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New species of *Geissorhiza* (Iridaceae: Crocoideae) from the southern African winter rainfall zone, range extensions, taxonomic changes, and notes on pollen morphology and floral ecology

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ABSTRACT

Field work during the past 15 years has resulted in the discovery of 12 new species of the western southern African genus *Geissorhiza* Ker Gawl. and range extensions for several more. Following a survey of pollen morphology in the genus, we describe new pollen types in one section each of the two subgenera: five species of section *Ciliatae* Goldblatt and two of section *Weihea* Eckl. ex Baker have more complex apertures than the plesiomorphic single aperture with a 2-banded operculum found in other species. In addition, populations currently referred to the typical white (cream)-flowered *G. inflexa* (D.Delaroche) Goldblatt with larger, pink, red or purple flowers, have a third pollen type and are recognized as *G. erosa* (Salisb.) R.C.Foster. The new species are *G.* **altimontana** from the high Langeberg near Grootvadersbos; *G.* **helmei** from the Piketberg; *G.* **lapidosa** from the Du Toits Kloof Mtns; *G.* **monticola** from the Swartberg; *G.* **platystigma** from Darling, north of Cape Town; *G.* **sufflava** from the Piketberg; *G.* **tricolor** from Riversdale (all subgenus *Weihea* (Eckl. ex Baker) Goldblatt); and *G.* **cantharophila** from the Klein Roggeveld; *G.* **demissa** from the Kamiesberg, Gifberg and Cold Bokkeveld; *G.* **exilis** from the Waaihoek Mtns in the Worcester District; *G.* **reclinata** from the Swartberg; and *G.* **saxicola** from the northern Cedarberg–Pakhuis Mountain complex (all subgenus *Geissorhiza*). We also report range extensions and provide morphological notes for several species, including *G. monanthos* Eckl., new collections of which show that the inclusion of *G. lewisiae* R.C.Foster in that species was incorrect and we resurrect the species. The addition of 12 new species and recognition of *G. erosa* and *G. lewisiae* bring to 99 the number of species in the genus. New identification keys for *Geissorhiza* are provided that include all new species. We have also accumulated observations of floral ecology in the genus and integrate them with what is known about this aspect of the biology of *Geissorhiza*. Unusual strategies include deceptive pollination in *G. tulbaghensis* F.Bolus by tabanid flies and in two species, pollination using empid flies in combination with halictid bees.

INTRODUCTION

Geissorhiza Ker Gawl., now with 99 species, is a large genus of Iridaceae subfamily Crocoideae *Burnett* centred in the southern African winter rainfall zone (Goldblatt 1985; Goldblatt & Manning 2000a; Manning *et al.* 2002) and largely confined to the Cape floristic region (as defined by Goldblatt & Manning 2000a). Field work conducted in the decade since the publication of the last revision of the genus (Goldblatt 1985) resulted in the discovery and collection of four new species (Goldblatt 1989; Goldblatt & Manning 1995a), increasing to 85 the number of known species. Further novelties that have accumulated since then include seven species of subgenus *Weihea* (Eckl. ex Baker) Goldblatt and five of subgenus *Geissorhiza*.

In addition, our knowledge of the pollen morphology of *Geissorhiza* has been expanded as a result of examination of pollen grains carried by insects captured after visiting *Geissorhiza* species (Goldblatt & Manning 2000b, 2007). While monosulcate grains with a 2-banded operculum are typical of Crocoideae (Goldblatt *et al.* 1991) and also of *Geissorhiza*, the two species *G. heterostyla* L.Bolus and *G. inflexa* (D.Delaroche) Ker Gawl. (both subgenus *Geissorhiza* section *Ciliatae* Goldblatt) were found to have pollen grains that depart from the norm in the genus and subfamily. Instead of the single, elliptic aperture, these species have a more complex condition with multiple apertures, described in detail below. Discovery of these striking pollen grains led us to examine a range of species of the genus. Most species of subgenus *Weihea* that we examined have normal grains with a 2-banded operculum as do species of subgenus *Geissorhiza*. However, four new species, *G. cantharophila*, *G. exilis*, *G. saxicola* and *G. reclinata* (all section *Ciliatae*), as well as *G. bracteata* and *G. nana* (section *Weihea*) have grains with complex, multiple apertures. Furthermore, the large-flowered populations of *G. inflexa* (sensu Goldblatt 1985), often with a pink, red or purple perianth, have a different pollen type from those with smaller, white flowers, indicating that they constitute a separate genetic race. For the most part these populations are readily separated from typical *G. inflexa* based on morphology as well as pollen type, and we recognize these plants as a separate species, *G. erosa*. We also include range extensions and morphological notes for *G. arenicola*, *G. divaricata*, *G. heterostyla* and *G. tenella*. With the 12 new species described here and the resurrection of *G. erosa*, *Geissorhiza* now comprises 99 species, all occurring within the Greater Cape Floristic Region (sensu Born *et al.* 2006) with only *G. bracteata* extending outside its confines. We provide new keys to the two subgenera of *Geissorhiza* (Appendix 1), which accommodate all species described since the publication of the last revision of the genus (Goldblatt 1985). The classification of the genus and renumbering of the species is presented in Table 1.

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TABLE 1.—Classification of *Geissorhiza* species arranged by subgenus and section including new species described here, based on Goldblatt's (1985) infrageneric classification

Subgenus *Weihea* (Eckl. ex Baker) Goldblatt

Section *Weihea* Eckl. ex Baker
1. *G. inconspicua* Baker
2. *G. elsiae* Goldblatt
3. *G. roseoalba* (G.J.Lewis) Goldblatt
4. *G. outeniquensis* Goldblatt
5. *G. fourcadei* (L.Bolus) G.J.Lewis
6. *G. uliginosa* Goldblatt & J.C.Manning
7. *G. foliosa* Klatt
8. *G. tricolor* Goldblatt & J.C.Manning, sp. nov.
9. *G. nigromontana* Goldblatt
10. *G. altimontana* Goldblatt & J.C.Manning, sp. nov.
11. *G. delicatula* Goldblatt
12. *G. monticola* Goldblatt & J.C.Manning, sp. nov.
13. *G. bracteata* Klatt
14. *G. nana* Klatt
15. *G. setacea* (Thunb.) Ker Gawl.
16. *G. lapidosa* Goldblatt & J.C. Manning, sp. nov.
17. *G. ornithogaloides* Klatt
18. *G. malmesburiensis* R.C.Foster
19. *G. platystigma* Goldblatt & J.C.Manning, sp. nov.
20. *G. geminata* E.Mey. ex Baker
21. *G. ovalifolia* R.C.Foster
22. *G. bolusii* Baker
23. *G. parva* Baker
24. *G. ovata* (L.f.) Asch. & Graebn.

Section *Tortuosa* Goldblatt
25. *G. corrugata* Klatt
26. *G. spiralis* (Burch.) M.P.de Vos ex Goldblatt
27. *G. karooica* Goldblatt

Section *Pusilla* Goldblatt
28. *G. pusilla* (Andrews) Klatt

Section *Includanthera* Goldblatt
29. *G. esterhuyseniae* Goldblatt
30. *G. cedarmontana* Goldblatt

Section *Angustifolia* Goldblatt
31. *G. lithicola* Goldblatt
32. *G. purpurascens* Goldblatt
33. *G. humilis* (Thunb.) Ker Gawl.
34. *G. darlingensis* Goldblatt
35. *G. hispidula* (R.C.Foster) Goldblatt
36. *G. pappei* Baker
37. *G. intermedia* Goldblatt
38. *G. unifolia* Goldblatt
39. *G. juncea* (Link) A.Dietr.
40. *G. furva* Ker Gawl. ex Baker
41. *G. sufflava* Goldblatt & J.C.Manning
42. *G. stenosiphon* Goldblatt

Section *Ixiopsis* Goldblatt
43. *G. umbrosa* G.J.Lewis
44. *G. alticola* Goldblatt
45. *G. hesperanthoides* Schltr.
46. *G. cataractarum* Goldblatt
47. *G. nubigena* Goldblatt

Section *Engysiphon* (G.J.Lewis) Goldblatt
48. *G. helmei* Goldblatt & J.C.Manning, sp. nov.
49. *G. brevituba* (G.J.Lewis) Goldblatt
50. *G. schinzii* (Baker) Goldblatt
51. *G. longifolia* (G.J.Lewis) Goldblatt
52. *G. confusa* Goldblatt
53. *G. bonaspei* Goldblatt
54. *G. tenella* Goldblatt
55. *G. exscapa* (Thunb.) Goldblatt

Subgenus *Geissorhiza*

Section *Intermedia* Goldblatt
56. *G. similis* Goldblatt
57. *G. scillaris* A.Dietr.

Section *Geissorhiza*
58. *G. imbricata* (D.Delaroche) Ker Gawl.
59. *G. purpureolutea* Baker
60. *G. barkerae* Goldblatt
61. *G. louisabolusiae* R.C.Foster
62. *G. brehmii* Eckl. ex Klatt
63. *G. sulphurascens* Schltr. ex R.C.Foster
64. *G. minuta* Goldblatt
65. *G. eurystigma* L.Bolus
66. *G. mathewsii* L.Bolus
67. *G. radians* (Thunb.) Goldblatt

Section *Monticola* Goldblatt
68. *G. burchellii* R.C.Foster
69. *G. grandiflora* Goldblatt
70. *G. callista* Goldblatt
71. *G. tabularis* Goldblatt
72. *G. ramosa* Ker Gawl. ex Klatt
73. *G. bryicola* Goldblatt
74. *G. scopulosa* Goldblatt
75. *G. ciliatula* Goldblatt
76. *G. pseudinaequalis* Goldblatt
77. *G. rupicola* Goldblatt & J.C.Manning
78. *G. silenoides* Goldblatt & J.C.Manning

Section *Planifolia* Goldblatt
79. *G. aspera* Goldblatt
80. *G. demissa* Goldblatt & J.C.Manning, sp. nov.
81. *G. inaequalis* L.Bolus
82. *G. lewisiae* R.C.Foster
83. *G. monanthos* Eckl.
84. *G. tulbaghensis* F.Bolus

Section *Ciliatae* Goldblatt
85. *G. namaquensis* W.F.Barker
86. *G. kamiesmontana* Goldblatt
87. *G. divaricata* Goldblatt
88. *G. subrigida* L.Bolus
89. *G. heterostyla* L.Bolus
90. *G. cantharophila* Goldblatt & J.C.Manning, sp. nov.
91. *G. reclinata* Goldblatt & J.C.Manning, sp. nov.
92. *G. arenicola* Goldblatt
93. *G. splendidissima* Diels
94. *G. inflexa* (D.Delaroche) Ker Gawl.
95. *G. erosa* (Salisb.) R.C.Foster
96. *G. exilis* Goldblatt & J.C.Manning, sp. nov.
97. *G. saxicola* Goldblatt & J.C.Manning, sp. nov.
98. *G. erubescens* Goldblatt
99. *G. leipoldtii* R.C.Foster

Lastly, we review what little is known about the floral ecology of *Geissorhiza* and present a range of observations on pollinator visits and nectar characteristics of several species. Available information shows that pollination in the genus is dominated by female bees of the families Andrenidae, Colletidae, Halictidae and Melittidae plus workers of *Apis mellifera* (Apidae), often in combination with hopliine scarab beetles, short-proboscid Tabanidae and butterflies. The specialized pollination system using one or more species of long-proboscid Nemestrinidae and Tabanidae is the second most important system in *Geissorhiza*, confirmed for five species and inferred for three more. Pollination primarily by hopliine scarab beetles is rare, and is reported for the first time in the genus, as are visits by empidid flies (Empididae), and also deceptive pollination by short-proboscid Tabanidae.

MATERIALS AND METHODS

Pollen grains obtained from fresh flowers or from herbarium specimens of a range of species (Table 2) were extracted from anthers with a needle moistened in Calberla's fluid (Ogden *et al.* 1974) and mounted on glass slides in a drop of the same fluid. Preparations were examined after 2–24 hours, by which time the exine is stained a darker colour than the aperture and grain contents. Only two species of the genus were included in a previous survey of pollen types in Crocoideae (Goldblatt *et al.* 1991). Thus, in an effort to determine the extent of the variation in pollen morphology in the genus, we have surveyed a wide range of species belonging to both subgenera and all sections (Table 1).

Nectar volumes were measured using micro tubes, and nectar concentrations were determined with a Bellingham & Stanley refractometer (0–50 %) (Goldblatt *et al.* 2004a; Manning & Goldblatt 2005).

For pollinator observations, insects visiting flowers and seen to contact anthers or stigmatic surfaces were captured and killed using ethyl acetate fumes following methods described by Goldblatt *et al.* (2004a) and Goldblatt & Manning (2007). The identity of pollen carried by captured insects was determined by microscopic examination of samples removed from their bodies using dissecting needles in the same way as described above for sampling from herbarium specimens.

RESULTS

POLLEN MORPHOLOGY

Our survey of pollen morphology establishes the presence of the plesiomorphic type pollen grains reported in our earlier survey of Crocoideae (Goldblatt *et al.* 1991) as the most common type in the genus (Table 2). These grains are monosulcate with tectate-perforate exine bearing small supratectal spinules. The sulcus field is largely smooth apart from a pair of narrow exine bands (elongated opercula), lying parallel to one another along the long axis of the aperture (Figure 1A). Often there is also a sprinkling of exine material lying in the centre of the three apertural zones defined by the opercular bands. One species of subgenus *Weihea*, *G. parva*, has poorly developed operculum bands, represented merely by two sparsely beaded lines of exine.

Two species of subgenus *Weihea*, among those examined, and four of subgenus *Geissorhiza* have grains of remarkably different appearance (Table 2). In contrast to the majority of species in the genus, *Geissorhiza cantharophila*, *G. exilis*, *G. inflexa*, *G. reclinata*, *G. saxicola* and most populations of *G. heterostyla* (subgenus *Geissorhiza* section *Ciliatae*) and *G. bracteata* and *G. nana* (subgenus *Weihea* section *Weihea)* have grains that depart radically from the standard type. Grains have typical tectate-perforate exine, but have more complex apertures. The ± orbicular and slightly larger grains of *G. bracteata*, *G. cantharophila*, *G. nana* and some populations of *G. heterostyla* have two discrete apertures, a smaller elliptic one surrounded by a broad band of exine (? or operculum) lying within a larger ± elliptic or circumferential sulcus (Figure 1B). We interpret this grain as derived from the basic type in which the two bands of the operculum have become wider and longer and their ends have fused, leaving an island of enclosed apertural membrane within the operculum. The aperture surrounding this structure may also be elliptic or continuous around the grain, leaving the non-apertural part of the grain as two separate pieces of exine. Curiously, six populations of *G. heterostyla* examined (Table 2), all from the north of its range, have normal grains with a 2-banded operculum. We have re-examined these collections and find no taxonomically significant difference between them and the more common *G. heterostyla*. One of the collections with normal type pollen grains (*Goldblatt 6216* MO) even consists of the mixture of short- and long-styled plants that is currently understood to be unique to this species.

Some populations of *Geissorhiza inflexa* have *G. heterostyla*-type grains (Figure 1B; Table 2) but in others the grains have five or six bands of exine running across the grain separated by apertures of about the same width (Figure 1C). The bands merge at one pole so that in this view five or six elliptic zones of apertural membrane are visible, whereas viewed at right angles, the apertures run the length of the grain separated by long bands of exine. At the opposite end the exine bands do not quite fuse but adjacent bands fuse toward their tips. All the large-flowered populations of *G. inflexa*, with either red, pink, purple or white flowers have this apertural pattern. These large-flowered colour morphs were included in *G. inflexa* by Goldblatt (1985) without infraspecific recognition.

A last variant is the plant described here as *Geissorhiza reclinata*, which has pollen grains with two large horse-

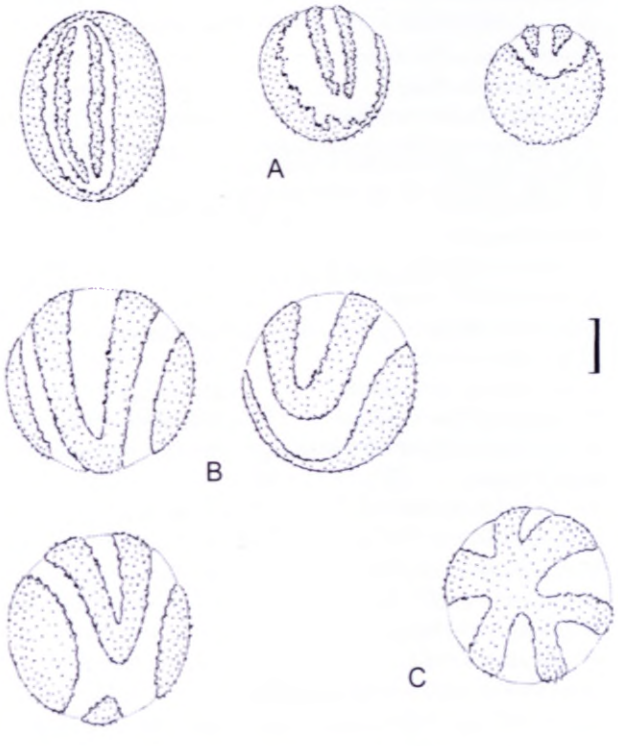


FIGURE 1.—Pollen grains of *Geissorhiza* species. A, *G. arenicola, Goldblatt & Manning 9465* (NBG); B, *G. heterostyla, Goldblatt & Porter 12185* (NBG); C, *G. erosa, Helme 2247* (NBG). Scale bar: 200 µm.

TABLE 2.—Pollen types in *Geissorhiza* species arranged by subgenus according to Goldblatt's (1985) infrageneric classification. Herbaria are abbreviated following Holmgren *et al.* (1990)

Taxon	Collection data and herbarium acronym or literature reference
Grains monosulcate with two-banded operculum	
Subgenus *Weihea*	
Section *Weihea*	
G. foliosa Klatt	*Goldblatt & Manning 10783* (MO)
G. inconspicua Baker	*Goldblatt & Nänni 11580* (MO)
G. monticola Goldblatt & J.C.Manning	*Goldblatt & Porter 11872* (MO, NBG)
G. ornithogaloides Klatt	*Goldblatt & Nänni 11197* (MO), *Goldblatt 11467* (MO)
G. ovata (L.f.) Asch. & Graebn.	no voucher
G. parva Baker	*Goldblatt & Porter 12266* (MO) (operculum vestigial)
Section *Angustifolia*	
G. juncea (Link) A.Dietr.	*Goldblatt 11554* (MO)
G. aff. *pappei* Baker	*Goldblatt & Manning 9944* (MO, NBG)
G. purpurascens Goldblatt	*Goldblatt & Manning 11560* (MO, NBG)
G. sufflava Goldblatt & J.C.Manning	*Goldblatt & Manning 9468* (MO, NBG)
Section *Ixiopsis*	
G. nubigena Goldblatt	*Goldblatt 10608* (MO)
Section *Engysiphon*	
G. bonaspei Goldblatt	*Goldblatt 11640* (MO)
G. confusa Goldblatt	*Goldblatt & Manning 10119* (MO)
G. exscapa (Thunb.) Goldblatt	*Goldblatt & Manning 10346* (MO)
G. longifolia (G.J.Lewis) Goldblatt	*Goldblatt & Manning 11486* (MO); *Oliver 4070* (NBG)
G. schinzii (Baker) Goldblatt	Goldblatt *et al.* (1991)
G. tenella Goldblatt	*Goldblatt & Manning 10376* (MO)
Subgenus *Geissorhiza*	
Section *Ciliatae*	
G. divaricata Goldblatt	*Goldblatt 10291* (NBG
G. erubescens Goldblatt	*Compton 19964* (NBG)
G. heterostyla L.Bolus	*Goldblatt 6261, 5305, 5824* (MO); *Goldblatt & Manning 10293* (MO); *Goldblatt & Porter 12770* (MO), *12822* (MO, NBG)
G. leipoldtii R.C.Foster	*Van Rooyen et al. 718* (NBG)
G. namaquensis W.F.Barker	*Goldblatt & Manning 9705* (NBG)
G. subrigida L.Bolus	*Lewis 5886* (NBG)
Section *Geissorhiza*	
G. barkerae Goldblatt	*Goldblatt 6391* (NBG)
G. eurystigma L.Bolus	no voucher
G. louisabolusiae R.C.Foster	*Goldblatt & Porter 12605* (MO)
G. purpureolutea Baker	*Goldblatt & Manning 11139* (NBG)
G. radians (Thunb.) Goldblatt	Goldblatt *et al.* (1991); *Van Zyl 3512* (NBG)
G. sulphurascens Schltr. ex R.C.Foster	*Snijman 896* (NBG); *Goldblatt & Manning 9465* (NBG)
Section *Intermedia*	
G. scillaris A.Dietr.	Goldblatt *et al.* (1991)
Section *Monticola*	
G. bryicola Goldblatt	*Williamson 3683* (NBG)
G. burchellii R.C.Foster	*Williams 3754* (NBG)
G. callista Goldblatt	*Goldblatt 8680* (NBG)
G. grandiflora Goldblatt	*Oliver & Oliver 11468* (NBG)
G. pseudinaequalis Goldblatt	*Manning 2220* (NBG)
G. ramosa Ker Gawl. ex Klatt	*Esterhuysen 36144* (NBG), *33703* (MO)
G. silenoides Goldblatt & J.C.Manning	*Goldblatt & Manning 9739* (NBG)
Section *Planifolia*	
G. arenicola Goldblatt	*Goldblatt & Nänni 11154* (NBG); *Goldblatt & Porter 11888A* (NBG)
G. aspera Goldblatt	*Goldblatt & Manning 9403* (NBG)
G. inaequalis L.Bolus	*Goldblatt & Porter 11795* (NBG)
G. monanthos Eckl.	*Beyers 77* (NBG); *Goldblatt & Nänni 11553*
G. splendidissima Diels	*Barker 9549* (NBG)
G. tulbaghensis F.Bolus	*Solomon 38* (NBG)
Grains with complex multiple apertures	
Type 1 grains: two elliptic apertures, smaller nested in larger; type 2: more complex apertures described in text	
Subgenus *Weihea*: section *Weihea*	
G. bracteata Klatt	type 1: *Goldblatt & Porter 12358A* (MO); *Goldblatt & Porter 12714* (MO, NBG)
G. nana Klatt	type 1: *Goldblatt & Manning 12255* (MO)

TABLE 2.—Pollen types in *Geissorhiza* species arranged by subgenus according to Goldblatt's (1985) infrageneric classification. Herbaria are abbreviated following Holmgren *et al.* (1990) (cont).

Subgenus *Geissorhiza*: section *Ciliatae*	
G. saxicola Goldblatt & J.C.Manning	type 1: *Goldblatt & Manning 9094* (MO)
G. cantharophila Goldblatt & J.C.Manning	type 1: *Hanekom 1562* (MO); *Manning 2797* (NBG); *Goldblatt & Porter 12704* (MO, NBG)
G. heterostyla L.Bolus	type 1: *Goldblatt 6203* (MO); *Goldblatt & Porter 12185, 12328, 12791, 12937,12942* (MO); *Goldblatt & Manning 12174* (MO); *Oliver 9643* (NBG); *Snijman 734* (NBG)
G. inflexa (D.Delaroche) Ker Gawl.	type 1: *Boucher 5439* (NBG); *Goldblatt 2497, 3996, 6203* (MO) (small white-flowered plants)
	type 2: *Goldblatt 2497, 11422A*; *11426, 12995* (MO); *Goldblatt & Manning 12687* (MO); *Helme 2247* (NBG)
G. exilis Goldblatt & J.C.Manning	type 1: *Goldblatt & Manning 13041* (MO, NBG)
G. reclinata Goldblatt & J.C.Manning	type 2: *Goldblatt & Porter 12057* (MO, NBG)

shoe-shaped bands of exine oriented at right angles to one another and thus one large sulcus of irregular shape.

Pollen grains with a 2-banded operculum are not universal in Crocoideae but are the only type known in 16 of the 29 genera recognized in the subfamily (Goldblatt *et al.* 1991). Exceptions are: 1, *Ixia* and *Xenoscapa*, one species of *Freesia*, section *Fastigiata* of *Lapeirousia*, a few species of *Romulea*, and several of *Thereianthus*, which have a 1-banded operculum (Goldblatt & Manning 1995b); 2, *Syringodea* and some species of *Crocus*, which have inaperturate grains (e.g. De Vos 1974); 3, *Cyanixia* and *Zygotritonia*, which have trisulculate grains (Goldblatt *et al.* 2004b); 4, *Savannosiphon*, which has polyaperturate pollen grains (Goldblatt *et al.* 1991); 5, *Afrocrocus*, which has trizonosulculate grains; and 6, *Micranthus*, which has zonosulcate grains with the exine reticulate except close to the aperture where the sculpturing grades from microreticulate to perforate immediately adjacent to the aperture margin (Goldblatt *et al.* 1991, and unpublished data).

The discovery of unusual pollen grains in two species of section *Weihea* of subgenus *Weihea* and several of section *Ciliatae* of subgenus *Geissorhiza* represents another significant departure from the standard type in Crocoideae and a striking specialization within the genus. The presence of divergent pollen types in *Geissorhiza* is most parsimoniously viewed as evidence for a close relationship of the species of each subgenus that share the character even though the precise morphology of the apertures may differ. *G. heterostyla* and *G. inflexa* are already believed to be closely related on account of their similar, derived leaf blades (Goldblatt 1985), and *G. exilis* shares a similar vegetative morphology (Goldblatt 1985). A fourth species with this pollen type, *G. cantharophila*, until now included in *G. heterostyla*, is obviously immediately related to that species. The appearance of normal-type pollen grains in the six northernmost populations sampled of *G. heterostyla* (Langberg to Hantamsberg and Bokkeveld Mountains) is surprising. No feature sets them apart in the genus and all that can be concluded at present is that the variation has a geographic component. Variation in pollen grain morphology within a species is surprising since pollen and seed morphology are widely believed to be highly conservative. Variation even within a genus on such a scale as reported here is unexpected. In section *Weihea*, *G. bracteata* and *G. nana* share similar divergent pollen grains, which supports Goldblatt's (1985) inference based on morphology that they are immediately allied.

The broader significance of the divergent pollen grains is uncertain. None of the species seem particularly unusual morphologically in *Geissorhiza*. Two of them, *G. inflexa* and *G. heterostyla* have what may be termed a generalist pollination system that includes female bees and *Apis mellifera* workers, hopliine beetles, and occasionally butterflies, a pattern encountered widely in *Geissorhiza* (see below). *Geissorhiza cantharophila* is adapted for pollination by hopliines, three species of which have been captured on the flowers.

Another issue concerns the significance at the taxonomic level of the grains of the large-flowered '*Geissorhiza erosa*' populations of *G. inflexa*, which have 5 (or 6) apertures. The justification for the reduction of this taxon in *G. inflexa* by Goldblatt (1985) was the presence in *G. inflexa sensu lato* of populations with larger than usual, pink or purple flowers that seemed to link the typical and common form of *G. inflexa*, which has moderate-sized, white flowers, with the large-flowered *G. erosa* with its brilliant scarlet perianth. In the light of the consistent association of this different pollen with large, white, pink or red-flowered plants we conclude that the larger-flowered plants constitute a separate genetic race and we re-evaluate their taxonomic status below.

SYSTEMATICS

The new species are arranged numerically within subgenera. Their position and number in the classification of *Geissorhiza* is given in Table 1.

Subgenus Weihea *(Eckl. ex Baker) Goldblatt*

8. **Geissorhiza tricolor** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 100–150(–200) mm altae, cormo globoso 5–6 mm diam. tunicis concentricis lignosis duris, foliis 6 ad 8 erectis vel falcatis 15–50 × (2–)3–5 mm planis, caule erecto simplici vel 1- vel 2-ramoso, spica (1)2- vel 3-flora, bracteis viridibus distaliter rubro-suffusis (12–)15–18 mm longis, floribus actinomorphis rotatis aureis ad centrum atromarroninis nitidis ad tubum flavoviridibus inodoris 30–38 mm diam., tubo perianthii 3–4 mm longo, tepalis late obovato-quadratis 15–18 mm longis, filamentis atromarroninis ± 3 mm longis, antheris sub anthesi ± 5 mm longis, stylo excentrico ± 6 mm longo ramis 2.5–3.0 mm longis.

TYPE.—Western Cape, 3421 (Riversdale): Werner Frehse Nature Reserve, south of N2, east of Riversdale,

pebbly ferricrete in renosterveld-fynbos transitional vegetation, (–AB), 6 October 2006, *Manning 3071* (NBG, holo.; MO, PRE, iso.).

Plants 100–150(–200) mm high, with pale membranous cataphylls. *Corm* obliquely globose, asymmetric and flattened slightly below on one side, 5–6 mm diam., tunics concentric, brown, hard and woody, fragmenting irregularly into sections. *Stem* erect, simple or 1- or 2-branched, either from base or from upper stem nodes. *Leaves* 6–8, lower 4 or 5 basal and largest, lanceolate to sword-shaped, short and mostly less than one third as long as stem, 15–50 × (2–)3–5 mm, upper decreasing progressively in size, uppermost bract-like and often without blade. *Spike* (1)2- or 3-flowered; bracts green, flushed reddish distally, elliptic, (12–)15–18 mm long, subequal, inner not notched apically. *Flowers* rotate, golden yellow with glossy blackish maroon eye covering basal quarter of tepals, yellowish green in tube, outer tepals flushed reddish on reverse, unscented, 30–38 mm diam.; perianth tube funnel-shaped, 3–4 mm long; tepals broadly obovate-quadrate, margins irregularly crenulate in distal half, 15–18 mm long, outer 10–11 mm wide, inner 12–14 mm wide. *Stamens*: filaments ± 3 mm long, exserted for ± 1 mm, dark maroon; anthers ± 5 mm long at anthesis, pollen yellow. *Ovary* obovoid, 5 mm long; style eccentric, ± 6 mm long, dark maroon, exserted for ± 1 mm, dividing opposite lower half of anthers, style branches 2.5–3.0 mm long. *Capsules* and *seeds* unknown. *Flowering time*: September and early October; flowers opening between mid-morning and early afternoon. Figure 2.

Eponymy: from the Latin, *tricolor*, three-coloured, for the golden yellow flower with a maroon central eye and pale yellow in the throat and tube.

Distribution and ecology: *Geissorhiza tricolor* apparently has a very limited range southeast of Riversdale in southern Western Cape (Figure 3). The largest population occurs in the small Werner Frehse Nature Reserve a few kilometres east of Riversdale, where it is protected from disturbance. Plants grow in pebbly ironstone at the transition between renosterveld and fynbos-thicket.

Diagnosis and relationships: according to available records *Geissorhiza tricolor* was discovered in September 2006 during a botanical survey of the site of a new housing development at Riversdale. A collection made by N.A Helme alerted us to the existence of the plant, which we re-collected in early October. The species is unique in *Geissorhiza* in its deep yellow flowers with exceptionally broad tepals and a dark, maroon-black central eye. The perianth tube is very short in comparison, 3–4 mm long. The species recalls *G. inconspicua* and *G. foliosa* in vegetative morphology but the flowers are larger than in both of these species and very different in coloration. *Geissorhiza foliosa* has pink to light purple flowers with a tube ± 5 mm long and tepals 13–17 mm long, and *G. inconspicua* has blue-violet, pink or white flowers with a perianth tube 4–6 mm long and tepals 8–11, rarely up to 15 mm long.

The flowers of *Geissorhiza tricolor* closely resemble those of orange-flowered *Ornithogalum dubium* which blooms together with it in the Werner Frehse Nature Reserve and we assume that both species are pollinated by the same suite of hopliine beetles. No hopliines or other potential pollinators have so far been recorded on *G. tricolor* or *O. dubium* at that locality but the latter species has been found to be pollinated by hopliine beetles at other sites (Goldblatt *et al.* 1998).

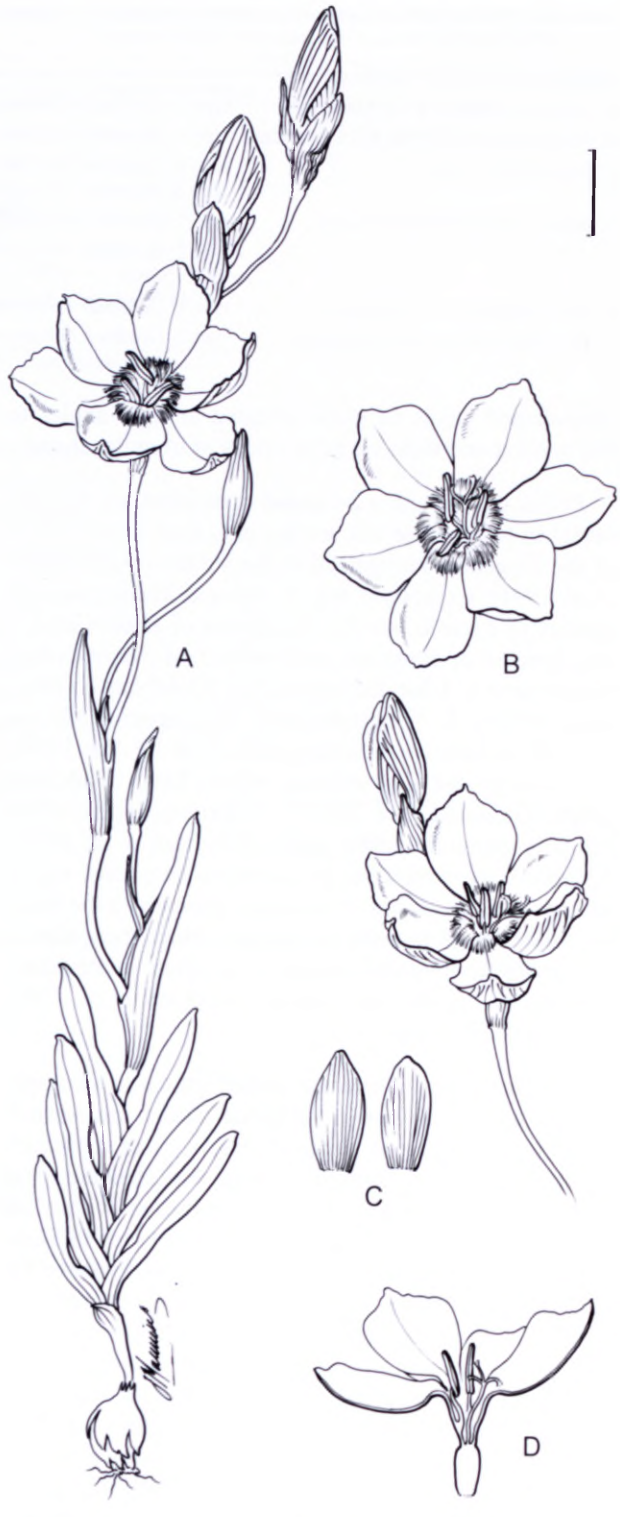


FIGURE 2.—*Geissorhiza tricolor*, *Manning 3071* (NBG). A, flowering plant; B, flowers; C, outer (left) and inner (right) floral bracts; D, half-flower. Scale bar: 10 mm. Artist: J.C. Manning.

Additional specimens examined

WESTERN CAPE.—3421 (Riversdale): southern edge of Riversdale, Rooidam, east of N2, stony well-drained loam, in renosterveld, (–AB), 22 September 2006, *Helme 4193* (NBG).

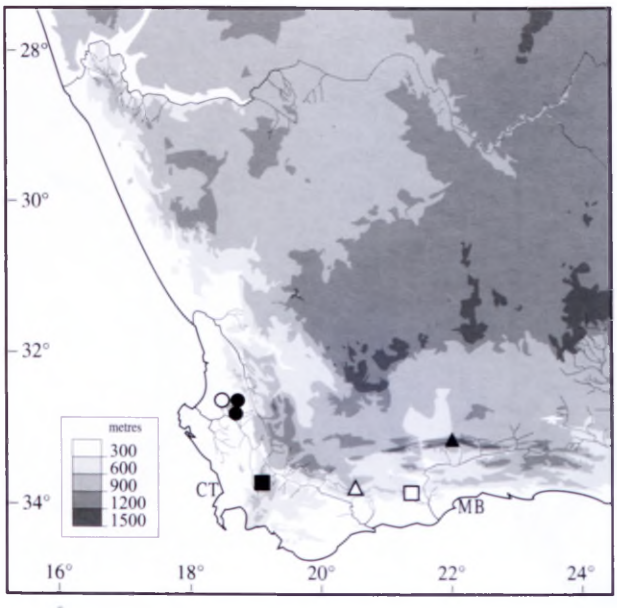


FIGURE 3.—Known distribution of *Geissorhiza altimontana*, △; *G. helmei*, ○; *G. monticola*, ▲; *G. sufflava*, ●; *G. tricolor*, □; *G. lapidosa*, ■.

10. **Geissorhiza altimontana** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 60–120 mm altae, cormo tunicis manifeste concentricis, foliis 5 vel 6, 4 inferiorbus basalibus prostratis lanceolatis 20–50 × 2.5–6.0 mm, spica 1- vel 2-flora, bracteis viridibus ad apicem rubris 7–10 mm longis, floribus actinomorphis carneis, perianthii tubo 7–8 mm longo ± cylindrico, tepalis subaequalibus oblongis ± 14 × 6 mm, filamentis ± 8 mm longis aequalibus, antheris ± 4 mm longis, ramis styli recurvatis ± 1.3 mm longis.

TYPE.—Western Cape, 3320 (Montagu): Langeberg, upper slopes of Leeuriviersberg, 300 m east of peak, 1 550 m, (–CD), 15 January 2006, *Helme 3778* (NBG, holo.).

Plants 60–120 mm high including flowers, stem base sheathed underground by a collar of dry, persistent leaf bases, and above ground by dry cataphylls. *Corm* ovoid, 4–6 mm diam., tunics soft-textured, light brown, evidently concentric, becoming fibrous and not accumulating with age. *Stem* erect or sometimes horizontal at ground level for a short distance, unbranched, smooth. *Leaves* 5 or 6, lower 4 basal, spreading horizontally and ± prostrate, blades lanceolate, leathery, 20–50 × 2.5–6.0 mm, margins moderately thickened, cauline leaves 1 or 2, shorter than basal leaves and sheathing for half their length. *Spike* erect, ± straight, 1- or 2-flowered; bracts green with red tips, 7–10 mm long, outer obtuse, inner notched apically. *Flowers* radially symmetric with tepals ascending, pink but ± greenish in throat, unscented; perianth tube ± cylindric, 7–8 mm long; tepals subequal, oblong, ± 14 × 6 mm, ascending and forming a wide cup. *Stamens*: filaments ± 8 mm long, equal; anthers ± 4 mm long, sagittate at base for ± 1 mm, yellow, pollen yellow. *Ovary* ovoid, ± 2.5 mm long; style slender, dividing opposite anther apices, style branches slightly recurved and arching over anthers, ± 1.3 mm long. *Capsules* and *seeds* unknown. *Flowering time*: January. Figure 4.

Eponymy: from Latin *alti*, high, *montanus*, mountains, referring to the habitat.

Distribution and ecology: known from just one collection on Leeuriviersberg (Grootberg) west of Swellendam, *Geissorhiza altimontana* occurs at high elevations in the Langeberg at ± 1 550 m (Figure 3). Plants were collected in unburned veld, growing on damp, mossy ledges on steep, south-trending slopes. The area is exposed to frequent summer cloud from southeast trade winds, making flowering of this soft geophyte possible in a region of predominantly summer drought.

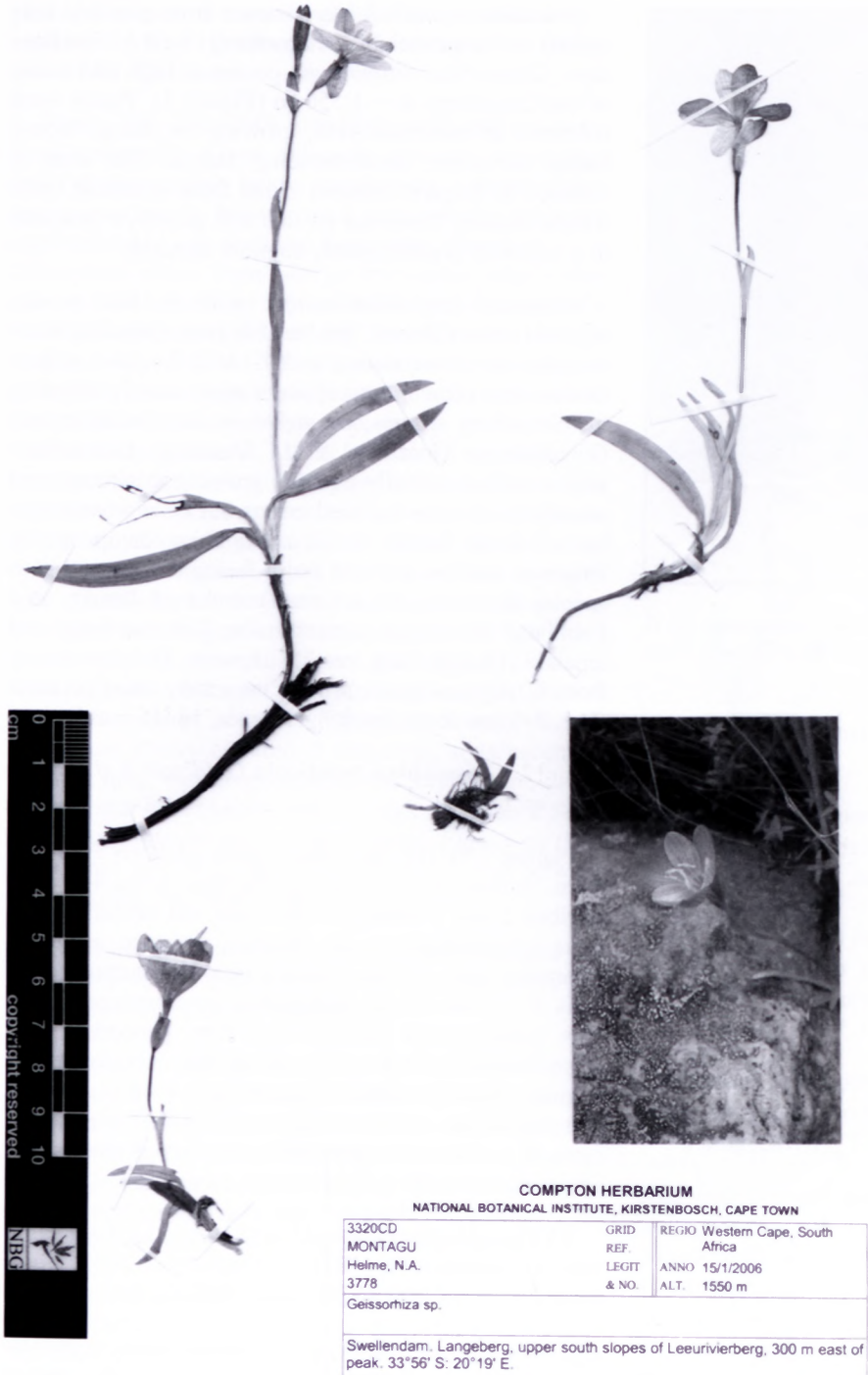
Diagnosis and relationships: with its five or six, relatively short leaves, the basal leaves spreading horizontally, the short stature and 1- or 2-flowered spikes, *Geissorhiza altimontana* appears most closely allied to the Swartberg species, *G. nigromontana* Goldblatt and *G. uliginosa* Goldblatt & J.C.Manning. *Geissorhiza uliginosa* is essentially aquatic, growing in streams and waterfalls, and has reduced corms but *G. nigromontana* has a similar habitat to *G. altimontana*: damp, mossy ledges in shallow soil and south-facing slopes, and both species flower in the summer months of January and February. The longer perianth tube, 7–8 mm long, and tepals ± 14 mm long, readily separate *G. altimontana* from *G. nigromontana*, which has a very short perianth tube, 2–3 mm long, and longer tepals, 14–16 mm long.

12. **Geissorhiza monticola** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 100–160 mm altae, cormo globoso ± 10 mm diam. tunicis concentricis atrobrunneis, foliis 4–7 inferioribus 2 vel 3 basalibus linearibus vel falcatis patentibus vel prostratis, caule filiformi flexuoso usque ad 4-ramoso, spica 1-flora, bracteis viridibus purpureo-suffusis 8–10 mm longis marginibus membranaceis, floribus zygomorphis caeruleo-malvinis, perianthii tubo infundibuliformi ± 3 mm longo leviter curvato, tepalis anguste oblongis obtusis patentibus 14–18 × 4.0–5.5 mm, filamentis unilateralibus declinatis 7–9 mm longis, antheris 3–4 mm hebetate roseis, stylo prope antherarum apices diviso ramis 3–4 mm longis recurvatis.

TYPE.—Western Cape, 3321 (Ladismith): Swartberg, road to Gamkakloof, (–BD), 10 September 2001, *Goldblatt & Porter 11872* (NBG, holo.; MO, iso.).

Plants 100–160 mm high. *Corm* globose, asymmetric with oblique, flattened side, ± 10 mm diam., tunics concentric, dark brown, fragmenting into vertical sections. *Stem* filiform, flexuose, with up to four, 1-flowered branches from axils of cauline leaves. *Leaves* 4–7, soft-textured, lower 2 or 3 basal and ± half as long as stem, spreading to prostrate, blades linear to falcate, plane with slightly thickened and raised central vein, 2–3 mm wide, upper leaves cauline, decreasing in size upward, partly to entirely sheathing. *Inflorescence*: flowers solitary on branches; bracts green, soft, flushed purple, margins membranous, transparent, 8–10 mm long, inner slightly shorter than outer. *Flowers* zygomorphic, facing to side with tepals held vertically, blue-mauve with greenish cream throat edged with dark blue; perianth tube funnel-shaped, slightly curved, ± 3 mm long; tepals narrowly oblong, obtuse, spreading at right angles to tube, 14–18 × 4.0–5.5 mm, inner slightly narrower than outer. *Stamens* unilateral and declinate; filaments 7–9 mm long, exserted for 7–8 mm; anthers 3–4 mm long, dull pink.



COMPTON HERBARIUM
NATIONAL BOTANICAL INSTITUTE, KIRSTENBOSCH, CAPE TOWN

3320CD	GRID	REGIO	Western Cape, South Africa
MONTAGU	REF.		
Helme, N.A.	LEGIT	ANNO	15/1/2006
3778	& NO.	ALT.	1550 m

Geissorhiza sp.

Swellendam. Langeberg, upper south slopes of Leeurivierberg, 300 m east of peak. 33°56' S: 20°19' E.

Fynbos biome. Mountain peak. Well-drained, sandy soil. Sandstone. Shade. Steep slope. Aspect south. No biotic effect seen. Geophyte. Flowers present, petals pink, anthers yellow. Stigma pink. Leaves not speckled (cf. ovata). Stamens of equal length. Rare and very localised above 1500 m. In mossy ledges , corms wedged into crevices. Exposed to frequent summer cloud. Veld ± 7 years old. With G. burchelli. Plant height 0.10 m.

Manning,J. DET. ACC.NO. NBG 203988.0

FIGURE 4.—*Geissorhiza altimontana, Helme 3778* (NBG).

Ovary ± 3.5 mm long; style dividing near apex of anthers, style branches 3–4 mm long, recurved. *Capsules* and *seeds* unknown. *Flowering time*: September. Figure 5.

Eponymy: from Latin, meaning growing in the mountains.

Distribution and ecology: the only known population of *Geissorhiza monticola* is from the central Swartberg, west of Swartberg Pass (Figure 3). Plants grow on south-trending, rocky sandstone slopes in pockets of peaty sand.

Diagnosis and relationships: *Geissorhiza monticola* is distinguished by solitary flowers with large, blue, zygomorphic flowers facing to the side, very short perianth tube and well-exserted, declinate stamens. Its relationships presumably lie with *G. delicatula* Goldblatt of the Langeberg and Swartberg and its allies, with which it shares an oblique corm, several plane leaves with the marginal vein set slightly away from the margin itself, herbaceous bracts, and solitary flowers. *Geissorhiza delicatula*, known to us only from dried specimens, has much smaller, cup-shaped

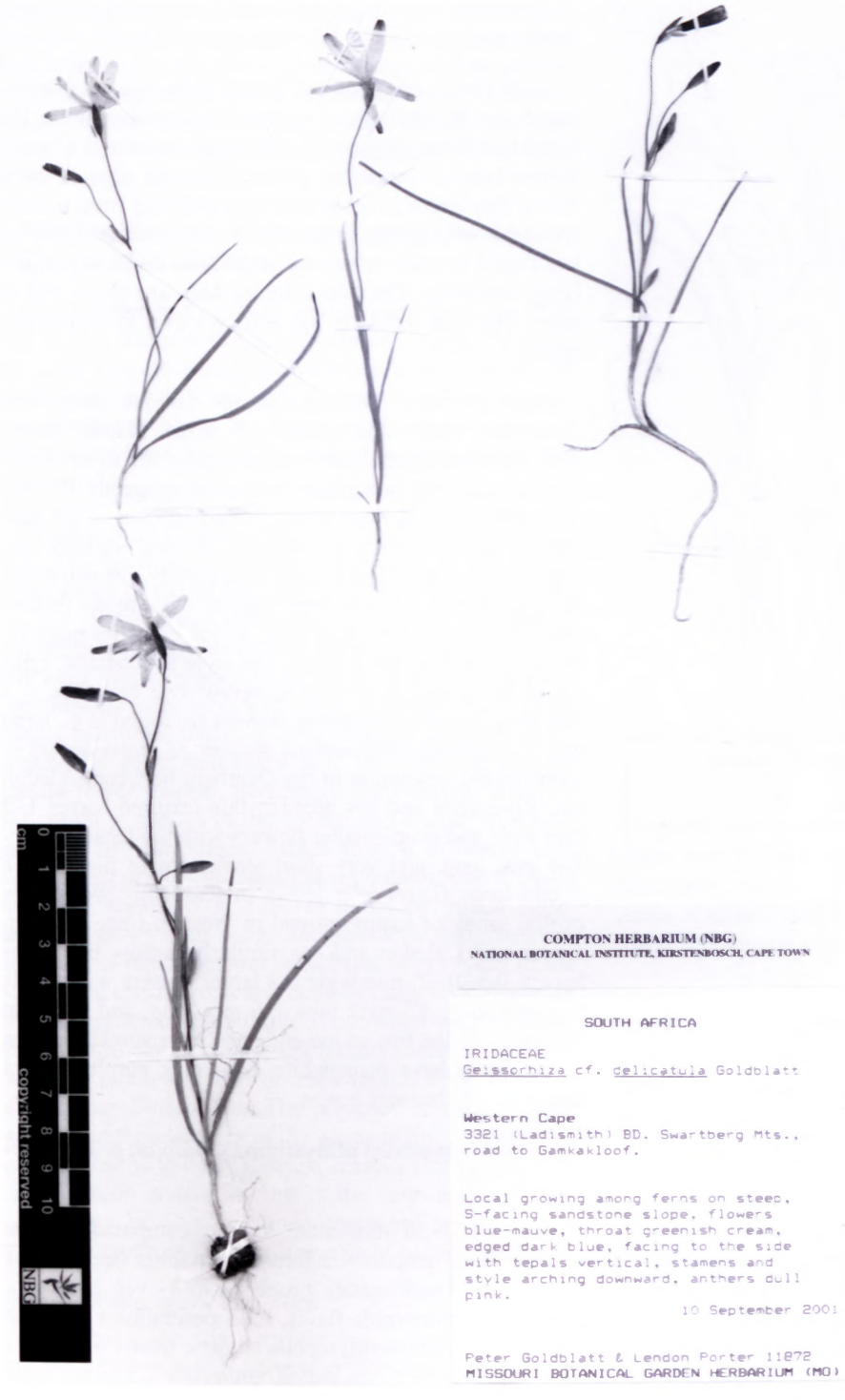


FIGURE 5.—*Geissorhiza monticola, Goldblatt & Porter 11872* (NBG).

flowers that are held upright, with elliptical or obovate, pale mauve tepals mostly 7–10 mm long, erect stamens with filaments 3–5 mm long, and a central style of similar length with short style branches up to 1.5 mm long, thus less than half as long as in *G. monticola*. *Geissorhiza nigromontana* may also be confused with *G. monticola* but it has a stem ± prostrate toward the base, a spike of 2 or 3 flowers (flowers always in *G. monticola*), bears cormlets in the leaf axils, shorter leaves with blades 4–10 mm wide (vs 2–3 mm in *G. monticola*) and the flowers are, as far as known (Goldblatt 1985), upright and radially symmetric.

The flowers of *Geissorhiza monticola* bear a remarkable similarity to those of *G. grandiflora* in their orientation, shape, and in the well-exserted, declinate stamens and style but this similarity is presumably due to convergence. *G. grandiflora* from the southwestern coastal mountains has leaves with prominently thickened margins and main vein, and is thus 2-grooved on each surface, has (1–)3–8-flowered spikes, and longer floral tubes, 10–22 mm long.

16. **Geissorhiza lapidosa** *Goldblatt & J.C.Manning*, sp. nov.

Plantae ± acaulescentes 20–40 mm altae eramosae, cormo 4–5 mm diam., tunicis concentricis lignosis nigrescentibus, foliis 4 laminis lineari-falcatis crassis coriaceis glaucis marginibus saepe rubrescentibus ad 50 × 0.5–1.0 mm, folio supremo vaginanti, spica 1- vel 2-flora, bracteis coriaceis glaucis ovatis bractea exteriori 4–5 mm longa, interiori ad apicem furcata, floribus

FIGURE 6.—*Geissorhiza lapidosa, Helme & Turner 5747* (NBG), whole plants. Scale bar: 10 mm. Artist: J.C. Manning.

actinomorphis albis tepalis exterioribus extus rubro-carneis, tubo perianthii infundibuliformi 2.0–2.5 mm longo, tepalis patentibus oblanceolatis ± 6 × 2 mm, filamentis 3.5–4 mm longis, antheris 1.5–2.0 mm longis ± albis, stylo dimidium inferiorem antherarum adversum diviso, ramis 1.5–2 mm longis.

TYPE.—Western Cape, 3319 (Worcester): Du Toitskloof Mtns, Goudini Sneeukop, western and southern edges of shale band, 1 700–1 730 m, seasonally damp, shallow moss and shale-derived silt overlying sandstone shelf, rare and localized, (–CC), 9 November 2008, *Helme & Turner 5747* (NBG, holo.).

Plants ± acaulescent, 20-40 mm high, unbranched with stem smooth, flushed red, not or barely extending above ground. *Corm* obliquely ovoid with narrow flat side, 4–5 mm diam., tunics woody, dark, blackish, concentric. *Leaves* 4, lower two basal, third leaf inserted at or shortly above ground, blades linear-falcate, exceeding the spike, 0.5–1.0 mm wide, thick and leathery, elliptical in section when fresh, glabrous, glaucous with margins often reddish, uppermost leaf cauline and bladeless. *Spike* 1- or 2-flowered; bracts leathery and glaucous flushed reddish but submembranous and finely flecked with brownish red along margins, broadly ovate, outer truncate or obscurely tricuspidate, 4–5 mm long, inner as long or slightly shorter, notched at apex. *Flowers* actinomorphic, white with outer tepals reddish pink on reverse; perianth tube funnel-shaped, 2.0–2.5 mm long; tepals subequal, oblanceolate, ± 6 × 2 mm. *Stamens* with filaments 3.5–4.0 mm long, white; anthers 1.5–2.0 mm long, ± white. *Ovary* obovoid, ± 2.5 mm long; style displaced to one side, dividing opposite lower half of anthers, ± 4 mm long, branches long and recurved, 1.5–2.0 mm long. *Capsules* and *seeds* unknown. *Flowering time*: November. Figure 6.

Eponymy: from the Latin, *lapidosus*, stony or rocky, for the habitat.

Distribution and ecology: known from two small colonies below the shale band on Goudini Sneeukop in the Du Toitskloof Mtns (Figure 3). Plants are localized along a narrow band of sandstone pavement at the edge of cliffs where they occur in moist seepages draining from a shale sponge overlying the sandstone, a very restricted habitat less than 4 m wide, where the shale band meets the underlying sandstone. The two colonies seen are about 800 m apart. The area regularly has a snow cover in winter and spring.

Diagnosis and relationships: the oblique corm with concentric tunics and smooth, ± plane, falcate leaves with the uppermost clearly cauline, place the dwarf *Geissorhiza lapidosa* in section *Weihea* of subgenus *Weihea*. It is distinguished from similar small species of the section by its high montane habit and unusual leathery, falcate leaves at most 1 mm wide. Particularly distinctive are the short-tubed, white flowers with the outer tepals flushed reddish pink and the short style, which branches opposite the lower half of the anthers. The style is eccentric, typical of the genus, as are the recurved style branches, ± 2 mm long. Similar, bicoloured flowers are found in *G. nana* and *G. setifolia*, both lowland species: *G. nana* occurs in renosterveld vegetation in the Overberg between Caledon and Riversdale and has broader, thin-textured leaves 1–2 mm wide and even smaller flowers with the tepals mostly 3–6 mm long, and very short stamens with filaments ± 2 mm long; *G. setifolia* grows in seasonally wet places on flat sandy or loamy ground in Western Cape between Gouda and Caledon and has similarly narrow but linear leaves, 0.5–1(–2) mm wide but larger flowers with tepals 6–8 mm long, a longer tube ± 6 mm long, and the style branching at the tips of the anthers. Other similar species in the group have plain white, mauve or purple flowers and generally broader leaves.

19. **Geissorhiza platystigma** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 25–50 mm altae, cormo campanulato basi ad marginem dentato ± 3 mm diam., foliis linearibus ± 1 mm latis, caule usitate prope basin 1- vel 2-ramoso, floribus actinomorphis flavis, tubo perianthii ± 1.5 mm longo infundibuliformi, tepalis anguste ovatis 6–7 × ± 3 mm, filamentis ± 2 mm longis, antheris ± 1.5 mm longis, ramis styli ± 1.5 mm longis prominenter villosis.

TYPE.—Western Cape, 3318 (Cape Town): gravelly, gently north-facing slopes in Darling Nature Reserve, (–AC), 22 September 1999, *Goldblatt & Nänni 11162A* (NBG, holo.; MO, iso.).

Plants 25–50 mm high. *Corm* bell-shaped, ± 3 mm diam. at widest, basal margin toothed, tunics light brown, concentric, woody. *Stem* usually 1- or 2-branched from near base. *Leaves* linear, ± 1 mm wide, sheaths inflated, plane, ± as long as stem. *Main and lateral spikes* 1-flowered; bracts green or flushed purple distally, outer ± 8 mm long, inner ± 6 mm long, not forked at apex. *Flowers* actinomorphic, upright, pale yellow, unscented; perianth tube funnel-shaped, ± 1.5 mm long; tepals narrowly ovate, 6–7 × ± 3 mm. *Stamens* erect, equal; filaments ±

2 mm long; anthers ± 1.5 mm long, pale yellow. *Ovary* with style erect, dividing opposite upper third of anthers, style branches recurved, ± 1.5 mm long, bearing prominent hairs longer than width of branch. *Capsules* barrel-shaped, ± 5 mm long. *Seeds* ± globose, slightly less than 1 mm diam. *Flowering time*: September, probably also in late August. Figure 7.

Eponymy: from the Greek, *platy*, broad, for the unusually broad style branches.

Distribution and ecology: known only from the Darling Nature Reserve in the hills above Darling in Western Cape (Figure 8), *Geissorhiza platystigma* grows in granite-derived soils on east- and north-trending slopes. The diminutive plants are found locally in open ground or in the shade of low shrubs in *Elytropappus*-dominated renosterveld.

Diagnosis and relationships: *Geissorhiza platystigma* is one of the most inconspicuous species in the genus. Each branch of the stem is just 30–50 mm high and bears a single flower. Most distinctive are the style branches, which are short and broad and densely covered in prominent hairs much longer than the width of the style branch. The flowers are otherwise unremarkable. The corm closely resembles that of *G. ornithogaloides* subsp. *ornithogaloides* in its bell shape with flat base and sharply dentate lower margin. Seemingly immediately allied to this common species of the coastal and interior of southern Cape. *G. platystigma* differs from it in flower size. *Geissorhiza ornithogaloides* has a perianth tube 2–3(–4) mm long, tepals (6–)7–12(–18) mm long, much larger anthers 3.0–4.5 mm long, and the style branches are slender, 2–3 mm long, and thread-like as is typical of the genus. The short, broad and densely hairy style branches of *G. platystigma* recall those of two other species of the genus from the Darling–Malmesbury area of Western Cape, *G. mathewsii* and *G. eurystigma*, both members of subgenus *Geissorhiza*. The presence of unusual style branches in three species of the genus in this small part of its range seems to be an unusual coincidence unrelated to its pollination system in view of the very different floral morphology of *G. platystigma* compared to larger, blue and red perianth of *G. eurystigma* and *G. mathewsii*.

Additional specimens examined

WESTERN CAPE.—3318 (Cape Town): gravelly slopes in Darling Nature Reserve, (–AC), 3 September 1999, *Littlewort s.n.* (MO), 12 September 2008, *Goldblatt & Porter 13202* (MO, NBG).

41. **Geissorhiza sufflava** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 100–150 mm altae foliis exclusis, cormo globoso ± 8 mm diam., tunicis pallide brunneis concentricis, caule eramoso, foliis (2 vel) 3 imo longiore saepe spicam excedenti, laminis teretibus anguste 4-sulcatis, spica forte flexuosa 1- vel 2-flora, bracteis ± siccis pallide translucente-brunneis 12–16 mm longis, floribus cupulatis pallide flavis in centro brunneolis, tubo perianthii infundibuliformi 7–9 mm longo, tepalis anguste ovatis 18–25 × 6.0–8.5 mm, filamentis 12–14 mm longis per 10–12 mm exsertis, antheris ± 5 mm longis flavis, ramis styli ± 5 mm longis.

TYPE.—Western Cape, 3218 (Clanwilliam): Piketberg, lower slopes of Versfeld Pass, light stony clay in renosterveld, (–DC), 22 September 1992, *Goldblatt & Manning 9468* (NBG, holo.; MO, PRE, iso.).

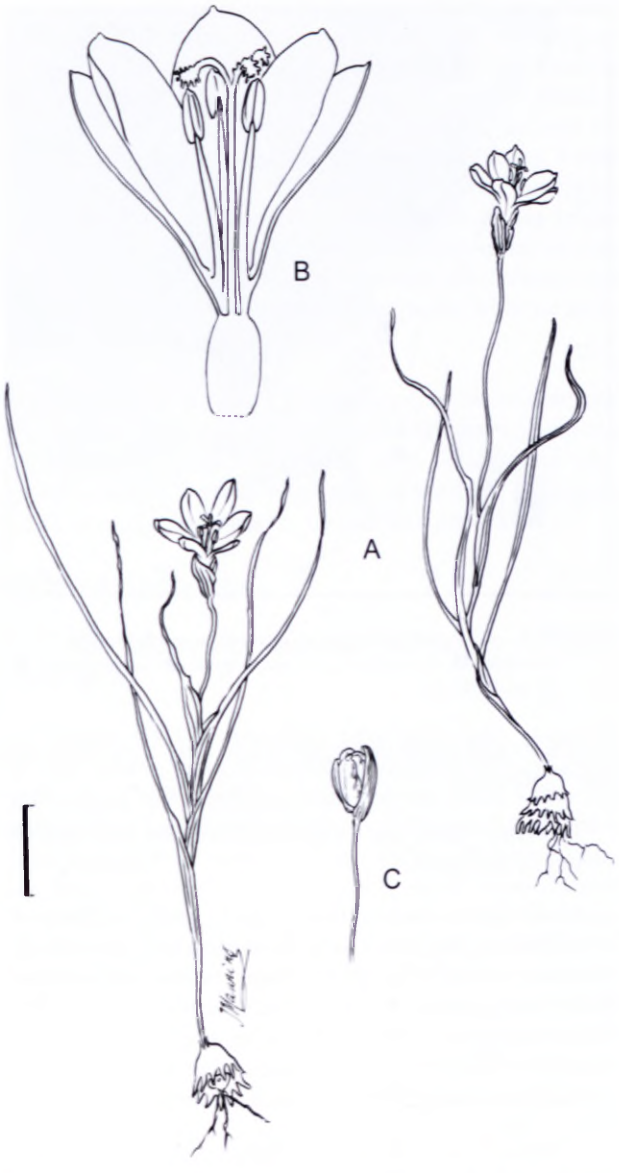


FIGURE 7.—*Geissorhiza platystigma*, *Goldblatt & Porter 13202* (NBG). A, flowering plants; B, half-flower; C, capsule. Scale bar: A, C, 10 mm; B, 2.5 mm. Artist: J.C. Manning.

Plants 100–150 mm high, not including leaves. *Corm* globose, ± 8 mm diam., tunics light brown, concentric, splitting longitudinally and drawn into short bristles above. *Stem* simple, smooth, erect below, flexed outward above sheaths of upper two leaves. *Leaves* 3, rarely 2, lowermost longest, often exceeding spike, up to 300 mm long, uppermost inserted in middle of stem, blades terete with 4 narrow, longitudinal grooves, 0.5–1.0 mm diam. *Spike* strongly flexuose, inclined and flowers borne on upper side, (1)2- or 3-flowered; bracts ± dry, light brown-translucent, 12–16 mm long, inner slightly shorter than outer, with two main veins and apex bilobed. *Flowers* cup-shaped, pale clear yellow, brownish in centre, drying pale yellow, unscented; perianth tube funnel-shaped, 7–9 mm long; tepals narrowly ovate, 18–25 × 6.0–8.5 mm. *Stamens*: filaments 12–14 mm long, exserted for 10–12 mm; anthers ± 5 mm long, yellow. *Ovary* ovoid, ± 3 mm long; style dividing opposite upper third of anthers, style branches ± 5 mm long.

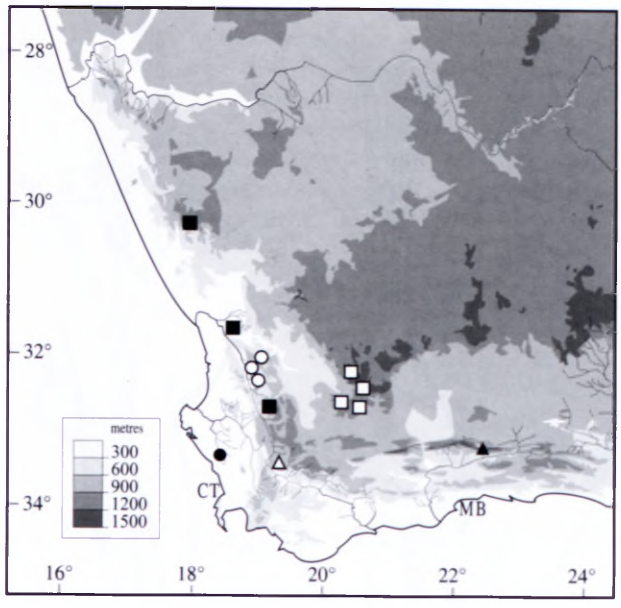


FIGURE 8.—Known distribution of *Geissorhiza cantharophila*, □; *G. demissa*, ■; *G. exilis*, △; *G. platystigma*, ●; *G. reclinata*, ▲; *G. saxicola*, ○.

Capsules and *seeds* unknown. *Flowering time*: September. Figure 9.

Eponymy: from the Latin, *sufflavus*, the pale yellow colour of the tepals.

Distribution and ecology: *Geissorhiza sufflava* is restricted to the lower eastern slopes and foot of the Piketberg range (Figure 3). Plants favour well-drained stony clay ground in renosterveld or renosterveld–fynbos transition and flower best after fire but continue to bloom for several years thereafter, until the surrounding shrubby vegetation forms a closed canopy.

Diagnosis and relationships: spikes of 1 or 2, large, pale yellow, cup-shaped flowers and the terete, four-grooved leaves, set *Geissorhiza sufflava* apart in section *Angustifolia* Goldblatt of subgenus *Weihea*. It has the typical, light brown, concentric corm tunics of the subgenus and falls closest to the widespread, small-flowered *G. juncea* (Link) D.Dietr. and the southwestern Cape endemic *G. furva* Banks ex Ker Gawl., both of which have similar, terete, four-grooved leaves. Of the two, *G. furva* has deep yellow flowers with a shorter perianth tube 3–5 mm long and tepals 15–22(–28) × 5–8(–9) mm, that spread ± at right angles to the tube when fully open, thus usually smaller and with a different orientation from those of *G. sufflava*. Even on warm days, the tepals of the often larger flowers of *G. sufflava* remain cupped rather than outspread. The two species appear to differ in ecology and distribution, and *G. furva* is endemic to the Swartland south of the Piketberg, between Hermon and Paarl, where it occurs in seasonally waterlogged clay flats. A curious feature of *G. furva* with an evident biochemical basis is that the tepals turn brownish when dry, often with a dull, metallic grey sheen, whereas those of *G. sufflava* retain their pale colour when dry.

Additional specimens examined

WESTERN CAPE.—3220 (Clanwilliam): 24 km north of Piketberg, Farm Kliprivier, (–DB), well-drained stony soil, 150 m, 6 September 2002, *Helme 2270* (NBG); Piketberg, lower slopes of Versfeld Pass, (–DC), 23 September 1999, *Goldblatt 11166A* (MO).

FIGURE 9.—*Geissorhiza sufflava*, *Goldblatt & Manning 9468* (NBG). A, flowering plant with leaf t/s (much enlarged); B, flower. Scale bar: 10 mm. Artist: J.C. Manning.

48. **Geissorhiza helmei** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 80–150 mm altae, cormo ovoideo 10–15 mm diam., tunicis concentricis pallide brunneis, foliis usitate 3, imo basali lamina 10–15 × 3–4 mm marginibus incrassatis alatisque extus glutinosis costa centrali incrassata marginibus alatis ciliatis, caule laevi suberecto usitate 1-ramoso, spica leviter flexuosa secunda 7- ad 10-flora ramis paucifloris, bracteis viridibus rubrovenosis marginibus membranosis 5–6 mm longis, floribus actinomorphis carneis inodoris, tubo perianthii ± 6 mm longo infundibuliformi, tepalis subaequalibus oblongis ± 12 × 5 mm, filamentis ± 6 mm longis, antheris ± 4 mm longis atropurpureis, ramis styli ± 2 mm longis.

TYPE.—Western Cape, 3218 (Clanwilliam): Piketberg, Farm Kleigat, lower slopes SE of Melkhoutkop, above track to Farm Weltevrede, burned the previous summer, 183 m, (–DA), 26 September 2006, *Helme 4200* (NBG, holo.).

Plants 80–150 mm high. *Corm* ovoid, 10–15 mm diam., tunics concentric, light brown, fragmenting vertically into segments tapering upward into short spines. *Stem* smooth, flexed outward above sheath of second leaf, suberect, usually with 1 branch, flexed at base of first flower. *Leaves* usually 3, lowermost basal, with a long, linear blade, 10–15 × 3–4 mm, margins thickened and raised into wings extended at right angles and ciliate along edges, sticky outside and with sand adhering, central vein also thickened and with winged, ciliate edges, plane and pale-coloured between margins and central vein, upper leaves similar but smaller, uppermost leaf sometimes subtending a branch. *Spike* horizontal, lightly flexuose, with flowers borne on upper side, main spike 7–10-flowered, branches with fewer flowers; bracts suberect, held ± at right angles to spike axis, green with red-flushed veins, margins membranous, outer ± 6 mm long, inner ± 1 mm shorter and forked apically. *Flowers* radially symmetric, pink, unscented; perianth tube funnel-shaped, ± 6 mm long; tepals subequal, oblong, ± 12 × 5 mm, spreading at right angles to tube. *Stamens*: filaments equal, ± 6 mm long; anthers ± 4 mm long, sagittate at base, dark purple, pollen brown. *Ovary* globose, ± 2 mm diam.; style suberect, dividing opposite middle third of anthers, style branches arched, ± 2 mm long. *Capsules* and *seeds* unknown. *Flowering time*: late August to mid September. Figure 10.

Eponymy: named in honour of N.A. Helme, a Cape Town botanist, who discovered the species.

Distribution and ecology: *Geissorhiza helmei* is a narrow endemic of the lower northern slopes of the southern arm of the Piketberg (Figure 3), growing in rocky ground in light sandy loam overlying clay. Plants were collected in the spring of 2006 after a fire earlier in the year and the species seems to be an absolute pyrophyte—a search for plants in spring in the following year failed to produce a single specimen of the species.

Diagnosis and relationships: in its general aspect *Geissorhiza helmei* recalls species of section *Engysiphon* (G.J.Lewis) Goldblatt of the genus, all members of which have fairly large corms with concentric tunics, the fragments of which taper above into short bristles, and a single long basal leaf, always with thickened and winged margins and central vein, and with the surface of the margins glandular and with sand adhering to them (Goldblatt 1985). Most other members of this alliance have flowers with a longer perianth tube, but at least *G. brevituba* (G.J.Lewis) Goldblatt has a short tube, ± 8 mm long, thus comparable to the tube of *G. helmei*; however, *G. brevituba*, also restricted to the Piketberg, has larger flowers with tepals 25–30 mm long. The spike of this species typically has only 1 to 3 flowers, the stamens and style of which are unilateral and declinate, with the style dividing well beyond the anther tips.

The species is named in honour of its discoverer, the botanist N.A. Helme, who also made the first collections of two more species described here, *Geissorhiza altimontana* and *G. tricolor*, as well as the type collection of *G. demissa*, and brought them to our attention.

Subgenus Geissorhiza

80. **Geissorhiza demissa** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 60–120 mm altae raro 1-ramosae, cormo ± 4 mm diam., tunicis imbricatis nigrescentibus, caule puberuloso sed subglabro infra spicam, foliis 4, duobus inferioribus basalibus linearibus vel falcatis 0.7–1.0 mm latis marginibus costaque leviter incrassatis alatis ciliatis, folio supremo caulem vaginanti, spica 1- vel 2-flora, bracteis viridibus in dimidio superiore siccis brunnescentibusque, bractea externa ± 5 mm longa interna ± 4 mm longa, floribus actinomorphis, albis pallide caeruleis infra venosis tepalis exterioribus caerulescentibus in dimidio distali, perianthii tubo ± 2 mm longo infundibuliformi, tepalis obovatis subaequalibus ± 7 × 3.5 mm, filamentis inaequalibus ± 3.5 mm longis, antheris ± 2 mm longis, stylo breviter ultra antherarum apices diviso ramis recurvatis ± 0.5 mm longis.

TYPE.—Northern Cape, 3018 (Kamiesberg): upper SE slopes of Stalberg, 3 km S of Farm Welkom, among granite boulders, 1 370 m, (–AC), 28 October 2005, *Helme 3626* (NBG, holo.).

Plants delicate, 60–120 mm high, rarely with 1 short branch; stems puberulous but subglabrous below spike. *Corm* obliquely narrowly ovoid, ± 4 mm diam., with several cormlets at base, tunics woody, blackish, imbricate. *Leaves* 4, lower two basal, third leaf inserted shortly above ground, blades linear-falcate, reaching to about base of spike, 0.7–1.0 mm wide, margins and central vein lightly thickened and narrowly winged, glabrous, uppermost leaf cauline, largely to entirely sheathing. *Spike* 1- or 2-flowered; bracts green below, dry and brown in upper half to two thirds, outer ± 5 mm long, inner ± 4 mm long. *Flowers* actinomorphic, white with veins tinged blue below and reverse of outer tepals flushed blue in distal half; perianth tube funnel-shaped, ± 2 mm long; tepals subequal, obovate, ± 7 × 3.5 mm. *Stamens* unequal; filaments ± 3.5 mm long, uppermost 0.5 mm shorter, white; anthers ± 2 mm long, pollen ± white. *Ovary* with style erect, dividing shortly beyond anthers, branches recurved, ± 0.5 mm long. *Capsules* and *seeds* unknown. *Flowering time*: late August to October, probably also in early November. Figure 11.

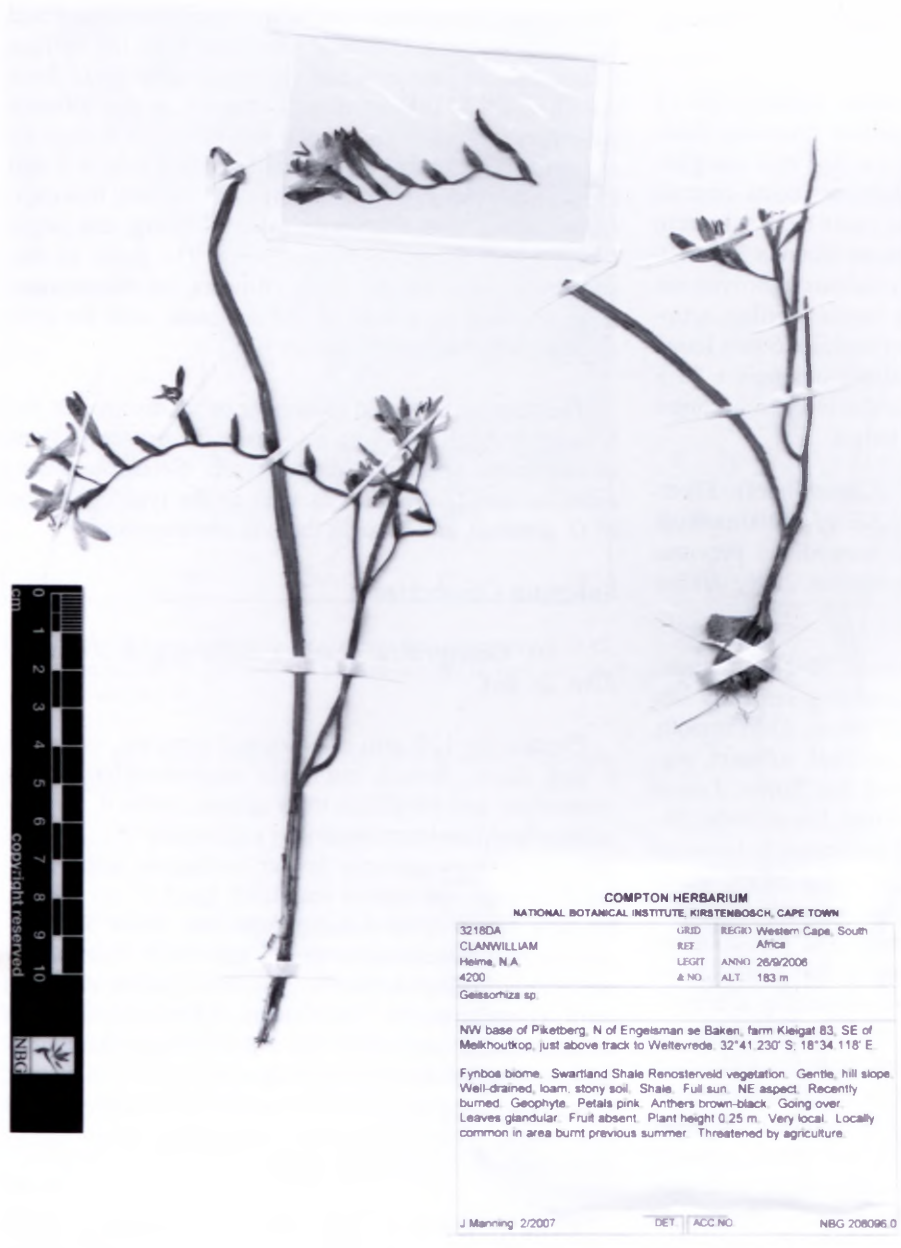


FIGURE 10.—*Geissorhiza helmei*, *Helme 4200* (NBG).

Eponymy: from the Latin, *demissa*, small in stature.

Distribution and ecology: known from just three collections, one from the upper slopes of Stalberg in the Kamiesberg of central Namaqualand, and the other two from Western Cape, on the plateau of the Gifberg near Vanrhynsdorp and in the Cold Bokkeveld (Figure 8). Plants are localized and evidently uncommon in seasonally damp places in the shelter of granite boulders in the Kamiesberg or among sandstone rocks in the Western Cape mountains.

Diagnosis and relationships: imbricate corm tunics, ± plane leaves with margins and central vein only lightly thickened, puberulous stem, and small, star-like flowers with unequal stamens, place *G. demissa* in the small section *Planifolia* Goldblatt of subgenus *Geissorhiza* (Goldblatt 1985), where it is remarkable for its small size and few-flowered spike. It is evidently closely allied to the widespread *G. aspera*, a variable species mostly with the flowers dark blue to violet although northern populations from the Cedarberg and Gifberg have white or bicoloured white and mauve flowers. *Geissorhiza aspera* is typically larger in all respects and almost invariably branched, with leaf blades 2–7 mm wide, 2–7-flowered spikes, and stems that are puberulous up to the base of the spike, even in the northern, white-flowered populations. The unbranched stems of *G. demissa* are subglabrous below the spike and the leaves are never more than 1 mm wide. Although the flowers of the two species are similar in shape, those of *G. aspera* are larger, with tepals 11–15 × 4–6 mm and similar short filaments, 3–5 mm long, but longer anthers, 3–5 mm vs ± 2 mm long.

Geissorhiza aspera is common in the southwestern Cape, from Swellendam and Bredasdorp northwards to the Gifberg. It is absent from the Bokkeveld Mtns, a short distance to the north, where the morphologically similar *G. inaequalis* occurs, a more robust species with larger, purple flowers with declinate or horizontal stamens.

Additional specimens examined

WESTERN CAPE.—3118 (Vanrhynsdorp): Gifberg, plateau above pass, (–DB), 23 August 1984, *Goldblatt 7232* (MO). 3219 (Wuppertal): Cold Bokkeveld, Wagenboomsrivier, rocky slopes just northeast of Waterval, (–CC), 10 October 2008, *Helme 5876* (NBG).

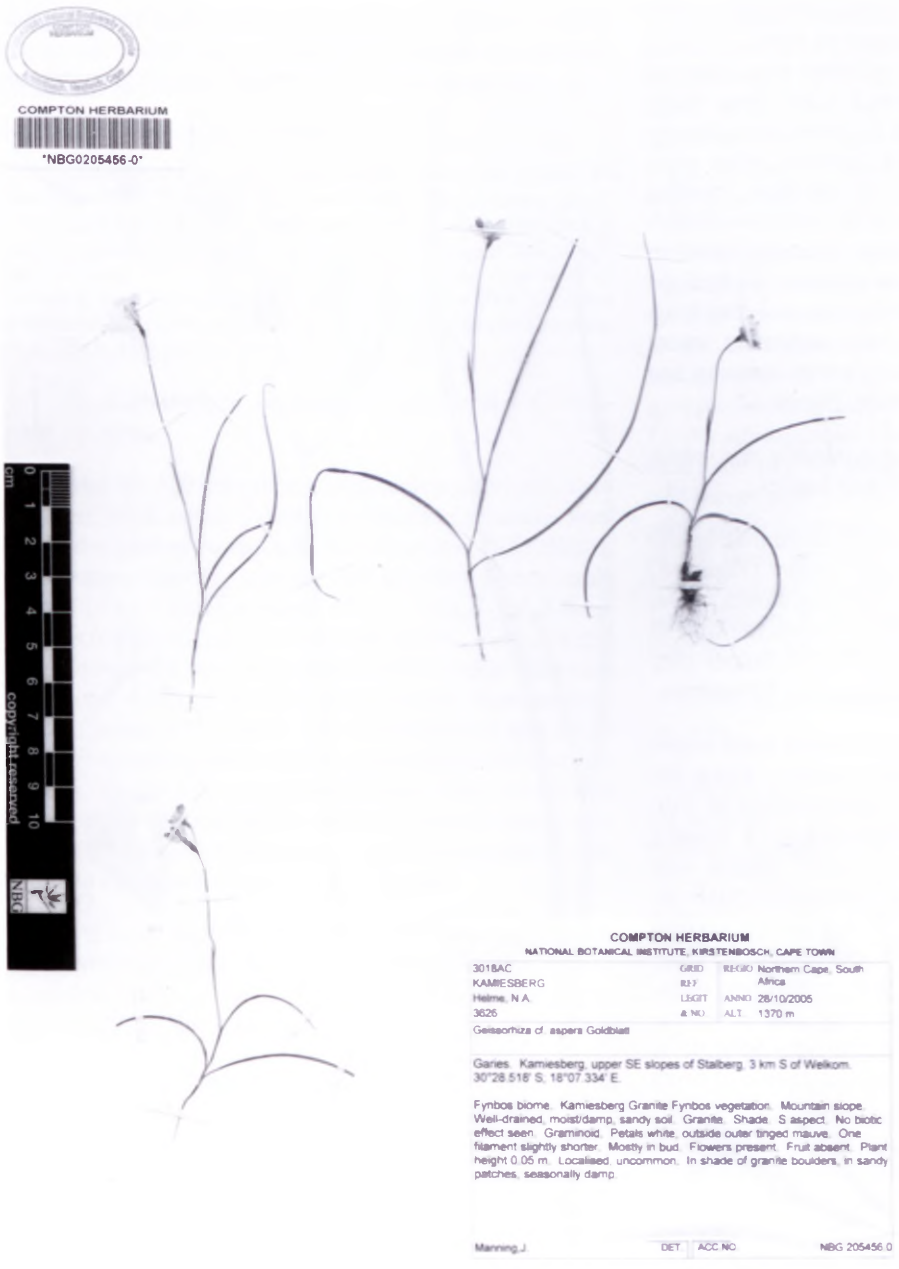


FIGURE 11.—*Geissorhiza demissa*. *Helme 3626* (NBG).

90. **Geissorhiza cantharophila** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 250–450 mm altae, cormi tunicis imbricatis, foliis 3 duobus inferioribus laminis productis linearibus marginibus et costa incrassata alis ciliisque munitis, caule usitate 1- ad 3-ramoso, parce piloso, spica (3- ad) 5- vel 6-flora, bracteis inaequalibus bractea externa griseo-viridi ± 10 mm longa interna ± 8 mm longa membranacea atroviridi bicarinata ad apicem furcata, floribus actinomorphis, nitide carneis in centro atropurpureis, perianthii tubo 2.0–2.5 mm longo infundibuliformi, tepalis ovatis subaequalibus patentibus ± 15 × 7 mm, filamentis styloque atropurpureis, filamentis 4–5 mm longis uno ± 1 mm breviore quam aliis, antheris 5–8 mm longis sagittatis lobulis ad basem per ± 2 mm divergentibus, stylo ± 3 mm longo ramis adscendentibus leviter recurvatis ± 3 mm longis.

TYPE.—Western Cape, 3320 (Montagu): Klein Roggeveld, 26.5 km north of N1 on road to Sutherland from Matjiesfontein, Farm Fortuin, (–BA), 26 August 2006, *Goldblatt & Porter 12704* (NBG, holo.; MO, PRE, iso.).

Plants 250–450 mm high. *Corm* 8–10 mm diam., ovoid, tunics imbricate, blackish. *Stem* erect, sparsely short-hairy, usually 1–3-branched, bearing a scale-like bract up to 10 mm long in upper third. *Leaves* 3, lower 2 with suberect to falcate blades, upper leaf sheathing stem but free distally, blades linear, margins raised into wings held at right angles to blade, central vein raised and bearing winged edges parallel to blade surface, ciliate on marginal and central vein wings, plane between margins and central vein. *Spike* flexed outward, flexuose, (3–)5- or 6-flowered; bracts unequal, outer dull grey-green in bud with submembranous margins, drying pale straw-coloured with age, ± 10 mm long, inner ± opaque-membranous with two dark green keels, ± 2 mm shorter than outer, apically forked. *Flowers* actinomorphic, bright, glistening pink (turning blue on drying) with a glossy, dark purple central zone, filaments, style and style branches also dark purple; perianth tube fun-

nel-shaped, 2.0–2.5 mm long; tepals subequal, ovate, spreading horizontally at right angles to tube, ± 15 × 7 mm. *Stamens* unequal: filaments 4–5 mm long, one ± 1 mm shorter than other two; anthers 5–8 mm long, sagittate, thecae diverging at base for ± 2 mm, pale mauve-pink to purple, pollen pale pink (yellow when dry). *Ovary* with style slender, short, ± 3 mm long, dividing opposite lower third of filaments, style branches ascending, slightly outcurved, ± 3 mm long, extending between lower third of anthers. *Capsules* subglobose, 3-lobed, 6–7 mm long. *Seeds* tetrahedral, colliculate, ± 2 mm long. *Flowering time*: late August to mid September, occasionally lasting until early October; flowers opening late morning and closing in late afternoon. Figure 12.

Eponymy: from the Latin, *cantharis*, a beetle, and *-phila*, loving, alluding to the pollinators, scarab beetles.

Distribution and ecology: *Geissorhiza cantharophila* is restricted to Klein Roggeveld and nearby (Figure 8) and is most often found on south-trending slopes or flat ground on shale and clay. In years of ample rainfall, as in 2006, plants can be so common that in flower they colour the veld with a haze of pink for many kilometres.

Diagnosis and relationships: the blackish corm tunics with overlapping layers that split regularly along the lower margin, place *Geissorhiza cantharophila* in subgenus *Geissorhiza*. The two basal leaves have broadly winged margins and a raised and winged central vein exactly like those of its presumed immediate relatives, *G. inflexa* and *G. heterostyla*, and it also has the derived pollen grains with complex aperture and operculum characteristic of its two relatives and their immediate allies. So alike are the three species that they can be distinguished only with difficulty in the herbarium. Seen alive, however, the glistening mauve-pink to purple flowers with a dark purple centre, purple filaments and a short purple style of *G. cantharophila* are unmistakable. The style, ± 3 mm long and dividing opposite the lower third of the filaments, and the almost straight style branches are unique in the subgenus and we infer that they are associated with its pollination system. The upright flowers are adapted for pollination by hopliine beetles, two or more species of which have been found on the flowers on warm sunny days. The short style results in the placement of the style branches at exactly the right level to brush against a beetle's body as it crawls across the perianth. A longer style, such as found in its relatives, would place the style branches beyond the level of a beetle visitor. Hopliine beetles captured in the flowers include *Anisochelus inornatus*, *Anisonyx hilaris* and *A. ignites*.

The widespread *Geissorhiza heterostyla* is vegetatively identical and is particularly difficult to distinguish from *G. cantharophila* when pressed and dried but alive, the blue to mauve or almost white flowers, pale yellow in the tube with the mouth sometimes edged in darker blue or mauve, and ± white stamens and style branches make it easy to separate the two species. When the flowers of *G. heterostyla* first open, the spreading tepals are held at ± 30° to the horizontal with the style and anthers unilateral and lying above the lowermost tepal. As the flower ages, the spike axis becomes straight and the flower is then held upright. In all but a few populations of the species, the style is relatively long and reaches the top of

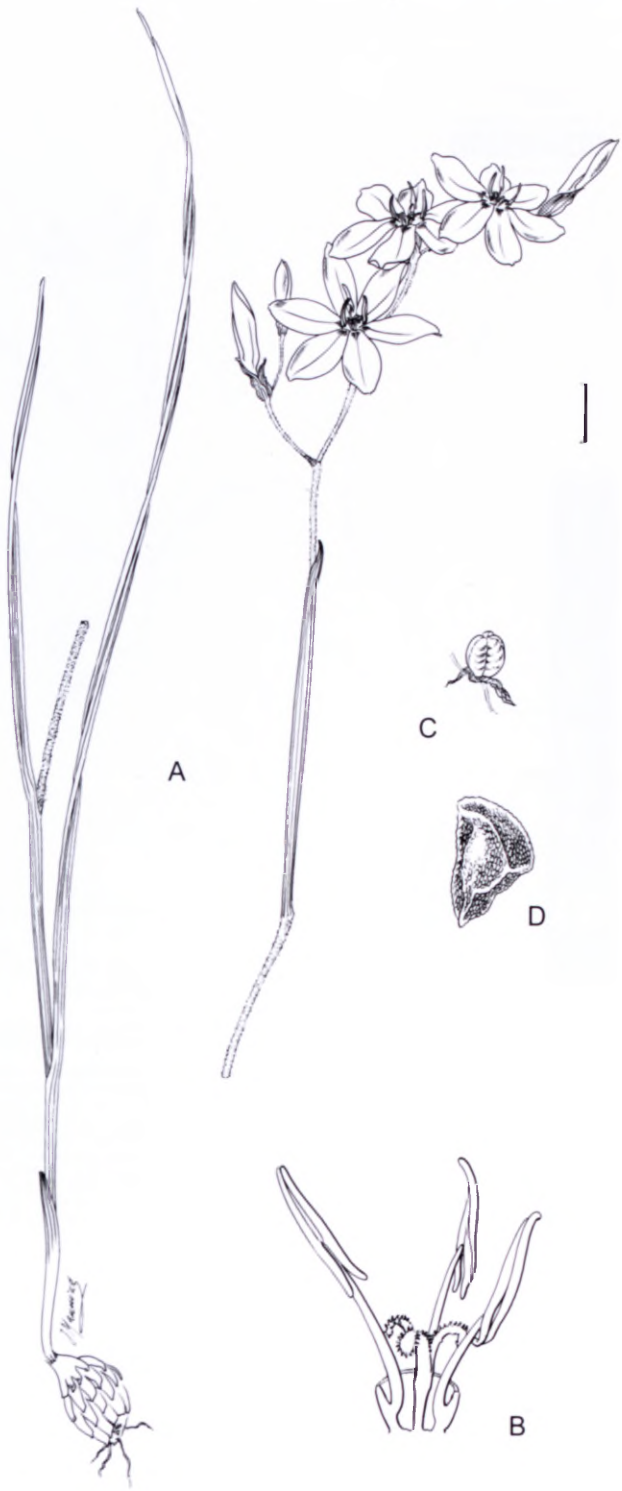


FIGURE 12.—*Geissorhiza cantharophila*, *Goldblatt & Porter 12704* (NBG). A, flowering plant; B, stamens and stigma; C, capsule; D, seed. Scale bar: A, C, 10 mm; B, 3 mm; D, 1 mm. Artist: J.C. Manning.

the anthers, and the style branches are clearly recurved as in most other species of *Geissorhiza*. Locally, in the southern Roggeveld, at Whitehill and elsewhere in the northern half of its range, there are populations of *G. heterostyla* that consist of plants with long, intermediate, or short styles, a feature well illustrated in the protologue (Bolus 1930), and it is these latter plants that are most easily confused with *G. cantharophila*. Short-styled plants of *G. heterostyla* are rare in any population (about one plant in 10 had a short style in two populations we

sampled near Sutherland) and the style branches in these plants are short and recurved, thus unlike the longer, nearly straight style branches of *G. cantharophila*.

Additional specimens examined

NORTHERN CAPE.—3220 (Sutherland): Houthoek, (–CA), 10 September 1971, *Hanekom 1562* (MO, NBG, PRE); Verlate Kloof, 4300 ft [± 1 410 m], (–DA), 8 September 1926, *Levyns 1647* (BOL); Klein Roggeveld, Farm Meintjieskraal, (–DC), 30 August 2007, *Goldblatt & Porter 12915* (MO, NBG, PRE); south-facing slope south of Komsberg Pass, Farm De Hoop, (–DC), 9 September 2006, *Goldblatt & Porter 12807* (MO); 13.5 miles [± 20 km) SSE of foot of Komsberg Pass, (–DC), 15 September 1955, *Acocks 18447* (BOL).

91. **Geissorhiza reclinata** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 80–120 mm altae, cormi tunicis imbricatis atrobrunneis, foliis usitate 3 duobus inferioribus prostratis linearibus marginibus costaque leviter incrassatis alatis ciliatis, folio supero caulem vaginanti sed distaliter libero, caule usitate 1- ad 3-ramoso, parce piloso, spica 1- ad 3-flora, bracteis inaequalibus bractea externa griseo-viridi ± 10 mm longa interna ± 8 mm longa membranacea viride bicarinata ad apicem integra, floribus zygomorphis, caeruleo-malvinis in centro viridi-flavis, perianthii tubo ± 2 mm longo infundibuliformi, tepalis anguste ovatis subaequalibus patentibus, 14–16 × ± 7 mm, filamentis duobus 10–12 mm longis uno 8–10 mm longo, antheris 5–8 mm longis subsagittatis lobulis ad basem per ± 2 mm divergentibus, stylo reclinato ramis recurvatis ± 1.5 mm longis.

TYPE.—Western Cape, 3322 (Oudtshoorn): Swartberg, Meiringspoort, southwest-trending slopes among sandstone rocks, (–BC), 16 August 2002, *Goldblatt & Porter 12057* (NBG, holo.; MO, PRE, iso.).

Plants 80–120 mm high. *Corm* ± 8 mm diam., ovoid, tunics imbricate, dark brown, fragmenting below into tile-like sections. *Stem* erect, sparsely and short-hairy or sometimes ± smooth in upper third, usually 1–3-branched, bearing scale-like bract up to 10 mm long in upper third. *Leaves* mostly 3, lower 2 ± prostrate, blades linear, 80–120 × 1.5–2.0 mm, margins and central vein raised into narrow wings held at right angles to blade, wings sparsely ciliate, upper leaf sheathing stem but free distally. *Spike* flexed outward, flexuose, 1–3-flowered; bracts unequal, green flushed purple above, margins membranous, outer ± 10 mm long, inner ± 8 mm long, apex entire. *Flowers* zygomorphic, held at ± 45° from vertical, blue-mauve (turning pale lilac on drying), greenish yellow in tube, upper 3 tepals dark blue-purple at base, filaments, style and style branches pale bluish; perianth tube funnel-shaped, ± 2 mm long; tepals narrowly ovate, subequal, spreading horizontally at right angles to tube, 14–16 × 7 mm. *Stamens* unequal; filaments 10–12 mm long, one 8–9 mm long; anthers 5–8 mm long, sagittate, thecae diverging at base for ± 2 mm, pale mauve pink, pale yellow (or brown) when dry. *Ovary* with style reclinate, lying beneath filaments, dividing opposite anther tips, style branches recurved, ± 1.5 mm long, extending above anthers. *Capsules* and *seeds* unknown. *Flowering time*: mid August to mid September, possibly later at higher elevations.

Eponymy: from the Latin, *reclinatus*, bent downward, describing the orientation of the stamens and style.

Distribution: endemic to the eastern Swartberg, *Geissorhiza reclinata* is known only from slopes above Meiringspoort east of Oudtshoorn (Figure 8). Plants grow on moist, peaty sand on southwest-trending slopes among sandstone rocks. Plants were in full bloom the year following a fire and we suspect that, as the surrounding shrubby vegetation regrows, *G. reclinata* will no longer flower.

Diagnosis and relationships: the dark brown, overlapping corm tunics and unequal filaments place *Geissorhiza reclinata* in subgenus *Geissorhiza* where it seems taxonomically isolated. It keys out in the current revision of the genus (Goldblatt 1985) with a small group of southwestern Cape mountain species, including *G. pseudinaequalis* Goldblatt and *G. scopulosa* Goldblatt, and like the latter it has sparsely short-hairy stems and leaves with the margins and central vein winged, the wing edges minutely ciliate (at least a 10× lens is needed to see these features). The short perianth tube ± 2 mm long is consistent with that of *G. scopulosa* but the fairly large flowers with tepals ± 15 mm long are much larger than in *G. scopulosa*, which has tepals 8–9 mm long.

96. **Geissorhiza exilis** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 70–140 mm altae, cormo 3–4 mm diam., tunicis imbricatis atrobrunneis, foliis usitate 3 duobus inferioribus basalibus 30–40 × 1.5–2.5 mm linearibus vel falcatis marginibus costaque leviter incrassatis alatis ciliatis, folio supero caulem vaginanti sed distaliter libero, caule usitate 1- vel 2-ramoso, glabro, spica 1- ad 3-flora, bracteis inaequalibus viridibus in dimidio superiore siccis brunnescentibusque, bractea externa 7–8 mm longa interna 5–6 mm longa bicarinata ad apicem furcata, floribus actinomorphis, albis tepalis exterioribus dorsaliter carneis, perianthii tubo ± 1.5 mm longo infundibuliformi, tepalis ovatis subaequalibus patentibus, ± 8 × 3–4 mm, filamentis aequalibus ± 2 mm longis, antheris 3–4 mm longis, stylo erecto ramis recurvatis ± 1.5 mm longis.

TYPE.—Western Cape, 3319 (Worcester): Waaihoek Mountains, Farm Boesmansvlei, steep slopes above vineyards, southwest-facing slopes among sandstone rocks, ± 390 m, (–CA), 22 September 2007, *Goldblatt & Manning 13014* (NBG, holo.; K, MO, PRE, iso.).

Plants 70–140 mm high. *Corm* 3–4 mm diam., ovoid, tunics imbricate, dark brown, fragmenting below into tile-like sections. *Stem* erect, smooth, usually 1- or 2-branched, bearing scale-like bract up to 10 mm long in upper third if second branch present. *Leaves* mostly 3, lower 2 erect, blades linear or falcate, 30–40 × 1.5–2.5 mm, margins and central vein raised into narrow wings held at right angles to blade, wings prominently ciliate, upper leaf sheathing stem but free distally. *Spike* flexed outward, flexuose, 1–3-flowered, branches when present 1- or 2-flowered; bracts unequal, green becoming dry and brown in upper half, outer 7–8 mm long, inner 5–6 mm long, 2-keeled and forked apically. *Flowers* radially symmetric, upright, white with outer tepals flushed pink on reverse; perianth tube funnel-shaped, ± 1.5 mm long; tepals subequal, ovate, spreading horizontally at right angles to tube, ± 8 × 3–4 mm. *Stamens* equal; filaments ± 2 mm long; anthers 3–4 mm long, white. *Ovary* with style erect, dividing oppo-

site upper third of anthers, style branches recurved, ± 1.5 mm long, extending above anthers. *Capsules* and *seeds* unknown. *Flowering time*: September.

Eponymy: from the Latin, *exilis*, small or slender.

Distribution and ecology: *Geissorhiza exilis* is known only from the slopes of the Waaihoek Mtns west of Worcester, where it grows on fairly steep slopes in sandy ground among sandstone boulders (Figure 8). The single collection was made in the spring following a fire during the previous summer.

Diagnosis and relationships: *Geissorhiza exilis* is identified by the narrow, sublinear to falcate leaves with the margins and central vein raised and extended into prominently ciliate wings, combined with a glabrous stem and flowers with equal filaments. Leaf morphology places the species in section *Ciliatae* (Goldblatt 1985) of subgenus *Geissorhiza* where it appears to be most like *G. inflexa*. This species is an altogether larger plant with corms 7–12 mm diam., leaves mostly at least 3–4 mm wide, and flowers with tepals at least 8 mm long and more often 10–18 mm long. The stamens of *G. inflexa* are also larger, the filaments 4–7 mm long, the anthers mostly 3–6 mm long, and the style branches 4–5 mm long. Whereas *G. inflexa* favours clay or loam slopes and flats in renosterveld, *G. exilis* is a plant of sandy slopes in fynbos habitats.

We have seen no other collections of the species but we suspect that it may not be as rare as it appears, for the plants are inconspicuous even when locally common and in full bloom. Difficulty in naming small-flowered species of *Geissorhiza* is also likely to discourage collectors.

97. **Geissorhiza saxicola** *Goldblatt & J.C.Manning*, sp. nov.

Plantae 35–100 mm altae, cormo ignoto, caule erecto papillato-villoso simplici vel uniramoso, foliis 3 omnibus basalibus vel folio summo cauli prope basin inserto, planis falcatis vel trahentibus sublinearibus 1.5–4.0 mm latis marginibus costaque alatis, alis prominenter pilosis, spica (1- vel)2- ad 6-flora (ramo, si adest, 1- vel 2-floro tantum), bracteis infra viridis in dimidio superiore siccis brunneisque, bractea externa 7–8(–10) mm longa interna breviore, floribus albis usque pallide carneis, perianthii tubo infundibuliformi 1.5–2 mm longo, tepalis 7–8 × 2–3 mm patentibus, filamentis inaequalibus duobus ± 3 mm longis uno ± 2 mm longo, antheris sagittatis 3.3–4.0 mm longis, stylo manifeste erecto ramis 1.3–1.8 mm longis.

TYPE.—Western Cape, 3319 (Wuppertal): Biedouw valley, east-facing slopes above Biedouw Jeugkamp, damp sheltered places among sandstone rocks, (–AA), 7 September 1992, *Goldblatt & Manning 9404* (NBG, holo.; MO, iso.).

Plants 35–100 mm high. *Corm* unknown. *Stem* erect, pubescent, simple or rarely with a single short branch. *Leaves* 3, all basal or uppermost inserted on stem shortly above ground level, ± plane, falcate to trailing, lower two longest and exceeding stem, sublinear to narrowly sword-shaped, 1.5–4.0 mm wide at widest point, margins and central veins winged with marginal wings held at right angles to blade, wing edges prominently ciliate. *Spike* (1)2–5(6)-flowered, branch when present 1- or 2-flowered; bracts green below, dry and brown in distal half, outer bract 7–8(–10) mm long, inner slightly shorter, 2-veined to 2-keeled, usually shallowly notched at tip. *Flowers* white to pale pink, outer tepals pink to light purple outside, unscented; perianth tube funnel-shaped, 1.5–2.0 mm long; tepals 7–8 × 2–3 mm, spreading. *Stamens* unequal; filaments with longer two ± 3 mm long, shorter one ± 2 mm long; anthers sagittate, 3.3–4.0 mm long. *Ovary* with style evidently erect, dividing opposite middle of anthers, style branches arching outward, 1.3–1.8 mm long. *Flowering time*: August to mid October. Figure 13.

Eponymy: from the Latin, *saxosa*, stony or rocky, and *-icola*, living in, describing the habitat.

Distribution: *Geissorhiza saxicola* is known from just three collections from the northern Cedarberg and Pakhuis Mountains east of Pakhuis Pass (Figure 8). Plants grow in sandy soil, in moist shady sites in the shelter of sandstone rocks, and may be locally abundant.

Diagnosis and relationships: *Geissorhiza saxicola* is recognized by the combination of a papillate-hairy stem, leaves with the margins and central veins winged with pilose wing edges and small, pink flowers with unequal filaments. The immediate relationships of *G. saxicola* are uncertain although it clearly falls in section *Ciliatae*. Pollen grains are specialized in their complex aperture, which places the species closest to *G. exilis* and *G. inflexa*, but in both these species the filaments are equal in length. Although its low stature and small flowers recall *G. minuta* of the Gifberg and Pakhuis Mountains, that species has a smooth stem, equal stamens, and the thickened leaf margins and central vein lack the wings with ciliate edges of *G. saxicola*. *Geissorhiza leipoldtii* is more distantly allied to *G. saxicola* but although it often has unequal stamens, the flowers are much larger (tepals (13–)18–28 mm long; anthers 6–8 mm long) and the style divides at or beyond the anther tips.

Additional specimens examined

WESTERN CAPE.—3218 (Clanwilliam) [or 3219 (–CA)]: Cedarberg, Boschkloof, shady damp places near rock, (–BB), 12 October 1923, *Pocock 114* (NBG) or 3219 (–CA), 3219 (Wuppertal): Cedarberg Forest Reserve, Langrug, shady moist places on shale band, 1 000 m, (–AC), 5 September 1982, *Viviers 584* (NBG).

RANGE EXTENSIONS, MORPHOLOGICAL NOTES AND TAXONOMIC CHANGES

The numbers of the species follow the classification in Table 1.

92. *Geissorhiza arenicola* L.Bolus

This blue-flowered species of subgenus *Geissorhiza* has until now been regarded as endemic to the northern end of the Bokkeveld Mountains and nearby Gifberg range, where, as its name suggests, it occurs in sandy, well-drained soils. Allied to the widespread *G. aspera*, *G. arenicola* is recognized by the puberulous stem, two basal leaves with thickened margins and raised and thickened central vein, minutely ciliate on the edges and slightly sticky on the raised surfaces, unequal fila-

ments and deep blue perianth with tepals mostly 12–15 mm long. We have now collected the species in the Olifants River Mountains west of Trawal (*Goldblatt & Porter 11888A* MO, NBG, PRE). The record establishes its range as a montane species of the northern portion of the Northwestern Centre (sensu Goldblatt & Manning 2000) of the Cape floristic region. A collection from Matjiesfontein Farm on the Bokkeveld Escarpment south of Nieuwoudtville (*Goldblatt & Nänni 11154* NBG) consists of uniformly white-flowered plants, and a white-flowered population is also known from Lokenburg, to the south. Elsewhere *G. arenicola* has blue flowers.

13. *Geissorhiza bracteata* Klatt

The recorded range for this species is the southern Cape, extending from near Swellendam eastward to Grahamstown (Goldblatt 1985). New records from Burgers Pass west of Montagu extend the range some 150 km to the west (27 August 2006, *Goldblatt & Porter 12714* MO, NBG, PRE). A second collection from the Voetpadsberg near Touws River (3 October 1999, *Goldblatt & Nänni 11198* MO) in fruit is probably also this species and if correctly identified extends the range inland where it has not before been found. The Burgers Pass collection has the derived pollen type, typical of *Geissorhiza bracteata* but has prostrate leaves, unlike most other collections of the species, and the perianth tube is ± 2.5 mm long. Elsewhere in *G. bracteata*, the perianth tube is 3–5 mm long.

87. *Geissorhiza divaricata* Goldblatt

A small-flowered species, *Geissorhiza divaricata* (subgenus *Geissorhiza*) was known from the northern

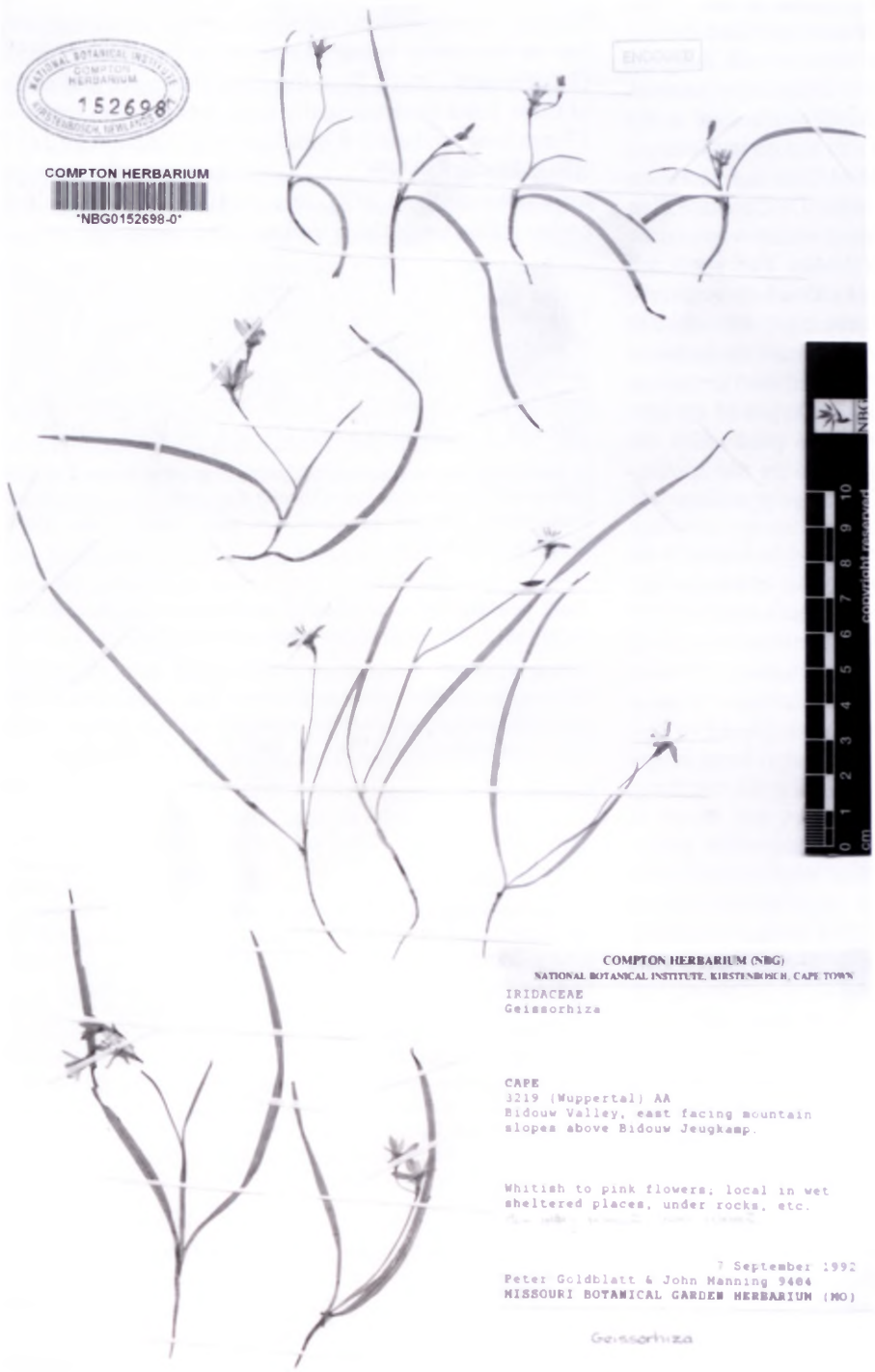


FIGURE 13.—*Geissorhiza saxicola*, *Goldblatt & Manning 9404* (NBG).

Bokkeveld Mountains and the Gifberg when described (Goldblatt 1985). The slender habit, divaricate branching with the branch about as long as the main axis, tepals ± 10 mm long and the two basal leaves with raised and narrowly winged, ciliate margins and primary and secondary veins, readily distinguish the species as belonging in subgen. *Geissorhiza*. A collection made in September 2006, 40 km south of Nieuwoudtville near Moedverloor at the southern end of the Bokkeveld Mountains, is a modest range extension (*Goldblatt & Porter 12432* MO, NBG). The population there consists largely of blue-flowered plants, but one pure white-flowered plant was included in the collection. Until now records of *G. divaricata* have been of plants with white flowers faintly flushed with purple and red-purple on the reverse of the tepals.

95. *Geissorhiza erosa* (Salisb.) R.C.Foster

Based on plants cultivated in England in the 1790s, this species (as *Ixia erosa*) was distinguished by the leaves with ciliate 'pleats' (what we now call marginal wings) and the tips of the tepals irregularly toothed. Nothing was mentioned about the flower colour in the protologue. The reason the name was linked to the large, red- or purple-flowered plants called *G. erosa* by Foster was his discovery of a specimen in the De Candolle Herbarium at Geneva bearing this name, which was sent by Salisbury to De Candolle (Foster 1941). This specimen is probably not a type in the current sense, but does serve to authenticate the species. Foster regarded *Ixia erosa* as the earliest valid name for the illegitimate *Geissorhiza hirta* (Thunb.) Ker Gawl. (the name used for the species by Baker, 1896, in *Flora capensis*). No types of the species described by Salisbury in his 1796 publication are known and so the matter has rested. To fix the application of the name we have designated a neotype here.

The large-flowered *Geissorhiza erosa* is vegetatively indistinguishable from *G. inflexa*, but the spikes usually have fewer flowers, usually 2–4, a perianth tube 1.5–2.0 mm long, tepals 18–24 × 8–10 mm and anthers (6–)7–10 mm long. The outer bracts are 18–20 mm long, the inner ± 2 mm shorter. In contrast, typical *G. inflexa* also has a perianth tube ± 2 mm long, but tepals 10–15(–17) × 5–7 mm, and anthers 4–6 mm long. The outer floral bracts are 10–15 mm long and the inner about 10–12 mm long; generally the bracts of *G. inflexa* are dry and brown at flowering, but in *G. erosa* the bracts are often green, turning light brown with age. Plants with a large, pink or occasionally white perianth that occur to the south at Villiersdorp and Bot River have, like typical *G. erosa*, tepals 18–22 mm long and anthers 8–10 mm long. Apart from perianth colour, the two sets of populations can be distinguished by bract length, tepal size and anther length (Table 3). There appear to be no consistent differences in the styles of the two species. The style generally divides opposite the level of the middle to upper third of the anthers and the style branches are 3–4 mm long.

Geographically, *Geissorhiza inflexa* in the narrow sense extends from the Piketberg and the Cape Peninsula eastward to Bredasdorp and Swellendam (Figure 14), whereas *G. erosa* occurs in the Tulbagh Valley and to the south between Villiersdorp and Bot River and near Stellenbosch, thus entirely within the range of *G. inflexa*. In view of the different pollen morphology now documented for *G. erosa* populations, which we take as an indication that they constitute a genotype distinct from *G. inflexa*, and the associated larger and differently coloured flowers, we recommend recognition of *G. erosa* and outline its synonymy below. As noted by Goldblatt (1985), *G. inflexa* specimens from the Cape Peninsula and north of Cape Town have unusually large flowers with tepals ± 17 mm long, anthers ± 6 mm long (e.g. *Fellingham 1617* NBG; *Marsh 732* NBG), and are thus apparently intermediate between those of *G. erosa* and *G. inflexa* but their pollen grains are of the *G. inflexa* type.

TABLE 3.—Comparison of taxonomically significant features of *Geissorhiza erosa* and *G. inflexa*. Filaments are measured from insertion on perianth tube to base of anther; for bracts measure the outer bracts in middle of spike

Character	*G. inflexa*	*G. erosa*
Perianth colour	white (–cream), outer tepals flushed red to purple outside	red, pink, purple, occ. white
Tepal size (mm)	10–15(–17) × 5–7	18–24 × 8–10
Outer bract length (mm)	11–16	18–20
Anther length (mm)	4–6	(6–)7–10
Filament length (mm)	4–5	(5–)6–7
Flowers per spike	(3)4–7	2–4(5)

Geissorhiza erosa *(Salisb.) R.C.Foster* in Contributions from the Gray Herbarium of Harvard University 135: 52 (1941). *Ixia erosa* Salisb.: 36 (1796). Type: unknown (possible authentic material at G—Herb. DC.), neotype here designated: South Africa, [Western Cape,] Tulbagh, 9 September 1945, *Lewis 5738* (neo., NBG).

Ixia hirta Thunb.: no. 6 (1782), nom. illeg. superfl. pro *I. inflexa* D.Delaroche. *Geissorhiza hirta* (Thunb.) Ker Gawl.: 224 (1804). Type: South Africa, [Western Cape], without date, *Thunberg s.n.* (Herb. Thunberg, UPS, holo.!).

Geissorhiza rosea Eckl.: 21 (1827). Type: South Africa, [Western Cape], near Tulbagh, cultivated in Cape Town, without date, *Ecklon s.n.* (S!, lecto., designated by Nordenstam 1972: 282).

Hesperantha kermesina Klatt: 15: 395 (1882). *Geissorhiza erosa* var. *kermesina* (Klatt) R.C.Foster: 53 (1941). Type: South Africa, [Western Cape], between Paarl and Pont, without date, *Drège 8480* (B, effectively designated by Foster, 1941: 53, BM!, G!, K!, L, MO!, S!, iso.).

Specimens examined

WESTERN CAPE.—3318 (Cape Town): near Stellenbosch, (–DD), Aug. 1878, *Lightfoot s.n.* (*BOL3194*); Stellenbosch, grounds of Veterinary Research, (–DD), *Schneider sub Fellingham 1614* (NBG); Onderpappagaiberg, lower slopes, rare on heuweltjies, (–DD), 23 August 1966, *Taylor 6882* (NBG). 3319 (Worcester): Tulbagh–Artois, (–AC), August 1885, *H. Bolus s.n.* (BOL); Tulbagh, lower slopes of Witzenberg, (–AC), 30 Sept. 1930, *Leighton 1338* (BOL, NBG); 2 miles [3 km] S of Tulbagh, (–AC), 9 September 1960, *Lewis 5740* (NBG); 1 mile [0.7 km] south of Tulbagh Road Station, (–AC), 1 September 1968, *Goldblatt 304* (BOL); Wellington, (–CC), 16 August 1926, *Lewis Grant 2376* (BOL). 3418 (Simonstown): Gordons Bay, (–AA), 26 September 1902, *H. Bolus 9939* (BOL). 3419 (Caledon): Van der Stel's Pass to Vyeboom, (–AA), 15 September 2007, *Goldblatt & Porter 12995* (MO, NBG); Farm Klipfontein, west of Queen Anne, (–AA), 20 September 2001, *Oliver & Oliver 11945* (NBG); 11 km SW of Villiersdorp, Fortuin 83, NE of Botrivier road, (–AA), 19 September 2001, *Helme s.n.* (NBG).

55. *Geissorhiza exscapa* (Thunb.) Goldblatt

The recorded range of *Geissorhiza exscapa* (Goldblatt 1985), a largely Western Cape coastal species, is from immediately north of Cape Town on the Farm Blaauw-

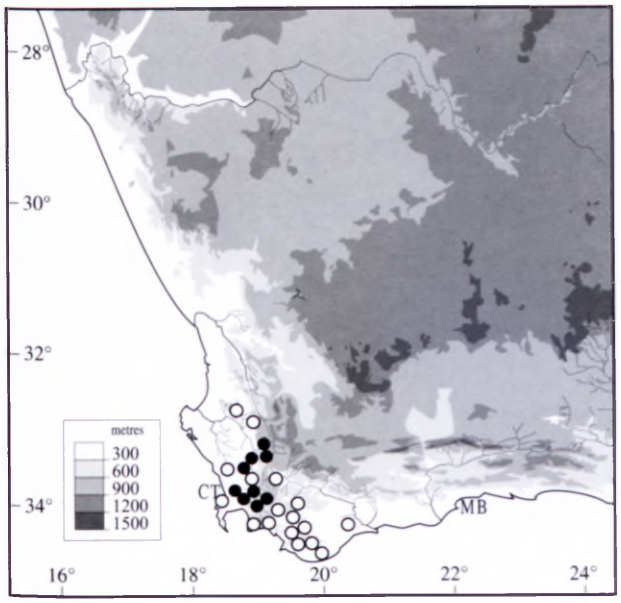


FIGURE 14.—Known distribution of *Geissorhiza erosa*, ●; *G. inflexa*, ○.

berg in the south to near Leipoldtville in the north, inland on the Olifants River and Bokkeveld Mountains and in the sandveld inland of Hondeklipbaai in Northern Cape, the latter a disjunction of nearly 200 km. New collections from the sandveld west of Koekenaap on the Farm Kommandokraal (*Goldblatt & Porter 13097* MO, NBG) and near Brand se Baai to the north (*Goldblatt & Porter 13125* MO, NBG) partly fills the gap in the range, leaving some 120 km between the Brand se Baai and Hondeklipbaai populations. We suspect that *G. exscapa* occurs between these two stations but has not, as yet, been documented.

89. *Geissorhiza heterostyla* L.Bolus

The most widespread species of the genus, *Geissorhiza heterostyla* has been recorded from Kubiskou Mountain near Loeriesfontein in the northwest, across the Bokkeveld Escarpment and Roggeveld to the southern Cape as far east as Port Elizabeth (Goldblatt 1985). We report here a modest range extension from the Langberg, an isolated, flat-topped massif about 70 km west of Loeriesfontein at the southeastern edge of Namaqualand. Plants are restricted to the summit plateau of the range, at ± 1 050 m, where they are common among dolerite rocks in the red clay derived from decomposed dolerite (5 September 2006, *Goldblatt & Porter 12770* MO; 16 September 2006, *Goldblatt & Porter 12841* MO, NBG). The species occurs there in mountain renosterveld with other typical western Karoo geophytes including among the Iridaceae, *Ixia rapunculoides*, *Moraea bifida* and *M. tripetala*, and *Boophone haemanthoides* (Amaryllidaceae) (Goldblatt *et al.* 2008).

64. *Geissorhiza minuta* Goldblatt

When described in 1985, this small-flowered species of section *Geissorhiza* was known only from the immediate vicinity of Pakhuis Pass and was thought to be endemic to this limited area, north of the main Cedarberg range (Goldblatt 1985). Additional collections have now been made some 50 km to the north on the Gifberg summit plateau (26 September 2008, *Goldblatt & Porter 13189* MO, NBG) and on sandstone rocks on the Matsikamma Mtns (19 October 1998, *Helme 1565* NBG). By sheer chance we were able to compare living plants in full bloom from Pakhuis Pass with those from the Gifberg in September 2008 and found them to differ in no significant way. The flowers are virtually identical in size with tepals 7–8 mm long and although white, as described, the outer tepals of both the Gifberg and Pakhuis plants are flushed light, or sometimes dark, purple outside, a feature not before recorded. We were also able to confirm that the stamens are equal in length, which was uncertain at the time the 1985 revision of the genus was published. The habitat in the northern populations is the same as at Pakhuis Pass: wet sandstone pavement in shallow sandy ground.

83. *Geissorhiza monanthos* Eckl.

In the 1985 account of the genus, *Geissorhiza lewisiae* R.C.Foster was included in the synonymy of *G. monanthos* (Goldblatt 1985). Field observations made since 2000 show that this decision was incorrect. Both *G. monanthos* and *G. lewisiae* have unilateral stamens and style but the flowers of *G. monanthos* have a large pale, translucent centre surrounded by a dark blue to purple or red zone, and curved, bicoloured filaments pale in the lower half but dark violet distally (Figure 15A, B). The median filament is always conspicuously shorter than the others. In contrast, *G. lewisiae* has a dark blue-violet perianth, usually pale yellow-green in the throat, uniformly violet filaments with little or no curvature, the median only very slightly shorter than the others, and the anthers are semi-prostrate (Figure 15C, D). It also usually has (1)2–5 flowers per spike in contrast to *G. monanthos*, which has 1(–4) flowers on the main spike and only one each on one or two lateral branches. Leaves of *G. monanthos* have slightly raised margins and central veins and are always glabrous, whereas leaves of *G. lewisiae* have raised and narrowly winged margins and central veins. Populations of the species from the vicinity of Saldanha have the central vein, margins and secondary veins ciliate but populations from Citrusdal and nearby have glabrous leaves. The pollen of *G. lewisiae* is pale mauve or ± white but *G. monanthos* has red-brown or occasionally white pollen.

We now follow Foster's (1941) decision to recognize the plants with dark, blue-violet flowers with a pale, yellow-green throat as *Geissorhiza lewisiae*. This species seems to us most closely related to *G. aspera* with which it is sometimes sympatric, but it is always distinguished by the larger flower size, unilateral, declinate stamens and style and more intense blue-violet pigmentation than *G. aspera* which has a ± radially symmetric flower (although an eccentric style), with erect stamens. Both species have one slightly shorter filament. *Geissorhiza lewisiae* occurs in two disjunct sets of populations: a northern one around Citrusdal in the Olifants River Valley, and a western set along the Western Cape coast, from Steenberg Cove on St Helena Bay to Saldanha Bay (Figure 16). Although typically associated with granite outcrops, it also occurs on limestone pavement and calcrete in the vicinity of Saldanha Bay. *Geissorhiza monanthos* occurs further south, extending from Darling and Mamre (Groenekloof) inland to Malmesbury and

FIGURE 15.—*Geissorhiza monanthos*. A, flowering plant; B, half-flower. *Geissorhiza lewisiae*. C, flowering plant; D, half-flower. Scale bar: 10 mm. Artist: J.C. Manning.

south to Klipheuwel and Joostenberg (Figure 16), typically occurring on gravelly, granite-derived soils.

Geissorhiza monanthos *Eckl.*, Topographisches Verzeichniss der Pflanzensammlung von C.F Ecklon: 21 (1827); R.C.Foster: 39 (1941), as *G. monantha* (Thunb.) Eckl.; Goldblatt: 422 (1985, including *G. lewisiae*). *Ixia monanthos* Thunb.: 226 (1811), hom. illeg. non D.Delaroche (1766) (= *Sparaxis* sp.). Type: South Africa, Cape: exact locality unknown, *Thunberg s.n.* (*Herb. Thunb. 975* UPS!, lecto., designated by Goldblatt 1982).

Plants 100–160(–250) mm high. *Corm* narrowly ovoid, ± 3.5 mm diam., bearing a cluster of cormlets at base, tunics imbricate, black. *Stem* minutely puberulous, simple or 1-, sometimes 2- or 3-branched. *Leaves* 3 or 4, lower 2 ± basal, ± linear to narrowly sword-shaped, slightly shorter than stem, blade narrowed and subpetiolate below, 1.5–4 mm wide, ± plane with central vein and margins slightly thickened, glabrous, uppermost leaf inserted in upper third of stem, much shorter than basal leaves. *Spike* nodding, 1 or 2(–5)-flowered, branches 1-(or 2)-flowered; bracts green below, becoming dry and brown in upper half, outer 10–13 mm long, inner 7–10 mm long. *Flowers* secund, zygomorphic, violet with glossy translucent white centre broadly edged with a band of intense violet or red; perianth tube ± 2 mm long; tepals subequal, obovate, 14–18 × 9–12 mm, sometimes narrowed into claws below leaving tepals windowed near bases. *Stamens* unilateral, declinate, unequal; filaments with lower two (6–)8–10 mm long, uppermost ± 1.5 mm shorter, slightly thicker in middle, curving upward distally, white below, distal two-thirds violet; anthers 5–6 mm long, ascending, violet, pollen white or brown. *Ovary* with style dividing opposite anther tips, branches recurved, 3–4 mm long. *Flowering time*: late August to end of September. Figure 15A, B.

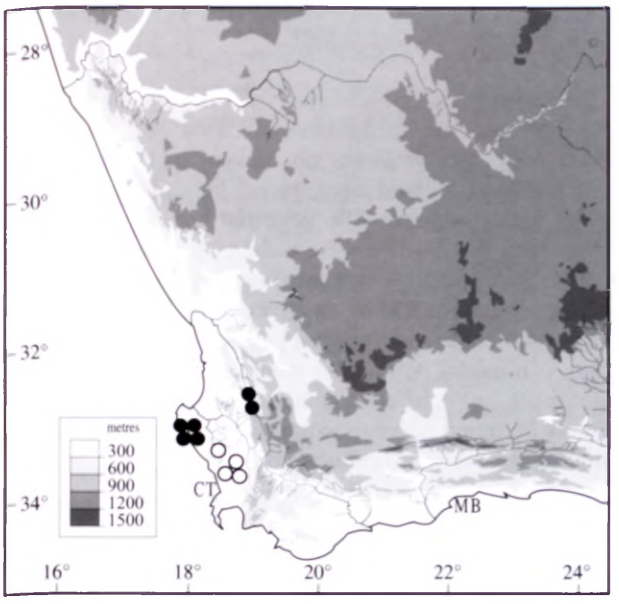


FIGURE 16.—Known distribution of *Geissorhiza lewisiae*, ●; *G. monanthos*, ○.

Selected specimens

WESTERN CAPE.—3318 (Cape Town): near Darling, (–AD), 13 September 1931, *Salter 1350* (BM, BOL), *Lavis s.n.* (*BOL19877*), 7 September 1953, *Barker 8045* (NBG); hills around Darling, (AD), *H. Bolus 12844* (BR, MO, PRE); Groenekloof [Mamre], (–AD), 1898, *MacOwan s.n.* in *Herb. Norm. Austr. Afr. 810* (B, BM, BOL, G, K, S, SAM), *H. Bolus 4341* (BOL, K); granite outcropping, Mud River road, (–AD), *Goldblatt 6286* (K, MO, PRE); near Oudepost, Malmesbury to Hopefield, (–BA), 28 September 1933, *Salter 3873* (BM, BOL, K); Abbotsdale Station, (–BC), 24 September 1949, *Martin 1168* (NBG); 10 km south of Malmesbury, hills west of Nassau, Farm Morgenwagt, (–DA), 17 September 2002, *Helme 2560* (NBG); 5.3 miles (± 7.5 km) north of Klipheuwel station, (–DA), 16 September 1982, *Acocks 20644* (NBG, PRE); N of Klipheuwel, (–DA), 16 September 1982, *Van Zyl 3186* (NBG); 0.3 mi. NE of Klipheuwel, (–DA), 6 October 1955, *Lewis 4450* (SAM); Hercules Pillar, (–DD), 20 September 1944, *Leighton 556* (BOL, K); Klapmuts, hard sandy ground, (–DD), 6 October 1955, *Lewis 4449* (MO, PRE, SAM); Joostenberg, sandy flats, (–DD), 18 October 1961, *Lewis 5902* (NBG); Bottelaryberg, Farm Koopmanskloof, (–DD), 13 September 1988, *Beyers 77* (NBG).

82. **Geissorhiza lewisiae** *R.C.Foster* in Contributions of the Gray Herbarium of Harvard University 135: 45 (1941). TYPE: South Africa, Cape: Langebaan, 7 September 1932, *Lewis s.n.* (K, holo., not seen; *BOL20303*, iso.!).

Plants 150–300 mm high. *Corm* narrowly ovoid, ± 4 mm diam., with several cormlets at base. *Stem* puberulous, often 1-, sometimes 2-branched. *Leaves* usually 4, lower two basal, blades ± linear, mostly 2–4 mm wide, margins and central vein somewhat thickened and narrowly winged, glabrous or wing margins and secondary veins ciliate-hairy, uppermost cauline leaf sparsely hairy to smooth. *Spike* nodding in bud, flexuose, (1)2–5-flowered, branches with fewer flowers; bracts green below, dry and brown in upper half to two-thirds, outer 10–17 mm long, inner 8–12 mm long. *Flowers* secund, zygomorphic, glossy dark violet, yellow-green at base of tepals and in throat narrowly edged darker violet; perianth tube funnel-shaped, ± 2 mm long; tepals subequal, oblanceolate, outer 15–18 × 7–8 mm, inner longer and narrower, 17–20 × ± 5 mm. *Stamens* unilateral, declinate, unequal; filaments 6–8 mm long, uppermost 0.5–1.5 mm shorter, laxly reclinate, violet, sometimes pale yellow-green at base; anthers 5–6 mm long, reclinate, pale violet, pollen white or mauve. *Ovary* with style reclinate, dividing opposite anther tips, branches recurved, 3–4 mm long. *Flowering time*: late August to end of September. Figure 15C, D.

Selected specimens

WESTERN CAPE.—3217 (Vredenburg): Steenberg Cove, (–CC), 2 September 1944, *Leighton 601* (BOL, K, PRE), *Lewis 1038* (BOL, PRE, SAM); Jacobsbaai, calcrete, (–DD), 29 August 2005, *Helme 3536* (NBG); Witteklip, near Vredenburg, (–DD), 1 September 1944, *Leighton 597* (BOL), *Lewis 1039* (SAM), *Compton 15915* (NBG); 18 September 1980, *Goldblatt 5846* (MO, NBG, US). 3218 (Clanwilliam): 5 miles [± 7 km] north of Citrusdal, (–CA), 1 September 1948, *Compton 20761* (NBG); 26 August 1957, *Lewis 5201* (NBG). 3317 (Saldanha): Postberg, (–BB), 8 September 1957, *Lewis 5244* (NBG). 3318 (Cape Town): Olifants Kop, east of Langebaan, (–AA), September 1974, *Goldblatt 2705* (BR, MO, PRE, S, US, WAG).

54. *Geissorhiza tenella* Goldblatt

Geissorhiza tenella, one of three species of *Geissorhiza* (all subgenus *Weihea* section *Engysiphon*) with leaves H-shaped in section with broadly winged margins held ± at right angles to the blade surface, is a lowland species of sandy, coastal and near inland habitats. Its recorded range is from Yzerfontein northwest of Darling in the west to De Hoop, near Bredasdorp in the southeast. A collection from Skulpiesbaai Reserve, Stilbaai (13 October 2000, *De Villiers & Pienaar SKB20* NBG) extends the range some 60 km to the east. Plants of this collection have a perianth tube 25–30 mm long and tepals 13 × 2 mm, the shortest and narrowest recorded in the species. Flower dimensions recorded until now for the species are perianth tube (20–)30–40(–50) mm long and tepals 14–23 × 3.0–4.5 mm (Goldblatt 1985).

FLORAL ECOLOGY

Vogel (1954), in his touchstone account of pollination in the southern African flora, predicted (largely based on floral morphology) that *Geissorhiza* was primarily a bee-pollinated genus. He also inferred that at least *G. juncea* (thought by him to have flowers open at night) was moth-pollinated and that *G. fourcadei*, *G. ovata*, and *G. namaquensis* were adapted for the syndrome he called phalaenophily, in which he included butterflies and long-proboscid flies. Vogel made no direct pollinator observations in *Geissorhiza* but knew of Scott Elliot's (1891) report of visits to *G. aspera* (as *G. secunda*) by bees (two species of Halictidae and *Apis mellifera*) and a bee fly (Bombyliidae). Pollination in *Geissorhiza* has remained among the least known of any African genus of Iridaceae (Goldblatt & Manning 2006) and we thus present those observations that we have accumulated over the past 15 years, noting that a more thorough study of floral ecology of *Geissorhiza* is needed.

A study of pollination at one site, Lions Head, Cape Town (Nänni unpubl. data, 1994 and 1995), has shown that four sympatric and ± co-blooming, short-tubed and small-flowered species, *G. aspera*, *G. inflexa*, *G. juncea* and *G. pusilla* are pollinated predominantly by small bees (mainly Halictidae) but with occasional visits by bee flies (Bombyliidae). Hover flies (Syrphidae) and hopliine beetles were also captured while visiting *G. aspera* and *G. pusilla*, and in addition, *Braunsapis* spp. (Apidae) and honey bees were captured on *G. aspera*

flowers (Table 4). For *G. inflexa* and *G. juncea*, halictid bees far outnumbered visits by other insects. The long-tubed *G. ovata*, also present at the Lions Head site and co-blooming, was occasionally visited by halictids but its long tube and ample nectar suggests that these insects are not its legitimate pollinators as they cannot reach the nectar held within the lower part of the tube. The white and pink flower of *G. ovata* combined with the well-developed tube suggest tabanid flies are the legitimate pollinators but none were seen at the Lions Head site, nor at a second site at Sir Lowry's Pass where we observed open flowers for two consecutive mornings on warm days ideal for pollinator studies.

Experimental pollinations conducted at Lions Head using standard methods for establishing self and cross compatibility showed that *Geissorhiza aspera* and *G. pusilla* are self-compatible when pollinated by hand but showed reduced seed-set when not manipulated by hand (in both crosses insect visitors were excluded). In contrast, *G. inflexa*, *G. juncea* and *G. ovata* were self-incompatible. Attempts to produce interspecific hybrids by hand-crossing consistently failed, whether species from the same or different subgenera are crossed. These results complement a report of self-compatibility and autogamy in *G. corrugata* (Goldblatt 1985) and our determination here of self-compatibility in *G. heterostyla*, otherwise unknown in the genus. In one respect these results are surprising, for interspecific crosses are readily made in *Gladiolus*, *Sparaxis* and *Watsonia*, all members of the same subfamily, Crocoideae (Horn 1962; Goldblatt & Manning 1998). Production of interspecific crosses is, however, possible in *Geissorhiza*, for there are occasional records of naturally occurring hybrids in the genus. One of these is a report of interspecific hybrids between *G. aspera*, *G. inflexa* and *G. tulbaghensis* (*Loubser 2185*, *2188* BOL, NBG); another between *G. ovata* and *G. parva* (Goldblatt 1985) and a third between *G. brehmii* and *G. radians* at Koelenhof near Stellenbosch (*Beyers 80* NBG). The hybrids exhibit various degrees of intermediacy between the species involved.

Observations that we have accumulated since 1998 while studying the pollination of other genera of Iridaceae add modestly to this record (Table 4). Species with a short perianth tube (typically 2–4 mm long) and a radially symmetric flower, including *G. imbricata*, *G. juncea*, *G. karooica*, *G. louisabolusiae* and *G. ornithogaloides*, are pollinated by female bees of the families Andrenidae, Colletidae and Halictidae and worker honey bees (Table 4), sometimes in combination with hopliine beetles or short-proboscid Tabanidae or butterflies. The only pollinator we have seen and captured on pink-flowered *G. foliosa*, which has a perianth tube ± 5 mm long, was the butterfly, *Colias electo*. Putative pollinators captured on *G. heterostyla* at different sites included halictid bees (*Patellapis* spp.), as well as the hopliine beetles, *Anisonyx* and *Anisochelus*, and at one site *Colias electo* alone. Nectar volumes were always small, 0.5 µl or less, sampled in the field using unbagged flowers. Nectar is evidently lacking in *G. bracteata*, *G. foliosa*, *G. louisabolusiae* and *G. tulbaghensis* (flowers we examined had no nectar in the middle of the afternoon). In contrast, we recorded nectar of high concentration in one population of *G. karooica* (46.5–> 50 %) and uniformly > 50 % in a second population of *G. karooica* as well as in *G. heterostyla* and *G. ornithogaloides*.

Populations of *Geissorhiza inflexa* with small white flowers seem primarily bee-pollinated; we have captured only *Apis mellifera* on flowers of the species at one site, and halictid bees, pierid butterflies and bombylid flies at another. The large red flowers of the Tulbagh form of *G. erosa* were visited by pollen-collecting female *Melitta* sp. (Melittidae) and *Scrapter heterodoxus* (Colletidae) bees and by two species of hopliine beetles (Table 4). These red-flowered populations thus appear to have a bimodal pollination strategy (sensu Manning & Goldblatt 2005), offering pollen to bees and a large, brilliantly coloured perianth to attract hopliines to a suitable site for assembly and copulation.

Particularly notable is our observation for *Geissorhiza inconspicua* and *G. ramosa* (Table 4), which were actively pollinated by empidid flies (*Empis* cf. *mavitii*: Empidideae), small nectar-feeding Diptera ± 5.5 mm long, in combination with small halictid bees (*Lasioglossum* spp.). Both these species of *Geissorhiza* had small white flowers at our study site in Tradouw Pass (and both may also have blue flowers). We have been unable to repeat observations on additional populations of either species. We know of no other published records of pollination in the family by empidid flies but we confirmed that the flies brushed against stigmatic surfaces and carried dorsal loads of pollen, exclusively of *G. foliosa* and *G. ramosa*, on their bodies. Thus at least at the Tradouw Pass site, empidid flies were effective agents for pollen transfer, as were the halictid bees, which were far outnumbered by the empidids. Empidid flies have also been recorded by us on the short-tubed flowers of *Ixia rapunculoides*, *Sparaxis pillansii* and *S. tricolor* at sites on the Bokkeveld plateau (unpublished observations). The two *Sparaxis* species are believed to be adapted for hopliine pollination (Goldblatt *et al.* 2000b) and *I. rapunculoides* for large anthophorine bee pollination (Goldblatt *et al.* 2000a).

Observations of pollination in the strikingly coloured, dark blue, red and white flowers of the *Geissorhiza radians* group are still unfortunately limited. We captured unidentified halictid bees and the horsefly *Philoliche atricornis* on *G. eurystigma* and the bee *Andrena* sp. (Andrenidae) and beetle *Anisonyx ursus* (Scarabaeidae–Hopliini) on *G. monanthos*. Again, these insects carried loads of pollen of the host species and were seen to brush against stigmatic surfaces. *Geissorhiza splendidissima*, which has a brilliant blue perianth and brown anthers and pollen, is visited by *Apis mellifera* and the large *Anthophora longipes*.

Geissorhiza cantharophila is so far the only species of the genus shown to be primarily adapted for pollination by hopliine beetles. As mentioned above, we captured three species of beetles on flowers of the species at two different sites, *Anisonyx hilaris*, *A. ignitus* and *Anisochelus inornatus* (Table 4). We infer the same pollination system for *G. tricolor* because of its flower pigmentation: bright yellow with a large dark-brown central eye. The purple-flowered form of *G. aspera* from Malmesbury also requires mention here. Unlike the blue-violet- and white-flowered populations, which have a yellow-green tube edged in a darker colour, in the Malmesbury

TABLE 4.—Insect pollinators captured on *Geissorhiza* species with plant voucher number. Arranged by subgenus (bee vouchers are deposited at the Snow Entomological Museum, Lawrence, Kansas; long-proboscid flies at KwaZulu-Natal Museum, Pietermaritzburg). Abbreviations: *G, Goldblatt; M, Manning; N, Nänni; P, Porter*

Taxon	Captured insects (plant voucher data or reference if not an original report)
Subgenus *Weihea*	
Section *Engysiphon*	
G. bonaspei Goldblatt	*Prosoeca nitidula, Philoliche rostrata* (*G 11640* MO)
G. confusa Goldblatt	*Philoliche gulosa* (*G & N 10572* MO); *P. rostrata* (*G & M 10119, 11042* MO)
G. exscapa (Thunb.) Goldblatt	*Moegistorhynchus longirostris* (*G & M 10346, G & P 12628* MO); (Manning & Goldblatt 1997)
G. schinzii (Baker) Goldblatt	*Prosoeca westermannii* (not captured) (*G & M 11035* MO)
G. tenella Goldblatt	*Moegistorhynchus longirostris* (Manning & Goldblatt 1997)
Sections *Weihea* and *Angustifolia*	
G. bracteata Klatt	*Apis mellifera* (*G & P 12714* MO)
G. foliosa Klatt	*Colias electo* (*G & M 10783* MO)
G. hispidula (R.C.Foster) Goldblatt	halictid bee (*G & N 11934* MO)
G. inconspicua Baker	*Empis* cf. *maviti, Lasioglossum* spp. (*G & N 11580* MO, NBG)
G. juncea (Link) A.Dietr.	*Patellapis* sp. (*G 11554*, MO); Halictidae (4 spp.), *Scrapter* sp. (no voucher)
G. karooica Goldblatt	*Apis mellifera* (*G & P 12929* MO, NBG)
G. ornithogaloides Klatt	*Apis mellifera, Vanessa cardui* (*G & N 11197* MO)
G. purpurascens Goldblatt	*Hoplitis* sp., *Anisonyx ursus* (*G & M 11560* MO)
G. pusilla (Andr.) Klatt	Halictidae (3 spp.), Bombyliidae, Syrphidae (no voucher)
Subgenus *Geissorhiza*	
G. aspera Goldblatt	*Apis mellifera* (*G & M 9403* NBG); Halictidae (2 spp.) *Braunsapis* sp., *Apis mellifera, Anisonyx ursus*, Bombyliidae, Syrphidae (no voucher); *Apis mellifera, Anthophora diversipes* (white form, *G & P 13072* MO, NBG); *Anisonyx ursus* (purple form, *G & P 13160* MO)
G. cantharophila Goldblatt & J.C.Manning	*Anisochelus inornatus* (*G & P 12704* MO, NBG); *Anisonyx hilaris, A. ignitus*, (*G & P 12915* MO)
G. eurystigma L.Bolus	halictid bee (109), *Philoliche atricornis* (no voucher)
G. heterostyla L.Bolus	*Patellapis* sp., *Apis mellifera, Anisonyx ignitus, Anisochelus inornatus* (*G & P 12791* MO, NBG); halictid bees (not captured), *Anisochelus inornatus* (*G & P 12792* MO); *Colias electo* (*G 11431* MO); *Lasioglossum* sp., *Anisochelus inornatus* (*G & P 12801* MO); *Lasioglossum* sp., *Apis mellifera* (*G & P 12962* MO)
G. imbricata (D.Delaroche) Ker Gawl.	halictid bee (*G & N 11937* MO)
G. inflexa (D.Delaroche) Ker Gawl.	
(small white flowers)	*Apis mellifera* (*G 10310A* MO); Halictidae (1 sp.), Bombyliidae, Pieridae (no voucher)
(large scarlet flowers)	*Scrapter heterodoxus, Melitta* sp., *Peritrichia rufotibialis, Lepithrix ornatella* (*G 11426* MO)
G. louisabolusiae R.C.Foster	*Lasioglossum* (2 spp.), *Patellapis* sp. (*G & P 12605* MO, NBG)
G. monanthos Eckl.	*Andrena* sp., *Anisonyx ursus* (*G & N 11553* MO)
G. ramosa Ker Gawl. ex Klatt	*Empis* cf. *maviti, Lasioglossum* spp., *Apis mellifera* (*G & N 11578* MO, NBG)
G. splendidissima Diels	*Apis mellifera, Anthophora longipes* (*G & P 13194* MO)
G. tulbaghensis F.Bolus	*Philoliche atricornis* (*G & M 13019*; *G 11573* MO)

populations the flowers are purple with the filaments and throat dark purple-black. We suspect the population has shifted from a generalist to an exclusively hopliine pollination system. *Anisonyx ursus* is sometimes seen on the flowers. Apart from perianth and filament pigmentation, we find no differences with typical *G. aspera*. This unusual form is threatened today by urban development as new suburbs develop around Malmesbury.

Lastly, the southwestern Cape endemic, *Geissorhiza tulbaghensis*, which has large, zygomorphic, white flowers with a dark brown centre, is visited exclusively by the horsefly, *Philoliche atricornis*, also a common visitor to co-blooming *Arctotheca capensis* and *Dimorphotheca pluvialis* (Asteraceae). These two species have flower heads with dark disk florets and yellow or white rays. We speculate that *G. tulbaghensis* is a Batesian mimic of these species of Asteraceae as it offers no apparent reward to the flies; the flowers lack nectar and the pollen is held distant from the dark centre of the flower, so that only the dorsum brushes against them. Captured flies all carried dorsal loads of brown *G. tulbaghensis* pollen and ventral loads of yellow asteraceous pollen. These naked-eye pollen identifications were confirmed by microscopic examination.

The remaining information about floral ecology of *Geissorhiza* consists of observations on pollinator and nectar characteristics accumulated during studies of the nemestrinid fly *Moegistorhynchus longirostris* (Nemestrinidae) pollination guild (Manning & Goldblatt 1997) and of long-proboscid fly pollination systems in southern Africa (Johnson & Steiner 1997; Goldblatt & Manning 2000b). Species of section *Engysiphon* (subgenus *Weihea*) with narrow, elongate perianth tubes exceeding 20 mm, are pollinated exclusively by long-proboscid flies: *G. bonaspei* by *Prosoeca nitidula* and *Philoliche rostrata* (Tabanidae); *G. exscapa* and *G. tenella* by *Moegistorhynchus longirostris* and *G. confusa* by *Philoliche rostrata*. We confirm pollination by long-proboscid flies in *G. confusa* and *G. exscapa* here with a record of *Philoliche gulosa* pollinating flowers of the former in Van der Stel's Pass near Bot River, and *M. longirostris* pollinating the latter in the Olifants River Mtns near Graafwater. We have also observed *G. schinzii* of section *Engysiphon* being visited by *Prosoeca westermannii* in the Houw Hoek Mountains, but the flies avoided capture (Table 4). In addition, *G. kamiesmontana* of section *Ciliata* (subgenus *Geisshorhiza*), which has a perianth tube

18–25 mm long, and *G. stenosiphon* with a tube 40–50 mm long, are inferred to be pollinated by long-proboscid flies. The violet flower colour in *G. kamiesmontana* suggests it belongs to the *Prosoeca peringueyi* pollination guild (Manning & Goldblatt 1996) and the white flower of *G. stenosiphon* suggests pollination by *M. longirostris* or *Philoliche rostrata*. Nectar of these long-proboscid fly-pollinated species is of moderate volume (1.9–5.6 µl) and concentration (19.6–29.0 % mean sucrose equivalents) (references cited above and unpublished for *G. schinzii*).

Available information thus shows two primary patterns in *Geissorhiza*. The majority of species with radially symmetric flowers and a short perianth tube have a mixed (or generalist) pollination system using a range of female bees of at least four families and worker honey bees, sometimes together with hopliine beetles, and occasionally butterflies, short-proboscid tabanid flies, bee flies and hover flies. Small halictid bees are the most frequent visitors. Visits by *Apis mellifera* workers may be opportunistic for we have seen no other large-bodied bees of the family Apidae visiting *Geissorhiza* flowers. A second pattern is the specialization for long-proboscid fly pollination in species with narrow, elongate tubes and unilateral stamens. Pollination primarily or exclusively by hopliine beetles is known for just one species, *G. cantharophila*, but is likely in a few more, e.g. *G. tricolor* described above. *Geissorhiza tulbaghensis* appears to be a radiate daisy flower mimic. Deceptive pollination using short-proboscid Tabanidae is unique not only in the genus but in Iridaceae and we know of no other examples matching the pollination system we found in *G. tulbaghensis*. Deceptive pollination using long-proboscid flies has been inferred for two species of *Hesperantha* (Iridaceae) and one of *Pelargonium* (Geraniaceae) (Goldblatt *et al.* 1995, 2004a) but these species have flowers that mimic those of similar shape and colour in co-blooming Iridaceae that offer nectar. The record of empidid fly pollination in *G. inconspicua* is also unusual, and may represent a purely opportunistic event. Too little is known about the role of Empididae in pollination.

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APPENDIX 1.—Keys to subgenera and species of *Geissorhiza*. Species numbers follow the classification in Table 1

Key to subgenera

1a Plants with concentric corm tunics, old tunics completely enclosed by new ones and layers splitting vertically from base or from apex, tunics usually brown and ± woody or ± fibrous; stamens always equal in length ..... subgenus *Weihea*
1b Plants with overlapping corm tunics, old tunics pushed upward and fragmenting into tile-like segments from base, usually blackish and woody; stamens equal or unequal with one filament shorter than other two ..... subgenus *Geissorhiza*

Key to *Geissorhiza* subgenus *Weihea*

1a Stamens and style included in lower half of perianth tube:
2a Leaves plane, 3–5 mm wide; flowers white ..... 29. *G. esterhuyseniae*
2b Leaves with margins and central veins heavily thickened, 1.5–2.0 mm wide; flowers pink with dark markings at bases of tepals 30. *G. cedarmontana*
1b Stamens and style, or at least style branches, exserted from perianth tube:
3a Foliage leaf solitary and stem with scale-like, membranous bract in upper half ..... 38. *G. unifolia*
3b Foliage leaves two or more in addition to scale-like bracts in upper half of stem:
4a Leaf blades spirally twisted; style usually dividing opposite base of anthers; flowering stems each with single flower:
5a Flowers yellow; perianth tube ± 3 mm long ..... 25. *G. corrugata*
5b Flowers mauve; perianth tube 4–5 mm long ..... 26. *G. spiralis*
4b Leaf blades more or less straight or falcate but not spirally twisted; style dividing opposite or beyond anthers; flowering stems with one to several flowers:
6a Corm tunics entirely of fibrous layers or softly membranous, either not accumulating or becoming fibrous with age:
7a Perianth tube 2–4 mm long; tepals 10–13 mm long:
8a Flower white to pale mauve-pink ..... 43. *G. umbrosa*
8b Flowers deep blue to mauve or violet ..... 44. *G. alticola*
7b Perianth tube 5–18 mm long; tepals 12–22 mm long:
9a Tepals 17–22 long; perianth tube 9–18 mm long, exserted from or included in bracts:
10a Perianth tube 10–18 mm long, well exserted from bracts; corm tunics of fine, netted fibres; leaves linear, 2-grooved on each surface with margins and central vein heavily thickened; plants of open rocky slopes ..... 47. *G. nubigena*
10b Perianth tube 9–13 mm long, not or barely exserted from bracts; corm tunics soft-textured, soft-papery, not becoming fibrous; leaves linear, ± plane with margins and central veins moderately thickened; plants of waterfalls and wet, shaded rocks ..... 6. *G. uliginosa*
9b Tepals 12–18 mm long; perianth tube 5–8(–10) mm long, not or barely exserted from bracts:
11a Perianth pink; plants 60–120 mm high; lower leaves prostrate, 20–50 × 2.5–6.0 mm, ± plane with thickened margins; flowering January ..... 10. *G. altimontana*
11b Perianth mauve to violet; plants 100–300 mm high; leaves linear, 1–3 mm wide, 2-grooved on each surface with margins and central vein heavily thickened; flowering mostly late November and December:
12a Corm tunics finely fibrous; leaves 2–3 mm wide; flowers without pale throat; perianth tube 5–8(–10) mm long .... 45. *G. hesperanthoides*
12b Corm tunics membranous; leaves 1.0–1.5 mm wide; flowers with pale throat; perianth tube 4–6 mm long .. 46. *G. cataractarum*
6b Corm tunics firm-papery to woody in texture, often drawn into bristles above:
13a Leaves not plane, either strongly ridged, or margins and central vein heavily thickened, or blade terete with 4 narrow longitudinal grooves:
14a Flowers moderate in size to large (tepals (14–)17–40 mm long), mostly whitish or cream-coloured to pink, usually darker pink on reverse; stamens unilateral and declinate; bracts acute (section *Engysiphon*):
15a Leaves not sticky, terete with hairline longitudinal grooves; perianth tube 12–20 mm long; tepals 20–30 mm long; plants of exposed rock outcrops only seasonally moist ..... 5. *G. fourcadei*
15b Leaves sticky, sometimes only sheaths, blades always with margins strongly thickened or raised but if 4-grooved then grooves clearly visible:
16a Leaf blades with margins raised and winged but central vein hardly thickened, thus appearing H-shaped in cross section, marginal wings often curving inward and blade thus appearing terete:
17a Tepals linear or narrowly lanceolate, 3.0–4.5 mm wide, usually uniformly white ..... 54. *G. tenella*
17b Tepals oblong to obovate, 4.5–7.0 mm wide, usually whitish flushed with pink or uniformly pink:
18a Perianth tube 15–30 mm long; spike borne on well-developed stem, (1)2–4(5)-flowered ..... 53. *G. bonaspei*
18b Perianth tube 40–80 mm long; spike borne on disproportionately short stem, sometimes spike virtually at ground level, (1–)3–9-flowered ..... 55. *G. exscapa*
16b Leaf blades terete to linear or falcate, with both central vein and margins thickened and winged but visibly with 2 narrow grooves on each surface:
19a Perianth tube ± 8 mm long, included in bracts and about a third as long as tepals ..... 49. *G. brevituba*

19b Perianth tube 20–50 mm long, reaching at least to bract apices or exceeding bracts and about as long as or longer than tepals:
20a Tepals 17–27 mm long, white or barely flushed with pink ..... 51. *G. longifolia*
20b Tepals 28–40 mm long, pink or cream-coloured, becoming flushed with pink with age:
21a Tepals slightly longer than perianth tube, 9–15 mm wide ..... 50. *G. schinzii*
21b Tepals shorter than perianth tube, 7–10 mm wide ..... 52. *G. confusa*
14b Flowers small to moderate in size; tepals mostly 6–25(–30) mm long, either white to yellow, or blue or deep pink (whitish flushed pink in two species); stamens either symmetrically arranged or unilateral and declinate; bracts obtuse:
22a Leaf blade terete with four hairline longitudinal grooves:
23a Perianth tube elongate, 40–80 mm long ..... 42. *G. stenosiphon*
23b Perianth tube short, 2–10 mm long:
24a Flowers small, cream-coloured to yellow; tepals outspread when fully open, 8–14 mm long; perianth tube 2–3 mm long ..... 39. *G. juncea*
24b Flowers moderate in size, pale to golden yellow; tepals often remaining cupped when fully open, 15–25 mm long; perianth tube 3–9 mm long:
25a Flowers golden yellow; perianth tube 3–5 mm long ..... 40. *G. furva*
25b Flowers lemon yellow; perianth tube 7–9 mm long ..... 41. *G. sufflava*
22b Leaf blade linear to falcate with two visible, relatively wide longitudinal grooves on each surface:
26a Flowers mauve, blue, purple or pink:
27a Perianth tube 7–8 mm long; spike 1–4-flowered ..... 31. *G. lithicola*
27b Perianth tube 3–6 mm long; spike 4–10-flowered:
28a Plants 150–350 mm tall; flowers pale mauve ..... 32. *G. purpurascens*
28b Plants 80–140 mm tall; flowers pale pink (darkening when dry) ..... 48. *G. helmei*
26b Flowers white to cream-coloured or yellow:
29a Stem minutely hairy in upper half ..... 37. *G. intermedia*
29b Stem smooth:
30a Flowers small; tepals 7–9 mm long ..... 36. *G. pappei*
30b Flower moderate in size, tepals 10–22 mm long:
31a Bracts not normally sticky; perianth tube 9–11 mm long; flowers with dark centre ..... 34. *G. darlingensis*
31b Bracts sticky and usually with sand adhering; perianth tube 3–6 mm long; flowers uniformly coloured inside:
32a Flowers whitish to cream-coloured, outer tepals usually flushed reddish outside; tepals 10–15 mm long and perianth tube 3–4 mm long ..... 35. *G. hispidula*
32b Flower pale yellow; tepals 16–26 mm long, not normally flushed red on reverse, and perianth tube 5–6(–10) mm long ..... 33. *G. humilis*
13b Leaves plane or nearly so, margins and central veins only slightly raised:
33a Flowers zygomorphic with stamens and style unilateral and declinate:
34a Flowers purple or blue; tepals 12–18 mm long:
35a Leaves prostrate, soft-textured; flowers blue-mauve; perianth tube ± 3 mm long ..... 12. *G. monticola*
35b Leaves upright, firm-textured; flowers purple; perianth tube (5–)6–8 mm long ..... 27. *G. karooica*
34b Flowers pink with darker markings; tepals 22–32 mm long:
36a Stems and leaves trailing; leaf blades soft-textured; perianth tube 10–13 mm long ..... 4. *G. outeniquensis*
36b Stems and leaves erect; leaf blades firm-textured; perianth tube 8–10 mm long ..... 3. *G. roseoalba*
33b Flowers actinomorphic with stamens symmetrically arranged:
37a Leaves linear to narrowly sword-shaped, mostly 1–2(–4) mm wide, never hairy even on margins; spike sometimes with only 1 or 2 flowers:
38a Perianth tube 6–8 mm long, usually exserted from bracts; flowers white to cream-coloured, rarely pale yellow:
39a Plants 40–80 mm high; stem rarely branched, never dichotomously ..... 15. *G. setacea*
39b Plants usually more than 120 mm high; stem usually dichotomously branched ..... 20. *G. geminata*
38b Perianth tube 2–5 mm long, included in bracts; flowers white, yellow or lilac:
40a Flowers clear yellow; corms pointed at base or bell-shaped with flat base:
41a Flowers cup-shaped; tepals 13–25 mm long; perianth tube ± 4 mm long ..... 18. *G. malmesburiensis*
41b Flowers rotate when fully open; perianth tube 2–3 mm long:
42a Style branches 2–3 mm long, filiform, ciliolate with hairs shorter than width of style branch; tepals 6–12(–18) mm long; anthers 3–6 mm long ..... 17. *G. ornithogaloides*
42b Style branches ± 1.5 mm long, linear, conspicuously ciliate with hairs longer than width of style branch; tepals 6–7 mm long; anthers ± 1.5 mm long ..... 19. *G. platystigma*
40b Flowers white or lilac; corms pointed at base:
43a Flowers tiny, tepals 3–6 mm long; perianth tube 1.0–2.5 mm long ..... 14. *G. nana*
43b Flowers somewhat larger; tepals 6–12 mm long; perianth tube 2–5 mm long:
44a Flowers pale lilac or purple; perianth tube 2–3 mm long; leaves soft-textured, spreading or prostrate ..... 11. *G. delicatula*
44b Flowers white; perianth tube 2–5 mm long; leaves firm, ascending to erect:
45a Perianth tube 3–5 mm long; outer tepals rarely flushed red or purple outside; leaves ± sword-shaped, 2–9 mm wide ..... 13. *G. bracteata*
45b Perianth tube 2–2.5 mm long; outer tepals red outside; leaves up to 1 mm wide, linear-falcate, exceeding the spike ..... 16. *G. lapidosa*
37b Leaves sword-shaped, lanceolate or ovate, (2–)3–10 mm wide, smooth or hairy, sometimes only on margins; spike often with more than 2 flowers:
46a Basal leaves ± upright:
47a Perianth tube 8–10 mm long; flowers pale pink ..... 2. *G. elsiae*
47b Perianth tube 2–6 mm long; flowers white, pink, or blue to violet:
48a Plants branching mainly at base; flowering stems mostly 1- or 2(3)-flowered; flowers white, sometimes flushed red on reverse ..... 13. *G. bracteata*
48b Plants branching above ground level, or unbranched; flowering stems usually with at least 3 flowers and as many as 7:
49a Flowers blue; leaf sheaths and sometimes proximal parts of blades and margins minutely hairy to pubescent .. 28. *G. pusilla*
49b Flowers never blue; leaves entirely smooth or minutely hairy on margins:
50a Leaves half to two-thirds as long as spike; flowers white or violet; tepals mostly 8–11 mm long, sometimes longer ..... 1. *G. inconspicua*
50b Leaves less than a third as long as spike; flowers mauve, pink or yellow to orange; tepals 13–17 mm long:
51a Flowers deep yellow to orange, dark brown-maroon in centre ..... 8. *G. tricolor*

51b Flowers pink or mauve, without dark centre:
52a Perianth tube 4–5 mm long; style branches ± 3 mm long ..... 7. *G. foliosa*
52b Perianth tube 2–3 mm long; style branches 4–5 mm long ..... 9. *G. nigromontana*
46b Basal leaves prostrate or inclined toward ground:
53a Perianth tube 10–30 mm long, as long as or longer than tepals; leaves usually broadly ovate and minutely velvety along margins ..... 24. *G. ovata*
53b Perianth tube 1.5–8.0 mm long; leaves narrowly ovate to lanceolate, usually hairless:
54a Leaves firm-textured; cormlets never produced in aerial leaf axils:
55a Perianth tube 3–4 mm long; flowers creamy white to pale yellow; spike mostly 3–6-flowered ..... 23. *G. parva*
55b Perianth tube 2.5–3.0 mm long; flowers white; spike 1- or 2-flowered ..... 13. *G. bracteata*
54b Leaves soft-textured, often flaccid; cormlets borne in aerial leaf axils:
56a Flowers solitary on each flowering stem, lilac or blue ..... 11. *G. delicatula*
56b Flowers usually more than one per flowering stem, white to pale yellow:
57a Stem either without or with only one cauline leaf; flowers fertile, capsules developing rapidly after flowering ..... 21. *G. ovalifolia*
57b Stem bearing 2 leaves or more above ground level; flowers sterile, and cormlets produced in bract axils in place of capsules after flowering ..... 22. *G. bolusii*

Key to *Geissorhiza* subgenus *Geissorhiza*

1a Stem minutely hairy, puberulous or pilose, sometimes only in lower part (hand lens usually needed to detect this character):
2a Perianth tube (6–)8–25 mm long:
3a Flowers pink; perianth tube 15–17 mm long; one filament shorter than other two ..... 78. *G. silenoides*
3b Flowers blue to violet; filaments equal:
4a Perianth tube (6–)8–11 mm long; filaments 5–6 mm long ..... 85. *G. namaquensis*
4b Perianth tube 18–23 mm long; filaments 8–10 mm long ..... 86. *G. kamiesmontana*
2b Perianth tube less than 3 mm long:
5a Stamens unequal, one filament at least 0.5 mm shorter than other two:
6a Leaves ± plane with margins and central vein slightly to moderately thickened, but not obviously winged; margins and central vein smooth or minutely puberulous:
7a Perianth predominantly purple, pale in throat; short filament at least 4 mm shorter than long filaments; tepals 18–23 mm long ..... 81. *G. inaequalis*
7b Perianth predominantly blue to violet or white; short filament no more than 2 mm shorter than long filaments; tepals 7–20 mm long:
8a Flowers radially symmetric except for eccentric style; tepals 7–11 mm long; flowers violet to pale blue or predominantly white:
9a Tepals mostly 11–14 × 4–6 mm; spike mostly with 3–7 flowers; anthers 3–5 mm long ..... 79. *G. aspera*
9b Tepals ± 7 × 3.5 mm; spike with 1 or 2 flowers; anthers ± 2 mm long ..... 80. *G. demissa*
8b Flowers zygomorphic with unilateral stamens and style; tepals 14–20 mm long; flowers predominantly violet with pale throat or pale centre edged in dark pigment:
10a Flowers with large pale, translucent centre edged with dark violet or red; filaments curved and slightly thickened in middle; spike with 1 or 2(–5) flowers; pollen usually red-brown or white ..... 83. *G. monanthos*
10b Flowers violet with pale throat; filaments straight and filiform throughout; spike with 2–5 flowers; pollen pale mauve or white ..... 82. *G. lewisiae*
6b Leaves with raised central vein (and sometimes secondary veins) bearing wings arching over leaf surface and margins with wings held ± at right angles to blade; wing edges smooth or ciliate to long-hairy:
11a Flowering stem with a short, membranous, scale-like bract in upper third sometimes subtending a branch:
12a Tepals 8–9 mm long; anthers ± 2.5 mm long ..... 74. *G. scopulosa*
12b Tepals 10–22 mm long; anthers 4–6 mm long:
13a Style always short, dividing below level of anthers; flowers glossy pink to purple with dark centre; filaments, style and style branches dark purple ..... 90. *G. cantharophila*
13b Style usually at least reaching to middle of anthers (occasional short-style plants may occur in some populations); flowers blue to violet, mauve or white with pale centre, often edged with darker colour, style and style branches white to pale blue or mauve:
14a Long filaments 10–12 mm long; basal leaves prostrate ..... 91. *G. reclinata*
14b Long filaments 4–6 mm long; basal leaves erect to falcate ..... 89. *G. heterostyla*
11b Flowering stem without a scale-like bract in upper third:
15a Leaves smooth or minutely hairy along margin edges; flowers blue or white ..... 92. *G. arenicola*
15b Leaves conspicuously hairy along margin edges; flowers pale mauve, whitish, or pale pink:
16a Plants rarely higher than 80 mm; tepals 7–8 × 2–3 mm ..... 97. *G. saxicola*
16b Plants (12–)16–30 mm high; tepals (13–)18–28 × 7–10 mm ..... 99. *G. leipoldtii*
5b Stamens equal:
17a Leaves plane with margins and central vein slightly thickened but not winged; flowers zygomorphic with stamens and style unilateral and declinate; anthers and pollen brown:
18a Flowers white with reddish to brown-patterned centre ..... 84. *G. tulbaghensis*
18b Flowers glossy dark blue-violet, pale in throat ..... 93. *G. splendidissima*
17b Leaves with margins significantly thickened and/or raised into wings; flowers radially symmetric except for eccentric style; anthers and pollen not brown, usually white to yellow:
19a Leaf margins and central vein thickened, rendering blades 2-grooved on each surface; margins smooth not ciliate ..... 75. *G. ciliatula*
19b Leaf margin edges raised at right angles to blade surface to form wings, these ciliate to hairy along edges:
20a Flowers small; tepals 6–8 mm long; anthers ± 2.5 mm long ..... 98. *G. erubescens*
20b Flowers larger; tepals (13–)15–28 mm long; anthers (3–)6–8 mm long ..... 99. *G. leipoldtii*
1b Stem smooth:
21a Stamens unequal, one at least 0.5 mm and usually more than 2 mm shorter than others; leaf margins lightly to moderately thickened but never raised into wings extended at right angles to surface:
22a Flowers small, with tepals 7–11 mm long:
23a Stem inclined to trailing, usually 1-branched, occasionally 2-branched; flowers white ..... 73. *G. brycola*
23b Stem erect, simple or usually 2- or 3-branched; flowers white or blue to violet:
24a Flowers blue to violet ..... 72. *G. ramosa*
24b Flowers white ..... 64. *G. minuta*

22b Flowers moderate in size to large; tepals (12–)14–30 mm long:
25a Flowers creamy yellow with or without dark centre:
26a Flower uniformly creamy yellow; tepals 18–28 mm long; stamens symmetrically arranged, longer filaments 7–9 mm long ..... 61. *G. louisabolusiae*
26b Flower pale yellow with blackish centre; tepals 22–30 mm long; stamens unilateral and declinate, longer filaments 15–20 mm long ..... 60. *G. barkerae*
25b Flowers blue, purple, mauve, or pink:
27a Perianth tube short, up to 3 mm long ..... 71. *G. tabularis*
27b Perianth tube 4–25 mm long:
28a Leaf blades plane ..... 76. *G. pseudinaequalis*
28b Leaf blades with margins and central vein moderately to heavily thickened:
29a Perianth tube 4–6 mm long ..... 68. *G. burchellii*
29b Perianth tube 10–25 mm long:
30a Tepals 12–15 mm long ..... 77. *G. rupicola*
30b Tepals 22–30 mm long:
31a Perianth tube 10–18 mm long; anthers and pollen yellow ..... 69. *G. grandiflora*
31b Perianth tube 22–25 mm long; anthers purple and pollen pinkish ..... 70. *G. callista*
21b Stamens equal in length; leaf margins either only lightly to moderately thickened or raised into wings held at right angles to surface and minutely hairy to hispid along edges:
32a Leaf blades minutely to velvety hairy on veins and margins; bracts ± dry and rust-coloured distally at anthesis:
33a Leaf blades with margins and central vein raised and winged, minutely hairy to pubescent on edges; stem without scale-like bract in upper half:
34a Plants small, 70–120(–140) mm high; tepals ± 8 × 3–4 mm ..... 96. *G. exilis*
34b Plants mostly 150–250 mm high; tepals (8–)10–24 × 6–10 mm:
35a Flowers white to cream-coloured; tepals (8–)10–18 × 6–7 mm; anthers 4–6 mm long ..... 94. *G. inflexa*
35b Flowers white to pink, red or purple; tepals 18–24 × 8–10 mm; anthers 7–8 mm long ..... 95. *G. erosa*
33b Leaf blades ± ribbed and velvety; stem with 1 or 2 scale-like bracts in upper half:
36a Flowers ± white, outer tepals flushed reddish on reverse or uniformly blue; tepals ± 10 mm long ..... 87. *G. divaricata*
36b Flowers blue to mauve; tepals 12–17 mm long ..... 88. *G. subrigida*
32b Leaf blades not visibly hairy or minutely hairy; bracts remaining green or dry and pale distally:
37a Leaf blades of lower two leaves linear or terete, margins and central veins moderately to heavily thickened, grooves between raised parts sometimes very narrow:
38a Foliage leaves 2, upper one sheathing lower half of stem and with short free blade; stem bearing short, membranous, scale-like bract in upper half ..... 57. *G. scillaris*
38b Foliage leaves 3, sometimes the lowermost lost by flowering time; stem without scale-like bract in upper half:
39a Leaf blades terete with 4 hair-like longitudinal grooves ..... 62. *G. brehmii*
39b Leaf blades with central vein and margins separated by wide grooves ..... 56. *G. similis*
37b Leaf blades of lower two leaves with two or more ribs (including central vein):
40a Flowers white to pale yellow, sometimes with dark central mark:
41a Tepals mostly 11–25 mm long and perianth tube mostly 4–8 mm long; tepals often flushed reddish on reverse, often without dark centre ..... 58. *G. imbricata*
41b Tepals mostly 10–16 mm long and perianth tube 2–4 mm long; tepals seldom flushed red on reverse and with dark centre:
42a Spikes mostly 2- or 3-flowered, rarely more; perianth cream to yellow with dark brown to purplish centre ..... 59. *G. purpureolutea*
42b Spikes mostly at least 5-flowered; perianth uniformly white or cream ..... 63. *G. sulphurascens*
40b Flowers blue-violet with red centre:
43a Stamens and style unilateral and declinate; style branches linear-filiform; red centre of flower edged in white ..... 67. *G. radians*
43b Stamens and style symmetrically arranged; style branches ovate-spathulate, about 2–3 × 2 mm; red centre of flower not edged in white:
44a Perianth tube 6–9 mm long; anthers erect, borne below style branches ..... 65. *G. eurystigma*
44b Perianth tube up to 2.5 mm long; anthers arching inward, borne above style branches ..... 66. *G. mathewsii*