terms used in the title.

6.10 They should answer the following questions:

6.10.1 What is the *active concept* in the document (activity, operation or process).

6.10.2 What is the *passive concept* or object of the active process (item on which the activity, operation or process takes place).

6.10.3 What is the means of accomplishment or how is the active concept achieved (technique, method, apparatus, operation or process).

6.10.4 What is the environment in which the active concept takes place (medium, location).

6.10.5 What are the independent (controlled) and dependent variables?

6.11 Questions 6.10.1 to 6.10.3 should preferably also be answered in the title.

7 Abstract

7.1 An abstract of no more than 200 words should be provided. Abstracts are of great importance and should convey the essence of the article.

7.2 It should refer to the geographical area concerned and, in taxonomic articles, mention the number of taxa treated. It should not contain information not appearing in the article.

7.3 In articles dealing with taxonomy or closely related subjects all taxa from the rank of genus downwards should be accompanied by their author citations (see also 13.6).

7.4 Names of new taxa and new combinations should not be italicized but put in bold. If the article deals with too many taxa, only the important ones should be mentioned.

8 Table of contents

A table of contents should be given for all articles longer than about 60 typed pages, unless they follow the strict format of a taxonomic revision.

9 Acknowledgements

Acknowledgements should be kept to the minimum compatible with the requirements of courtesy. Please give all the initials of the person(s) you are thanking.

10 Literature references

In text

10.1 Literature references in the text should be cited as follows: 'Jones & Smith (1986) stated...', or '...(Jones & Smith 1986)' or (Ellis 1988: 67) when giving a reference simply as authority for a statement. For treatment of literature references in taxonomic papers see 14.

10.2 When more than two authors are involved in the paper, use the name of the first author followed by *et al.*

10.3 When referring to more than one literature reference, they should be arranged chronologically and separated by a semicolon, e.g. (Nixon 1940; Davis 1976; Anon. 1981, 1984).

10.4 Titles of books and names of journals should preferably not be mentioned in the text. If there is good reason for doing so, they should be treated as described in 10.12 and 10.13.

10.5 Personal communications are given only in the text, not in the list of references. Please add the person's full initials to identify the person more positively, e.g. C. Boucher pers. comm.

In References at end of article

10.6 References of the same author are arranged in chronological sequence.

10.7 Where two or more references by the same author are listed in succession, the author's name is repeated with every reference, except in an obituary, where the name of the deceased in the list of publications (not in the references) is replaced by an N-dash.

10.8 All publications referred to in the text, including those mentioned in full in the treatment of correct names in taxonomic papers, but no others, and no personal

communications, are listed at the end of the manuscript under the heading References.

10.9 The references are arranged alphabetically according to authors and chronologically under each author, with a, b, c, etc. added to the year, if the author has published more than one work in a year. This sequence is retained when used in the text, irrespective of the chronology.

10.10 If an author has published both on his own and as a senior author with others, the solo publications are listed first and after that, in strict alphabetical sequence, those published with one or more other authors.

10.11 Author names are typed in **capital letters**.

10.12 Titles of journals and of books are written out in full and are italicized as follows: *Transactions of the Linnean Society of London* 5: 171–217, or *Biology and ecology of weeds*: 24.

10.13 Titles of books should be given as in *Taxonomic literature*, edn 2 by Stafleu & Cowan and names of journals as in the latest edition of *World list of scientific periodicals*.

10.14 Examples of references:

Collective book or Flora

BROWN, N.E. 1909. Asclepiadaceae. In W.T. Thiselton-Dyer, *Flora capensis* 6,2: 518–1036. Reeve, London.

CUNNINGHAM, A.B. 1994. Combining skills: participatory approaches in biodiversity conservation. In B.J. Huntley, Botanical diversity in southern Africa. *Strelitzia* 1: 149–167. National Botanical Institute, Pretoria.

Book

DU TOIT, A.L. 1966. *Geology of South Africa*, edn 3: 10–50. S.M. Haughton (ed.). Oliver & Boyd, London.

HUTCHINSON, J. 1946. *A botanist in southern Africa*: 69. Gawthorn, London.

Journal

DAVIS, G. 1988. Description of a proteoid-restioid stand in Mesic Mountain Fynbos of the southwestern Cape and some aspects of its ecology. *Bothalia* 18: 279–287.

SMOOK, L. & GIBBS RUSSELL, G.E. 1985. Poaceae. *Memoirs of the Botanical Survey of South Africa* No. 51: 45–70.

STEBBINS, G.L. Jr. 1952. Aridity as a stimulus to plant evolution. *American Naturalist* 86: 35–44.

In press, in preparation

TAYLOR, H.C. in press. *A reconnaissance of the vegetation of Rooiberg State Forest*. Technical Bulletin, Department of Forestry.

VOGEL, J.C. 1982. *The age of the the Kuiseb river silt terrace at Homeb. Palaeoecology of Africa* 15. In press.

WEISSER, P.J., GARLAND, J.F. & DREWS, B.K. in prep. Dune advancement 1937–1977 and preliminary vegetation succession chronology at Mlalazi Nature Reserve, Natal, South Africa. *Bothalia*.

Thesis

KRUGER, F.J. 1974. *The physiography and plant communities of the Jakkalsrivier Catchment*. M.Sc. (Forestry) thesis, University of Stellenbosch.

MUNDAY, J. 1980. *The genus Monechma Hochst. (Acanthaceae tribe Justiciae) in southern Africa*. M.Sc. thesis, University of the Witwatersrand, Johannesburg.

Miscellaneous paper, report, unpublished article, technical note, congress proceedings

ANON. no date. *Eetbare plante van die Wolkberg*. Botanical Research Unit, Grahamstown. Unpublished.

BAWDEN, M.G. & CARROL, D.M. 1968. *The land resources of Lesotho*. Land Resources Study No. 3, Land Resources Division, Directorate of Overseas Surveys, Tolworth.

BOUCHER, C. 1981. Contributions of the Botanical Research Institute. In A.E.F. Heydon, *Proceedings of workshop research in Cape estuaries*: 105–107. National Research Institute for Oceanology, CSIR, Stellenbosch.

NATIONAL BUILDING RESEARCH INSTITUTE 1959. *Report of the committee on the protection of building timbers in South Africa against termites, woodboring beetles and fungi*, edn 2. CSIR Research Report No. 169.

11 Tables (also electronic submissions)

11.1 Each table should be presented on a separate sheet and be assigned an Arabic numeral, i.e. the first table mentioned in the text is marked 'Table 1'.

11.2 In the captions of tables the word 'TABLE' is written in capital letters. See recent numbers of *Bothalia* for the format required.

11.3 Avoid vertical lines, if at all possible. Tables can often be reduced in width by interchanging primary horizontal and vertical heads.

12 Figures (original or electronic submissions)

12.1 **The Publications Section of SANBI prefers to scan original drawings and photographs.** Figures should be **planned to fit, after reduction, into a width of either 80, 118 or 165 mm, with a maximum vertical length of 230 mm.** Allow space for the caption in the case of figures that will occupy a whole page.

12.2 Line drawings (original artwork) should be in jet-black Indian ink, preferably on fine art paper, 200 gsm. Lines should be clear enough to accommodate reduction. If submitted electronically, provide each drawing as a separate TIF or JPG file at 600 dots/pixels per inch (dpi/ppi) or higher.

12.3 **Drawings in pencil will not be accepted.**

12.4 Graphs and histograms should be submitted as **EPS, Adobe Illustrator CS2 (AI), or CorelDraw 12 files.** Do not submit graphs in colour. If tints are used they should be easily discernible. If the files were generated in other software programmes, export them as TIF or JPG files **at a resolution of 600 dpi/ppi or higher.**

12.5 Photographs should be of excellent quality on glossy paper with clear detail and moderate contrast so that the figures can be scanned without retouching them electronically. If submitted electronically, provide as a TIF or JPG file at 600 dpi or higher and NOT AS A DOC, PDF, EXCEL OR POWERPOINT FILE.

12.6 Photograph mosaics **should be submitted as separate photographs or files at 600 dpi or higher, as well as a photocopy/layout of the mosaic. Final layout of the mosaic will be done by our graphics department.**

12.7 **Do not number the original images but include a scale bar. Numbering must be indicated on the pho-**

tocopy and not on the original image or electronic copy.

12.8 If several illustrations are treated as components of a single composite figure they should be designated by capital letters.

12.9 Note that the word 'Figure' should be written out in full, both in the text and the captions and should begin with a capital 'F' (but see 14.7 for taxonomic papers).

12.10 In the text the figure reference is then written as in the following example: 'The stamens (Figure 4A, B) are...'

12.11 In captions, 'FIGURE' is written in capital letters.

12.12 Scale bars or scale lines should be used on figures, or appropriate magnifications should be put in the captions.

12.13 In figures accompanying taxonomic papers, voucher specimens should be given in the relevant caption.

12.14 Figures are numbered consecutively with Arabic numerals in the order they are referred to in the text. These numbers, as well as the author's name and an indication of the top of the figure, must be written in soft pencil on the back of all figures.

12.15 Captions of figures must **not** be pasted under the photograph or drawing and must also **not** be included in any electronic version of the figures.

12.16 Captions of figures should be collected together and typed at the end of the MS and headed *Captions for figures*.

12.17 Authors should indicate in pencil in the text where they would like the figures to appear.

12.18 Authors wishing to have the originals of figures returned must inform the editor in the original covering letter and must mark each original 'To be returned to author'.

12.19 Authors wishing to use illustrations already published elsewhere must obtain written permission before submitting the manuscript and inform the editor of this fact.

12.20 It is strongly recommended that taxonomic articles include dot maps as figures to show the distribution of taxa. **Maps will be reduced to column width (80 mm): the dots and numbers** used must be large enough to stand reduction (recommended size: 5 mm diameter).

12.21 Blank distribution maps of southern Africa, Africa and the world are available from the Bookshop, SANBI Pretoria.

12.22 A dot map PC programme for distribution of taxa in South Africa, called **MAPPIT2** is available for purchase from the Data Section, South African National Biodiversity Institute, Pretoria. Please submit this map as a high resolution JPG file at 600 dpi to fit the column width of 80 mm.

12.23 ArcView GIS maps are acceptable. The layout representing all the appropriate themes (including grid

lines) should be **submitted as an encapsulated file (EPS)**.

12.24 Colour figures are permitted only if: a) it will clarify the article and b) the cost of reproduction and printing is borne by the author.

12.25 **Magnification of figures in the caption should be given for the size as submitted.**

13 Text

13.1 As a rule, authors should use the plant names (but not of all authors of plant names—see 13.6) as listed in PRECIS (National Herbarium **PRE**toria **C**omputerised **I**nformation **S**ystem).

13.2 Names of genera and infrageneric taxa are usually italicized, with the author citation (where relevant; see 13.6) not italicized. Exceptions include names of new taxa in the abstract, correct names given in the synopsis or in paragraphs on species excluded from a given supra-specific group in taxonomic articles; in checklists and in indices, where the position is reversed, correct names are not italicized and synonyms are italicized.

13.3 Names above generic level are not italicized.

13.4 In articles dealing with taxonomy, the complete scientific name of a plant (with author citation) should be given at the first mention in the text. The generic name should be abbreviated to the initial thereafter, except where intervening references to other genera with the same initial could cause confusion (see 16.6).

13.5 In normal text, Latin words are italicized, but in the synopsis of a species, Latin words such as *nom. nud.* and *et al.* are not italicized (see 16.4, 17.9).

13.6 In accordance with Garnock-Jones & Webb (1996) in *Taxon* 45: 285, 286, authors of plant names are not to be added to plant names except in taxonomic papers. Names of authors of plant names should agree with the list published by the Royal Botanic Gardens, Kew, entitled, *Authors of plant names*, edited by R.K. Brummitt & C.E. Powell (1992).

13.7 Modern authors not included in the list should use their full name and initials when publishing new plant names. Other author names not in the list should be in agreement with the recommendations of the Code.

13.8 Names of authors of publications are written out in full, without initials, except in the synonymy in taxonomic articles where they are treated like names of authors of plant names.

13.9 Names of plant collectors are italicized whenever they are linked to the number of a specimen. The collection number is also italicized, e.g. *Acocks 14407*.

13.10 Surnames beginning with 'De', 'Du' or 'Van' begin with a capital letter unless preceded by an initial.

13.11 For measurements use only units of the International System of Units (SI). **In taxonomic papers only mm and m, should be used; in ecological papers cm or m should be used.**

13.12 The use of '±' is preferred to c. or ca (see 17.7).

13.13 Numbers 'one' to 'nine' are spelt out in normal text, and from 10 onwards they are written in Arabic numerals.

13.14 In descriptions of plants, numerals are used throughout. Write 2.0–4.5 (not 2–4.5) and 2.0–4.5 ¥ 6–9. When counting members write 2 or 3 (not 2–3), but 2–4.

13.15 Abbreviations should be used sparingly but consistently. No full stops are placed after abbreviations ending with the last letter of the full word (e.g. edition = edn; editor = ed.); after units of measure; after compass directions; after herbarium designations; after countries, e.g. USA and after well-known institutions, e.g. CSIR.

13.16 Apart from multi-access keys, indented keys should be used with couplets numbered 1a–1b, 2a–2b, etc. (without full stops thereafter).

13.17 Keys consisting of a single couplet have no numbering.

13.18 Manuscripts of keys should be presented as in the following example:

1a Leaves closely arranged on elongated stem; a submerged aquatic with only capitula exserted . . . 1b. *E. setaceum* var. *pumilum*

1b Leaves in basal rosettes; stems suppressed; small marsh plants, ruderals or rarely aquatics:

2a Annuals, small, fast-growing pioneers, dying when habitat dries up; capitula without coarse white setae; receptacles cylindrical:

3a Anthers white . . . 2. *E. cinereum*

3b Anthers black . . . 3. *E. nigrum*

2b Perennials, more robust plants; capitula sparsely to densely covered with short setae:

13.19 Herbarium voucher specimens should be referred to wherever possible, not only in taxonomic articles.

13.20 The word Figure should be written out in full and should begin with a capital F, also in captions where the whole word is in capital letters (see 12.8–12.10).

14 Species treatment in taxonomic papers

14.1 The procedure to be followed is illustrated in the example (17.9), which should be referred to, because not all steps are described in full detail.

14.2 The correct name (bold, not italicized) is to be followed by its author citation (italicized) and the full literature reference, with the name of the publication written out in full (not italicized).

14.3 Thereafter all literature references, including those of the synonyms, should only reflect author, page and year of publication, e.g. C.E.Hubb. in *Kew Bulletin* 15: 307 (1960); Boris et al.: 14 (1966); Boris: 89 (1967); Sims: t. 38 (1977); Sims: 67 (1980).

14.4 The description and the discussion should consist of paragraphs commencing, where possible, with italicized leader words such as *flowering time*, *etymology*, *diagnostic characters*, *distribution and habitat*, **with a**

colon following the leader word and the first word of the sentence beginning with a lower case letter.

14.5 When more than one species of a given genus is dealt with in a paper, the correct name of each species should be prefixed by a sequential number followed by a full stop. Intraspecific taxa are marked with small letters, e.g. 1b., 12c., etc.

14.6 Names of authors are written as in 13.6, irrespective of whether the person in question is cited as the author of a plant name or of a publication.

14.7 The word 'figure' is written as 'fig.', and 't.' is used for both 'plate' and 'tablet' (but see 12.8 for normal text).

14.8 Literature references providing good illustrations of the species in question may be cited in a paragraph commencing with the word *Illustrations* followed by a colon. This paragraph is given after the last paragraph of the synonymy, see 17.9.

14.9 When new combinations are made, the full literature reference must be given for the basionym, e.g.:

***Antimima saturata* (L.Bolus) H.E.K. Hartmann, comb. nov.**

Ruschia saturata L.Bolus in Notes on Mesembrianthemum and allied genera, part 2: 122 (1929). *Mesembryanthemum atrocinctum* N.E.Br.: 32 (1930). Type: *Pillans* BOL18952 (BOL, holo.–photo!).

15 Citation of specimens

15.1 Type specimen in synopsis: the following should be given (if available): country (if not in RSA), province, grid reference (at least for new taxa), locality as given by original collector, modern equivalent of collecting locality in square brackets (if relevant, e.g. Port Natal [now Durban]), quarter-degree square, date of collection (optional), collector's name and collecting number (both italicized).

15.2 The abbreviation s.n. (*sine numero*) is given after the name of a collector who usually assigned numbers to his collections but did not do so in the specimen in question (see 15.11), or the herbarium number can then be cited with no space between the herbarium and its number e.g. *Marloth* SAM691 (see 17.9). The herbaria in which the relevant type(s) are housed are indicated by means of the abbreviations given in the latest edition of *Index Herbariorum*.

15.3 The holotype (holo.) and its location are mentioned first, followed by a semicolon, the other herbaria are arranged alphabetically, separated by commas.

15.4 Authors should indicate by means of an exclamation mark (!) which of the types have been personally examined.

15.5 If only a photograph or microfiche was seen, write as follows: *Anon.* 422 (X, holo.–BOL, photo!).

15.6 Lectotypes or neotypes should be chosen for correct names without a holotype. It is not necessary to lectotypify synonyms.

15.7 When a lectotype or a neotype are newly chosen, this should be indicated by using the phrase 'here designated' (see 17.9). If reference is made to a previously selected lectotype or neotype, the name of the designating author and the literature reference should be given. In cases where no type was cited, and none has subsequently been nominated, this may be stated as 'not designated'.

15.8 In brief papers mentioning only a few species and a few cited specimens the specimens should be arranged according to the grid reference system: Provinces/countries (typed in capitals) should be cited in the following order: Namibia, Botswana, Limpopo (previously Northern Transvaal, Northern Province), North-West (previously northeastern Cape and southwestern Transvaal), Gauteng (previously PWV), Mpumalanga (previously Eastern Transvaal), Free State (previously Orange Free State), Swaziland, KwaZulu-Natal (previously Natal), Lesotho, and Northern Cape, Western Cape and Eastern Cape (Figure 1).

15.9 Grid references should be cited in numerical sequence.

15.10 Locality records for specimens should preferably be given to within a quarter-degree square. Records from the same one-degree square are given in alphabetical order, i.e. (–AC) precedes (–AD), etc. Records from the same quarter-degree square are arranged alphabetically according to the collectors' names; the quarter-degree references must be repeated for each specimen cited.

15.11 The relevant international code of the herbaria in which a collection was seen should be given in brackets after the collection number; the codes are separated by commas. The following example will explain the procedure:

KWAZULU-NATAL.—2731 (Louwsburg): 16 km E of Nongoma, (–DD), 10-10-1960, *Pelser* 354 (BM, K, PRE); near Dwarsrand, *Van der Merwe* 4789 (BOL, M). 2829 (Harrismith): near Groothoek, (–AB), *Smith* 234; Koffiefontein, (–AB), *Taylor* 720 (PRE); Cathedral Peak Forest Station, (–CC), 8 July 1905, *Marriot* s.n. (KMG); Wilgerfontein, *Roux* 426. Grid ref. unknown: Sterkstroom, *Strydom* 12 (NBG).

15.12 For records from outside southern Africa authors should use degree squares without names, e.g.:

KENYA.—0136: Nairobi plains beyond race course, *Napier* 485.

15.13 Monographs and revisions: in the case of all major works of this nature it is assumed that the author has investigated the relevant material in all major herbaria and that he has provided the specimens seen with determinavit labels. It is assumed further that the author has submitted distribution maps for all relevant taxa and that the distribution has been described briefly in words in the text. Under the heading 'Vouchers' no more than five specimens should be cited, indicating merely the collector and the collector's number (both italicized). Specimens are alphabetically arranged according to collector's name. If more than one specimen by the same collector is cited, they are arranged numerically and separated by a comma. **A collector's name and the voucher number(s) is separated from the next collector by a semicolon.** The purpose of the cited specimens is not to indicate distribution but to convey the author's concept of the taxon in question.

15.14 The herbaria in which the specimens are housed are indicated by means of the abbreviation given in the latest edition of *Index Herbariorum*. They are given between brackets, arranged alphabetically and separated by commas behind every specimen as in the following example:

Vouchers: *Arnold* 64 (PRE); *Fisher* 840 (NH, NU, PRE); *Flanagan* 831 (GRA, PRE), 840 (NH, PRE); *Marloth* 4926 (PRE, STE); *Schelte* 6161, 6163, 6405 (BOL); *Schlechter* 4451 (BM, BOL, GRA, K, PRE).

15.15 If long lists of specimens are given, they must be listed together before Acknowledgements under the heading *Specimens examined*. **They are arranged alphabetically by the collector's name and then numerically for each taxon.** The species is indicated in brackets by the number that was assigned to it in the text and any infra-specific taxa by a small letter; **this number follows the specimen number.** If more than one genus is dealt with in a given article, the first species of the first genus mentioned is indicated as 1.1. This is followed by the international herbarium designation. Note that the name of the collector and the collection number are italicized:

Acocks 14724 (1.13a) BOL, K, P; 12497 (2.1b) BM, K, PRE. *Archer* 1507 (1.4) BM, G.

Barker 9738 (1) NBG; 1916 (2) NBG; 295, 4766, 9478, 9796, 10330 (4) NBG; 1919 (5) BOL, NBG; 1917, 1923, 1935, 2570, 2606, 2646, 3332, 4198, 4858, 10534, 10801 (5) NBG. *Burchell* 2847 (2.8c) MB, K. *Burman* 2401 (3.3) MO, S. B.L. *Burt* 789 (2.6) B, KMG, STE.

Esterhuysen 11497 (1) BOL; 1433 (5) BOL; 71402 (5) NBG.

16 Synonyms

16.1 In a monograph or a revision covering all of southern Africa, all synonyms based on types of southern African origin, or used in southern African literature, should be included.

16.2 Illegitimate names are designated by *nom. illeg.* after the reference, followed by non with the author and date, if there is an earlier homonym.

16.3 *Nomina nuda* (*nom. nud.*) and invalidly published names are excluded unless there is a special reason to cite them, for example if they have been used in prominent publications.

16.4 In normal text, Latin words are italicized, but in the synopsis of a species Latin words such as *nom. nud.*, *et al.* are not italicized (see 13.5, 17.9).

16.5 Synonyms should be arranged chronologically into groups of nomenclatural synonyms, i.e. synonyms based on the same type, and the groups should be arranged chronologically by basionyms, except for the basionym of the correct name which is dealt with in the paragraph directly after that of the correct name.

16.6 When a generic name is repeated in a given synonymy it should be abbreviated to the initial, except where intervening references to other genera with the same initial could cause confusion (see 13.4).

17 Description and example of species treatment

17.1 Descriptions of all taxa of higher plants should, where possible, follow the sequence: Habit; sexuality;

underground parts (if relevant). *Indumentum* (if it can be easily described for the whole plant). *Stems/branches*. *Bark*. *Leaves*: arrangement, petiole absent/present, pubescence; blade: shape, measurements, apex, base, margin; midrib: above/below, texture, colour; petiole; stipules. *Inflorescence*: type, shape, measurements, position; bracts/bracteoles, involucral bracts: inner, outer. *Flowers*: shape, measurements, sex, colour. *Receptacle*. *Calyx*. *Corolla*. *Disc*. *Androecium*. *Gynoecium*. *Fruit*. *Seeds*. *Flowering time*. *Chromosome number (reference)*. *Conservation status*. Figure number (word written out in full).

17.2 As a rule, shape should be given before measurements.

17.3 In general, if an organ has more than one of the parts being described, use the plural, otherwise use the singular, for example, petals of a flower but blade of a leaf.

17.4 Language must be as concise as possible, using participles instead of verbs.

17.5 Dimension ranges should be cited as in 17.9.

17.6 Care must be exercised in the use of dashes and hyphens. A *hyphen* is a short stroke joining two syllables of a word, e.g. ovate-lanceolate or sea-green, with no space between the letter and the stroke. An *N-dash* (*en*) is a longer stroke commonly used instead of the word 'to' between numerals, '2–5 mm long' (do not use it between words but rather use the word 'to', e.g. 'ovate to lanceolate'; it is produced by typing three hyphens with spaces in between, or in MS Word the code is alt + 0150. An *M-dash* (*em*) is a stroke longer than an N-dash and is used variously, e.g. in front of a subspecific epithet instead of the full species name; it is produced by typing two hyphens with spaces in between, or in MS Word the code is alt + 0151. See also 2.10–2.12.

17.7 The use of '±' is preferred to c. or ca when describing shape, measurements and dimensions (see 13.12).

17.8 The decimal point replaces the comma in all units of measurement, e.g. leaves 1.0–1.5 mm long.

17.9 Example:

1. **Englerophytum magalismontanum** (Sond.) T.D.Penn., The genera of Sapotaceae: 252 (1991). Type: Gauteng, Magaliesberg, *Zeyher* 1849 (S, holo.–BOL, photo.!).

Bequaertiodendron magalismontanum (Sond.) Heine & Hemsl.: 307 (1960); Codd: 72 (1964); Elsdon: 75 (1980).

Chrysophyllum magalismontanum Sond.: 721 (1850); Harv.: 812 (1867); Engl.: 434 (1904); Bottmar: 34 (1919). *Zeyherella magalismontana* (Sond.) Aubrév. & Pellegr.: 105 (1958); Justin: 97 (1973).

Chrysophyllum argyrophyllum Hiern: 721 (1850); Engl.: 43 (1904). *Boivinella argyrophylla* (Hiern) Aubrév. & Pellegr.: 37 (1958); Justin et al.: 98 (1973). Types: Angola, *Welwitsch* 4828 (BM!, lecto., here designated; PRE!); Angola, *Welwitsch* s.n. (BM!).

Chrysophyllum wilmsii Engl.: 4, t. 16 (1904); Masonet: 77 (1923); Woodson: 244 (1937). *Boivinella wilmsii* (Engl.) Aubrév. & Pellegr.: 39 (1958); Justin: 99 (1973). Type: without locality and collector [B, holo.†; K!, P!, lecto., designated by Aubrév. & Pellegr.: 38 (1958), PRE!, S!, W!, Z!].

Bequaertiodendron fruticosum De Wild.: 37 (1923), non Bonpl.: 590 (1823); D.Bakker: 167 (1929); H.Fr.: 302 (1938); Davy: 640 (1954); Breytenbach: 117 (1959); Clausen: 720 (1968); Palmer: 34 (1969). Type: Mpumalanga, Tzaneen Dist., *Granville in Herb. Pillans K48625* (K, holo.; G!, P!, PRE!, SI).

B. fragrans auct. non Oldemann: Glover: 149, t. 19 (1915); Henkel: 226 (1934); Stapelton: 6 (1954).

Illustrations: Harv.: 812 (1867); Henkel: t. 84 (1934?); Codd: 73 (1964); Palmer: 35 (1969).

Woody perennial; main branches up to 0.4 m long, erect or decumbent, grey woolly-felted, leafy. *Leaves* linear to oblanceolate, 3–10(–23) × 1.0–1.5(–4.0) mm, obtuse, base broad, half-clasping. *Heads* heterogamous, campanulate, 7–8 × 5 mm, solitary, sessile at tip of axillary shoots; involucre bracts in 5 or 6 series, inner exceeding flowers, tips subopaque, white, very acute. *Receptacle* nearly smooth. *Flowers* ± 23–30, 7–11 male, 16–21 bisexual, yellow, tipped pink. *Achenes* ± 0.75 mm long, elliptic. *Pappus* bristles very many, equalling corolla, scabridulous. *Flowering time*: September. *Chromosome number*: 2n = 22. Figure 23B.

18 New taxa

18.1 The name of a new taxon must be accompanied by at least a Latin diagnosis. Authors should not provide full-length Latin descriptions unless they have the required expertise in Latin at their disposal.

18.2 It is recommended that descriptions of new taxa be accompanied by a good illustration, **preferably a line drawing, or a photograph (second choice)** and a distribution map.

18.3 Example:

109. *Helichrysum jubilatum* Hilliard, sp. nov., *H. alsinoides* DC. affinis, sed foliis ellipticis (nec spatulatis), inflorescentiis compositis a foliis non circumcinctis, floribus femineis numero quasi dimidium hermaphroditorum aequantibus (nec capitulis homogamis vel floribus femineis 1–3 tantum) distinguitur.

Herba annua e basi ramosa; caules erecti vel decumbentes, 100–250 mm longi, tenuiter albo-lanati, remote foliati. *Folia* plerumque 8–30 × 5–15 mm, sub capitulis minora, elliptica vel oblanceolata, obtusa vel acuta, mucronata, basi semi-amplexicauli, utrinque cano-lanato-arachnoidea. *Capitula* heterogama, campanulata, 3.5–4.0 × 2.5 mm, pro parte maxima in paniculas cymosas terminales aggregata; capitula subterminalia interdum solitaria vel 2 vel 3 ad apices ramulorum nudorum ad 30 mm longorum. *Bractae involucrales* 5-seriatae, gradatae, exteriores pellucidae, pallide stramineae, dorso lanatae, seriebus duabus interioribus subaequalibus et flores quasi aequantibus, apicibus obtusis opacis niveis vix radiantibus. *Receptaculum* fere laeve. *Flores* ± 35–41. *Achenia* 0.75 mm longa, pilis myxogenis praedita. *Pappi* setae multae, corollam aequantes, apicibus scabridis, basibus non cohaerentibus.

TYPE.—Northern Cape, 2817 (Vioolsdrif): Richtersveld, (–CC), ± 5 miles E of Lekkersing on road to Stinkfontein, kloof in hill south of road, annual, disc whitish, 7–11–1962, *Nordenstam 1823* (S, holo.; E, NH, PRE).

19 New provinces of South Africa (Oct. 1996)

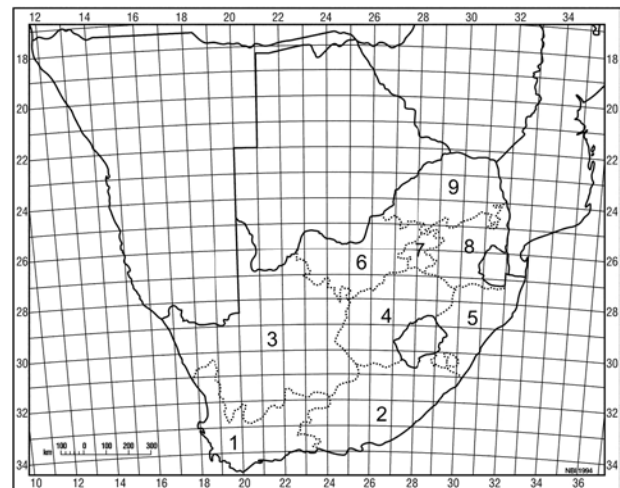


FIGURE 1.—1, Western Cape; 2, Eastern Cape; 3, Northern Cape; 4, Free State (previously Orange Free State); 5, KwaZulu-Natal (previously Natal); 6, North-West (previously northeastern Cape and southwestern Transvaal); 7, Gauteng (previously PWV); 8, Mpumalanga (previously Eastern Transvaal); 9, Limpopo (previously Northern Transvaal, Northern Province).

20 Proofs

Only page proofs are normally sent to authors. They should be corrected in red ink and be returned to the editor **as soon as possible**. Do not add any new information.

21 Reprints

Reprints will no longer be issued. A PDF file of the article will be sent via the E-mail to authors and co-authors. It is for private use only, the SANBI copyright protects it from being used in another publication.

22 Documents consulted

Guides to authors of the following publications were made use of in the compilation of the present guide: *Annals of the Missouri Botanic Garden*, *Botanical Journal of the Linnean Society*, *Flora of Australia*, *Smithsonian Contributions to Botany*, *South African Journal of Botany* (including instructions to authors of taxonomic papers), *South African Journal of Science*.

23 Address of editor

Manuscripts should be submitted to: The Editor, *Bothalia*, South African National Biodiversity Institute, Private Bag X101, Pretoria 0001.

24 FSA contributions

24.1 Figures and text must conform to *Bothalia* format.

24.2 These articles will be considered as a full contribution to the *Flora of southern Africa* and will be listed as published in the '*Plan of Flora of southern Africa*', which appears in all issues of the FSA series.

25 Place names

Ensure that local place names are correct. If in doubt, consult the Internet at

<http://sagns.dac.gov.za/searchplacenedatabase.asp>

INDEX

- abbreviation, 13.4, 13.15, 15.2, 15.14, 16.6
- abstract, 2.1, 2.3, 2.4, 7, 13.2
- acknowledgements, 2.4, 9
- address of
 - authors, 2.3, 4
 - editor, 23
- Adobe Illustrator version CS2 (AI), 3.9, 12.4
- AI, 3.9, 12.4
- alphabetical, 6, 10.9, 10.10, 15.3, 15.10, 15.13, 15.14, 15.15
- ArcView GIS maps, 12.23
- Arabic numerals, 11.1, 12.14, 13.13
- author(s), 1.3, 2.1, 2.3, 4, 10.14, 12.17–12.19
 - address, 2.3, 4
 - citation, 5, 7.3, 13.2, 13.4, 14.2
 - first, 10.2
 - names, 2.3, 10.2, 10.7, 10.9, 10.11, 12.14, 13.7, 13.8, 14.3, 14.6, 15.7
 - names of plant names, 5, 13.1, 13.2, 13.6, 13.7, 13.8, 14.6
 - senior, 10.10
- book reviews, 1.1, 2.4
- books, 10.4, 10.12, 10.13, 10.14
- Bothalia, 1, 2.2, 11.2, 24.1
- brief taxonomic articles, 15.8
- BRUMMITT, R.K. & POWELL, C.E. (eds) 1992. *Authors of plant names*. Royal Botanic Gardens, Kew, 13.6
- c., 13.12, 17.7
- ca, 13.12, 17.7
- Cape, 15.8, 18.3, 19
- capital letters, 10.2, 11.2, 12.8, 12.9, 12.11, 13.20, 15.8
- captions, 2.1, 2.4, 2.5, 11.2, 12.1, 12.9, 12.11–12.13, 12.15, 12.16, 12.25, 13.20
- CD, 3.2, 3.8, 3.11
- CDR file, 3.9
- checklist, 13.2
- chromosome number, 17.1, 17.9
- chronological sequence, 10.3, 10.6, 10.9, 16.5
- citation
 - author, 5, 7.3, 13.2, 13.4, 14.2
 - of specimens, 15
- cm, 13.11
- collection
 - date, 15.1
 - number, 13.9, 15.1, 15.2, 15.11, 15.13, 15.15
- collective book, 10.14
- collector, 13.9, 15.1, 15.2, 15.10, 15.13, 15.15
- colon, 2.13, 14.4, 14.8
- colour figures, 12.24
- comma, 2.13, 15.3, 15.11, 15.13, 15.14, 17.8
- compass directions, 13.15
- composite figure, 12.8
- congress proceedings, 10.14
- contents, 8
- CorelDraw up to version 12, 3.9, 12.4
- correspondence, 4
- countries, 6.7, 15.8
- deadline dates for submission of MS, 1.6
- decimal point, 17.8
- description and example of species treatment, 17
- determinavit labels, 15.13
- discussion, 2.4, 14.4
- distribution maps, 12.20–12.23, 15.13, 18.2
- documents consulted, 22
- dot maps, 12.20–12.23, 15.13, 18.2
- double
 - line spacing, 2.1
 - space, 2.13
- dpi (dots per inch), 12.2, 12.4–12.6, 12.22
- drawing paper, 12.2
- drawings, 3.7, 12.1–12.3
- Eastern Transvaal, see Mpumalanga, 15.8, 19
- edition, 13.15
- editor, 1.5, 12.18, 13.15, 23
- editorial
 - board, 1.4
 - policy, 1
- electronic
 - copy, 12.7
 - files, 3, 3.2, 3.8–3.10, 12.2, 12.4–12.6
 - submissions of graphics, tables, 11, 12
- E-mail, 3.2, 3.8, 21
- encapsulated file (EPS), 12.4, 12.23
- EPS file, 12.4, 12.23
- et al.*, 10.2, 13.5, 14.3, 17.9
- example of
 - new taxa, 18.3
 - species treatment, 17.9
- exclamation mark, 2.13, 15.4
- EXCEL file, 12.5
- family name, 5, 6.7
- fig., 14.7
- figure(s), 12, 13.20, 14.7, 17.1
 - colour, 12.24
 - electronic submissions of, 12
 - reduction of, 12.1, 12.2, 12.20
 - returned, 12.18
- file
 - electronic, 3, 3.2
 - extensions, 3.9
 - CDR, 3.9
 - EPS, 12.4, 12.23
 - JPG, 12.2, 12.4, 12.5, 12.22
 - POWERPOINT, 12.5
 - RTF, 3.3
 - TIF, 3.9, 12.2, 12.4, 12.5
- firewall, 3.8
- first author, 10.2
- first language, 1.3
- flora, 10.14
- Flora of southern Africa*, 24
- footnote, 2.3, 3.4
- Free State (previously Orange Free State), 15.8, 19
- FSA contributions, 24
- ftp site, 3.8
- full stop, 2.13, 13.15, 13.16, 14.5
- GARNOCK-JONES, P.J. & WEBB, C.J. 1996. The requirement to cite authors of plant names in botanical journals. *Taxon* 45: 285, 286, 13.6
- Gauteng (previously PWV), 15.8, 17.9, 19
- genera, 13.2
- generic name, 13.3, 13.4, 16.6
- geographical area, 7.2
- granting agencies, 2.3
- graphics, 3.7
 - electronic submissions of, 12
- graphs, 3.7, 12.4
- grid reference system, 15.1, 15.8, 15.9, 15.11
- headings, 3.4 3.6
- sequence of, 2.3, 2.4
- herbaria, 15.2, 15.3, 15.11, 15.13, 15.14
- herbarium
 - code, 15.11
 - designations, 13.15, 15.15
 - numbers, 15.2
 - voucher specimens, 12.13, 13.19
- here designated, 15.7, 17.9
- histograms, 12.4
- holo., 15.3, 15.5, 17.9, 18.3
- holotype, 15.3, 15.6
- homonym, 16.2
- hyphenated words, 2.9
- hyphen, 2.10–2.12, 17.6
- illegitimate names (nom. illeg.), 16.2
- illustrations, 12.2, 12.8, 12.19, 14.8, 17.9
 - previously published, 12.19
- image files, 3.8–3.10
- indentations, 3.4, 3.6
- Index Herbariorum*, 15.2, 15.14

- index of names, 2.4
- indices, 13.2
- infrageneric taxa, 13.2
- initials, 9, 10.5, 13.7
- in prep., 10.14
- in preparation, 10.14
- in press, 10.14
- International
 - Code of Botanical Nomenclature, 13.7
 - System of Units (SI), 13.11
- invalidly published names, 16.3
- italics, 3.5, 7.4, 10.12, 13.2, 13.3, 13.5, 13.9, 14.2, 15.1, 15.13, 15.15
- journals, 10.4, 10.12, 10.14
 - names of, 10.4, 10.13
- JPG file, 12.2, 12.4, 12.5, 12.22
- justify, 2.8
- keys, 2.16, 3.4, 13.16, 13.17, 13.18
- keywords, 2.3, 2.4, 6
- KwaZulu-Natal (previously Natal), 15.8, 19
- language, 1.3
- Latin, 13.5, 16.4
 - descriptions, 18.1
- layout, 2.2, 12.6
- lecto., 15.6, 15.7, 17.9
- lectotype, 15.6, 15.7, 17.9
- Limpopo (previously Northern Transvaal, Northern Province), 15.8, 19
- line
 - drawings, 2.1, 12.2, 18.2
 - spacing, 2.1
- literature
 - references, 2.1, 10, 14.2, 14.3, 14.8, 14.9
 - within synonymy, 14.8
- localities outside southern Africa, 15.12
- locality, 15.1, 15.10
- location, 6.7
- m, 13.11
- magnification of figures, 12.12, 12.25
- manuscript
 - language, 1.3, 17.4
 - requirements, 1.1, 1.2, 1.3, 2
 - sequence, 2.3, 2.4
- map
 - ArcView GIS, 12.23
 - distribution, 12.21–12.23, 15.13, 18.2, 19
 - dot, 12.20, 12.22
- MAPFIT2, 12.22
- M-dash, 2.12, 17.6
- mm, 13.11
- margin, 2.1, 2.16, 3.4, 17.1
- material, 2.3, 2.4
- measurements, 13.11, 17.1, 17.2, 17.7, 17.8
- methods, 2.4, 6.10.3
- microfiche, 15.5
- miscellaneous paper, 10.14
- monograph, 2.4, 15.13, 16.1
- Mpumalanga (previously Eastern Transvaal), 15.8, 19
- MSWord, 2.7, 2.11, 2.12, 3.3, 3.5
- name(s)
 - collector's, 15.10
 - illegitimate, 16.2
 - invalidly published, 16.3
 - of author(s), 2.3, 10.2, 10.7, 10.9, 10.11, 12.14, 13.7, 13.8, 14.3, 14.6, 15.7
 - of authors of plant names, 5, 7.3, 13.1, 13.2, 13.6, 13.7, 13.8, 14.6
 - of publications, 13.8
- Natal, see KwaZulu-Natal, 15.8, 19
- N-dash, 2.11, 10.7, 17.6
- neotype, 15.6, 15.7
- new
 - combinations, 7.4, 14.9
 - provinces of South Africa (Oct. 1996, April 2002), 15.8, 19
 - taxa, 7.4, 13.2, 13.7, 15.7, 18
- nom. illeg., 16.2
- nom. nud., 13.5, 16.3, 16.4
- non-breaking space, 2.7
- normal style, 3.1
- Northern
 - Province, see Northern Transvaal, 15.8, 19
 - Transvaal, see Northern Province, Limpopo, 15.8, 19
- North-West, 15.8, 19
- notes, 1, 2.4
 - technical, 10.14
- number
 - chromosome, 17.1, 17.9
 - herbarium, 15.2
- numbering, 12.7, 13.13
 - of figures, 12.7, 12.14, 17.1
 - of keys, 13.16, 13.17
 - of pages, 2.5
 - of taxa, 14.5, 15.15
- numerals, Arabic, 11.1, 12.14
- obituaries, 1.1, 2.4, 10.7
- Orange Free State, see Free State, 15.8, 19
- original figures, 12.1, 12.2, 12.7, 12.18
- page charges, 1.5
- paragraphs, 3.6
- PDF file, 12.5, 21
- pencil drawings, 12.3
- permission (written)
 - to copy material, 3.8
 - to use previously published material (text and illustrations), 12.19
- pers. comm., 10.5, 10.8
- personal communications (pers. comm.), 10.5, 10.8
- photocopies, 2.1, 12.6, 12.7
- photograph, 3.7, 12.1, 12.5, 12.6, 12.15, 15.5, 18.2
 - mosaic, 12.6, 12.7
- pixels, 12.2
- plant
 - collectors, 13.9
 - name, 5, 13.4, 13.6, 13.7, 13.8, 14.6
- plate (t.), 14.7
- POWERPOINT file, 12.5
- ppi (pixels per inch), 12.2, 12.4
- PRECIS (National Herbarium **PRE**toria **C**omputerised **I**nformation **S**ystem), 13.1
- prepositions, 6.4
- proceedings, 10.14
- proofs, 20
- provinces, 6.7, 15.1, 15.8
 - of South Africa, 15.8, 19
- publications, 10.8, 13.8, 14.3
 - name of, 14.2
 - solo, 10.10
 - year of, 10.9, 14.3
- PWV, see Gauteng, 15.8, 19
- quarter-degree squares, 15.1, 15.10
- quotes, 2.15
- reduction of
 - figures, 12.1, 12.2, 12.20
 - tables, 11.3
- referees, 1.4
- reference(s), 2.4, 2.5, 10.6, 10.7–10.9, 10.14
 - figure, 12.10
 - grid, 15.1, 15.8, 15.9, 15.11
 - list, 10.5, 10.8, 10.9
 - literature, 2.1, 10
- report, 10.14
- reprints, 21
- requirements for manuscript, 2
- results, 2.4
- revision, 2.4, 8, 15.13, 16.1
- RTF file, 3.3
- scale bar, 12.7, 12.12
- scan, 12.1
- semicolon, 2.13, 10.3, 15.3, 15.13
- senior author, 10.10
- sequence of headings, 2.3, 2.4
- short notes, 1.1, 2.4
- space
 - double, 2.13
 - non-breaking, 2.7
 - one, 2.16
- special characters, 2.6
- species treatment in taxonomic papers, 14
- specimens examined, 2.4, 15.15
- square brackets, 15.1, 17.9
- STAFLEU, F.A. & COWAN, R.S. 1976–1988. *Taxonomic literature*. Vols 1–7, 10.13

- style(s), 3.1, 3.4
- submission of MS, 1.2, 1.6
- surnames, 13.10
- synopsis, 13.2, 13.5, 15.1, 16.4
- synonymy, 13.8, 14.8, 16.6
- t., 14.3, 14.7, 17.9
- table(s), 2.1, 2.4, 2.5, 11
 - electronic submissions, 11
 - of contents, 8
- tablet (t.), 14.7
- tabs, 3.4
- taxa
 - name of, 5, 7.4, 10.8, 13.2, 13.3
 - new, 7.4, 13.2, 13.7, 15.7, 18
 - numbering of, 14.5, 15.15
- taxonomic
 - articles/papers, 7.2, 10.8, 12.13, 12.20, 13.2, 13.6, 13.8, 13.11, 14
 - revision, 8
- taxonomy, 5, 7.3, 13.4
- technical note, 10.14
- text, 2.1, 3.7, 10.1, 10.4, 10.5, 10.8, 10.9, 11.1, 12.9, 12.10, 12.14, 12.17, 13, 15.13, 15.15, 16.4
- thesis, 10.14
- TIF file, 3.9, 12.2, 12.4, 12.5
- times sign, 2.14
- title, 2.3, 5, 6.9, 6.11
 - of books, 10.4, 10.12, 10.13, 10.14
 - of journals, 10.4, 10.12, 10.13, 10.14
 - page, 2.3, 2.5
- tracked changes, 3.11
- Transvaal, 15.8, 17.9, 19
- type, 15.2, 15.4, 15.7, 16.1, 16.5, 17.9
 - here designated, 15.7, 17.9
 - not designated, 15.7
 - specimen, 15.1
- units of measure, 13.11, 13.15, 17.8
- unpublished article, 10.14
- voucher(s) specimens, 12.13, 13.19, 15.13, 15.4
- Word for Windows, 3.3
- World list of scientific periodicals*, 10.13
- year of publication, 10.9, 14.3

CONTENTS

1. New species of <i>Moraea</i> (Iridaceae: Iridoideae), with range extensions and miscellaneous notes for southern African species. P. GOLDBLATT and J.C. MANNING	1
2. Three new species of <i>Diascia</i> (Scrophulariaceae) from the Western Cape, South Africa. K.E. STEINER	11
3. <i>Aloe</i> in Angola (Asphodelaceae: Alooiidae). R.R. KLOPPER, S. MATOS, E. FIGUEIREDO and G.F. SMITH	19
4. Three new species of <i>Gladiolus</i> (Iridaceae) from South Africa, a major range extension for <i>G. rubellus</i> and taxonomic notes for the genus in southern and tropical Africa. J.C. MANNING and P. GOLDBLATT	37
5. A revision of Fumariaceae (Fumarioideae) in southern Africa, including naturalized taxa. J.C. MANNING, P. GOLDBLATT and F. FOREST.	47
6. Two new species of <i>Nemesia</i> (Scrophulariaceae) from arid areas of the Northern Cape, South Africa. K.E. STEINER	67
7. Taxonomy and phylogeny of two subgroups of <i>Pelargonium</i> section <i>Otidia</i> (Geraniaceae). 1. The <i>Pelargonium carnosum</i> complex. M. BECKER and F. ALBERS	73
8. A review of the genus <i>Curtisia</i> (Curtisiaceae). E. YU. YEMBATUROVA, B-E. VAN WYK and P.M. TILNEY	87
9. Notes on African plants:	
Asphodelaceae: Alooiidae. <i>Aloe hahnii</i> , a new species in the section <i>Pictae</i> , in the Soutpansberg Centre of Endemism, Limpopo Province, South Africa. R.R. KLOPPER and G.F. SMITH	98
Asphodelaceae: Alooiidae. Formalizing the synonymy of <i>Bulbine triebneri</i> . R.R. KLOPPER and G.F. SMITH	100
Campanulaceae. <i>Theilera robusta</i> , the correct name for <i>Theilera capensis</i> . C.N. CUPIDO	97
Ebenaceae. Typification and a new status in <i>Diospyros</i> . M. JORDAAN	101
Thymelaeaceae. The true identity of <i>Synaptolepis kirkii</i> . M. JORDAAN and C.L. BREDEN-KAMP	104
10. Closing bodies in the capsular fruits of Ruschioideae (Aizoaceae)—a review. H. KURZWEIL and P. BURGOYNE	107
11. Obituary: Robert Baily Drummond (1924–2008). M. COATES PALGRAVE	117
12. Book review	121