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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Keywords: Apoidea, compatibility, Empididae, floral biology, Geissorhiza Ker Gawl., nectar characteristics, Nemestrinidae, new keys, new species, pollen morphology, pollination, southern Africa, Tabanidae, taxonomy

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. We also report range extensions and provide morphological notes for several species, including G. magniniana 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 brings 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 Burt et al. 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.
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 hopline 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 hopline 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.

| TABLE 1.—Classification of *Geissorhiza* species arranged by subgenus and section including new species described here, based on Goldblatt’s (1985) infrageneric classification |
|---------------------------------|---------------------------------|---------------------------------|
| **Subgenus Wethea (Eckl. ex Baker) Goldblatt** | **Subgenus Geissorhiza** |
| Section Wethea Eckl. ex Baker | Section Includanthera Goldblatt |
| 1. G. inconspicua Baker | 29. G. esterhuesenii Goldblatt |
| 2. G. elisa Goldblatt | 30. G. cedarmontana Goldblatt |
| 3. G. rosea Goldblatt | Section Angustifolia Goldblatt |
| 5. G. fourcadei (L.Bolus) G.J.Lewis | 32. G. purpurascens Goldblatt |
| 7. G. fuscata Klett | 34. G. darlingensis Goldblatt |
| 8. G. truncator Goldblatt & J.C. Manning, sp. nov. | 35. G. hipsulica (R.C. Foster) Goldblatt |
| 10. G. altimontana Goldblatt & J.C. Manning, sp. nov. | 37. G. intermedius Goldblatt |
| 11. G. delicatula Goldblatt | 38. G. umfolozi Goldblatt |
| 13. G. bracteata Klett | 40. G. furva Ker Gawl. ex Baker |
| 15. G. setacea (Thunb.) Ker Gawl. | 42. G. stenomphphon Goldblatt |
| 16. G. lapidosa Goldblatt & J.C. Manning, sp. nov. | Section Isoptis Goldblatt |
| 17. G. ornithogaloides Klett | 43. G. umbrosa G.J.Lewis |
| 18. G. malmebriensis R.C.Foster | 44. G. alticola Goldblatt |
| 20. G. gimenata E.Mey. ex Baker | 46. G. cataractarum Goldblatt |
| 21. G. ovatifolia R.C.Foster | 47. G. multigena Goldblatt |
| 22. G. bolusii Baker | Section Engysiphon (G.J.Lewis) Goldblatt |
| 24. G. ovata (L.) Asch. & Graebn. | 49. G. brevistyla (G.J.Lewis) Goldblatt |
| Section Tortuosa Goldblatt | 50. G. schinzii (Baker) Goldblatt |
| 25. G. corrugata Goldblatt | 51. G. longifolia (G.J.Lewis) Goldblatt |
| 26. G. spiralis (Burch.) M.P.de Vos ex Goldblatt | 52. G. confusa Goldblatt |
| 27. G. karooica Goldblatt | 53. G. bonaperti Goldblatt |
| Section Passilia Goldblatt | 54. G. tenella Goldblatt |
| 28. G. pusilla (Andrews) Klett | 55. G. escapa (Thunb.) J.C. Manning |

Section Intermedia Goldblatt |

56. G. similis Goldblatt |

57. G. scillaris A.Dietr. |

Section Geissorhiza |

58. G. imbricata (D.Delaroche) Ker Gawl. |

59. G. purpureoleuca Baker |

60. G. barkerae Goldblatt |

61. G. lousiabulosaue R.C.Foster |

62. G. bremilii Eckl. ex Klett |

63. G. sulphurascens Schltr. ex R.C.Foster |

64. G. minuta Goldblatt |

65. G. eurystigma L.Bolus |

66. G. mathewszii L.Bolus |

67. G. raulans (Thunb.) Goldblatt |

Section Monticola Goldblatt |

68. G. burchelli R.C.Foster |

69. G. grandiflora Goldblatt |

70. G. callista Goldblatt |

71. G. tabularis Goldblatt |

72. G. ramosa Ker Gawl. ex Klett |

73. G. brivcola Goldblatt |

74. G. scopulosa Goldblatt |

75. G. ciliaris Goldblatt |

76. G. pseudnaeuquis Goldblatt |

77. G. napauica Goldblatt & J.C. Manning |

78. G. silenoides Goldblatt & J.C. Manning |

Section Plantifolia Goldblatt |

79. G. aspera Goldblatt |

80. G. demissa Goldblatt & J.C. Manning, sp. nov. |

81. G. inaequilis L.Bolus |

82. G. lewissiae R.C.Foster |

83. G. monanthos Eckl. |

84. G. talbagnensis F.Bolus |

Section Ciliatae Goldblatt |

85. G. namaquensis W.F.Barker |

86. G. kamemontana Goldblatt |

87. G. davanata 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 Dels |

94. G. inflexa (D.Delaroche) Ker Gawl |

95. G. erson (Salisb.) R.C.Foster |

96. G. elis 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 |
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 Bellington & 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 MORPHOLGY

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 spines. 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-
<table>
<thead>
<tr>
<th>Taxon</th>
<th>Collection data and herbarium acronym or literature reference</th>
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<tbody>
<tr>
<td><strong>Grains monosulcate with two-banded operculum</strong></td>
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<tr>
<td><strong>Subgenus Weihea</strong></td>
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<tr>
<td><strong>Section Weihea</strong></td>
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<tr>
<td>G. foliosa Klatt</td>
<td>Goldblatt &amp; Manning 10783 (MO)</td>
</tr>
<tr>
<td>G. inopinataea Baker</td>
<td>Goldblatt &amp; Nānni 11580 (MO)</td>
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<tr>
<td>G. monticola Goldblatt &amp; J.C.Manning</td>
<td>Goldblatt &amp; Porter 11872 (MO, NBG)</td>
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<td>G. ornithogaloides Klatt</td>
<td>Goldblatt &amp; Nānni 11197 (MO), Goldblatt 11467 (MO)</td>
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<tr>
<td>G. ovato (L.f.) Asch. &amp; Graebn.</td>
<td>no voucher</td>
</tr>
<tr>
<td>G. parvula Baker</td>
<td>Goldblatt &amp; Porter 12266 (MO) (operculum vestigial)</td>
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<tr>
<td><strong>Section Angustifolia</strong></td>
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<tr>
<td>G. juncea (Link) A.Dietr.</td>
<td>Goldblatt 11554 (MO)</td>
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<td>G. aff. pappei Baker</td>
<td>Goldblatt &amp; Manning 9944 (MO, NBG)</td>
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<td>G. purpurascens Goldblatt</td>
<td>Goldblatt &amp; Manning 11560 (MO, NBG)</td>
</tr>
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<td>G. safflava Goldblatt &amp; J.C.Manning</td>
<td>Goldblatt &amp; Manning 9468 (MO, NBG)</td>
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<td><strong>Section Ixiopsis</strong></td>
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<tr>
<td>G. nubigena Goldblatt</td>
<td>Goldblatt 10608 (MO)</td>
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<tr>
<td><strong>Section Engysiphon</strong></td>
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<tr>
<td>G. bonaspei Goldblatt</td>
<td>Goldblatt 11640 (MO)</td>
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<tr>
<td>G. confusa Goldblatt</td>
<td>Goldblatt &amp; Manning 10119 (MO)</td>
</tr>
<tr>
<td>G. excapa (Thumb.) Goldblatt</td>
<td>Goldblatt &amp; Manning 10346 (MO)</td>
</tr>
<tr>
<td>G. longifolia (G.J.Lewis)</td>
<td>Goldblatt &amp; Manning 11486 (MO), Oliver 4070 (NBG)</td>
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<td>G. schizae (Baker) Goldblatt</td>
<td>Goldblatt et al. (1991)</td>
</tr>
<tr>
<td>G. tenella Goldblatt</td>
<td>Goldblatt &amp; Manning 10376 (MO)</td>
</tr>
<tr>
<td><strong>Subgenus Geissorhiza</strong></td>
<td></td>
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<tr>
<td><strong>Section Ciliatae</strong></td>
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<tr>
<td>G. divaricata Goldblatt</td>
<td>Goldblatt 10291 (NBG)</td>
</tr>
<tr>
<td>G. erubescens Goldblatt</td>
<td>Compton 19964 (NBG)</td>
</tr>
<tr>
<td>G. heterostyla L.Bolus</td>
<td>Goldblatt 6261, 5305, 5824 (MO); Goldblatt &amp; Manning 10293 (MO); Goldblatt &amp; Porter 12770 (MO), 12822 (MO, NBG)</td>
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<td>G. leipoldtii R.C.Foster</td>
<td>Van Rooyen et al. 718 (NBG)</td>
</tr>
<tr>
<td>G. namaquensis W.F.Barker</td>
<td>Goldblatt &amp; Manning 9705 (NBG)</td>
</tr>
<tr>
<td>G. subrigida L.Bolus</td>
<td>Lewis 5886 (NBG)</td>
</tr>
<tr>
<td><strong>Section Geissorhiza</strong></td>
<td></td>
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<tr>
<td>G. barkerae Goldblatt</td>
<td>Goldblatt 6391 (NBG)</td>
</tr>
<tr>
<td>G. euryystigma L.Bolus</td>
<td>no voucher</td>
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<tr>
<td>G. louisaboulosiae R.C.Foster</td>
<td>Goldblatt &amp; Porter 12605 (MO)</td>
</tr>
<tr>
<td>G. purpureulater Baker</td>
<td>Goldblatt &amp; Manning 11139 (NBG)</td>
</tr>
<tr>
<td>G. radians (Thumb.) Goldblatt</td>
<td>Goldblatt et al. (1991); Van Zyl 3512 (NBG)</td>
</tr>
<tr>
<td>G. sulphurascens Schltr. ex R.C.Foster</td>
<td>Snijman 896 (NBG); Goldblatt &amp; Manning 9465 (NBG)</td>
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<tr>
<td><strong>Section Intermedia</strong></td>
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<tr>
<td><strong>Section Monticola</strong></td>
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<tr>
<td>G. bryicola Goldblatt</td>
<td>Williamson 3683 (NBG)</td>
</tr>
<tr>
<td>G. burchelli R.C.Foster</td>
<td>Williams 3754 (NBG)</td>
</tr>
<tr>
<td>G. callista Goldblatt</td>
<td>Goldblatt 8680 (NBG)</td>
</tr>
<tr>
<td>G. grandiflora Goldblatt</td>
<td>Oliver &amp; Oliver 11468 (NBG)</td>
</tr>
<tr>
<td>G. pseudinaequalis Goldblatt</td>
<td>Manning 2220 (NBG)</td>
</tr>
<tr>
<td>G. ramosa Ker Gawl. ex Klatt</td>
<td>Esterhuysen 36144 (NBG), 33703 (MO)</td>
</tr>
<tr>
<td>G. silenosoides Goldblatt &amp; J.C.Manning</td>
<td>Goldblatt &amp; Manning 9739 (NBG)</td>
</tr>
<tr>
<td><strong>Section Planifolia</strong></td>
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<tr>
<td>G. arenicola Goldblatt</td>
<td>Goldblatt &amp; Nānni 11154 (NBG); Goldblatt &amp; Porter 11888A (NBG)</td>
</tr>
<tr>
<td>G. aspera Goldblatt</td>
<td>Goldblatt &amp; Manning 9403 (NBG)</td>
</tr>
<tr>
<td>G. inaequalis L.Bolus</td>
<td>Goldblatt &amp; Porter 11795 (NBG)</td>
</tr>
<tr>
<td>G. monanthos Eckl.</td>
<td>Breyers 77 (NBG); Goldblatt &amp; Nānni 11553</td>
</tr>
<tr>
<td>G. splendidissima Diels</td>
<td>Barker 9549 (NBG)</td>
</tr>
<tr>
<td>G. tulbaghensis F.Bolus</td>
<td>Solomon 38 (NBG)</td>
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<tr>
<td><strong>Grains with complex multiple apertures</strong></td>
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<tr>
<td>Type 1 grains: two elliptic apertures, smaller nested in larger; type 2: more complex apertures described in text</td>
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<tr>
<td><strong>Subgenus Weihea</strong></td>
<td></td>
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<tr>
<td>G. bracteata Klatt</td>
<td>type 1: Goldblatt &amp; Porter 12358A (MO); Goldblatt &amp; Porter 12714 (MO, NBG)</td>
</tr>
<tr>
<td>G. nama Klatt</td>
<td>type 1: Goldblatt &amp; Manning 12255 (MO)</td>
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</table>
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 species of Geissorhiza, which 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 Huntsamberg 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 Weihnea, G. bracteata and G. nama 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, hopline beetles, and occasionally butterflies, a pattern encountered widely in Geissorhiza (see below). Geissorhiza cantharophila is adapted for pollination by hopliones, 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 subgenus. Their position and number in the classification of Geissorhiza is given in Table 1.

Subgenus Weihnea (Eckl, ex Baker) Goldblatt

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

Plantae 100–150–(200) mm altae, coromo globoso 5–6 mm diam. tunicis concentricis lignonis duris, foliis 6 ad 8 erectis vel falcatis 15–50 × (2–)3.5–5 mm planis, caule erecto simplici vel 1-vel 2-ramoso, spica (12–)vel 3-flora, bracteis viridis distillator rubro-suffusis (12–) 15–18 mm longis, floribus actinomorphae rotatis aureis ad centrum atromarroninis nitidis ad tubum flavoviridis 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.
Bothalia 39,2 (2009)

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 hopline beetles. No hoplines 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 hopline beetles at other sites (Goldblatt et al. 1998).

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).
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.

Plants 100–160 mm altae, cormo globoso ± 10 mm diam., tunics concentricis atrobrunneis, foliis 5 vel 6, 4 inferioribus basaliis prostratis lanceolatis 20–50 x 2.5–6.0 mm, spica 1- vel 2-flora, bracteis viridis ad apicem rubris 7–10 mm longis, floribus actinomorphis caeruleo-malvineis. perianthii tubo 7–8 mm longo, filamentis ± 8 mm longis, 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 100–160 mm high including flowers, stem base sheathed underground by a collar of dry, persistent leaf bases, and above ground by dry calli thyrsi. 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 x 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 ± cylindrical, 7–8 mm long; tepals subequal, oblong, ± 14 x 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.
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.

Eponym: 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.
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., tunics concentricis lignosis nigrescentibus, foliis 4 laminis linearis-limbatis crassis coriaceis glaucis marginibus saepe rubrescentibus ad 50 x 0.5–1.0 mm, folio supremo vaginanti, spica 1–vel 2-flora, bracteis coriaceis glaucis ovatis bractea exteri- or 4–5 mm longa, interiori ad apicem furcata, floribus
actinomorphis albis tepalis exterioribus extus rubro-car- 
cenis, tubo perianthii infundibuliformi 2.0–2.5 mm longo, 
tepalis petalitis oblongoellatis ± 6 x 2 mm, filamentis 
3.5–4 mm longis, antheris 1.5–2.0 mm longis ± albis, 
stylus dimidium inferiorem antherarum adversum diviso, 
ramis 1.5–2 mm longis.

TYPE.—Western Cape, 3319 (Worcester); Du Toits-
kleo Mtms., Goudini Sneekup, westem 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-flow-
ered; bracts leathery and glaucous flushed reddish but sub-
membranous and finely flecked with brownish red along 
margins, broadly ovate, outer truncate or obscurely tri-
cuspidate, 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 subequall, obovatoellate, 
± 6 x 2 mm. Stamens with filamentis 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 oppo-
site 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.

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

Distribution and ecology: known from two small colo-
nies below the shale band on Goudini Sneekup in the Du 
Toitskloof Mtms (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 under-
lying 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 Geis-
sorhiza lapidosa in section Weitha of subgenus Weiha. 
It is distinguished from similar small species of the sec-
tion by its high montane habit and unusual leathery, fal-
cate 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, typi-
ical 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 filamentes ± 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. Man-
ning, sp. nov.

Plants 25–50 mm altae, cormo campanolatu basi 
ad marginem dentato ± 3 mm diam., foliis linearibus 
1 mm latis, caule usitate prope basin 1- vel 2-ramoso, 
floris actinomorphis flavis, tubo perianthii ± 1.5 mm 
longo infundibuliformi, tepalis anguste ovatis ± 6 x 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 & Nönni 111624 
(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-flow-
ered; bracts green or flushed purple distally, outer ± 8 
mm long, inner ± 6 mm long, not forked at apex. Flowers 
actinomorphic, upright, pale yellow, unscented; peri-
ant tube funnel-shaped, ± 1.5 mm long; tepals narrowly 
ovoate, 6–7 x ± 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.

Eponymology: from the Greek, plat·y, 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. matthewii 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. matthewii.

Additional specimens examined


41. Geissorhiza suftlava Goldblatt & J.C. Manning, sp. nov.

Plants 100–150 mm altae foliis exclusis, cormo globo-so ± 8 mm diam., tunicis pallide brunnescs concentricis, caule eramoso, foliis (2 vel) 3 imo longiore saepe spicam excedentis, laminis terebratis angustis 4-sulcatis, spica forte flexuosa 1–vel 2-flora, bracteis ± siccis pallide translucens brunneis 12–16 mm longis, floribus cupulatis pallide flavis in centro brunnis. 7–9 mm longis, tepalis angustis ovatis 18–25 x 6.0–8.5 mm. Stylo 12–14 mm longis, ramis stylis ± 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, hol.; MO, PRE, iso.).

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 x 6.0–8.5 mm. Stamens: filaments 12–14 mm long, exerted 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.
Capsules and seeds unknown. Flowering time: September. Figure 9.

**Eponym:** 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 Gaul., 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 111664 (MO).
Bothalia 39.2 (2009)

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

Plantae 80–150 mm altae, cormo ovoideo 10–15 mm diam., tunics concentric, pinkish 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 paler-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 spine 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, unsecented; 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, sagitate 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 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 Engysphon (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 decline, 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., tunics imbricatis nigrescentibus, caule puberuloso sed subglabro infra spicam, foliis 4, duobus inferioribus basibus linearius longi vel falcatis ± 0.7–1.0 mm latiis marginibus costaque leviter incrassatis. bracteis viridibus in dimidio superiore siccis brunnescentibus, tecta caerulea ± 5 mm alta, tunicis imbricatis nigrescentibus. bractea externa ± 5 mm longa, bractea interna ± 4 mm longa, floribus actinomorphicis, caeruleis, tepalis exterioreae ± 6 mm longi, antherae ± 2 mm longae, pollen ± white. Capsules and seeds unknown. Flowering time: late August to October, probably also in early November. Figure 11.

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

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

Plants 250–450 mm altae, cormi tunicis imbricatis, foliis 3 duobus inferioribus laminis productis linearibus marginibus et costa incrassata alis cilisque 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 bicornata ad apicem furcata, floribus actinomorphis, nitide carneis in centro atropurpureis, perianthii tubo 2.0–2.5 mm longo infundibuliformi, tepalis ovatis subaqualibus patentibus ± 15 × 7 mm, filamentis styloque atropurpureis, filamentis 4–5 mm longis uno ± 1 mm breviore quam alii, antheris 5–8 mm longis sagittatis lobulis ad basem per ± 2 mm divergentibus, stylo ± 3 mm longo ramis ascendentibus 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, tunic 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, flexuous, (3–)5– 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, sagitate, 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-facing 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 hopline 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. Hopline beetles captured in the flowers include Anisochelus mornatus, 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 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 *C. cantharophila*.

**Additional specimens examined**


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

Plants 80—120 mm altae, corni tunics imbricatis abrurcnesce, folis usitate 3 duobus inferioribus prostratis linearibus marginibus costaque leviter incrassatis alatis ciliatis, folio supero caulem vaginant sed distaliter libero, caule usitate 1- ad 3-ramoso, parce piloso, spica 1- ad 3-flora, spatula 7—8 mm longa integra, floribus zygomorphis, caeruleo-malininis in centro viridi-flavis, perianthii tubo ± 2 mm longo influndibiliformi, tepalis anguste ovatis subaequalibus patentibus, ± 8 x ± 7 mm, filamentis duobus 10—12 mm longis uno 8—10 mm longo, anthers 5—8 mm longis subgagatissatis lobulis ad basem per ± 2 mm dervinentibus, stylo reclinato ramis recurvatis ± 1.5 mm longis.

**TYPE.** — Western Cape, 3322 (Oudtshoom): Swartberg, Meiringspoort, southwest-facing slopes among sandstone rocks, (—BC), 16 August 2002, *Goldblatt & Porter 12057* (NBG, hol.; MO, PRE, isoo.).

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 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* zygomorphische, 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 ± 3—4 mm. *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 Oudtshoom (Figure 8). Plants grow on moist, peasy sand on southwest-facing 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. pseudoaequalis* 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.

Plants 70—140 mm altae, corno 3—4 mm diam., tunics imbricatis abrurcnesce, folis usitate 3 duobus inferioribus basalius 30—40 × 1.5—2.5 mm linearius vel falcatus marginibus costaque leviter incrassatis alatis ciliatis, folio supero caulem vaginant sed distaliter libero, caule usitate 1- vel 2-ramoso, glabro, spica 1- ad 3-flora, bracteis inaequalibus viridibus in dimidio superiore siccis brunnescentibus, perianthi tubo ± 1.5 mm longo, interna 5—6 mm longa, tepalis ovatis subaequalibus patentibus, ± 8 x ± 3—4 mm, filamentis aequalibus ± 2 mm longis, anthers 3—4 mm longis, stylo erecto ramis recurvatis ± 1.5 mm longis.

**TYPE.** — Western Cape, 3319 (Worcester): Swartberg, Meiringspoort, southwest-facing slopes among sandstone rocks, ± 390 m, (—CA), 22 September 2007, *Goldblatt & Manning 13014* (NBG, hol.; K, MO, PRE, isoo.).

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—2-branched, bearing scale-like bract 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 x 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.

Eponym: from the Latin, exilis, small or slender.

Distribution and ecology: Geissorhiza exilis is known only from the slopes of the Waaioek Mins 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 corns 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, corumo ignoto, caule erecto papillato-villoso simplici vel uniramosis, foliiis 3 oblongis, basalis vel folio summo caule prope basin inserto, planis falcatis vel trahentibus sublinearibus 1.5–4.0 mm latis marginibus subacutis alatis, alis prominenter pilosis, spica (1–)2–3 ad 6-flora (ramo, si adest, 1– vel 2-flora tantum), bracteis infra viridibus in dimidio superiore siccis brunneisque, bractea exterma 7–8(–10) mm longa interna breviore, floribus albis usque pallide cameis, perianthii brunneisque, bractea externa 7–8(–10) mm longa interna 2-veinata, anomeris sagittatis 3.3–4.0 mm longis, stylo manifeste erecto ramis 1.3–1.8 mm longis.

TYPE.—Western Cape, 3319 (Wuppertal) [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 moss places on shale band, 1 000 m, (-AC), 5 September 1982, Viviers 584 (NBG).

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 moss 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 Gra-hamstown (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
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Bokkeveld Mountains and the Gitberg 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. diversicata 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 (Thunn.) 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 x 8-10 mm and anthers (6-)7-10 mm long. The outer bracts are 18-20 mm long, the inner tepals ± 2 mm shorter. In contrast, typical G. inflexa also has a perianth tube ± 2 mm long, but tepals 10-15 x 7-8 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.


Geissorhiza rosea Eckl.: 21 (1827). Type: South Africa, [Western Cape], near Tulbagh, cultivated in Cape Town, without date, Ecklon s.n. (St., lecto., designated by Nordenskiöld 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, Drege 8480 (B, effectively designated by Foster, 1941: 53; BM; G; K; L; MO, iso.).

Specimens examined

WESTERN CAPE.—3318 (Cape Town): near Stellenbosch, (-DD), Aug. 1878, Lightfoot s.n (BOL,1943); Stellenbosch, grounds of Veterinary Research, (-DD), Schneider sub Fellingham 1614 (NBG); Onderpappelberg, lower slopes, rare on heuweltjies, (-DD), 23 August 1966, Lewis 6882 (NBG). 3319 (Worcester): Tulbagh-Artois, (-AC), August 1885, H. Bolus s.n. (BOL); Tulbagh, lower slopes of Witzberg, (-AC), 30 Sept. 1930, Leighton 1338 (BOL, NBG); 2 miles [3 km] S of Tulbagh, (-AC), 9 September 1960, Lewis 5109 (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 (Simons-town): Gordons Bay, (-AA), 26 September 1902, H. Bolus 9939 (BOL); 3419 (Caledon): Van der Stel's Pass to Vyeboom, (-AA), 15 September 2001, Goldblatt & Porter 12995 (MO, NBG); Farm Klipfontein, west of Stellenbosch, (-CC), 19 June 2001, Oliver & Oliver 11945 (NBG); 11 km SW of Villiersdorp, 83, NE of Botriver road, (-AA), 19 September 2001, Helme s.n. (NBG).

55. Geissorhiza excappa (Thunb.) Goldblatt

The recorded range of Geissorhiza excappa (Goldblatt 1985), a largely Western Cape coastal species, is from immediately north of Cape Town on the Farm Blauw-
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 inland on the Olifants River and Bokkeveld Mountains 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. escapa 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 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)–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...
south to Klipheuwel and Joostenberg (Figure 16), typically occurring on gravelly, granite-derived soils.


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.
Selected specimens

WESTERN CAPE.—3318 (Cape Town): near Darling, (-AD), 13 September 1931, Salter 1550 (BM, BOL), Lewis s.n. (BOL19777), 7 September 1953, Barker 8945 (NBG); hills around Darling, (AD), H. Bolos 12844 (BR, MO, PRE); Groenekloof [Namee], (-AD), 1988, MacCown s.n. in Herb. Norm. Aust. Afr. 810 (B, BM, BOL, G, K, S, SAM), H. Bolos 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); Abbottsdale Station, (-BC), 24 September 1949, Martin 1168 (NBG), 10 km south of Malmesbury, hills west of Nassau, Farm Morgenwacht, (-DA), 17 September 2002, Helme 2560 (NBG); 5.3 miles (+ 7.5 km) north of Klipheweal station, (-DA), 16 September 1982, Acocks 26044 (NBG, PRE); N of Klipheweul, (-DA), 16 September 1982, Van Zyl 3186 (NBG); 0.3 mi. NE of Klipheweul, (-DA), 6 October 1955, Lewis 4450 (SAM), Hercules Pillar, (-DD), 20 September 1944, Leighton 556 (BOL, K); Klappmuts, hard sandy ground, (-DD), 6 October 1955, Lewis 4449 (MO, PRE, SAM); Joostenberg, sandy flats, (-DD), 18 October 1961, Lewis 5902 (NBG); Bottelaryberg, Farm Koopmans-kloof, (-DD), 13 September 1988, Beyer 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, holotype, not seen; BOL20303, iso!).

Plants 150–300 mm high. Corm narrowly ovoid, ± 4 mm diam., with several cornelets 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 leaf margin sparingly hairy to smooth. Spike nodding in bud, flexuose, (12)–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 subequall, ob lanceolate, outer 15–18 x ± 8 mm, inner longer and narrower, 17–20 x ± 5 mm. Stamens unilaterial, 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 1058 (BOL, PRE, SAM); Jacobsbaai, calcrite, (-DD), 29 August 2005, Helme 3535 (NBG); Witteklip, near Vredenburg, (-DD), 1 September 1944, Leighton 597 (BOL), Lewis 1059 (SAM), Compton 15915 (NBG); 18 September 1980, Goldblatt 3845 (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 27105 (BOL, 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 × 23–30 x ±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 hopline 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 (Louwerse 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. louisiabolusiae 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 hoplinite beetles or short-proboscid Tabanidae or butterflies. The only pollinator we have seen and captured on pink-flowered was the butterfly, Colias electo. Putative pollinators captured on G. heterostyla at different sites included halictid bees (Patellapis spp.), as well as the hoplinite 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. louisiabolusiae 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. aspera were visited by pollen-collecting female Melitta sp. (Melitididae) and Scraper heterodoxus (Colletidae) bees and by two species of hoplinite 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 hoplinites 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: Empidiidae), 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 pilansis and S. tricolor at sites on the Bokkeveld plateau (unpublished observations). The two Sparaxis species are believed to be adapted for hoplinne 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 radiis group are still unfortunately limited. We captured unidentified halictid bees and the horsefly Philolichia atrocoris on G. eurystigma and the bee Andrena sp. (Andrenidae) and beetle Anisonyx ursus (Scarabaeidae-Hoplini) on G. monanthos. Again, these insects carried loads of pollen of the host species and were seen to brush against stigmatic surfaces. Geissorhiza splendistissima, 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 hoplinite 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

<table>
<thead>
<tr>
<th>Subgenus</th>
<th>Captured insects (plant voucher data or reference if not an original report)</th>
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<td>Wehea</td>
<td>Table 4-insect pollinators captured on</td>
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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 *Philolache rostrate*. 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 hoplini 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 unilaterial stamens. Pollination primarily or exclusively by hoplini bees is known for just one species, *G. cantharophila*, but is likely in a few more, e.g. *G. tricolor* described above. *Geissorhiza tubulagennis* 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. tubulagennis*. 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.

**ACKNOWLEDGEMENTS**

Support for this study by grants 6704-00, 7103-01, 7316-02, 7799-05 and 8248-07 from the National Geographic Society is gratefully acknowledged. We thank Robert Brooks, Holger Dombrow, Charles Michener, Brian Stuckenberg and the late V. Whitehead for their help with the identification of insects, and Nick Helme for regularly bringing novelties to our attention, including four of the new species described here. We also extend our gratitude to Elizabeth Parker and Lendon Schinz for revising our literature; Roy Gereau for revising our Latin descriptions; and Sharon Bodine for help with herbarium searches. Collecting permits were provided by the nature conservation authorities of Western Cape and Northern Cape Provinces, South Africa.

**REFERENCES**


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

### Key to subgenera

1a Plants with concentric corollum tunic, old tunics completely enclosed by new ones and layers splitting vertically from base or from apex, tunics usually brown and ± woody or ± fibrous; stamens equal in length
   subgenus *Weihea*

1b Plants with overlapping corollum tunic, 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
   2b Leaves with margins and central veins heavily thickened, 1.5-2.0 mm wide; flowers pink with dark markings at bases of tepals

1b Perianth tube 5-13 mm long, not or barely exserted from bracts; corm tunics soft-textured, soft-papery, not becoming fibrous with age
   3a Corm tunics entirely of fibrous layers or softly membranous, either not accumulating or becoming fibrous with age:
   4a Leaf blades spirally twisted; style usually dividing opposite base of anthers; flowering stems each with single flower
   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

### Key to *Geissorhiza* subgenus *Geissorhiza*

1a leave 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
   8b Flowers deep blue to mauve or violet

7b Perianth tube 5-18 mm long; tepals 12-22 mm long:
   9a Tepals 17-22 long; perianth tube 9-13 mm long, exserted from or included in bracts:
   10a Perianth tube 10-18 mm long, well exserted from bracts; corollas of fine, netted fibres; leaves linear, 2-grooved on each surface with margins and central vein heavily thickened; plants of open rocky slopes
   10b Perianth tube 9-13 mm long, not or barely exserted from bracts; corollas soft-textured, not becoming fibrous; leaves linear, ± plane with margins and central veins moderately thickened; plants of waterfalls and wet, shaded rocks

11a Perianth pink; plants 60-120 mm high; leaves lower prostrate, 20-50 × 2.5-6.0 mm, ± plane with thickened margins; flowering January
   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
   13a Leaves not plane, either strongly ridged, or margins and central vein heavily thickened, or blade terete with 4 narrow longitudinal grooves
   14a Leaves 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
   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, margin wings often curving inward and blade thus appearing terete:
   17a Tepals linear or narrowly lanceolate, 3.0-4.5 mm wide, usually uniformly white
   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
   18b Perianth tube 8-30 mm long; spike borne on disproportionately short stem; sometimes spike virtually at ground level

19a Perianth tube ± 8 mm long, included in bracts and about a third as long as tepals
   49. *G. brevinae*
13b Leaves plane or nearly so, margins and central veins only slightly raised:

33b Flowers actinomorphic with stamens symmetrically arranged:

37b Leaves sword-shaped, lanceolate or ovate. (2—)3— 10 mm wide, smooth or hairy, sometimes only on margins; spike often

37a Leaves linear to narrowly sword-shaped, mostly l-2(— 4) mm wide, never hairy even on margins; spike sometimes with only

34b Flowers pink with darker markings; tepals 22-32 mm long:

34a Flowers purple or blue; tepals 12-18 mm long:

22b Leaf blade linear to falcate with two visible, relatively wide longitudinal grooves on each surface:

22a Leaf blade terete with four hairline longitudinal grooves:

26a Flowers mauve, blue, purple or pink:

27a Perianth tube 7–8 mm long; spike 1–4-flowered:

27b Perianth tube 3–6 mm long; spike 4-10-flowered:

28a Plants 150–350 mm tall; flowers pale mauve

28b Plants 80–140 mm tall; flowers pale pink (darkening when dry)

26b Flowers white to cream-coloured or yellow:

29a Stem minutely hairy in upper half:

29b Stem smooth:

30a Flowers small; tepals 7–9 mm long

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

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

32b Flower pale yellow; tepals 16–26 mm long, not normally flushed red on reverse, and perianth tube 5–6x(—10) mm long

13b Leaves plane or nearly so, margins and central veins only slightly raised:

33a Flowers zygomorphic with stamens and style unilarial 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

35b Leaves linear to narrowly sword-shaped, mostly l-2(— 4) mm wide:

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

36b Stems and leaves erect; leaf blades firm-textured; perianth tube 8–10 mm long

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 excised from bracts; flowers white to cream-coloured, rarely pale yellow:

39a Plants 40–80 mm high; stem rarely branched, never dichotomously

39b Plants usually more than 120 mm high; stem usually dichotomously branched

40a Flowers clear yellow; corms pointed at base or bell-shaped with flat base:

40b Flowers white or lilac; corms pointed at base:

41a Flowers cup-shaped; tepals 13–25 mm long; perianth tube ± 4 mm long

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

42b Style branches ± 1.5 mm long, linear, conspicuously ciliolate with hairs longer than width of style branch; tepals 6–7 mm long; anthers ± 1.5 mm long

40b Flowers white or lilac; corms pointed at base:

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

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

45b Perianth tube 2–2.5 mm long; outer tepals red outside; leaves up to 1 mm wide, linear-falcate, exceeding the spike

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

47b Perianth tube 2–6 mm long; flowers white, pink, or blue to violet:

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

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

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

Bothalia 39,2 (2009)
Bothalia 39,2 (2009)

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, 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. bolasti 

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 6–18–25 mm long: 78. G. silexides 
3a Flowers pink; perianth tube 15–17 mm long; one filament shorter than other two: 
3b Flowers blue to violet; filaments equal: 
4a Perianth tube (6–)8–11 mm long; filaments 5–6 mm long  ........................................................................................................ 85. G. namaquaensis 
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 3 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 2 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. levisiae 

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: 
40. G. cartharophila 
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 protrate  .................................................. 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. tubulbennsis 
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. ciliata 
19b Leaf margin edges raised at right angles to blade surface to form wings, these ciliate along hairy 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 (13-)16–8 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. bricula 
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

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. burchelli

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. erosum

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. subrugosa

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. burchellii

39b Leaf blades with central vein and margins separated by wide grooves: .................................................................................................................................................................. 56. G. scillaris

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 .................................................................................................................................................................. 63. G. sulphurascens

42b Spikes mostly at least 5-flowered; perianth uniformly white or cream ........................................................................................................................ 64. 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. eurycaulis

44b Perianth tube up to 2.5 mm long; anthers arching inward, borne above style branches .................................................................................................................................................................. 66. G. matthewsi