

Taxonomy of the genus *Pelargonium* (Geraniaceae): the section *Polyactium*¹

2. The subsection *Caulescentia*

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The monospecific subsection *Caulescentia* of *Pelargonium* section *Polyactium* is treated taxonomically. Its systematic position is discussed in terms of its macromorphology, pollen grain sculpturing, anatomy of the petiole, chromosome number, and breeding behaviour.

Die monospesifieke subseksie *Caulescentia* van *Pelargonium* seksie *Polyactium* word taksonomies behandel. Sy sistematiese posisie word bespreek in die lig van sy makromorfologie, stuifmeelkorrelskulptuur, anatomie van die petiolus, chromosoomgetal, en voortplantingsgedrag.

Keywords: Geraniaceae, *Pelargonium*, *Polyactium*, taxonomy.

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Introduction

The subsection *Caulescentia* of *Pelargonium* section *Polyactium* consists of a single species, *Pelargonium gibbosum* (L.) L' Hérit. It differs from the remainder of the section by the absence of an underground tuber and the well-developed perennial growth above ground level; yet in other respects it conforms to the section *Polyactium*, particularly the subsection *Polyactium* which it closely resembles in its floral morphology.

Taxonomy

Pelargonium subsect. *Caulescentia* Knuth in Das Pflanzenreich 4, 129, 53: 352 (1912). Type species: *Pelargonium gibbosum* (L.) L' Hérit. (lecto., here designated).

Pelargonium subser. *Gibbosa* DC., Prodrumus 1: 662 (1824). Type species: *Pelargonium gibbosum* (L.) L' Hérit. (lecto., here designated).

Stem well branched, extensively developed above ground level, semi-succulent with substantial internodes and conspicuously swollen nodes, without an underground tuber. *Lamina* glaucous, glabrous, pinnatifid to pinnately compound; stipules ovate with apices acute. *Peduncle* up to 120 mm long. *Flower* ca. 15 mm in diameter, pedicel inconspicuously short, petals pale greenish-yellow and mostly without markings.

A monotypic subsection of the sandy western coastal belt of the Western Cape Province:

Pelargonium gibbosum (L.) L' Héritier in Aiton, Hortus kewensis ed. 1, 2: 422 (1789); Salisb.: 313 (1796); Willd.: 3: 684 (1800); Pers.: 233 (1807); Desf.: 1: 463 (1809); Willd.: 711 (1809); Haw.: 308 (1812); Sweet: t. 61 (1821); DC.: 662 (1824); Sprengel: 57 (1826); Harvey: 276 (1860); Marloth: 312, t. 126 (1908); Knuth: 361 (1912); Marloth 2: 89, t. 56 (1925); Adamson & Salter: 515 (1950); Mason: 132, t. 4 (1972); Van der Walt: t. 17 (1977).

Geranium gibbosum L., Species plantarum ed. 1, 2: 667 (1753); Linnaeus 2: 1142 (1759); Burman f.: 39 (1759); Linnaeus 2: 946 (1763); Miller: no. 30 (1768); Burman f.: 18 (1768); Linnaeus 14: 613 (1784); Cav. 4: 265, t. 109.1 (1787); Thunb.: 117 (1800); Andr.: without page number, icon. (1805); Thunb. 2: 513 (1823). Type: unnumbered plate in Hermann, Horti academici lugduno-batavi catalogus, p. 285 (1687) (PRE, lecto., here designated).² (Figure 2.)

Polyactium gibbosum (L.) Ecklon & Zeyher 1: 67 (1835).

Geranospermum gibbosum (L.) Kuntze 1: 95 (1891).

Previous illustrations: Hermann, unnumbered plate on p. 285 (1687); Stisser t. 3 (1697); Cavanilles t. 109.1 (1787); Andrews, unnumbered plate (1805); Sweet t. 61 (1821); Marloth t. 126 (1908); Marloth t. 56 (1925); Mason t. 4 (1972); Van der Walt t. 17 (1977); Ward-Hilhorst, unnumbered plate on p. 55 (1983).

²The protologue of *Geranium gibbosum* consists of five elements. All are books, and three of them contain illustrations:

- 1) Linnaeus, *Hortus upsaliensis* ..., p. 345 (1748). This page number may be wrongly quoted.
- 2) Van Royen, *Flora leydensis prodromus* ..., p. 354 (1740).
- 3) Dillenius, *Hortus elthamensis* ..., t. 127, fig. 154 (1732).
- 4) Hermann, *Horti academici lugduno-batavi catalogus*, p. 284, unnumbered plate on p. 285 (1687).
- 5) Stisser, *Botanica curiosa* ..., t. 3 (1697).

Dr. C.A. Jarvis (see acknowledgements) could not trace any specimens which could be considered for typifying *Geranium gibbosum*. There are no extant specimens associated with Linnaeus (1748), and he unsuccessfully searched Leiden herbarium for specimens associated with van Royen (1740). In LINN there is a specimen (LINN 858.11), annotated in Linnaeus' hand, but lacking the *Species plantarum* number 8 which almost invariably indicates that the specimen concerned was seen by Linnaeus when compiling *Species plantarum*, so that this specimen cannot be considered for lectotypification purposes. Of the remaining elements, fig. 154 which is part of t. 127 of Dillenius (1732) clearly represents not *Pelargonium gibbosum* but *Pelargonium carnosum* (L.) L'Hérit. Stisser's (1697) t. 3 and Hermann's (1687) plate on p. 285 are recognizable representations of *P. gibbosum*, but as Stisser's plate was obviously copied from that of Hermann, we selected the Hermann plate as lectotype.

¹Continued from *S. Afr. J. Bot.* 61(2): 53–59 (1995).



Figure 1 *Pelargonium gibbosum*: a plant collected at Llandudno, near Cape Town. After a watercolour painting by Ellaphie Ward-Hilhorst which first appeared in *Veld & Flora* 69: 55 (1983), by courtesy of the Brenthurst Library.



Figure 2 *Pelargonium gibbosum*: the lectotype illustration of *Geranium gibbosum* in Hermann's Horti academici lugduno-batavi catalogus, p. 285 (1687).

A low shrub up to 300 mm tall, or up to 1 m tall when scrambling over surrounding vegetation, well branched above ground level without an underground tuber,³ in nature deciduous during summer, unarmed. *Stems* smooth, semi-succulent, glabrous, internodes well-developed and up to 10 mm in diameter, nodes conspicuously swollen to diameter of up to 25 mm. *Leaves* pinnatifid to pinnate, somewhat succulent, superficially glaucous but sparsely strigose or hispid on abaxial veins and ciliate on apices of segments, with microscopical short glandular hairs; lamina ovate-cordiform in outline, base cordate, apices of lobes rounded, 25–130 × 15–75 mm; petiole shorter than lamina: up to 65 mm long, deciduous; stipules narrowly ovate with apices acute, 5–12 × 2–4 mm, membranous, abaxially very densely strigose and adaxially glabrous and conspicuously ciliate, deciduous. *Inflorescence* a peduncle of up to 120 mm long, carrying a many-flowered pseudo-umbel of flowers; flowers ca. 15 mm in diameter, almost regular. *Pedicel* inconspicuously short. *Hypanthium*

³There is no underground root tuber as in the other subsections. Stems which become buried by wind-blown sand, develop nodal swellings which are sometimes considerably larger than on the exposed stems. These are however not homologous with the underground root tubers found elsewhere in the section.



Figure 3 *Pelargonium gibbosum*: a, a plant in habitat in the Cape of Good Hope Nature Reserve during summer, when leafless; b, a plant in cultivation in Stellenbosch, retaining its foliage during summer.

20–25 mm long, strigose and with densely crowded glandular hairs. *Sepals* narrowly ovate, abaxially densely strigose, yellow-green with hyaline margins, 6–9 × 1.5–2.0 mm. *Petals* 5, nearly similar, spathulate with rounded apices, pale greenish-yellow and mostly without markings; 9–13 × 4–6 mm. *Stamens* hardly exerted, 7 fertile, of three different lengths as per Figure 1, filaments white, anthers 1.0–1.5 mm long, pollen pale yellow. *Ovary* ovoid, ca. 2.5 mm long and 2.0 mm in diameter, densely covered in apically directed hairs; style hardly exerted, 1.0–1.5 mm long; stigma orange yellow to reddish; mericarp base ca. 7 mm long, tail ca. 35 mm long. Chromosome number: $2n = 22$ (Gibby & Crompton 34 – counted by Gibby, Van der Walt 489 – counted by Maggs, Van der Walt s.n. sub STEU 721 – counted by Maggs

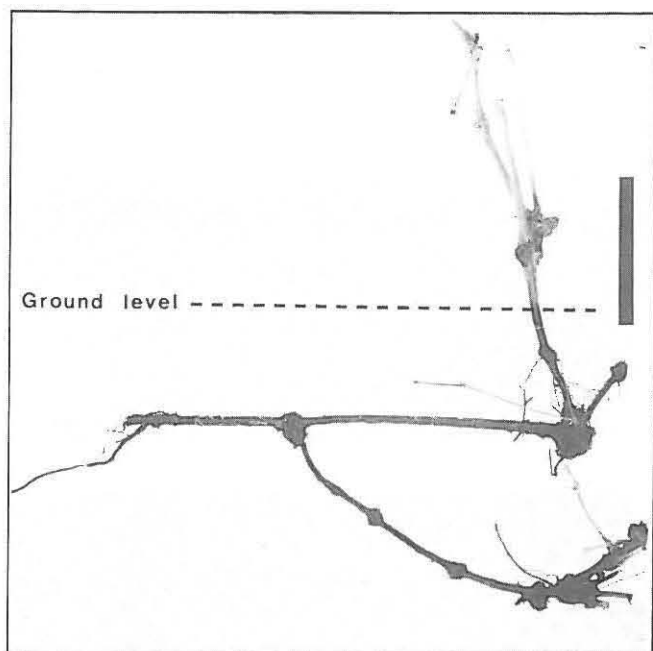


Figure 4 *Pelargonium gibbosum*: a plant unearthed near Ysterfontein, showing nodal swellings above and below ground level. Scale bar = 100 mm.

& by Albers, *Ward s.n.* sub *STEU 902* – counted by Maggs & by Albers). (Figures 1, 3 & 4.)

Flowering

Flowering takes place at the onset of the dry season, stretching from November to March with a peak in December. A few stragglers may flower as late as April.

The pollen vector has not been identified, but it is suspected of being a dusk-flying moth. The flowers open at dusk more fully than during daytime, while at the same time emitting a strong and characteristic scent. The pale coloration of the petals is also thought to suggest a dusk- or night-flying insect, whereas the long nectar-containing hypanthium suggests exploitation by a moth, as flies with long probosci are normally only active in bright light.

Geographical distribution

Occurs from the western shore of False Bay northwards to Kleinsee (Figure 5). It occurs mostly close to the ocean, often just above the high-water mark where it grows on leached, sandy or rocky soils of the dunes and intervening flats as a component of coastal fynbos and strandveld in association with *Rhus mucronata* Thunb., *Euclea racemosa* Murray, and *Protasparagus* species (Figure 3a). Climatologically this area is characterized by cool and relatively moist winters without frost, and dry but still moderately cool summers due to the cold Benguella Current washing the shores. The rainfall rarely exceeds 750 mm in the south, diminishing to less than 100 mm in the north. In Stellenbosch, under cultivation, plants retain their foliage throughout the year (Figure 3b), but in nature the plants are deciduous during summer (Figure 3a). The plants are almost constantly battered by cold winds from the sea which often reach gale force. This species is not collected as often as one would expect, because the leafless plants when intermingled with other vegetation are difficult to see, and the flower colour is inconspicuous to the human eye.

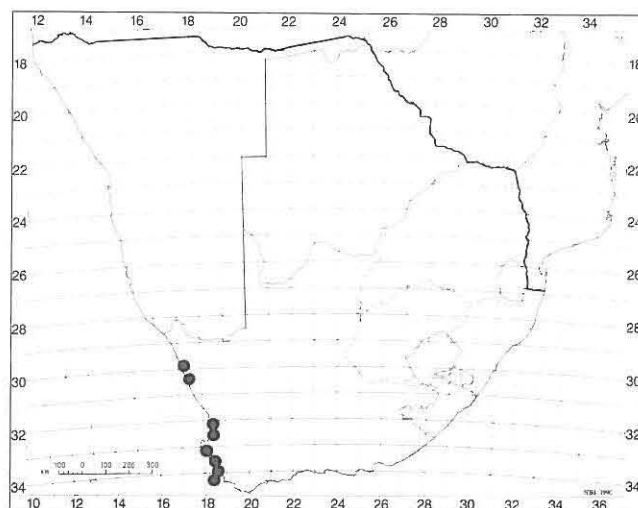


Figure 5 *Pelargonium gibbosum*: known geographical distribution.

Discussion

This species is undoubtedly closely related to those of the subsection *Polyactium*, as manifested by its basic chromosome number of $x = 11$, the morphologically similar flowers, the unusual dusk-scentedness of the flowers, and the pale yellow pigmentation of the petals. Yet its unusually strong stem development above ground level, which lends the plant a shrubby appearance, and its lack of an underground tuber, places it apart from the other species, for which reason we retain it in a separate subsection.

Three different types of pollen grain sculpturing were observed in the section *Polyactium* (Maggs, Vorster & Van der Walt 1995). The pollen grains of *P. gibbosum* are reticulate-striate (Figure 6), therefore supporting its presumed close relationship to the subsection *Polyactium*.

Marais (1977) studied the subterranean tuber of *P. triste* and found that it is of root origin. Haberlandt (1914) studied the cambium formation in the stem of *P. gibbosum*. As part of the present investigation, a comparative study of the petiole was made within the section *Polyactium*. Howard (1958) found that cambial development is initiated in the middle portion of the petiole, and that secondary tissue is also most highly developed in this region. For this reason, our investigation was restricted to this part of the petiole. Like in other species in the section, the petiole of *P. gibbosum* is bilaterally symmetrical when viewed in transverse section (Figure 7). From outside to inside, the following tissue types can be discerned:

Cuticle: a relatively thin layer, mostly smooth and always lacking ornamentation.

Epidermis: a uniseriate layer of regular, more or less isodiametric to rectangular cells, with the guard cells of the stomata raised above the surface of the epidermis.

Hypodermis: a single layer of rectangular hyaline cells.

Chlorenchymatous cortex: several layers of larger cells with intercellular spaces.

Extraxylary fibres: a more or less unbroken zone of several cell layers thick.

Vascular bundles: a cylinder of discrete collateral vascular bundles (11 counted in the examined material) encloses the pith parenchyma. Embedded in the pith parenchyma, and more or less in the centre of the petiole, occurs a single amphivasal medullary vascular bundle, consisting of an outer zone of xylem which can be 1–4 cell layers thick, an inner zone of considerably smaller phloem vessels, and a central bundle of fibres which are interme-

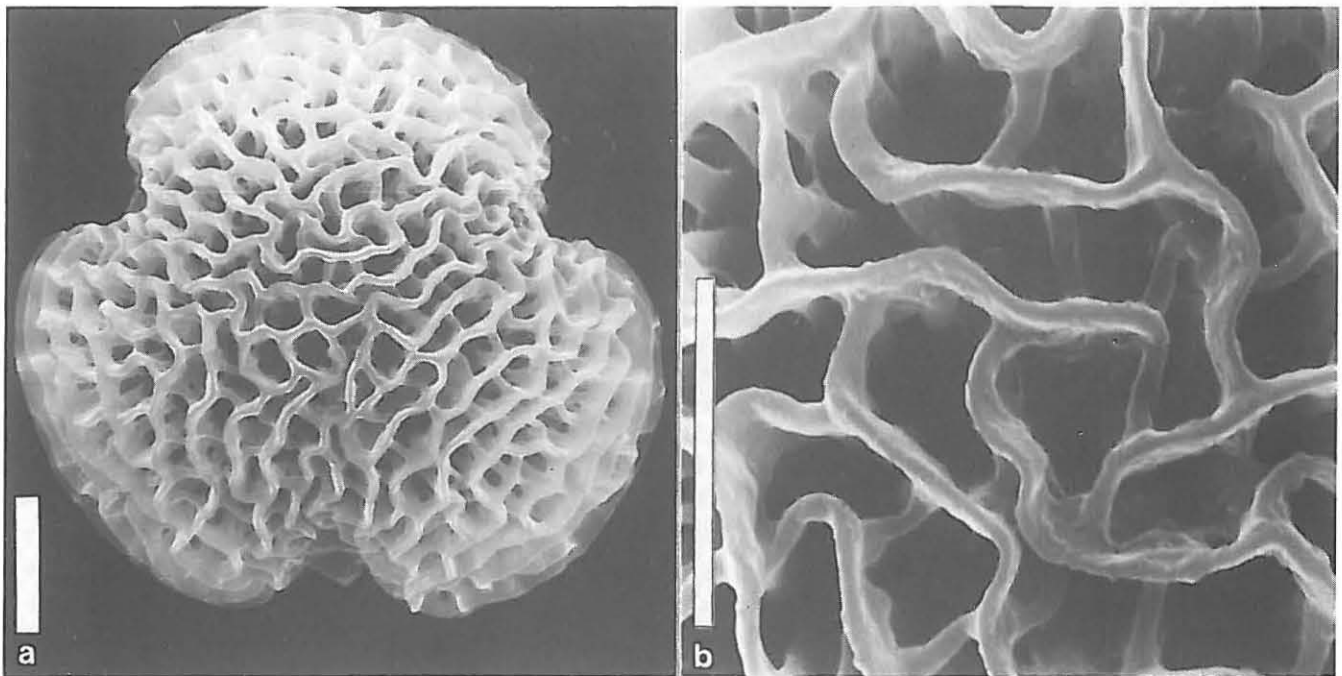


Figure 6 *Pelargonium gibbosum*: scanning electron micrograph of a pollen grain, showing reticulate-striate sculpturing. **a**, complete grain; **b**, detail of surface. Scale bar = 10 μm . From Van der Walt 597.

diate in size between the phloem and xylem vessels as seen in transverse section.

We found that the anatomy of the petiole is remarkably constant throughout the section, and that it made no contribution towards the infrasectional taxonomy. Furthermore, in many respects this pattern is similar to those reported in other sections of the genus *Pelargonium*:

Cuticle: like in subsection *Caulescentia*, a smooth cuticle was reported in section *Eumorpha* (Ecklon & Zeyher) Harvey (*P. patulum* Jacq. var. *patulum*, locally slightly grooved, Van Wyk 1990), section *Glaucophyllum* Harvey [*P. lanceolatum* (Cav.) Kerner only, Schonken 1980], and section *Cortusina* DC. excluding section *Reniformia* (Knuth) Dreyer (some species, Dreyer 1990). Cuticles with wavy or irregularly extruded outer surfaces (as seen in transverse section) have been reported in section *Glaucophyllum* (most species, Schonken 1980), section *Pelargonium* L' Hérit. (*P. tomentosum* Jacq., Van Wyk 1990), section *Cortusina* excluding section *Reniformia* (some species, Dreyer 1990) and section *Reniformia* (Dreyer 1990). Volschenk (1980) found that in *P. cucullatum* (L.) L' Hérit. the cuticle varies from smooth to grooved in certain areas but grooved in others, while in *P. betulinum* (L.) L' Hérit. the cuticle is invariably grooved as seen in transverse section.

Epidermis: in section *Pelargonium*, like in the subsection *Caulescentia*, the guard cells of the stomata are flush with the surface of the epidermis in *P. cucullatum* subsp. *strigifolium* Volschenk, but raised above the surface of the epidermis in *P. cucullatum* subsp. *cucullatum* and *tabulare* Volschenk (Volschenk 1980).

Hypodermis: usually well differentiated and uniseriate, but up to two layers thick in section *Pelargonium* (*P. tomentosum*, Van Wyk 1990). A completely hyaline hypodermis has previously only been recorded in the section *Myrrhidium* (Boucher 1978), but not in all species. In sections *Cortusina* and *Reniformia*, Dreyer (1990) found the hypodermis to be hyaline, except directly underneath stomata. In the section *Eumorpha*, Van Wyk (1990) found the hypodermis of *Pelargonium patulum* var. *patulum* to be sparsely chlorenchymatous.

Extraxylary fibres: like in the subsection *Caulescentia*, an unbroken cylinder of extraxylary fibres surrounds the cylinder of peripheral vascular bundles in sections *Pelargonium* (*P. tomentosum*, Van Wyk 1990), *Eumorpha* (*P. patulum* var. *patulum*, Van Wyk 1990), *Myrrhidium* (Boucher 1978), *Reniforme* (Dreyer 1990), *Jenkinsonia* (most species, Scheltema & Van der Walt 1990), and *Glaucophyllum* (most species, Schonken 1980). The fibrous sheath is interrupted, i.e. present only opposite peripheral vascular bundles, in the sections *Cortusina* (Dreyer 1990) and

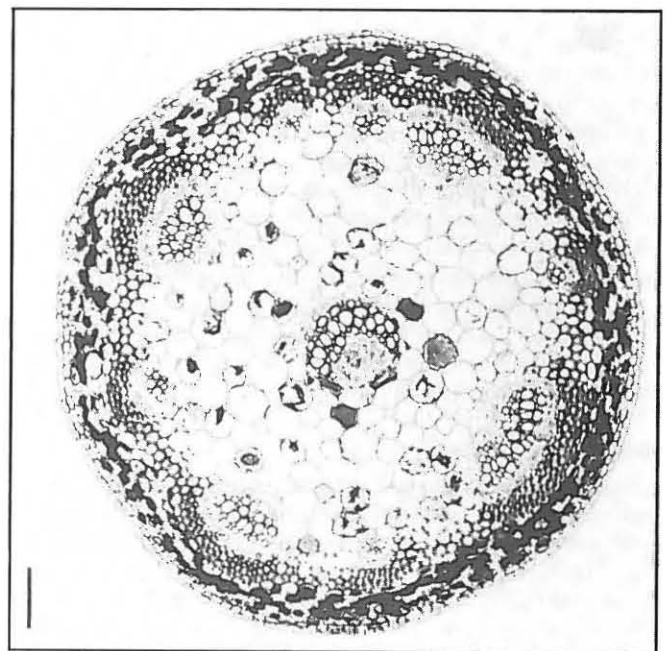


Figure 7 *Pelargonium gibbosum*: transverse section through middle portion of petiole. Scale bar = 100 μm . From Van der Walt s.n. sub STEU 721.

Jenkinsonia [*P. praemorsum* (Andr.) Dietr. subsp. *praemorsum*, Scheltema & Van der Walt 1990]. In *P. laevigatum* (L.f.) Willd. subsp. *laevigatum* and *P. fruticosum* (Cav.) Willd. of the section *Glaucophyllum*, the larger leaves were found to have a continuous sheath of extraxylary fibres, whereas the sheath is interrupted in smaller leaves (Schonken 1980). In section *Campylia* the sheath can be continuous or interrupted, depending on the species (Van der Walt & Van Zyl 1988).

Vascular bundles: in most sections, apart from the outer cylinder of collateral vascular bundles, a single central amphivasal medullary vascular bundle is present, including sections *Cortusina* and *Reniformia* (Dreyer 1990), *Eumorpha* (*P. patulum* var. *patulum*, Van Wyk 1990), *Glaucophyllum* (Schonken 1980), and *Pelargonium* (*P. tomentosum*, Van Wyk 1990). In *P. cucullatum* of section *Pelargonium*, the central vascular bundle was found to be collateral (Volschenk 1980).

In sections *Jenkinsonia* (Scheltema & Van der Walt 1990) and *Myrrhidium* (Boucher 1978, Van der Walt & Boucher 1986) the medullary vascular bundle is present in some species and absent in others, whereas in section *Campylia* the number of medullary vascular bundles can vary from 0 to 3, depending on the species (Hugo 1978). A central fibre bundle is invariably present in section *Campylia* (Hugo 1978), but absent in the section *Pelargonium* (Volschenk *et al.* 1982, Volschenk 1980).

P. gibbosum occurs sympatrically with several species of the subsection *Polyactium*, including *P. triste* (L.) L' Hér. ($2n = 66$) and *P. lobatum* (Burman f.) L' Hér. ($2n = 44$); yet no natural hybrids are known, which is strange as there seems to be no obvious barrier against interbreeding. This species is outbreeding, with the pollen ripening before the pistil becomes receptive.

The following artificial hybrids have been reported (the female parent cited first):

- *P. gibbosum* × *P. lobatum* ($2n = 44$) [Sweet: t. 179 (1823)];
- *P. gibbosum* × [*P. reniforme* ($2n = 16$ or 32) × *P. cortusifolium* L' Hér. ($2n = 22$)] [Sweet: t. 213 (1824)];
- *P. gibbosum* × [*P. reniforme* Curtis ($2n = 16$ or 32) × *P. echinatum* Curtis ($2n = 22$)] [Sweet: t. 239 (1824)];
- *P. multiradiatum* Wendl. ($2n = 22$) × *P. gibbosum* [Sweet: t. 279 (1825)];
- *P. triste* ($2n = 66$) × *P. gibbosum* [Sweet: t. 425 (1829)].

Also sympatric with *P. gibbosum* and having similar habitat preferences, is *P. fulgidum* (L.) L' Hér. It has the same growth form and chromosome number as *P. gibbosum*, and was grouped together with *P. gibbosum* by most previous authors. It has been hybridized artificially with species in the subsection *Polyactium*, such as *P. lobatum*, and could therefore be expected to hybridize freely with *P. gibbosum*. However, no natural or artificial hybrids are known. Our own experimental cross pollinations suggest that it is indeed incompatible with *P. gibbosum*. Apart from its probable innate barriers against interbreeding, the pollination mechanism acts against natural interbreeding: unlike *P. gibbosum* the flowers are not dusk-scented, the flowers are markedly irregular, and the bright red pigmentation of the petals seems geared to attract quite a different pollinator.

Specimens seen

Acocks 15189 (PRE); *Andraeae 553* (PRE, STE); *Bayliss 8570* (MO); *Becker s.n.* sub *MEL 94108* (MEL); *Bernhardi s.n.* sub *MO 1891633* (MO); *Bolus 2982* (BOL); *Boucher 2940* (STE); *Drijfhout 2839* (K, PRE, STEU); *Dümmer 1819* (E); *Engelmann 11917* (MO); *Esterhuysen 21174* (BOL); *Esterhuysen 21272* (BOL); *Hugo 2866* (STE); *Leipoldt s.n.* (Z); *Low 265* (STE); *Macnae s.n.* sub *BOL 31343* (BOL, 2 sheets); *Maggs 48* (STEU); *Marloth 2534* (PRE); *Pillans 17960* (BOL); *Pillans s.n.* sub *BOL 31342* (BOL); *Sonder s.n.* sub *MEL 94110* (MEL); *Van der Walt 489* (PRE, STEU); *Van der Walt 597* (PRE, STEU); *Van der Walt 1052* (STEU); *Van der Walt s.n.* sub

STEU 721 (STEU); *Van Jaarsveld 3685* (STE); *Van Rensburg 132* (STE); *Van Rooyen & Ramsey 257* (STE); *Ward s.n.* sub *STEU 902* (STEU); *Wolley Dod 934* (BOL).

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References

- ADAMSON, R.S. & SALTER, T.M. 1950. Flora of the Cape Peninsula. Juta, Cape Town.
- AITON, W.: see L' HÉRITIER de BRUTELLE, C.-L. 1789.
- ANDREWS, H.C. 1805. Geraniums. Taylor, London.
- BOUCHER, D.A. 1978. 'n Morfologiese en taksonomiese studie van die seksie *Myrrhidium* van *Pelargonium*. M.Sc. thesis, Univ. of Stellenbosch.
- BURMAN, N.L.B. 1759. Specimen botanicum de geraniis. Haak, Leiden.
- BURMAN, N.L.B. 1768. Flora indica, ... Haak, Leiden.
- CANDOLLE, A.P. de: see De Candolle.
- CAVANILLES, A.J. 1787. Monadelphiae classis dissertationes decem; quarta dissertatio botanica, de Geranio. Didot, Paris.
- De CANDOLLE, A.P. 1824. Prodrômus systematis naturalis regni vegetabilis, Vol. 1. Treuttel & Wurtz, Paris.
- DEFONTAINES, R.L. 1809. Histoire des arbres et arbrisseaux ..., Vol. 1. Brosson, Paris.
- DILLENIUS, J.J. 1732. Hortus elthamensis ... Cornelius, Leiden.
- DREYER, L.L. 1990. 'n Taksonomiese studie van *Pelargonium* seksie *Cortusina* (Geraniaceae). M.Sc. thesis, Univ. of Stellenbosch.
- ECKLON, C.F. & ZEYHER, K.L.P. 1835. Enumeratio plantarum ..., Vol. 1. Authors, Hamburg.
- HABERLANDT, G. 1914. Physiological plant anatomy. MacMillan, London.
- HAWORTH, A.H. 1812. Synopsis plantarum succulentarum ... Taylor, London.
- HARVEY, W.H. 1860. *Pelargonium*. In: Flora capensis, eds. Harvey, W.H. & Sonder, O.W., Vol. 1. Robertson, Cape Town.
- HERMANN, P. 1687. Horti academici lugduno-batavi catalogus. Boute-steyn, Leiden.
- HOWARD, R.A. 1958. The vascular structure of the petiole as a taxonomic character. *Proc. 15th Int. hort. Congr.* 3: 7-13.
- HUGO, L. 1978. 'n Morfologiese en taksonomiese studie van die seksie *Campylia* van *Pelargonium*. M.Sc. thesis, Univ. of Stellenbosch.
- KNUTH, R. 1912. *Pelargonium*. In: Das Pflanzenreich 4, 129, Vol. 53. Engelmann, Berlin.
- KUNTZE, C.E.O. 1891. Revisio genera plantarum ..., Vol. 1. Felix, Leipzig.
- L' HÉRITIER de BRUTELLE, C.-L. 1789. Geraniaceae. In: Hortus kewensis ..., ed. Aiton, W., 1st edn, Vol. 1. Nicol, London.
- LINNAEUS, C. 1748. Hortus upsaliensis ... Salvius, Stockholm.
- LINNAEUS, C. 1753. Species plantarum ..., 1st edn, Vol. 2. Salvius, Stockholm.
- LINNAEUS, C. 1759. Systema naturae ..., 10th edn. Salvius, Stockholm.
- LINNAEUS, C. 1763. Species plantarum ..., 2nd edn, Vol. 2. Salvius, Stockholm.
- LINNAEUS, C. 1784. Systema vegetabilium, 14th edn. Dietrich, Göttingen.
- MAGGS, G.L., VORSTER, P. & VAN DER WALT, J.J.A. 1995. Taxonomy of the genus *Pelargonium* (Geraniaceae): the section *Polyactium*. I. Circumscription and infrasectional classification. *S. Afr. J. Bot.* 61: 53-59.
- MARAIS, E.M. 1977. 'n Taksonomiese, morfologiese en anatomiese studie van *Pelargonium triste*. B.Sc. (Hons.) research report, Univ. of Stellenbosch.

- MARLOTH, R. 1908. Das Kapland ... In: *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer 'Valdivia' 1898-1899*, ed. Chun, C., Vol. 2, Part 3. Fischer, Jena.
- MARLOTH, R. 1925. *The flora of South Africa*, Vol. 2. Darter, Cape Town.
- MASON, H. 1972. *Western Cape sandveld flowers*. Struik, Cape Town.
- MILLER, P. 1768. *The gardener's dictionary*, 8th edn. Rivington, London.
- PERSOON, C.H. 1807. *Synopsis plantarum ...*, 2nd edn. Cramer, Paris.
- SALISBURY, R.A. 1796. *Prodromus ...* Edmondson, London.
- SCHELTEMA, A.G. & VAN DER WALT, J.J.A. 1990. Taxonomic revision of *Pelargonium* section *Jenkinsonia* (Geraniaceae) in southern Africa. *S. Afr. J. Bot.* 56: 285-302.
- SCHONKEN, C.M. 1980. 'n Morfologiese en taksonomiese studie van die seksie *Glaucophyllum* van *Pelargonium*. M.Sc. thesis, Univ. of Stellenbosch.
- SPRENGEL, K. 1826. *Caroli Linnaei ... systema vegetabilum ...*, Vol. 3. Dietrich, Göttingen.
- STISSER, J.A. 1697. *Botanica curiosa ...* Hamm, Helmstedt.
- SWEET, R. 1821. *Geraniaceae*, Vol. 1, sub t. 61. Ridgeway, London.
- SWEET, R. 1823. *Geraniaceae*, Vol. 2, sub t. 179. Ridgeway, London.
- SWEET, R. 1824. *Geraniaceae*, Vol. 3, sub t. 213 & 239. Ridgeway, London.
- SWEET, R. 1825. *Geraniaceae*, Vol. 3, sub t. 279. Ridgeway, London.
- SWEET, R. 1829. *Geraniaceae*, Vol. 5, sub t. 425. Ridgeway, London.
- THUNBERG, C.P. 1800. *Prodromus plantarum capensium*, Vol. 2. Edman, Uppsala.
- THUNBERG, C.P. 1823. *Flora capensis*, 2nd edn. Cott, Stuttgart.
- VAN DER WALT, J.J.A. 1977. *Pelargoniums of southern Africa*, [Vol. 1]. Purnell, Cape Town.
- VAN DER WALT, J.J.A. & BOUCHER, D.A. 1986. A taxonomic revision of the section *Myrrhidium* of *Pelargonium* (Geraniaceae) in southern Africa. *S. Afr. J. Bot.* 52: 438-462.
- VAN DER WALT, J.J.A. & VAN ZYL, L. 1988. A taxonomic revision of *Pelargonium* section *Campylia* (Geraniaceae). *S. Afr. J. Bot.* 54: 145-171.
- VAN ROYEN, A. 1740. *Flora leydensis prodromus ...* Luchtmans, Leiden.
- VAN WYK, N. 1990. 'n Taksonomiese studie van *Pelargonium patulum*, *P. tomentosum*, en 'n natuurlike *Pelargonium*-hibried. M.Sc. thesis, Univ. of Stellenbosch.
- VOLSCHENK, B. 1980. 'n Morfologiese en taksonomiese studie van *Pelargonium cucullatum* (L.) L' Hérít. en *P. betulinum* (L.) L' Hérít. M.Sc. thesis, Univ. of Stellenbosch.
- VOLSCHENK, B., VAN DER WALT, J.J.A. & VORSTER, P.J. 1982. The subspecies of *Pelargonium cucullatum* (Geraniaceae). *Bothalia* 14: 45-51 (1982).
- WARD-HILHORST, E. 1983. In search of *Pelargonium gibbosum*. *Veld Flora* 69: 54-55.
- WILLDENOW, C.L. 1800. *Caroli a Linné species plantarum ...*, Vol. 3. Nauk, Berlin.
- WILLDENOW, C.L. 1809. *Enumeratio plantarum ...*, 2nd edn. Libreria Scholae, Berlin.