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Judith A. Petterson

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## Revision of the genus *Wahlenbergia* (Campanulaceae) in New Zealand

JUDITH A. PETTERSON

24 Eruini Street  
Waikanae 6454, New Zealand

**Abstract** The New Zealand species of *Wahlenbergia* are revised from historical, morphological, and cytological evidence, and their relationships with Australian, Pacific, and Asian species are discussed. *Wahlenbergia marginata* is regarded as indigenous to Japan, *W. gracilis* as indigenous to New Caledonia, and *W. dehiscens* as indigenous to West Bengal. One indigenous and nine endemic species are recognised from New Zealand, of which three are described as new: *W. akaroa*, *W. violacea*, *W. vernicosa*. Five New Zealand endemic subspecies are described as new: *W. albomarginata* subsp. *decora*, *W. albomarginata* subsp. *olivina*, *W. congesta* subsp. *haastii*, *W. pygmaea* subsp. *drucei*, *W. pygmaea* subsp. *tararua*. Natural hybridism is discussed.

**Keywords** Taxonomic revision; Campanulaceae; *Wahlenbergia*; new species *W. akaroa*, *W. violacea*, *W. vernicosa*; new subspecies *W. albomarginata* subsp. *decora* and subsp. *olivina*, *W. congesta* subsp. *haastii*, *W. pygmaea* subsp. *drucei* and subsp. *tararua*; Australia; Lord Howe Island; New Zealand; New Caledonia; Japan; West Bengal; hybridism

### INTRODUCTION

*Wahlenbergia* is a genus of Campanulaceae (harebells) indigenous to New Zealand, New Caledonia, New Guinea, Australia, Malaysia, Japan, Taiwan, China, India, Africa, and some of the small volcanic Pacific islands. The latitudinal range is from 37°N

in Japan to 47°S in New Zealand. There are 267 species currently recognised in *Wahlenbergia*, 81% of which are African, and 13% of which are Australasian (T. S. Lammers pers. comm. 27 Sep 1995).

In *Wahlenbergia* the capsules open by apical valves, while in *Campanula*, the earlier described genus, they open by lateral slits. This difference was first noted in botanical literature by Brown (1810), and was used by Schrader (1814, 1828) and Roth (1821) to establish the genus *Wahlenbergia*. Roth's valid publication has priority since Schrader's (1814) was invalid, but this was not generally known until pointed out by van Steenis (1960). Before 1828, newly discovered species now included in *Wahlenbergia* were referred to *Campanula*. An historical account of the collection of key specimens is given by Pettersen (1997).

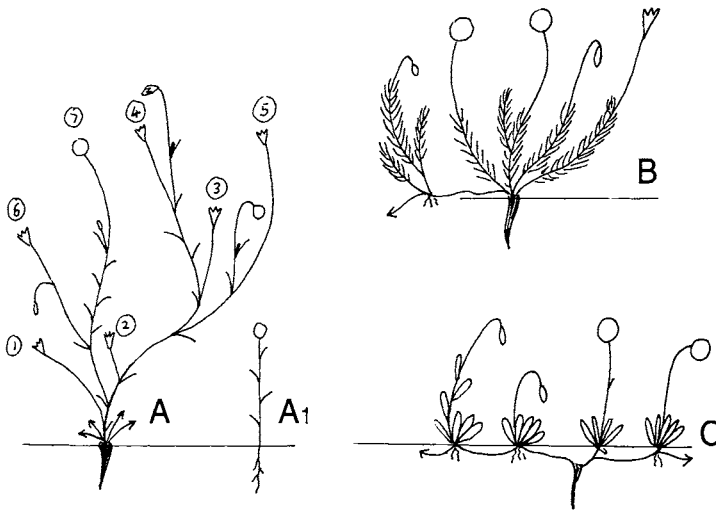
The present account consists of a discussion of the morphological criteria of New Zealand species, using the same terminology as Thulin (1975), Smith (1992), and Stearn (1992). This is followed by the taxonomic revision. Discussions of hybridism are appended to the descriptions of species where it has been observed.

Authorities for names of taxa are given at the first usage or, for new names, when they are treated in full in the taxonomic descriptions. In nomenclatural discussion, quotation marks are used where misapplied names are quoted from literature.

### MATERIAL AND METHODS

Living specimens of the following non-New Zealand species have been cultivated by the author at different times and places as they became available over the past 40 years: *W. dehiscens* (Roxb.) A.DC., *W. gracilis* (G.Forst.) A.DC. *sens. strict.*, *W. marginata* (Thunb.) A.DC. *sens. strict.*, *W. quadrifida* (R.Br.) A.DC., *W. saxicola* (R.Br.) A.DC., and *W. stricta* Sweet subsp. *stricta* Smith.

All were collected in natural habitats, and all except *W. stricta* have been raised from seed collected as near as possible to the type localities.



**Fig. 1** Growth-forms in New Zealand *Wahlenbergia* species. A, radicate (flowers numbered in order of anthesis); A1, false annual; B, suffruticose; C, rhizomatous.

Specimens of *W. stricta* (then named *W. trichogyna* Stearn) originated from an adventive colony at Rarangi, Marlborough, now almost extinct, and were cultivated at Botany Division, Department of Scientific and Industrial Research, Wellington during 1949–1951 (Pettersen 1953); *W. saxicola* from Mt. Rufus, Tasmania, was also cultivated there at that time and is currently in cultivation in Waikanae. *W. gracilis* from three sites in New Caledonia was cultivated at Massey University, Palmerston North during 1966–1967; *W. quadrifida* from Australia and *W. dehiscens* from West Bengal at Grasslands Division, Department of Scientific and Industrial Research in Palmerston North during 1976–1981; and *W. marginata* from Honshu, Japan, at both Waikanae and Landcare Research, Lincoln in 1994. Nine of the 10 New Zealand species and most of the subspecies are currently in cultivation at Waikanae, and have been under close recent observation for up to four years during 1992–1996.

*Wahlenbergia* collections have been borrowed from or studied in the following herbaria: GOET, T, TAI, NSW, AK, CANU, CHR, MPN, OTA, WAIK, WELT, and WELTU. Internationally accepted abbreviations of the names of herbaria follow Holmgren et al. (1990).

Living and herbarium specimens have been examined and their characters and measurements recorded. Morphological criteria, chromosome numbers, and breeding systems are considered.

The Horticultural Colour Chart (HCC) Vol. 1 and 2 (1942) is used to define colours. A system of recording floral proportions has proved useful in comparing allied species, as follows:

diameter of corolla : length of corolla : length × width of corolla tube : length × width of corolla lobes:

length × width of calyx lobes: length × width of capsule: HCC formula and colour name. Tables presenting these measurements from living flowers are given for each species.

Floral and leaf dimensions are given as length × breadth. Calyx lobes are excluded in capsule dimensions.

*Abbreviations:* v.v.— I have seen it alive; v.s.— I have seen the dried specimen; v.p.— I have seen a photograph or photocopy; p.p.— partly.

*Conservation status* follows the terminology of Cameron et al. (1995) where relevant.

## MORPHOLOGICAL CRITERIA

### Habit

New Zealand *Wahlenbergia* species are normally herbaceous perennials. They fall into two main categories, radicate and rhizomatous. Species of radicate habit are deceptively variable in the stems and foliage. In practice it is very difficult to distinguish the various radicate species from dried specimens alone. Floral characters, especially the shape and colour of the corolla and the shape and size of calyx and capsule, are the only reliable taxonomic criteria.

There are no consistently annual endemic New Zealand species. False annuals are found when seedling plants of radicate species are subjected to hot, dry, or crowded conditions in the wild (cf. Tuyn 1960). Artificially induced false annuals have been produced in several species in cultivation by starving and crowding, and have then been normalised by being potted up and given more shade and water.

*W. colensoi* was originally named from false annuals of several taxa (Petterson 1997).

Four growth forms are distinguished, and these are confirmed by chromosome counts.

*Temperate radicate* ( $2n = 72$ )

Fig. 1 A

Herbaceous perennials living up to 4 years, with fleshy white branching taproot and one to many slender, erect or decumbent, branching leafy stems in which every branch or branchlet is terminated by a flower. The upper part of the plant forms a synflorescence as described by Smith (1992). The first flower terminates the main stem, and each subsequent branch from the nodes immediately below produces a terminal flower followed by further flowering branches from the nodes below that flower. The first few flowers are usually the largest, and the later ones can be much smaller, down to half the size of the first flowers on the same plant. The taproot thickens and the number of stems increases with each year of growth. A plant with a slender taproot 1–2 mm diam. is less than 6 months old, but a plant with branching roots 5–10 mm thick and with multiple stems is 3–4 years old and near the end of its life. Reproduction is mainly by seed and plants set seed freely in cultivation. Plants may be transplanted from the wild by planting the top 2–5 cm of rootstock in sandy soil and clipping the stems short. New shoots will grow from the rootstock.

Four New Zealand species have this growth-form: *W. akaroa* sp. nov., *W. ramosa* Simpson, *W. rupestris* Simpson, and *W. violacea* sp. nov. *Wahlenbergia marginata* from Honshu, Japan, and *W. gracilis* from montane New Caledonia also belong to this group.

*Subtropical radicate* ( $2n = 54$ )

Short-lived herbaceous perennials with similar growth-form to the temperate radicates, but shorter lifespan (2 years) and differing in chromosome count and floral proportions. One indigenous species is recognised in northern New Zealand, *W. vernicosa* sp. nov. Five Australian species and one in Papua New Guinea have the same chromosome count (Smith 1992).

*Suffruticose rhizomatous* ( $2n = 36$ )

Fig. 1 B

Herbaceous perennial with suffruticose habit, having multiple erect leafy branches from the base, and naked terminal scapes bearing solitary large campanulate flowers. It is taprooted at first. Lateral rhizomes develop later from which new shrublets arise. Propagation is by seed, by tip cuttings, or by rhizome

growth. In New Zealand there is one endemic species with restricted natural distribution, *W. matthewsii* Cockayne.

*Creeping rhizomatous* ( $2n = 36$ )

Fig. 1 C

Long-lived herbaceous perennials with slender, flexible, interlacing underground rhizomes which emerge from the rootstock at the top of the seedling taproot and produce leafy shoots at their tips and fine rootlets at their nodes. The rhizomes are 1–2 mm diam. The growth habit usually consists of rosulate tufts of leaves at ground-level with bell-shaped flowers borne singly on erect naked scapes. Seedling plants begin with a slender taproot and rhizomes develop later. This can be seen when plants are growing in loose debris, when the whole root and rhizome system may be lifted out intact. All species have indefinite lifespans: in cultivation plants have been known to persist for 15 years or more. Increase is mainly by rhizome growth, and artificial propagation is by tip cuttings set in sand or by planting a matted clump of rhizomes and shoots. Some species set seed freely in cultivation.

Four endemic species are recognised with restricted natural distribution: *W. albomarginata* Hook., *W. cartilaginea* Hook.f., *W. congesta* (Cheeseman) N.E.Br., and *W. pygmaea* Colenso.

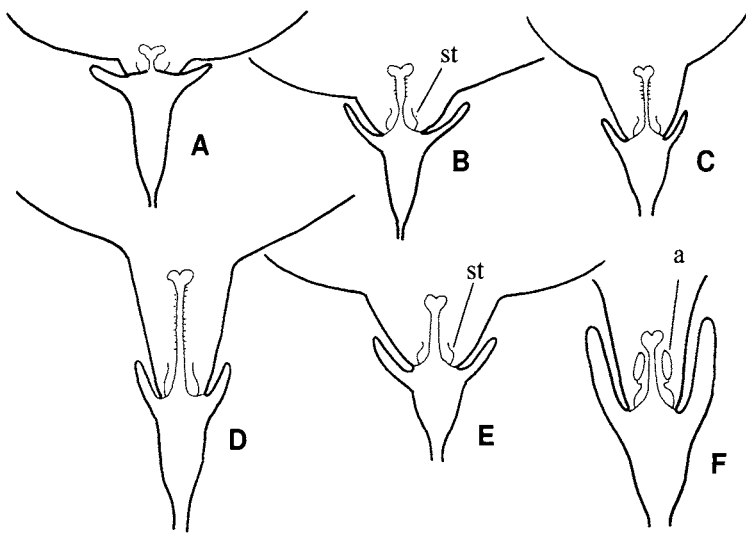
### Hairs

The pedicel, calyx, and capsule are always glabrous in endemic New Zealand species, whereas *W. stricta* subsp. *stricta* and *W. gracilentia* (Australia) are usually hispid in those parts (Smith 1992). The presence of hairs on the lower leaves, stem, and young shoots in all New Zealand species is variable and not diagnostic. These hairs are straight, simple, more or less stiff, 1–2 mm long. All species have small, stout, blunt, whitish, translucent glandular “callus teeth” (hydathodes) inserted in the leaf margins. These are diagnostic for *Wahlenbergia*, in the absence of flowers or capsules, and can be seen with the naked eye or a 5× magnification hand-lens in mature leaves.

The corollas of New Zealand species are glabrous inside and out, unlike the African and some Australian species (cf. Thulin 1975; Smith 1992), which are more or less puberulous inside.

### Leaves and stems

In radicate species, leaves are variable in size and shape depending on location on the stem. In general the lower leaves are more crowded and spatulate to oblanceolate, and the upper leaves and bracts are more distant and lanceolate to linear. Leaf margins



**Fig. 2** Corolla shapes in *Wahlenbergia*. A, Rotate, with style strongly constricted below stigma lobes (*W. marginata*, *W. ramosa*, *W. rupestris*, *W. akaroa*); B, Shortly campanulate, with style constricted halfway down (*W. violacea*); C, Campanulate with style slightly thickened in top half (*W. gracilis*, *W. vernicosa*); D, Deeply campanulate, style unconstricted (*W. albomarginata*); E, Broadly campanulate, style unconstricted (*W. pygmaea*, *W. congesta*); F, Funnel-form, style unconstricted (*W. cartilaginea*, *W. congesta* ssp. *haastii*); st = staminal filament; a = anther.

vary with habitat conditions, often becoming thickened, cartilaginous, and undulate at the margins in hot, dry, or salt-sprayed conditions. In most species the leaves are usually alternate, only occasionally opposite. Juvenile plants and young shoots of *W. violacea* and *W. vernicosa* have the lower leaves usually opposite. The stems are stiffly erect in dry conditions, decumbent or lax in shade or moist conditions. When growing through grass or shrubs, the stems may be very tall and almost leafless. The old stems die in winter, and new shoots growing from the rootstock in spring often have large, broad, crowded leaves. These have a pleasant flavour like lettuce and are very palatable to sheep and goats.

In rhizomatous species growing in hot, dry, or windswept conditions the leaves are sessile, stiff, channelled, and confined to small compact separate rosettes, but in more sheltered conditions the plants may form a lush, ground-hugging turf with the rosettes crowded together. This is the form often assumed in cultivation. In shade, or when growing through bushes, the rosettes may elongate into tall slender stems up to 40 cm in height with petiolate leaves and tall naked scapes.

### Corolla

Corolla size and shape are diagnostic. Measurements of the length of the corolla tube are taken from the base of corolla to the sinus between the lobes, and the diameter of the tube is measured across the flower at sinus level. Measurements are best taken in living flowers. Rotate flowers are "compact" when lobes touch in the open flower; "starry" when lobes are separate to the base.

Corolla shapes in New Zealand species are shown in Fig. 2, and are defined as follows:

"rotate", corolla tube  $\frac{1}{10}$  to  $\frac{1}{5}$  corolla length, saucer-shaped, lobes spreading; "shortly campanulate", corolla tube  $\frac{1}{4}$  corolla length, porringer-shaped, lobes spreading; "campanulate", corolla tube  $\frac{1}{2}$  corolla length, cup-shaped, as wide as long, lobes spreading; "deeply campanulate", corolla tube  $\frac{1}{2}$  to  $\frac{1}{3}$  corolla length, tubular, distinctly longer than wide, lobes spreading; "broadly campanulate", corolla tube about  $\frac{1}{3}$  corolla length, bowl-shaped, distinctly wider than long, lobes spreading; "funnel-shaped", corolla lobes spreading only at the tips.

Corolla colour, allied to shape, is diagnostic in the radicate group, but not in the rhizomatous group. The colours found in different New Zealand species are blue-violet, pale flax blue, pale pastel lilac, and pure white.

### Calyx lobes

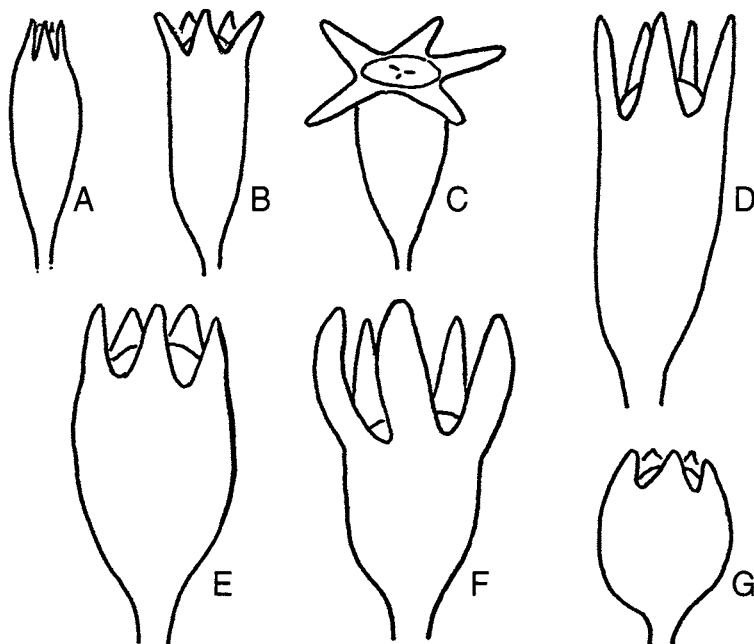
Most New Zealand species have triangular or narrowly triangular calyx lobes both in flower and in fruit (Fig. 3). *W. cartilaginea* alone has large, thick, oblong calyx lobes.

The ratio of calyx lobe length to corolla tube length is significant. The calyx lobes persist in fruit, and become stiff and slightly larger than in flower. In *W. vernicosa* the calyx lobes recurve and radiate at right angles to the axis of the capsule. This is a diagnostic feature for this species.

### Capsules

There are seven significant capsule shapes in New Zealand species and subspecies (Fig. 3). Capsules are

**Fig. 3** Capsules and calyx lobes in N.Z. *Wahlenbergia*. A, ellipsoid (false annuals, several species); B, obconic (all temperate radicate species); C, flat-topped obconic (*W. vernicosa*); D, domed cylindric (*W. albomarginata*); E, barrel-shaped (*W. pygmaea*); F, broadly turbinate, big thick lobes (*W. cartilaginea*); G, globose (*W. congesta*).



always glabrous. In measuring capsules, the persistent calyx lobes are ignored

### Style and stigmas

In all New Zealand species the shape of the style correlates with the corolla shape in the same way as in Australian species (Smith 1992: 96–97) (Fig. 2 A–F). A corolla with a short wide tube has a style which is thickened at the top, just below the stigma lobes. A shortly campanulate or campanulate corolla has the style thickened in the upper half. A corolla with a long narrow tube has an unthickened style. In each case the pollen clings to the pollen-presenting hairs of the upper portion, doubling its apparent thickness. The shape of the style is not diagnostic in itself, but indicates the shape of the corolla tube and is useful in studying dried specimens. The stylar glands, when present, are small and inconspicuous, visible only with a microscope (cf. Thulin 1975; Smith 1992).

Generally, radicates have 3-lobed stigmas but occasional flowers on the same plant have 2 lobes. Rhizomatous species have 2-lobed stigmas but occasional flowers on the same plant have 3 lobes. *W. vernicosa*, normally 3-lobed, may have some flowers with 4-lobed stigmas.

### Stamens

The stamens dehisce within the closed bud, coating the upper part of the elongating style with pollen. Self-pollination is by the recurving stigmas picking

up pollen from the style, often several days after anthesis.

Von Brehmer (1915a, 1915b) recommended the shape of the filament base as a diagnostic character. Tuyn (1960) and Carolin (1964) attempted to use this without success, and Thulin (1975) and Smith (1992) questioned its value and reliability in African and Australian species, respectively, finding much variation within species.

All New Zealand radicate species, together with *W. marginata* from Japan and *W. gracilis* from New Caledonia, have approximately similar rhombic filament bases.

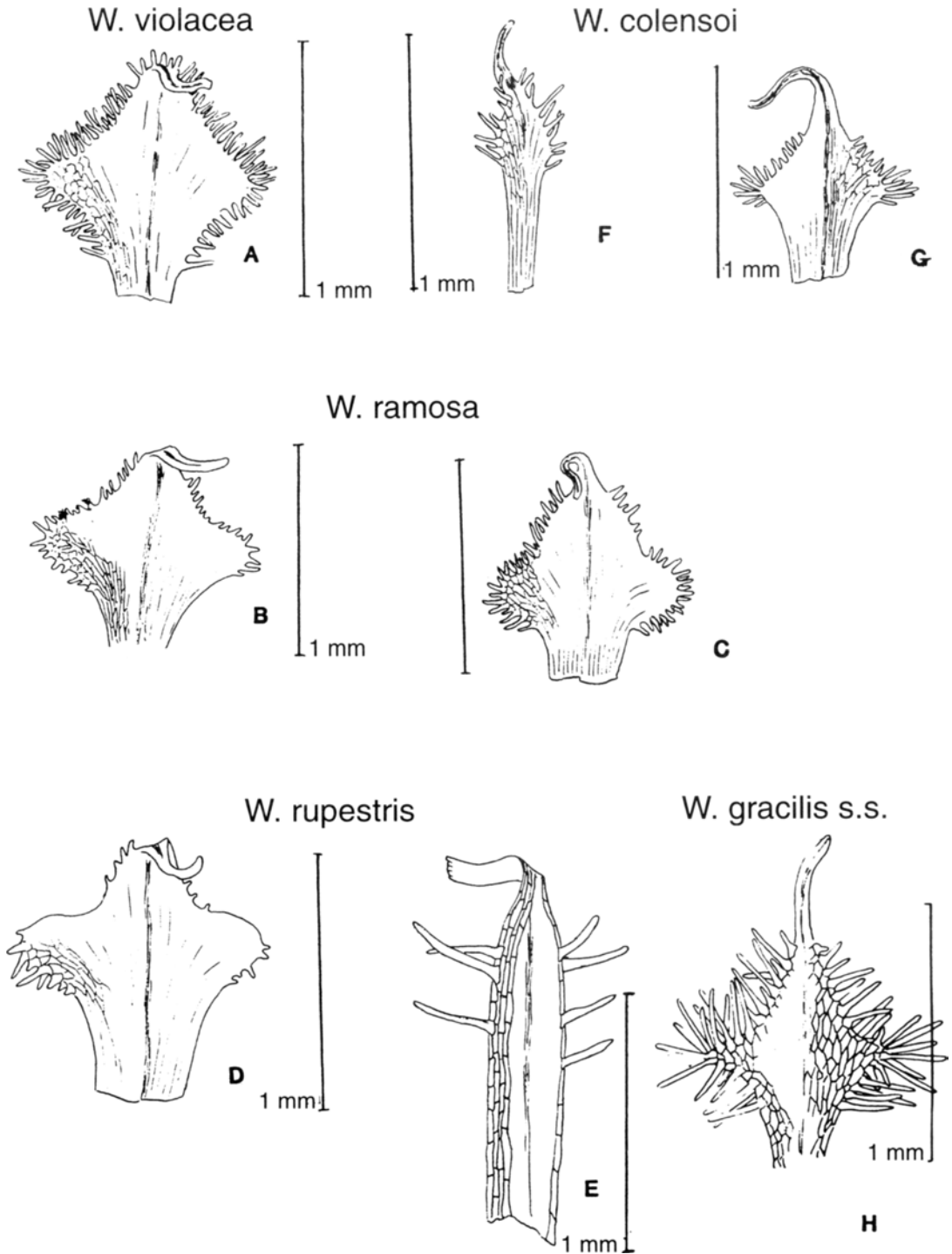
All New Zealand rhizomatous species have oblong, often shouldered, filament bases.

Within each group the shapes and fringing of the filaments may vary in adjacent populations of the same species, and are of no value for separating species.

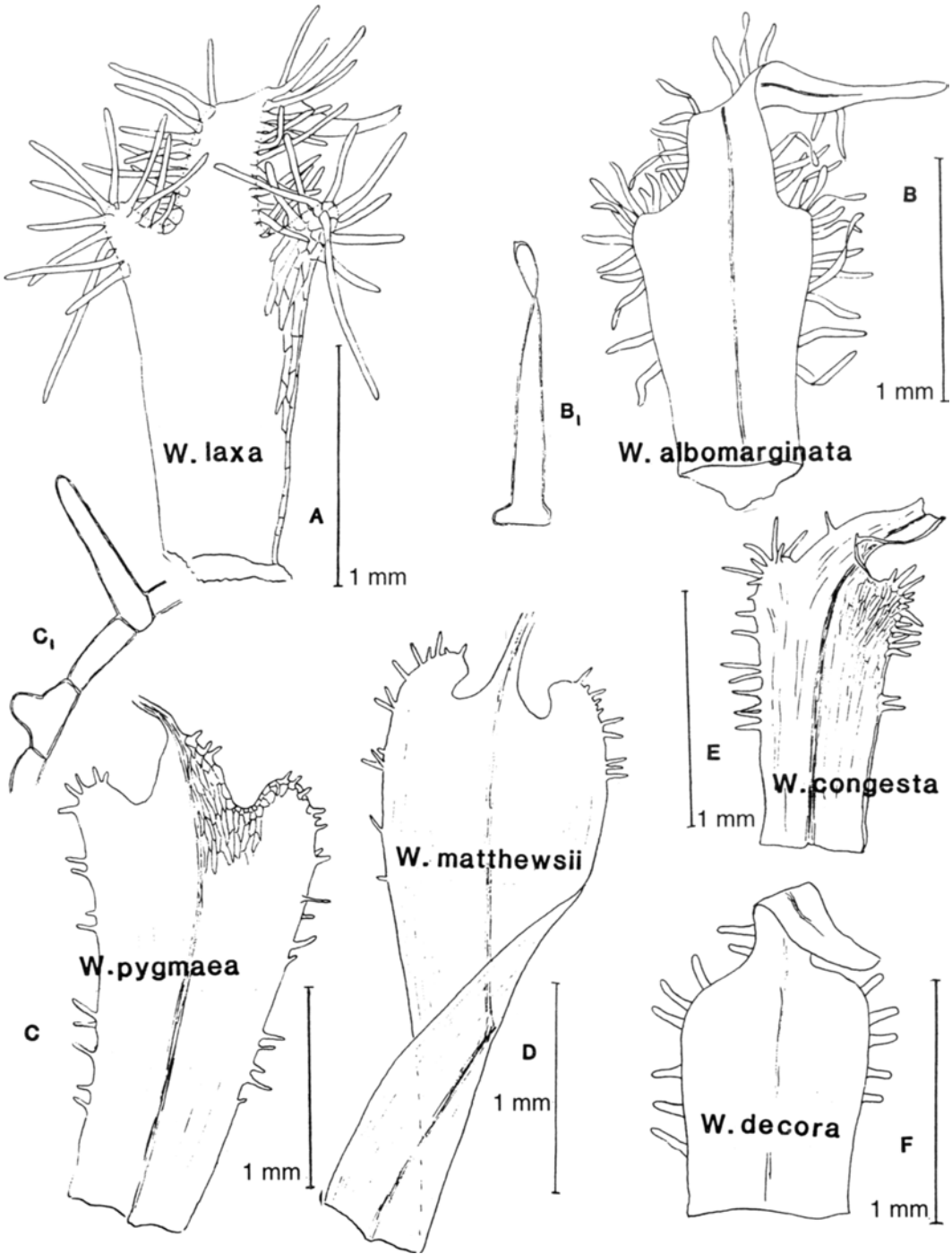
Filaments of living flowers in several New Zealand taxa are shown in Fig. 4, 5. These minute organs are delicate and fragile, one cell thick in all species except *W. cartilaginea*, in which they are two cells thick.

### CHROMOSOME NUMBERS

Chromosome counts of all New Zealand taxa, and several from other countries (Petterson et al. 1995), have been helpful in making taxonomic decisions.



**Fig. 4** Staminal filaments in radicate species. A, *W. violacea*, Horokiwi Valley, Wellington; B, C, *W. ramosa*, Pukerua Bay and Paekakariki; D, E, *W. rupestris*, Manawatu Gorge and Ballance Reserve; F, G, *W. colensoi*, Palliser Bay and Awatere Valley; H, *W. gracilis sens. strict.*, New Caledonia. Bars = 1 mm.



**Fig. 5** Staminal filaments in rhizomatous species. A, *W. albomarginata* ssp. *laxa*, Travers Valley; B, *W. albomarginata* ssp. *albomarginata*, Canterbury; C, *W. pygmaea*, Ruahine Range; D, *W. matthewsii*, Waima R., Kaikoura; E, *W. congesta*, Greymouth coast; F, *W. albomarginata* ssp. *decora*, Cupola Basin, Nelson, drawn from dried type specimen CHR 79014.



New Zealand species have three categories:  $2n = 72$ ,  $2n = 54$ , and  $2n = 36$ .

Apart from *W. marginata* and *W. gracilis*, which belong to the temperate radicates with  $2n = 72$ , a radicate species in Taiwan has both  $2n = 18$  and  $2n = 36$  (Hsu 1967, 1968, as "*W. gracilis*"). A species in Bonin Islands has  $2n = 36$  (Ono & Masuda 1981, as "*W. marginata*"). The way is open for revision, as these taxa are unlikely to be conspecific with either *W. gracilis* or *W. marginata* in the strict sense.

*W. dehiscens* (West Bengal) has  $2n = 18$  (Pettersen et al. 1995).

Australian species grown and studied in New Zealand are *W. quadrifida* (= "*W. gracilis*" in Smith (1992)),  $2n = 54$  (Smith 1992; Pettersen et al. 1995); *W. stricta* subsp. *stricta*,  $2n = 36$  (Smith 1992; Pettersen et al. 1995); *W. saxicola* of Tasmania  $2n = 72$  (Gulline in Darlington & Wylie 1955).

None of these Australian species is conspecific with any New Zealand species.

## BREEDING SYSTEMS

All members of both New Zealand radicate groups are self-pollinated and set seed freely in cultivation, whether isolated from other species or not. Of the temperate radicates, *W. akaroa* flowers have abundant nectar (J. A. Pettersen pers. obs.) and are attractive to bumblebees, honey bees, and hoverflies. *W. violacea* and *W. rupestris* are suspected of cross-pollinating each other both in disturbed wild places and in cultivation but produce good seed when kept in isolation and selfed. In the open garden *W. akaroa* may hybridise with the other temperate radicates, with large-flowered progeny (J. A. Pettersen pers. obs.). *W. stricta* (= *W. trichogyna* in Allan (1961)) in New Zealand is suspected of hybridising with *W. violacea*, resulting in semi-sterile hybrids (Pettersen 1953; Allan 1961).

Montane rhizomatous species rarely produce seed in cultivation in the absence of their normal pollinating insects. *W. matthewsii* and *W. congesta*, both lowland species, set seed freely in cultivation by selfing, as do some clones of *W. pygmaea*.

Other clones of *W. pygmaea* and some of *W. albomarginata* have broad, dark veins at the base of the corolla as honey-guides, and small beetles and ants have often been observed creeping inside such flowers in their natural habitats, but not in cultivation.

*W. cartilaginea* and *W. albomarginata* subsp. *decora*, both high altitude species, are scented, indicating insect pollination.

## TAXONOMIC TREATMENT

The following description and key cover all New Zealand indigenous and endemic species, also *W. marginata* from Japan, *W. gracilis* from New Caledonia, and *W. dehiscens* from West Bengal. These three species are re-described after all the New Zealand species.

Of the Australian species, *W. stricta* subsp. *stricta* from Rarangi, Marlborough (presumed ex New South Wales), and *W. saxicola* from Tasmania, are figured but not re-described here. They have been studied in cultivation (Pettersen et al. 1995; Pettersen 1997) but differ markedly from all New Zealand species. Good descriptions of both are found in Smith (1992).

The Australian species *W. quadrifida*, *W. littorcola*, *W. gracilentia*, *W. insulae-howei*, *W. multicaulis*, and *W. planiflora* are compared at the end of this paper with the newly described New Zealand species they most resemble, and also with *W. gracilis* and *W. marginata*.

### *Wahlenbergia* Roth (1821)

Annual or perennial herbs with sweet milky juice. Leaves usually alternate, sometimes opposite, sessile or petiolate, margins always with conspicuous, short, blunt, pale, spine-like hydathodes. Young shoots usually sparsely hairy with straight simple hairs 1–2 mm long. Flowers solitary, terminal, regular; corolla glabrous with campanulate tube and (3–)5(–7) spreading lobes, valvate and coherent in bud. Calyx tube glabrous, adnate to the inferior ovary; calyx lobes glabrous, discrete, the same number as the corolla lobes and alternate with them, persistent in fruit. Stamens dehiscent in the elongating bud; anthers oblong, free; filaments delicate, transparent, dilated at the base, arching over the nectary; ovary 2- or 3-celled; style columnar, sometimes thickened and coloured in the upper half which is usually coated with pollen at anthesis. Stigmas are 2-, 3-, or rarely 4-lobed, lobes short, oblong, papillose on the inner surface, opening after the flower has opened. Capsules open by 2 or 3 apical valves within the calyx. Seeds numerous, 0.5–1 mm long, ellipsoid, dark brown and glossy when mature.

Flowering Oct–Apr, capsules ripe Nov–Apr in cultivation.

DISTRIBUTION: North India, China, Japan, Taiwan, Malaysia, volcanic islands of the Pacific Basin, Africa, Australia, New Guinea, New Zealand, from 37° N to 47° S.

TYPE SPECIES: *W. elongata* (Willd.) Schrader ex

Roth, nom. illeg. Taxonomic synonym *W. capensis* (L.) A.DC.

Descriptions of these species follow those of the New Zealand species.

**Key to New Zealand indigenous and endemic species**

- 1 Leaves all linear, uniform, subentire, crowded on branching suffruticose stems ..... **6. *W. matthewsii***
- Leaves otherwise ..... 2
- 2 Leaves very thick, broad, glaucous, and cartilaginous, calyx lobes thick, as long as the corolla ..... **7. *W. cartilaginea***
- Leaves and calyx lobes otherwise ..... 3
- 3 Plant tap-rooted, with branching leafy aerial stems and terminal erect flowers ..... 4
- Plant rhizomatous, with leaves usually radical and rosulate, and solitary bell-shaped flowers on short erect scapes ..... 9
- 4 Flowers pale blue or bright blue-violet ..... 5
- Flowers white or palest lilac ..... 7
- 5 Flower sub-rotate, 20–35 mm diam. .... **4. *W. akaroa***
- Flower campanulate or shortly campanulate, 10–18 mm diam. .... 6
- 6 Bright blue-violet, calyx lobes erect in fruit ... **1. *W. violacea***
- Pale flax-blue, calyx lobes patent in fruit ..... **5. *W. vernicosa***
- 7 Flower campanulate, calyx patent in fruit ..... **5. *W. vernicosa***
- Flower rotate, calyx not patent in fruit ..... 8
- 8 Corolla pale lilac, petals ovate, touching ..... **2. *W. ramosa***
- Corolla white, petals elliptic, separate ..... **3. *W. rupestris***
- 9 Corolla tube usually longer than wide ..... **9. *W. albomarginata***
- Corolla tube usually wider than long ..... 10
- 10 Capsule large, barrel-shaped, plant montane ... **10. *W. pygmaea***
- Capsule small, globose, plant always coastal .. **8. *W. congesta***

**Key to non-New Zealand radicate species cultivated for this study**

- 1 Corolla lilac, campanulate, inflated, 12–15 mm diam., ovary globose (*W. Bengal*) ..... **13. *W. dehiscens***
- Corolla blue-violet, ovary obconic ..... 2
- 2 Corolla rotate 10–20 mm diam. (Honsu, Japan) ..... **11. *W. marginata***
- Corolla deeply campanulate, 5–10 mm diam. (New Caledonia) ..... **12. *W. gracilis***

**The New Zealand radicate species**

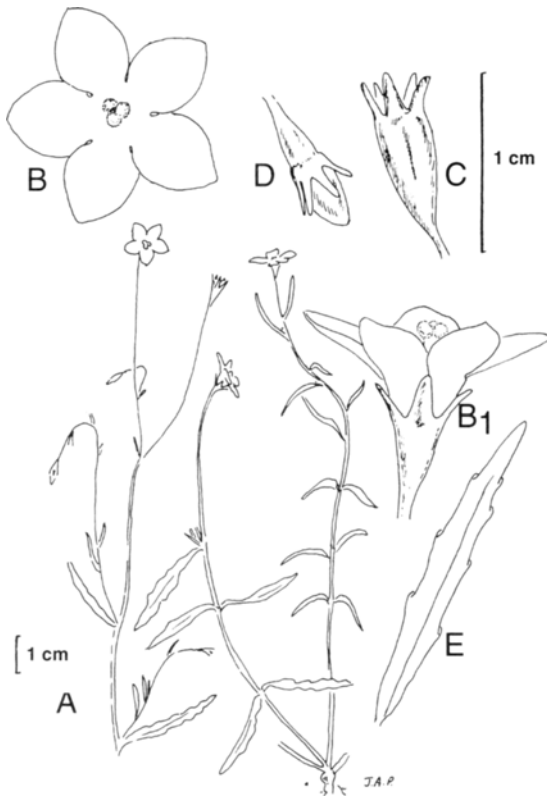
- 1. *W. violacea*** J.A.Petterson sp. nov. Fig. 6
- W. marginata sens. lat.* in Petterson et al. *New Zealand Journal of Botany* 33: 489–496 (1995).
- W. gracilis* Allan, *Flora of New Zealand* 1 (1961) p.p.
- W. marginata sensu* Tuyn (1960) p.p.
- W. marginata* var. *australis* Hatch, *Trans. Roy. Soc. N.Z.* 79: 368 (1952) nom. nud.
- W. gracilis* Cheeseman, *Manual of the New Zealand Flora* (1925) p.p.
- W. gracilis* Hook.f., *Flora Novae-Zelandiae* (1852), *Handbk. N.Z. Fl.* (1867) p.p.
- W. gracilis* A.Rich., *Essai d'une flore de la Nouvelle-zelande* (1832) p.p.

DIAGNOSIS: *W. marginatae* et *W. gracilis* similis, corolla caeruleo-violacea. Differt corolla campanulato-rotata, corollae tubo c. 3 × 4 mm, lobis ovatis, acutis, c. 6 × 4 mm, basi contingentibus. Folia interdum opposita.

Similar to *W. marginata* and *W. gracilis* in the blue-violet corolla; differs in the corolla being campanulate-rotate, with tube c. 3 × 4 mm, lobes ovate, acute, c. 6 × 4 mm, touching at the base. Leaves sometimes opposite.

HOLOTYPUS : Wellington, South Karori Road, P.A. Williamson, 11 Jan 1958, CHR 79031. v.v. Isotype: MPN 14346.

DESCRIPTION: Habit of radicate group. Stems 10–50 cm tall, slender, erect or decumbent. Leaves oblanceolate to lanceolate to linear, shallowly dentate to subentire, dark green, the lowermost 2–5 pairs opposite in seedlings and young shoots. Pedicels slender, 3–15 cm long. Flowers glabrous, (5–)12–15(–18) mm diam., (2–)7–10 mm long, bright blue-violet, paler outside. Corolla shortly campanulate, bowl-shaped, often with tube distinctly angled at the sinus; tube 1.5 × 3 mm to 3 × 4 mm, ¼ to ½ length of corolla; corolla lobes ovate, acute, overlapping or touching in open flower, 3 × 2 mm to 7 × 4 mm. Style capitate, thickened and blue at the top, stigmas white, often large and fluffy. Calyx lobes glabrous, 1.5 × 0.7 mm to 4 × 1 mm, narrowly triangular, equal in length to the corolla tube. Capsule glabrous, 8 × 4 to 12 × 5 mm, obconic, with protruding apical valves. Bud at anther dehiscence tinted blue. Self-fertile. Seeds 0.5 mm long. FL Nov–Apr, FT Dec–Apr. Chromosome number: 2n = 72 (Petterson et al. 1995), vouchers CHR 79096, CHR 79097, MPN 14337.



**Fig. 6** *W. violacea*, cultivated from Laingholm, Auckland. A, habit; B, rotate compact corolla; B1, flower with corolla tube = sepals; C, capsule; D, bud at anther dehiscence; E, cauline leaf.

Description based on New Zealand specimens originating from four well-separated sites: Laingholm (Auckland), Otaki Forks (Tararua foothills), Palliser Bay (Wellington), Broughton Bay (Marlborough Sounds), all in cultivation and flowering together at Waikanae in November–December 1994.

**DISTINCTIVE FEATURES:** Blue-violet flower colour, shortly campanulate corolla with bowl-shaped tube, and ovate acute corolla lobes, touching or overlapping in the open flower, giving the flower a “compact” appearance. Usually there are 2–6 pairs of opposite leaves in young shoots and seedlings.

The corolla tube is often angled where it meets the lobes.

Table 1 shows the flower and capsule proportions of *W. violacea*.

**DISTRIBUTION:** New Zealand: Three Kings Is, North I., South I., widespread throughout (Fig. 7).

**HABITAT:** Lowland scrub or bracken-clothed hills, or

thin pasture, usually on clay; rural roadsides, burnt or eroded or disturbed places, often invasive in gardens, usually away from the sea. Sea level to c. 500 m.

**CONSERVATION STATUS:** Widespread and not at risk but, in common with other species, does not survive grazing or pasture improvement.

**ETYMOLOGY:** The epithet “violacea” refers to the often bright blue-violet colour of the corolla. This is the only New Zealand species with this colour. The red-violet or purple colour in some published photographs is an error or artefact of some types of photographic film, e.g., Salmon (1967, p. 129; 1985, t. 115, both named as “*W. gracilis*”).

**DISCUSSION:** This taxon, long known as *W. gracilis* until referred to by Hatch (1952) as “*W. marginata* var. *australis*”, is the common blue-flowered species of New Zealand. It has been regarded by some New Zealand botanists (Sykes in Webb et al. 1988; A. P. Druce pers. comm.) as adventive to New Zealand because it is often found in waste places and as a pioneer after fire and roadworks. The same could be said for *W. gracilis* in New Caledonia, *W. marginata* in Japan, and *W. quadrifida* and *W. communis* in Australia.

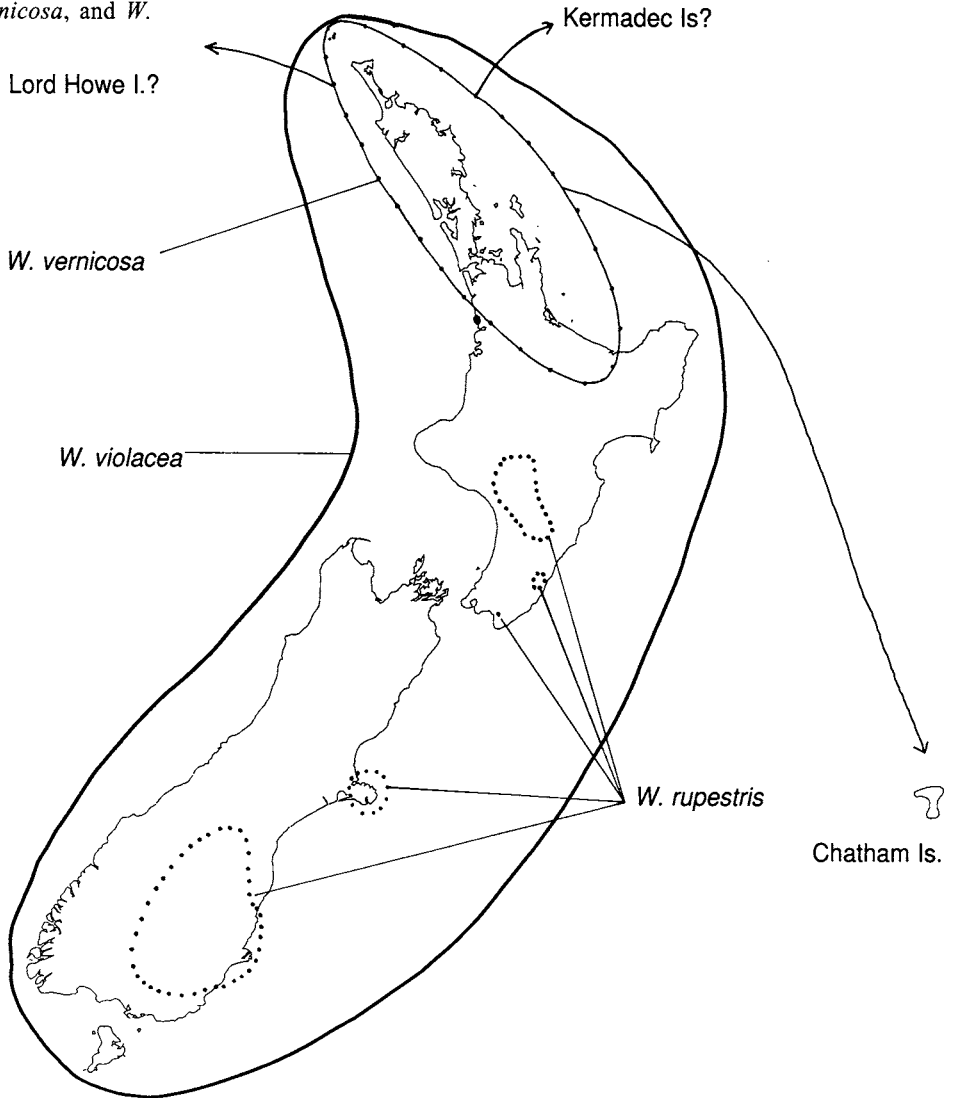
*W. violacea* is regarded here as indigenous to New Zealand because it was collected by Banks and Solander during Cook’s first voyage to the Pacific in 1769 (Pettersen 1997). This was the first recorded collection by European botanists. Compared with *W. marginata* and *W. gracilis*, the blue-violet colour is only one of several factors to be considered. The corolla shape is compact and shortly campanulate in *W. violacea*, starry and rotate in *W. marginata*, and deeply campanulate with short petals in *W. gracilis*. Young single-stemmed plants have opposite leaves in *W. violacea*, but both *W. marginata* and *W. gracilis* have only alternate leaves.

**VARIATION:** *W. violacea* varies greatly in stature depending on season and site, the first flowers in

**Table 1** Typical corolla, calyx, and capsule dimensions of *W. violacea*. All measurements in mm from living plants.

Diam.	length	calyx			capsule	HCC
		tube	lobe	lobe		
15	9	3 × 5	6 × 5	4 × 1	15 × 5	Lobelia blue
12	7	2 × 4	5 × 3	2 × 0.7	8 × 5	41/1
7	4	1 × 2	3 × 2	1.5 × 0.5	7 × 4	

**Fig. 7** Natural distribution of *W. violacea*, *W. vernicosa*, and *W. rupestris*.



early summer on vigorous plants being the largest (15–18 mm diam.). Starved plants, and old plants full of ripening capsules, produce smaller flowers (5–10 mm diam.). Young plants in dry shaded sites are slender-stemmed with distant leaves, which are often opposite, and rather small flowers. Very large, coarse plants with big flowers and large crowded leaves are found in rich soil, rubbish heaps, and warm ground near thermal springs. Specimens with large, rosetted basal leaves and almost naked stalks have been collected at Whale Island, Bay of Plenty (AK 173524) and also at Putangirua Stream, Palliser Bay (MPN 15154, CHR 201824). These are likely to be products of similar growing conditions, e.g., a hot dry surface with moisture beneath. The

distinctive basal leaves are not retained in cultivation. I am not prepared to separate various forms of *W. violacea*, as each isolated undisturbed population is self-pollinated and has its own minor inherited characteristics.

REPRESENTATIVE SPECIMENS: NORTH ISLAND: NORTHLAND: Puketi State Forest, *A. E. Wright* 7233, Apr 1985, AK 170030; Bay of Islands, Stone Store, *W. R. Sykes*, Dec 1981, CHR 460936; Kaipara Harbour, Moturemu Island, *W. R. Sykes*, Dec 1990 (shade form), CHR 473713. AUCKLAND: Laingholm, *E. D. Hatch*, Dec 1950, AK 27442. BAY OF PLENTY: Motuhora (Whale Island), *A. E. Wright* 7441, 1 Jan 1986, AK 173524; Whale Island,

*A. P. Druce*, Dec 1986 (cult), CHR 471680. TARANAKI: Mohakitino, nr Mokau, *G. B. Petterson*, Jan 1993, MPN 15020. HAWKES BAY: Waipatiki Bush Reserve, nr Napier, *F. D. H. Pitt*, 7 Jan 1987, WELT 78404. WELLINGTON: Palmerston North, Kahuterawa Track, *J. A. Petterson*, 1966, CHR 79199, MPN 14334; Cytology voucher  $2n = 72$ , Palmerston North, *J. A. Petterson*, 3 Jun 1967, CHR 79096, MPN 14337; Otaki Forks, *G. B. Petterson*, 15 Nov 1993 (cult.), MPN 15097; Mangaone, above Waikanae, *J. A. Petterson*, 21 Mar 1993, MPN 15033; Cytology voucher  $2n = 72$ , Horokiwi Valley, Paekakariki, *A. P. Druce*, 1967, CHR 79097; Palliser Bay, Putangirua Stream, *J. A. Petterson*, 3 Dec 1994, CHR 201822, MPN 15154; Putangirua Stream, *A. P. Druce*, Nov 1972, CHR 245042, 245045. SOUTH ISLAND: MARLBOROUGH: Nova Zelandia, Queen Charlotte Sound, *Wm. Anderson* (c. 1774), BM; Marlborough Sounds, Waterfall Bay, *I. Pring*, 1950, CHR 76439; Picton, Lochmara Bay, waste places, 10 m, *A. T. Dobson*, Dec 1974, CANU 20806; Kaikoura, Kowhai Bush, grassy margins of forest, *A. T. Dobson*, 11 Mar 1974, CANU 19730. NELSON: Richmond Hill, *G. B. Petterson*, 26 Dec 1993, MPN 15144; Nelson, Kaiteriteri, *W. R. Sykes*, 1986, CHR 437831; Karamea, Heaphy, Katipo Creek, *D. Manning*, 1985, CHR 419540. CANTERBURY: Springston, *R. Mason*, 10 May 1966, CHR 169120; Banks Peninsula, Scarborough, *W. R. Sykes*, 27 Nov 1990, CHR 473553; Banks Peninsula, Port Levy, 100 ft, *A. T. Dobson*, 10 Nov 1972, CANU 18607; Banks Peninsula, Mt Herbert, *W. R. Sykes*, 25 Apr 1981, CHR 400601; Carvossa, east of Waikare, 1000 ft, *B. H. Macmillan*, 10 Apr 1979, CHR 257038. SOUTHLAND: South Westland, Gillespies Beach, *P. Wardle*, 9 Dec 1970, CHR 208335; Awarua Bay, *R. Powell*, Dec 1974, CHR 358039.

HYBRIDISM: *W. violacea* is self-fertile when grown in isolation. In many places in New Zealand it occurs in pure populations far from other related species, e.g., western Tararua foothills. It occasionally (rarely) hybridises with *W. rupestris* where they come into contact in disturbed wild conditions and in cultivation, and the progeny form hybrid swarms with flowers in various blues, lilacs, and white, including larger than normal bright sapphire-blue flowers (cytology voucher  $2n = 72$ , Pahaoa Gorge, *J. A. Petterson*, 1967, CHR 79088).

The Putangirua Stream population of *W. violacea* has maintained itself unchanged for at least 22 years (*A. P. Druce*, 1972, CHR 245042–5, cf. *J. A.*

*Petterson*, 1994, CHR 201822). It grows there in proximity with a population of white-flowered *W. rupestris* without observable signs of hybridism. Hybrid swarms can be observed on roadsides and tracks at Rakaia Gorge and Banks Peninsula (Canterbury) and in the Pahaoa Gorge (Wairarapa). The progeny have the starry flowers of *W. rupestris* in shades of bright blue, pale blue, lilac, or rosy-lilac, in a range from 10 mm to 25 mm diam. Pure populations of *W. violacea* and *W. rupestris* are in the vicinity.

**2. *W. ramosa*** *G. Simpson*, *Trans. Roy. Soc. N.Z.* 75: 196 (1945) Fig. 8

*W. gracilis* Allan, *Flora of New Zealand* 1 (1961) p.p.

*W. gracilis* Cheeseman, *Man. N. Z. Fl.* (1925) p.p.  
*W. colensoi* N.E.Br., *The gardeners' chronicle* 54: 317 (1913) p.p.

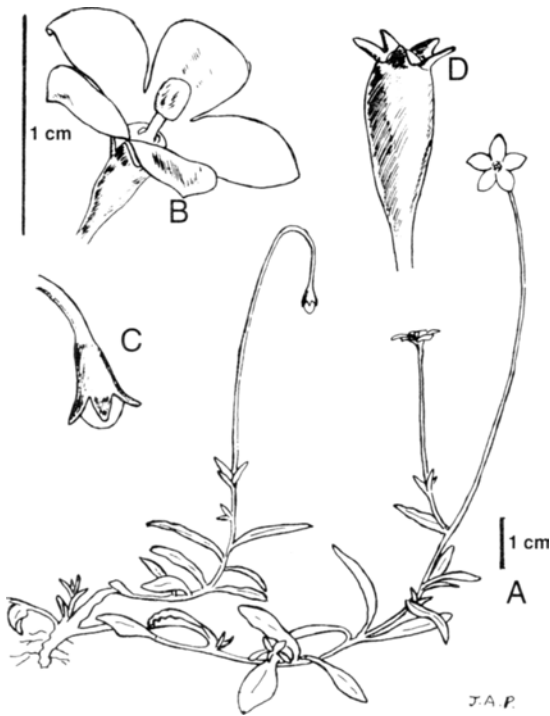
*W. gracilis* Hook.f., *Flora Novae-Zelandiae* (1852), *Handbk. N.Z. Fl.* (1867) p.p.

*W. gracilis* A.Rich., *Essai d'une flore de la Nouvelle-zelande* (1832) p.p.

LECTOTYPE: (Here chosen) Wellington, Seatoun, *Mrs H. W. Samson*, CHR 50062. Isolectotype: AK 22890.

DESCRIPTION: Habit of radicate group. Stems 10–50 cm long, 1–2 mm thick, decumbent or ascending or stiffly erect. Mature leaves and bracts pale-green, alternate, sessile, variable, usually obovate-spathulate to oblanceolate on lower stem, grading to linear-lanceolate in upper stem,  $8 \times 2$  to  $30 \times 10$  mm; margins flat and distantly denticulate to strongly undulate, usually with scattered hairs on margins and lamina. Callus teeth 4–5 on each margin. Pedicels slender, 3–10 cm long. Flowers glabrous, 3–5-lobed, pastel lilac at anthesis, fading to off-white or pure white in different populations, (5–)10–15(–20) mm diam., 4–9 mm long. Corolla rotate with shallow saucer-shaped tube,  $1 \times 3$ –4 mm; lobes spreading,  $5 \times 4$  to  $8 \times 5$  mm, broadly ovate, touching or overlapping in open flower. Style thickened at top, white. Calyx lobes glabrous,  $1.5 \times 1$  to  $3 \times 1.5$  mm, triangular; capsule glabrous 5–7  $\times$  4 mm, ellipsoid to obconic, with protruding apical valves. Bud at anther dehiscence short and rounded. Self-fertile. Seeds 0.5 mm long. FL Nov–Apr, FT Dec–Mar. Chromosome number:  $2n = 72$  (*Petterson et al.* 1995), vouchers CHR 79098, CHR 483947.

Description based on living specimens from Seatoun (Wellington), Pukerua Bay (Kapiti Coast), and several localities around Palliser Bay, southern Wairarapa, Marlborough Sounds, and Cook Strait.



**Fig. 8** *W. ramosa*, cultivated from Seatoun coast, Wellington. A, habit; B, rotate compact flower; C, young bud before anther dehiscence; D, capsule.

**DISTINCTIVE FEATURES:** Alternate pale green leaves; flower pale-lilac at anthesis, opening to off-white; corolla rotate with shallow saucer-shaped tube, the broadly ovate lobes overlapping in the open flower in life, giving it a compact appearance; mainly coastal habitat. Simpson's type description of *W. ramosa* has "flowers 1 cm diam." but the flowers may be larger or smaller.

Table 2 shows the flower and capsule proportions of *W. ramosa*.

**DISTRIBUTION:** Coastal New Zealand mainly in and around Cook Strait (v.v.): Wellington city and coast, Wairarapa, Palliser Bay, Marlborough Sounds, Abel Tasman National Park, and off-shore islets in Cook Strait. Also recorded from East Cape and Taranaki coast (v.s.). Endemic. Fig. 9.

**HABITAT:** Coastal rocks, cliffs, grassy places and scrub near the sea, mainly from sea-level to 100 m.

**CONSERVATION STATUS:** Not at risk.

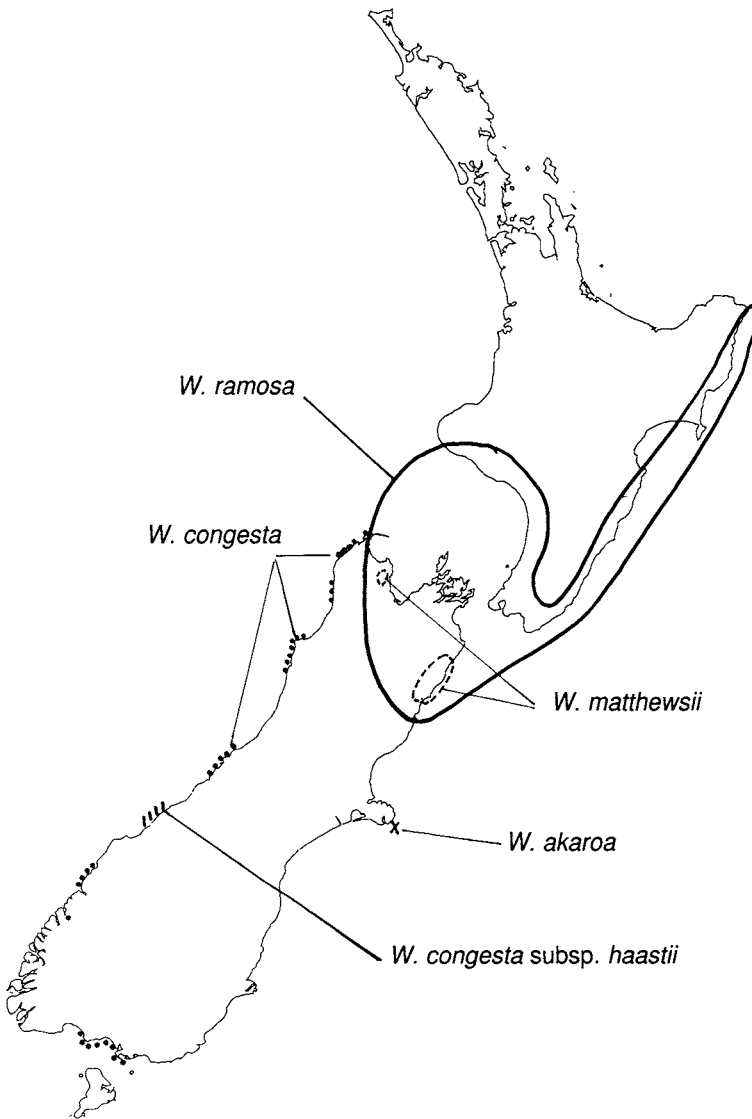
**VARIATION:** Starved, small-flowered specimens collected from dry shade under manuka (*Leptospermum*) in coastal Wairarapa have been referred

to *W. colensoi* in herbaria. These rightly belong in *W. ramosa* because they are sympatric with normal *W. ramosa* growing in adjacent light places. I have confirmed this variation with cultivation experiments. Specimens of *W. ramosa* growing on rocky islets and promontories in Cook Strait and Wellington Harbour with abundant guano, develop strong thick stems, thick glossy or fleshy leaves, large flowers, and very large capsules. These look very different from the arid "colensoi" form.

**REPRESENTATIVE SPECIMENS:** NORTH ISLAND: GISBORNE: East Cape lighthouse, *G. Collett*, May 1965, CHR 183306. TARANAKI: Ohawe beach, trackside up cliff, *A. P. Druce*, Mar 1972, CHR 245996. WELLINGTON: Mount Bruce Bird Reserve, *J. A. Petterson*, 16 Dec 1994, CHR 201835, MPN 15227; southern Wairarapa, above Lake Onoke, ex cult., *J. A. Petterson*, 11 Feb 1994, CHR 201847, also MPN 151903, the same plant, 3 Nov 1995; Paekakariki Hill, *M. B. Ashwin*, 1 Mar 1958, MPN 1254; Cytology voucher  $2n = 72$ , Paekakariki to Pukerua Bay, rocks on seaward side of Highway 1, *A. P. Druce*, 29 Mar 1967, CHR 79098; Cytology voucher  $2n = 72$ , Pukerua Bay, ex cult., *J. A. Petterson*, 1994 (suspected hybrid seedling), CHR 483947; Wellington, Seatoun, Pass of Branda, cult., *J. A. Petterson*, 22 Feb 1970, CHR 287829, MPN 14320; Wellington south coast, near Red Rocks, under karaka trees, *C. Ogle, R. Lewington, & E. Williams*, 1 Dec 1973, WELT 51370; Wellington Harbour, Mokopuna Island, *P. J. de Lange & G. M. Crowcroft*, 4 Sep 1992, CHR 479561, WELT 79189; Palliser Bay, *M. B. Ashwin*, 22 Mar 1958, MPN 1269; Cape Palliser, "dry places under manuka trees", *J. A. Petterson*, ex cult., 3 Nov 1995, CHR 201846. SOUTH ISLAND: Cook Strait, Stephens Island, *B. H. Macmillan*, 20 Feb 1971, CHR 217635; Cook Strait, Trio Island, *D. J. Campbell*, Nov 1964, WELTU 8806; Chetwode Islands, *A. E. Wright*, 26 Mar 1984, AK 174625; "Nouvelle Zelande, legit Lesson" v.p. [Cook Strait 24 Jan 1827 *fide* Dumont D'Urville's diary], P; Queen Charlotte Sound, Ship

**Table 2** Typical corolla, calyx, and capsule dimensions of *W. ramosa*. All measurements in mm from living plants.

	Diam.	length	tube	lobes	calyx	capsule	HCC
15	8	1 × 4	6 × 5	3 × 1	7 × 4	pastel	
10	6	1 × 3	5 × 4	1.5 × 1	5 × 4	lilac	
7	3	1 × 2	4 × 2	1.5 × 0.7	7 × 3	437/3	



**Fig. 9** Natural distribution of *W. ramosa*, *W. matthewsii*, *W. akaroa*, *W. congesta* subsp. *congesta*, and subsp. *haastii*.

Cove, *A. P. Druce*, Dec 1953, CHR 79030; Picton, Lochmara Bay, coastal rocks, *A. T. Dobson*, Dec 1974, CANU 20805; Marlborough, Cloudy Bay, Rarangi, coastal rock face near sea, *J. A. Petterson*, 28 Nov 1957, CHR 79033, MPN 14319; Pelorus Sound, Crail Bay, *M. B. Ashwin*, 15 Nov 1957, MPN 1275; Golden Bay, Abel Tasman Point, coastal cliff, 10 ft, *A. P. Druce*, Nov 1976, CHR 311845.

HYBRIDISM: *W. ramosa* and *W. violacea* often grow naturally in the same area, separated only by altitude. Hybridism has been sought but not recognised in the wild (Petterson 1993: 117).

**3. *W. rupestris*** G.Simpson, *Trans. Roy. Soc. N.Z.* 79: 431 (1952) Fig. 10

*W. gracilis* Allan, *Flora of New Zealand I* (1961) p.p.

*W. gracilis* Cheeseman, *Man. N. Z. Fl.* (1925) p.p.

*W. gracilis* Hook.f., *Flora Novae-Zelandiae* (1852), *Handbk N.Z. Fl.* (1867) p.p.

*W. colensoi* N.E.Br. *The Gardners' Chronicle* 54: 317 (1913) p.p.

HOLOTYPE: Alexandra, rock crevices, *G. Simpson*, 1947, CHR 76433.

**DESCRIPTION:** Habit of radicate group. Stems slender, erect, 10–50 cm tall, branching from the base, terete. Leaves alternate, often dark green, usually linear-ob lanceolate to linear, 15–20 mm long, subentire, with scattered hairs on margins and lamina. Callus teeth 4–5 on each margin. Bracts linear, 4–20 × 2 mm. Flowers pure white, (9–)15–25 mm diam., 6–13 mm long, on slender pedicels 5–10 cm long. Corolla rotate, almost tubeless, with long lobes and shallow, saucer-shaped tube 2 × 5 mm. Corolla lobes 8 × 5 mm to 11 × 6 mm, elliptic to oblanceolate, acute, separated at base. Style strongly constricted below stigma lobes, white. Calyx glabrous, lobes 2 × 0.7 mm to 3 × 1 mm, narrow-triangular, erect. Capsule glabrous, 7 × 3 to 10 × 4 mm, ellipsoid to obconic. Bud at anther dehiscence slender, pointed. Self-fertile. Seeds 0.5 mm long. FL Nov–Apr, FT Dec–Apr. Chromosome number:  $2n = 72$  (Petterson et al. 1995), vouchers CHR 79109, MPN 58.

Description based on living specimens from Manawatu Gorge, Pahaoa Gorge, Banks Peninsula, and Central Otago.

**DISTINCTIVE FEATURES:** Dark green, often narrow, alternate leaves, pure white long-petalled flowers with shallow saucer-shaped tube and elliptic corolla lobes which are separate to base, giving a starry appearance.

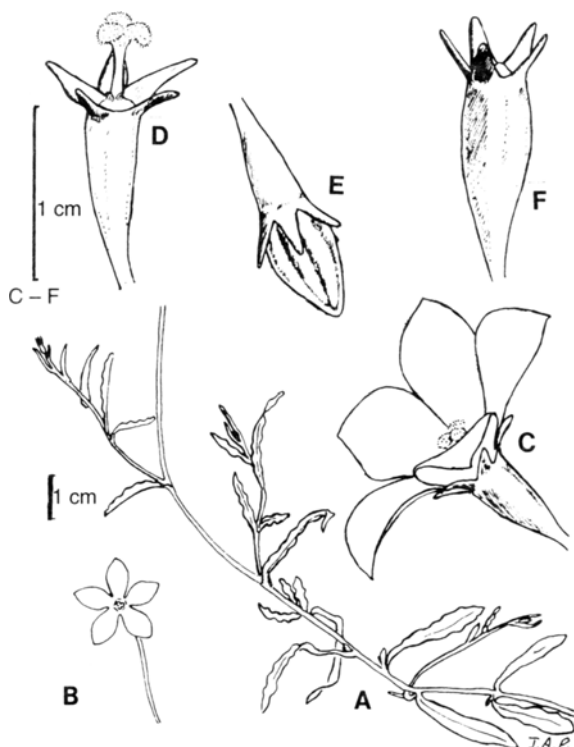
Table 3 shows the flower and capsule proportions in *W. rupestris*.

**DISTRIBUTION:** New Zealand, North I., South I., mainly inland sites from Wanganui, Rangitikei, Manawatu, and Wairarapa to Central Otago, excluding Canterbury Plains but including Banks Peninsula and Otago Peninsula (Fig. 7). Endemic.

**HABITAT:** Inland rocks, cliffs, river gorges and terraces, about 100 m to 700 m. On Banks Peninsula in valleys and terraces in reserves where sheep are excluded.

**CONSERVATION STATUS:** Not at risk.

**VARIATION:** Specimens of *W. rupestris* collected in the Manawatu Gorge have very large flowers, 20–25 mm diam. In the Pahaoa Gorge and on Banks Peninsula, flower size varies in every population but the flower shape remains constant. Small flowered plants (corolla 8 mm diam.) from Banks Peninsula developed larger flowers in cultivation (MPN 15021, 15083). Starved plants with tiny flowers and capsules from inland rock clefts and dry riverbeds in Wairarapa, Marlborough, Canterbury, and Otago, formerly referred in herbaria to *W. colensoi*, rightly belong here because they are sympatric with normal



**Fig. 10** *W. rupestris*, cultivated from Manawatu Gorge. A, habit; B, rotate starry corolla; C, flower; D, dissected flower; E, bud just before anthesis; F, capsule.

*W. rupestris*. A selection of these is listed separately below.

**REPRESENTATIVE SPECIMENS:** NORTH ISLAND: WELLINGTON: Cytology voucher  $2n = 72$ , Manawatu Gorge, (cult. A. P. Druce, Pinehaven) J. A. Petterson, 30 Mar 1967, CHR 79109, MPN 58; Manawatu Gorge (right hand specimen), K. J. Mitchell, 1942, MPN 11293; Wairarapa, Pahaoa River, M. B. Ashwin, 30 Nov 1958, MPN 1273; Pahaoa Gorge, dry roadside bank, J. A. Petterson, 2 Jan 1993, MPN 15024. SOUTH ISLAND: NEL-

**Table 3** Typical corolla, calyx, and capsule dimensions of *W. rupestris*. All measurements in mm from living plants.

Diam.	length	tube	lobe	calyx lobes	capsule
25	15	2 × 5	14 × 7	3 × 1	8 × 4
20	12	2 × 5	10 × 5	2 × 0.7	5 × 4
10	6	1.5 × 3	4.5 × 2	1.5 × 0.7	4 × 2



SON: Takaka, shaded bank of Spring Creek, *J. A. Petterson*, 8 Feb 1959, CHR 79035, MPN 14342; NW Nelson, above Cobb Reservoir, *A. P. Druce*, Feb 1985, CHR 396051; Nelson, Pelorus Bridge, *A. P. Druce*, Aug 1973, CHR 208582, 208583; Top V., Richmond Range, 260 m, rocky river bank, *A. P. Druce*, 1985, CHR 401613. CANTERBURY: Banks Peninsula, Taylors Mistake, volcanic point on coast, *J. A. Petterson*, Oct 1993, MPN 15208; Banks Peninsula, Hoon Hay valley (small fls), *H. D. Wilson*, 7 Mar 1993, MPN 15021; same plant as MPN 15021 (larger fls in cult.), *J. A. Petterson*, 16 Dec 1993, MPN 15083; Banks Peninsula, Decanter Bay, *M. Barker*, 1 Jan 1975, CANU 20931; Heathcote Hill, *D. G. Lloyd*, July 1951, CANU 4190; Okuku District, Rocky Ridge, *M. C. Barker*, 8 Dec 1968, CANU 11800. OTAGO: Lower slopes of Remarkables, 2000 ft, *J. A. Petterson*, 30 Dec 1991, MPN 15046; Clutha terraces, *J. A. Petterson*, Jan 1992, MPN 15078.

Small-flowered, small-capsule specimens placed in *W. colensoi* when collected, but rightly belonging to *W. rupestris*: NORTH ISLAND: MANAWATU: Palmerston North, Centennial Park, road verge, "narrow white petals", *A. E. Esler*, 20 Apr 1959, MPN 11277. SOUTH ISLAND: MARLBOROUGH: Mt Ben More, nr Keekerengu, 800 ft, forest margin, *A. P. Druce*, Nov 1973, CHR 249245; Keekerengu valley, 300 ft, scrub, *A. P. Druce*, Nov 1971, CHR 245259; Pelorus River, riverbank rocks, "fls white", *A. P. Druce*, Dec 1981, CHR 387360; Cytology voucher  $2n = 72$ , roadside, Awatere Valley (cult.), *J. A. Petterson*, 17 Jan 1968, CHR 79198, MPN 14322. CANTERBURY: "Carvossa", east of Waikari, *B. H. Macmillan*, 10 Apr 1979, CHR 257026; foot of Mt Somers, *A. P. Druce*, Mar 1986, CHR 401859. OTAGO: Hector Range, ledges on schist outcrops, 1500 ft, *A. P. Druce*, CHR 421200.

Hybridism is discussed with *W. violacea*.

**4. *W. akaroa* J.A.Petterson sp. nov.** Fig. 11

DIAGNOSIS: *W. rupestris* similis, differt corolla pallide caesio-violacea, subrotata, 18–25 mm diametro, tubo 1.5 × 5–6 mm, lobis oblanceolatis, 8 × 5 to 14 × 6 mm, usque ad basem separatis. Caulibus et foliis carnosiss.

Similar to *W. rupestris*, differing in the pale blue-violet corolla, which is subrotate, 18–25 mm diam., tube 1.5 × 5–6 mm, lobes oblanceolate, 8 × 5 to 14 × 6 mm, separate to the base. Stems and leaves fleshy.

HOLOTYPE: Banks Peninsula, nr Akaroa Heads, foot of Palm Gully, "rock cranny in vertical sea cliff,

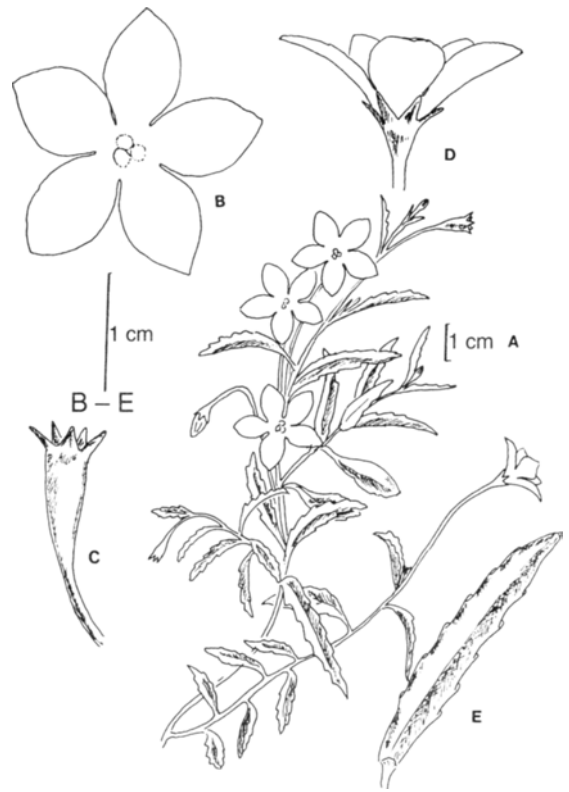


Fig. 11 *W. akaroa*, cultivated from Akaroa Heads, Banks Peninsula. A, habit; B, flower; C, capsule; D, rotate broad-petalled corolla; E, cauline leaf.

lava", *H.D. Wilson BP 483*, 4 Dec 1984, CHR 481407. v.s.

DESCRIPTION: Habit of radicate group, stems branching from the base, somewhat fleshy and brittle, the upper  $\frac{2}{3}$  of the plant forming a many-flowered much-branched multiple panicle. Leaves dark green, sessile, rather fleshy, oblong to obovate-spathulate to oblanceolate to lanceolate to linear, margins obscurely dentate to sharply serrate, more or less undulate, up to 40 × 15 mm. Flowers erect on slender pedicels 5–10 cm long, pale blue-violet, paler outside (HCC hyacinth blue 40/2 inside, 40/3 outside), sometimes white. Corolla 18–30 mm diam., 10–15 mm long, subrotate, broad-petalled, tube saucer-shaped, 1 × 5 to 1.5 × 6 mm, lobes curving up before spreading, broadly oblanceolate, acute, separate at base, touching or overlapping at widest point, 8 × 5 to 14 × 6 mm. Style thickened and blue at top. Calyx lobes glabrous, 2 × 1 to 4 × 1.5 mm, triangular,

erect or spreading. Capsules glabrous, 5 × 3 to 6 × 4 mm, obconic with protruding valves. Seeds 0.5 mm long. FL Oct–Apr, FT Nov–Apr. Chromosome number: 2n = 72 (Petterson et al. 1995), voucher CHR 478659, CHR garden no. 207/92.

**DISTINCTIVE FEATURES:** Large, subrotate, pale blue-violet or white flowers, and dark green, rather fleshy stems and leaves. This is by far the best of the endemic radicate species in horticulture, the whole plant forming an inflorescence of large flowers almost hiding the leaves and stems.

Table 4 shows the flower and capsule proportions in *W. akaroa*.

**DISTRIBUTION:** Coastal cliffs on the east and south-east margin of Banks Peninsula, Canterbury (Fig. 9). Possibly also on Cook Strait islets. Endemic.

**HABITAT:** Crevices in vertical rocky cliffs, s.l.–300 ft, also in rough shrubby pastures where protected from sheep.

**CONSERVATION STATUS:** Rare, vulnerable to grazing animals.

**ETYMOLOGY:** The epithet *akaroa* refers to the geographic location where the plant was first found. It was tag-named “Akaroa Heads” by Wilson (1987), who first recorded it as distinct, and tag-named “Akaroa” by Petterson (1993).

**REPRESENTATIVE SPECIMENS:** SOUTH ISLAND: BANKS PENINSULA: Hickory Bay, *M. J. A. Simpson* 8517, 26 Apr 1983, CHR 404376; Akaroa Harbour, north of Palm Gully, “Stiffly fleshy herb, glossy green leaves, fls pale blue”, *H. D. Wilson BP* 341, 14 Nov 1984, CHR 481268; Te Oka Road, rocky cliff, *M. D. Stolp*, 14 Apr 1983, CHR 418814; Cytology voucher 2n = 72, Akaroa Heads ex cult., *M. I. Dawson*, 1994, CHR 478659; Akaroa Heads, ex cult. at Waikanae, *J. A. Petterson*, 1994, MPN 15104.

**VARIATION:** When isolated in cultivation, my first plants of *W. akaroa* were self-pollinated and produced viable seed which developed into blue-flowered progeny identical with the parent. Later, in open

cultivation at Waikanae, not far from plants of the smaller flowered *W. rupestris* and *W. ramosa*, one plant of *W. akaroa* produced progeny with varied flower colouring from blue to lilac to white, each colour on a different F1 plant. Progeny testing of about 100 plants showed 72% with large blue flowers. The remainder had mostly large white flowers of the same shape, and a few had large rosy-lilac flowers. There were no small flowers in the F1 progeny, as one would expect if hybridism with small-flowered species were involved. On Banks Peninsula *W. akaroa* has been found in six sites, mostly on coastal cliffs. Some specimens have large white or lilac flowers (*H. D. Wilson* pers. comm. 1993). I consider this variation to be normal for the species.

**HYBRIDISM:** Both *W. violacea* (shortly-campanulate compact blue flowers) and *W. rupestris* (rotate starry white flowers) occur inland on Banks Peninsula at Hinewai Reserve and along Long Bay road and the track to Palm Gully. There appears to be hybridism between the two (occasional colonies with small, pale-blue, rotate, starry flowers). *W. akaroa* differs from the suspected hybrids in having more vigorous growth and more prolific and larger flowers, with abundant nectar. In the natural habitat I observed tiny native hover flies (Syrphidae) and tiny beetles visiting the flowers of *W. akaroa*.

In cultivation at Waikanae, larger Syrphidae, bumble bees, and honey bees have been seen working the flowers of *W. akaroa* and other available *Wahlenbergia* species. Some vigorous large-flowered hybrids may have resulted from seed collected from *W. ramosa* and others growing in the same nursery. For example, CHR 483947, cytology voucher “*W. ramosa*” 2n = 72, garden no. 271/94 (flowering in the glasshouse at Landcare Research, Lincoln during 1994), was raised from seed which I collected from a small-flowered, pale-lilac *W. ramosa*. The flowers of this voucher seedling were broad-petalled white, 25 mm diam., twice as large as those of the seed parent, and the plant was very vigorous with fleshy serrated foliage, unlike the parent. The seed parent had been collected in the wild at Pukerua Bay, but had been cultivated two years at Waikanae where the suspected hybridism with *W. akaroa* could have occurred during the second year. Also, CHR 483929, the cytology voucher for “*W. violacea* × *rupestris*” 2n = 72, was raised from seed collected from a plant from Pahaoa Gorge, in cultivation at Waikanae. The parent (suspected hybrid) had sapphire-blue narrow-petalled flowers 20 mm diam., but the voucher seedling had larger, broad-petalled, blue-violet flowers 30 mm diam. and

**Table 4** Typical corolla, calyx, and capsule dimensions of *W. akaroa*. All measurements in mm from living plants.

Diam.		length	tube	lobe	calyx	capsule	HCC
30	18	2 × 8	14 × 9	4 × 1.5	7 × 4	hyacinth	
25	16	2 × 7	14 × 9	4 × 1	7 × 4	blue	
20	10	1.5 × 5	8.5 × 6	2 × 1	7 × 3	40/2	

very vigorous fleshy growth unlike the seed parent. I believe both of these to be of accidental hybrid origin with *W. akaroa* as the pollen parent (cf. Petterson et al. 1995).

INCERTAE SEDIS: MPN 14918, Kokomohua Is, Queen Charlotte Sound, collected in the wild by S. Courtney, seedling cultivated by C. Ogle, ex cult. *J. A. Petterson*, 7 Mar 1994. This pure white, large-flowered, fleshy-leaved form has persisted several generations in cultivation, both at C. Ogle's garden in Wanganui, and at my own garden in Waikanae. It appears in life identical to the white-flowered forms of *W. akaroa*. Further live collections from pure populations on outlying Cook Strait islets are desirable for comparison with *W. akaroa* and *W. ramosa*.

**5. *W. vernicosa* J.A.Petterson sp. nov.** Fig. 12

*W. gracilis* Hook.f., *Flora Novae-Zelandiae* (1852), *Handbk N.Z.Fl.* (1867) p.p.

*W. gracilis* Cheeseman, *Man. N. Z. Fl.* (1925) p.p.

*W. gracilis* Allan, *Flora of New Zealand 1* (1961) p.p.

*W. colensoi* N.E.Br. *The Gardners' Chronicle* 54: 317 (1913) p.p.

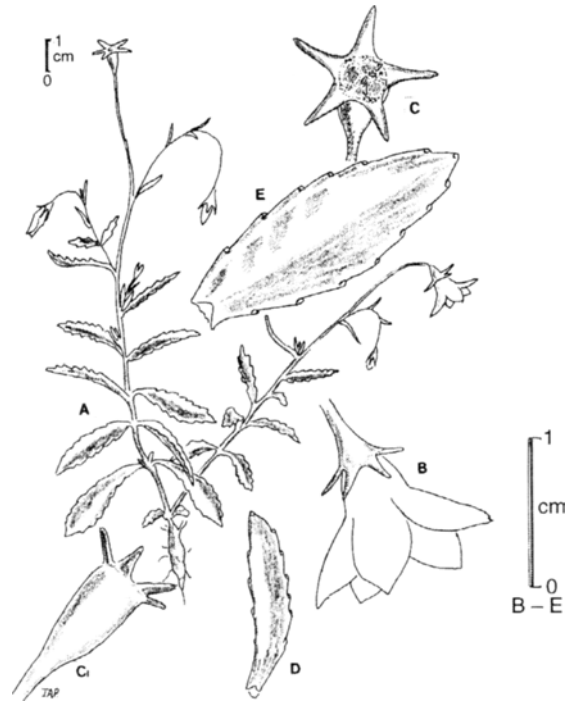
cf. *W. insulae-howeii* Lothian in Smith (1992, pp. 122–124, fig. 12 g,h).

DIAGNOSIS: *W. insulae-howeii* similis, differt foliis serratis, supra politis, vernicosis, sparse pilosis. Corolla campanulata, 10–20 mm diam. Corollae tubus cylindricus, 3 × 3 mm to 4 × 4 mm; lobi oblongi, acuti, 5–6 mm longi, 4 mm lati. Capsula obconica, supra applanata, lobis radiantibus.

Similar to *W. insulae-howeii*, but differs in the serrate leaves, glossy above as if varnished, sparsely pilose. Flowers 10–20 mm diam., corolla tube cylindrical, 3 × 3 mm to 4 × 4 mm; corolla lobes oblong, acute, 5–6 mm long, 4 mm wide. Capsule obconic, flat on top, lobes radiating.

HOLOTYPE: West of Coromandel, Motukakarikitahi Island, *A. E. Esler*, 15 Oct 1971, CHR 287845. v.s. Paratype: AK 214152. Fig. 13.

DESCRIPTION: Characters of the radicate group. Short-lived perennials with lifespan about 2 years. Root branching, fleshy, brittle. Stems 10–150 cm tall, fleshy and brittle in life, juveniles with opposite leaves, adult plants with mostly alternate sessile leaves, some stems and laterals with lower leaves opposite. Branches often closely divaricating, young shoots hairy, with crowded leaves. Leaves usually elliptic to oblanceolate, 10–40 × 5–10 mm, regularly and closely serrate, glabrous, bright green, fleshy and

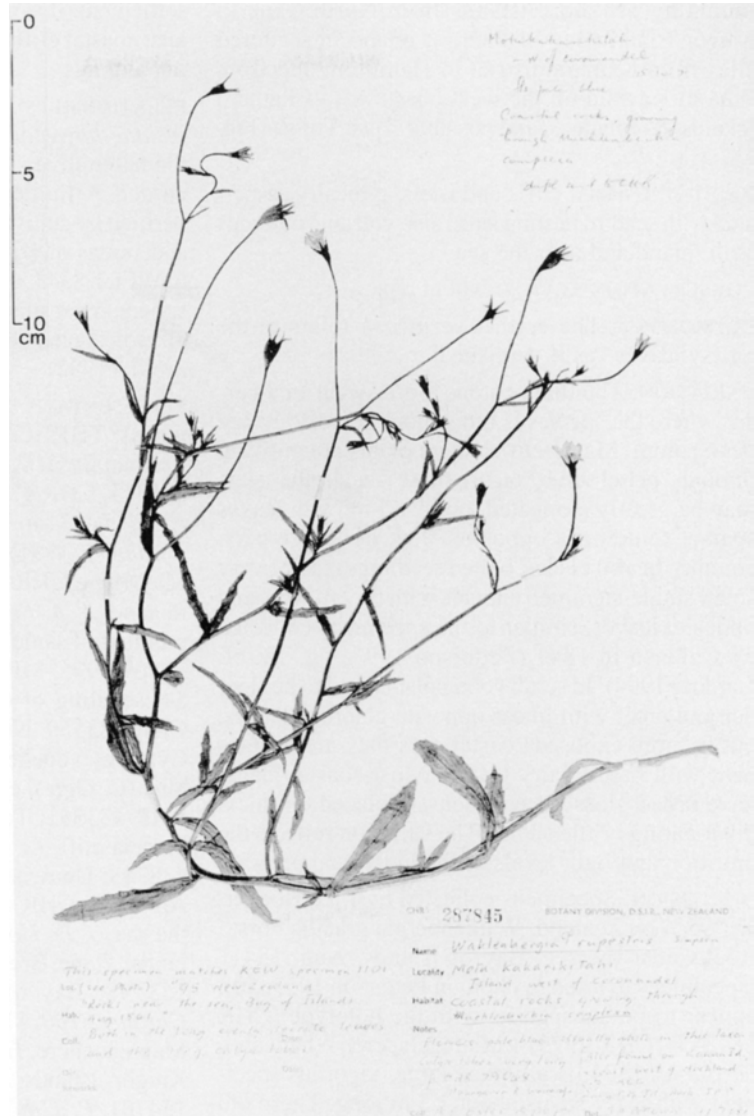


**Fig. 12** *W. vernicosa*, cultivated from Three Kings Islands. A, habit; B, campanulate flower; C, ripe capsules with radiating lobes; D, upper cauline leaf; E, basal leaf.

glossy as if varnished (in life), sparsely hairy, with prominent midrib below; sometimes linear, entire. Flowers in different populations may be white, pastel lilac (HCC 437/1), or flax blue (HCC 642/2), on short slender pedicels 2–7 cm long. Corolla campanulate, (10–)12–15(–20) mm diam., 9–12 mm long, tube cylindrical (cup-shaped), 2 × 2 to 4 × 4 mm, lobes 5 × 4 to 8 × 5 mm, oblong, subacute, spreading; style protruding slightly from tube, slightly thickened in upper half, white. Stigmas 3 or 4, small. Calyx lobes glabrous, 3 × 1 to 4 × 1.5 mm, narrowly triangular, becoming radiate or recurved in fruit. Capsule glabrous, obconic, 6 × 4 to 10 × 5 mm, flat-topped or slightly concave at the top, valves flat until ripe. Self-fertile. Seeds 0.5 mm long. FL Oct–May, FR Nov–May. Chromosome number:  $2n = 54$  (Petterson et al. 1995), vouchers CHR 483550, 483551.

The description is made from living cultivated specimens from Three Kings Islands, Surville Cliffs, Mokohinau Islands, Great Barrier Island, Rakitu

**Fig. 13** *W. vernicosa*, Holotype, CHR 287845.



Island, and Rangitoto Island. These were collected by A. Silbery, C. Ogle, P. J. de Lange, and E. K. Cameron, respectively, and sent to me as living plants for cultivation at Waikanae. Others were raised to flowering from seed collected from recent herbarium specimens held in AK.

**DISTINCTIVE FEATURES:** Pale flax blue, pale lilac, or pure white campanulate flowers with cup-shaped tube and spreading lobes, flat-topped or dish-topped obconic capsules with radiating or recurved calyx lobes. (These appear somewhat twisted or curly in dried specimens.) In cultivation in the open garden

the glossy, bright green, serrate leaves are very distinctive and ornamental, together with the compact densely divaricating habit, forming a rounded mass up to 30 cm high and 50 cm diam. covered in short-stemmed flowers. The lower stem becomes much thickened and rather woody with brittle branches and sparse foliage in moribund plants in their second year of life.

Table 5 shows the flower and capsule proportions in *W. vernicosa*.

**DISTRIBUTION:** Northern New Zealand from Three Kings Islands to Coromandel Peninsula on the east,

including off-shore islands from North Cape to Mayor Island (Bay of Plenty); inland in scattered sites from Kaipara district to Hamilton, and from Piha to Kawhia on the west coast. Also Chatham Islands, Kermadecs, and possibly 'Eua, Tonga (Fig. 7).

HABITAT: Coastal cliffs and islets, typically associated with seabird nesting sites, also volcanic outcrops both inland and near the sea.

CONSERVATION STATUS: Not at risk.

ETYMOLOGY: The epithet *vernica* refers to the glossy leaves "as if varnished".

VARIATION: The three colour forms occur in all areas where the species is indigenous (P. J. de Lange pers. comm. May 1996). Where plants are growing through "petrel scrub" on off-shore islands, the stems may be greatly elongated, up to 1.5 m, with leaves sparse, sometimes opposite (P. J. de Lange pers. comm.). In arid places, bolted seedlings may be very small single-stemmed annuals with tiny flowers and opposite leaves, similar to the specimens collected by Colenso in 1841 (Pettersen 1997, fig. 12; cf. Gardner 1994). In scrub young plants tend to be slender and erect with linear opposite glabrous leaves, but in more exposed coastal sites they are decumbent with broad hairy leaves. Most coastal plants have broad glossy leaves densely placed on thick, divaricating brittle stems. The variation reflects the nutrition and light levels of the individual plant.

DISCUSSION: Specimens collected by J. D. Hooker, K, "95 New Zealand, Wahlenbergia gracilis Forst., Rocks near the sea, Bay of Islands, Aug. 1841" (specimens marked *b*, photo in Pettersen 1953: 50), appear to be conspecific with the holotype (CHR 287845). CHR 297514 Maungatapere, Whangarei, H. Carse, 1894, is a typical large, vigorous specimen with leafy stems about 1.5 m long. These old specimens show that *W. vernica* used to be more common on the mainland in the early days of

settlement. It is now mainly confined to isolated islets, coastal cliffs, and poor scrubland with no grazing animals.

RELATIONSHIPS: *W. vernica* appears similar to *W. insulae-howei* of Lord Howe Island. I have not seen the latter alive, and chromosome counts are not recorded. Affinities with *W. insulae-howei* need to be verified by cultivation and chromosome count. Good specimens of *W. insulae-howei* are WELT 74105–6, WELT 8344, and AK 92489. These all have hemispherical capsules with twisted calyx lobes, and are all radicate in habit, not rhizomatous as described by Smith (1992).

REPRESENTATIVE SPECIMENS (mostly without colour notes): THREE KINGS ISLANDS: Great Island, Tasman Bay, P. J. de Lange 1083, 15 Oct 1991, AK 206314, CHR 474999, WELT 79076; SW King, G. F. Buddle, 3 Jan 1947, AK 22339; Great King (coll. A. Silbery, 1991), fls lilac, ex cult., J. A. Pettersen, May 1994, CHR 201833; seedlings of same, grown in sand, J. A. Pettersen, Dec 1994, CHR 201834; seedling of same from open garden, J. A. Pettersen, 8 Nov 1995, MPN 15829; Cytology voucher  $2n = 54$ , seedling of CHR 201833, M. Dawson, 1994, CHR 483550. NORTH ISLAND: NORTHLAND: Cytology voucher  $2n = 54$ , Surville Cliffs, fls. flax blue (C. Ogle), ex cult. J. A. Pettersen, May 1994, CHR 483551; Tom Bowling Bay, Tomahanga Pa, breccia cliff, C. C. Ogle 1418, 31 Oct 1986, CHR 438283; Unuwhaeo massif, P. J. de Lange 778, 18 Apr 1991, CHR 473295; Bay of Islands, rocks near the sea, J. D. Hooker, Aug 1841, K 95; Bay of Islands, Cape Brett, G. I. Collett, Sep 1964, CHR 153798; Bay of Islands, S of Waipapa, R. O. Gardner 2100, 4 Nov 1978, AK 145264; Whangarei, Maungatapere, H. Carse, 1897, CHR 297514; Poor Knights Islands, A. E. Wright 3929, 7 Sep 1980, AK 154701; P. J. de Lange & G. M. Crowcroft, 26 Oct 1995, AK 226781–2; Hen & Chicken Islands, Taranga (Hen) Island, L. B. Moore & L. M. Cranwell, 1934, AK 37148; Mokohinau Islands, Stack "H", P. J. de Lange, 10 Nov 1993, AK 226785; same collection ex cult., J. A. Pettersen, May 1994, CHR 201831; seedlings of same, grown in sand, J. A. Pettersen, 28 Jan 1995, CHR 483928; Hauraki Gulf, Tiritiri Island, A. E. Esler, 19 Dec 1970, CHR 223502. SOUTH AUCKLAND: Colville, New Chums Beach, P. J. de Lange & G. M. Crowcroft 1710, 27 Sep 1992, AK 210972; Colville District, Wekorua Island, A. E. Esler, 8 Oct 1971, AK 214151; Taruru, N of Thames, P. Hynes, 23 Oct 1971, AK 129216; Mayor Island, A. E. Wright 4313,

**Table 5** Typical corolla, calyx, and capsule dimensions of *W. vernica*. All measurements in mm from living plants.

Diam.	length	tube	lobe	calyx	capsule	HCC
20	15	4 × 4	11 × 4	3 × 1.3	7 × 4	pas.lilac
15	10	4 × 4	6 × 4	4 × 1.5	7 × 4	flax blue
12	8	3 × 3	5 × 4	3 × 1	5 × 4	flax blue
10	7	2 × 2	3 × 3	3 × 1	3 × 2	white
15	11	4 × 4	7 × 4	4 × 1	5 × 4	white

19 Nov 1981, AK 159624. CHATHAM ISLANDS: Rekohu, Red Bluff, *P. J. de Lange* CH224 & *G. M. Crowcroft*, 1 Mar 96, AK 226783.

TONGA: 'Eua Island, *A. E. Wright*, 15 Oct 1986, AK 177774, appears to belong here. v.s.

Specimens with small white flowers, formerly identified as "*W. colensoi*" or "*W. gracilentia*" by collectors, are probably false annuals or starved juveniles of *W. vernicosa*, e.g., KERMADEC ISLANDS: Macauley Island, Plateau, *W. R. Sykes*, 22 Nov 1970, CHR 211836. THREE KINGS ISLANDS: Great Island, near Bald Hill, *P. J. de Lange*, 2 Dec 1995. NORTH ISLAND: NORTHLAND: Te Pahi Farm Park, E of Spirits Bay, *W. R. Sykes*, 1989, CHR 465016; Te Pahi Farm Park, in scrub, *A. E. Wright*, 1989, AK 189997; Maunganui County, *H. Carse*, 20 Oct 1912, CHR 1427; Great Barrier Island, Medland's Rock, *P. J. de Lange*, 20 Nov 1989, AK 199912; Great Barrier Island, Miners Head, *E. K. Cameron* 7438, 18 Jan 1994, AK 218536; Rakitu Island, *E. K. Cameron* 7446, 19 Jan 1994, AK 218535. AUCKLAND: Rangitoto Wharf, *P. J. de Lange* 2362, 1 Nov 1993, AK 218970; Rangitoto Wharf, *E. K. Cameron* 7387, 9 Nov 1993, AK 215370;

Cultivated seedlings from New Zealand *W. vernicosa* specimens, when grown in dry sand at Waikanae, developed into similarly dwarfed single-stemmed annuals, e.g., CHR 201831, MPN 14927, Mokohinau Islands ex cult., *J. A. Petterson*, 1995, and CHR 201834, Three Kings Islands, ex cult., *J. A. Petterson*, 1994. Seedlings of the same batches of seed, given richer soil and adequate moisture, developed into vigorous branching plants, e.g., CHR 453550, WELT 74520, 74523.

HYBRIDISM: Hybridism with other New Zealand species is unlikely because of the chromosome difference. Specimens of *W. vernicosa* in cultivation at Waikanae have bred true to colour for two or three generations when isolated in "island gardens". Crossing between colour forms can occur in adjacent garden specimens visited by bees, resulting in mingled colours in the flowers of the progeny, e.g., white corollas with mauve or pale blue tips.

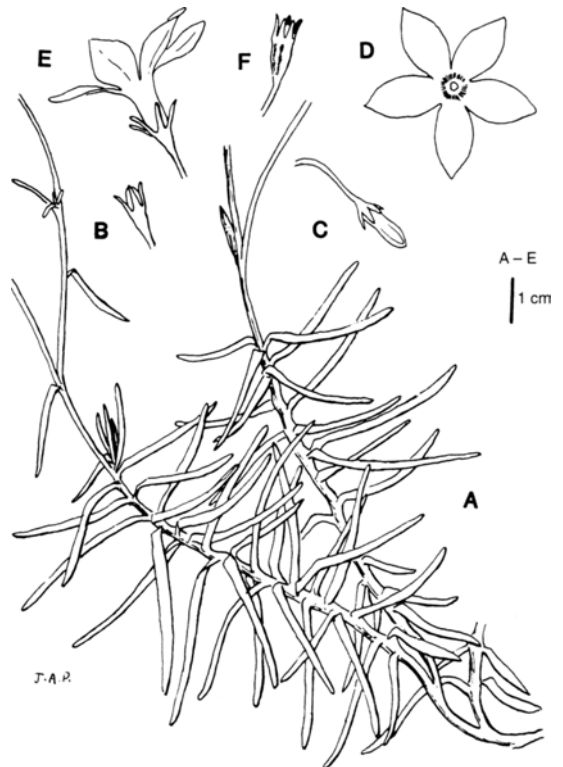
**The New Zealand rhizomatous species**

**6. *W. matthewsii*** Cockayne *Trans.N.Z.Inst.* 47: 113 (1915)

Fig. 14

HOLOTYPE: Clarence Valley near coast, *H.J. Matthews*, Oct 1905, WELT 4705. v.s.

DESCRIPTION: Perennial herb of erect or spreading sub-shrubby growth, 10–30 cm tall, initially with



**Fig. 14** *W. matthewsii*, cult. from Isolation Creek, Waima R., Marlborough. A, leafy stem; B, C, flower buds; D, E, flower full-face and in profile; F, young capsule.

fleshy white tap-root, rhizomes developing later in suitable conditions. Stems branching from the root-stock, brownish white at the base, 2–3 mm diam., aerial parts purplish, glabrous, clothed with numerous, crowded, spirally arranged, spreading, sessile leaves. Leaves uniform, linear, glabrous, 10 × 1 to 50 × 3 mm, margins entire or distantly and obscurely toothed, sometimes recurved. Stems branching at the top into 2 or more almost naked scapes 10–15 cm long, simple or branched again with a few narrow-linear bracts 5–15 mm long, distantly placed. Flowers terminal on each peduncle, pale flax blue to pale blue-lilac with white zoning and deeper blue or violet veins, or completely white; corolla 20–40 mm diam., deeply campanulate with tube 7 × 5 to 9 × 6 mm, lobes spreading, ovate-lanceolate, 10 × 6–20 × 8 mm. Anthers linear, 4 mm long, style equaling corolla tube, stigma usually 2-lobed. Calyx glabrous, linear-triangular, 4–5 × 1 mm; capsule glabrous, domed obconic, 6 × 4 to 12 × 6 mm long. Seeds 0.5 mm long. FL Dec–Apr, FT Jan–Apr.

Chromosome number:  $2n = 36$  (Pettersen et al. 1995), voucher CHR 79194.

**DISTINCTIVE FEATURES:** Suffruticose growth, crowded linear leaves, large, deeply campanulate flax-blue, lilac, or white flowers.

Table 6 shows the flower and capsule proportions in *W. matthewsii*.

**DISTRIBUTION:** South Island: blue-tinted flowers on Kaikoura coast, Marlborough, from Flaxbourne Creek to Clarence mouth; white-flowered at Gorge Creek, Takaka Valley, Golden Bay (Fig. 9). Endemic.

**HABITAT:** Limestone gorges and terraces, sea-level to 500 ft.

**CONSERVATION STATUS:** Rare in Takaka, vulnerable in Marlborough.

**REPRESENTATIVE SPECIMENS: MARLBOROUGH:** Cytology voucher  $2n = 36$ , Marlborough, Waima (Ure) River, *A. P. Druce*, May 1967, CHR 79194; Woodside Creek, on limestone rock and rubble, *Wm. Martin*, Jun 1931, WELT 65300; Ure River, *H. F. Hursthouse*, WELT 47875; Ure River, *B. C. Aston*, 26 Apr 1915, WELT 47879; Marlborough, Clarence Valley, *A. P. Druce*, Apr 1975, CHR 274958; Mt Ben More, 1200 ft, *A. P. Druce*, Nov 1973, CHR 249362; Marlborough, Hapuku River, *D. G. Lloyd*, 24 Apr 1971, CANU 16843; Puhipuhi Res. nr Kaikoura, *P. J. Garnock-Jones*, 21 Jun 1973, CANU 19267. **NELSON:** NW Nelson, Pikipiruna Range, Gorge Creek, marble cliff, "white flowers", *A. P. Druce*, Jan 1979, CHR 365571; Gorge Creek nr Takaka, *W. R. Philipson & F. Soper*, 27 Dec 1968, CANU 12238.

**HYBRIDISM:** *W. matthewsii* hybridises with *W. albomarginata* when cultivated in the same area. Hybrids are intermediate in habit and foliage and may take several forms. v.v.

**DISCUSSION:** *W. matthewsii* makes a fine and rewarding rock garden plant which seeds freely in cultiva-

tion, and can also increase by short rhizomatous growths, with new plants surrounding the original taprooted seedling. It is perennial with indefinite lifespan in suitable garden conditions.

CHR 84745 (Allan 1961: 788 as BD 84745) is *Gentiana astonii*.

**7. *W. cartilaginea*** Hook.f., *Handbk. N. Z. Fl.* 169–170 (1867). Fig. 15

**HOLOTYPE:** Tarndale, *Sinclair*, K.

**DESCRIPTION:** A perennial deep-rooting rhizomatous scree plant with distant rosettes of very thick, glaucous, (sometimes yellowish) sessile leaves, glabrous or pubescent. Leaves  $8 \times 5$ – $25 \times 15$  mm, spatulate, obtuse, narrowed to a thick flat petiole; margins entire, thickened, cartilaginous. Scapes 2–3 cm long, stout, glaucous, with 1–3 small bracts, usually simple and stiff. Flower c. 12 mm long, 8–12 mm diameter, lilac, scented. Corolla broadly funnel-shaped, 5-partite, tube c.  $5 \times 6$  mm, lobes c.  $7 \times 5$  mm, enclosed within the large calyx lobes which are thick and coriaceous, glabrous, linear-oblong, obtuse,  $6 \times 2$  to  $10 \times 3$  mm. Capsule glabrous, often glaucous, globose to broadly turbinate, c.  $8 \times 8$  to  $10 \times 10$  mm. Seeds larger than in other species, 1 mm long, ellipsoid, glossy brown when mature. Insect-pollinated. FL Dec–Jan, FT Jan–Mar. Chromosome number:  $2n = 36$  (Pettersen et al. 1995), voucher CHR 201801).

**DISTINCTIVE FEATURES:** Scree plant, thick greyish or yellowish leaves in separate rosettes, short thick flower stems, calyx lobes about as long as corolla, fragrant flowers. The long slender rhizomes may be 2–3 m long and each plant can be distinguished by the colour of its widely separated rosettes.

The insect pollinator is not known but the black scree butterfly, *Percnodaimon pluto*, is likely.

Table 7 shows the flower and capsule proportions in *W. cartilaginea*.

**DISTRIBUTION:** South Island, Inland Kaikoura and Amuri Ranges from Mt. Tapuaenuku to Mt. Terako and Mt. Percival, and drainage areas of upper Wairau, Waiau, Clarence, and Awatere rivers (Fig. 16). Endemic.

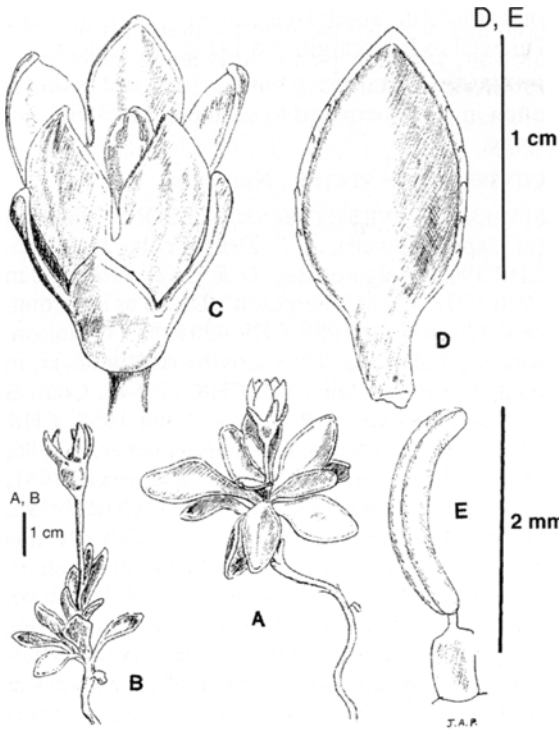
**HABITAT:** Confined to deep fine greywacke screes and semi-consolidated debris slopes, 3000–5000 ft.

**CONSERVATION STATUS:** Not considered at risk.

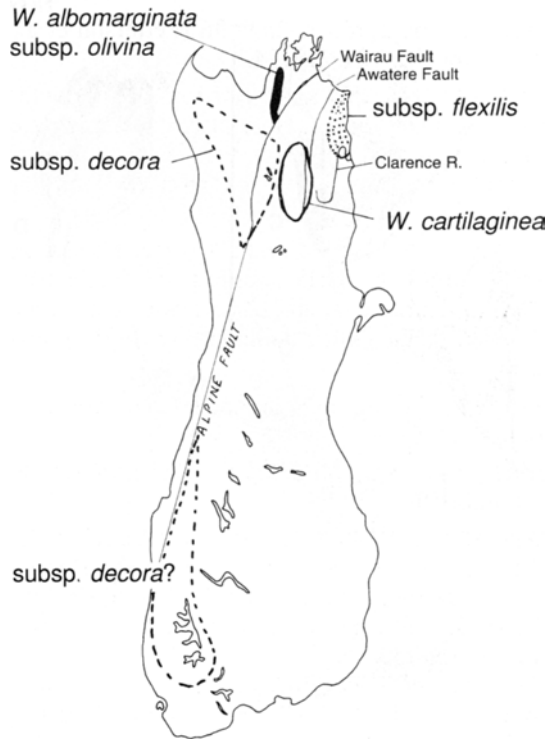
**REPRESENTATIVE SPECIMENS: MARLBOROUGH:** Cytology voucher  $2n = 36$ , Inland Kaikoura Range, Mt. Terako, *T. Packer*, 31 Jan 1970, CHR 201801; Mt. Terako, scree 4000 ft, *B. H. Macmillan*, 26 Jan 1969, CHR 193818; Mt. Southey, nr. Lake Tennyson,

**Table 6** Typical corolla, calyx, and capsule dimensions of *W. matthewsii*. All measurements in mm from living plants.

Diam.	length	tube	lobe	calyx	capsule	HCC
30	18	$7 \times 5$	$15 \times 8$	$5 \times 1.5$	$11 \times 6$	flax blue
32	23	$8 \times 5$	$15 \times 8$	$4 \times 1.5$	$12 \times 6$	642/3
38	28	$8 \times 6$	$20 \times 9$	$5 \times 1.5$	$12 \times 6$	40/2



**Fig. 15** *W. cartilaginea*, Mt Terako. A, habit in flower; B, habit in fruit; C, flower; D, leaf; E, stamen and filament.



**Fig. 16** Natural distribution of *W. cartilaginea*, *W. albomarginata* subsp. *olivina*, subsp. *decora*, and subsp. *flexilis*.

*J. A. Petterson*, 19 Jan 1976 (showing root system), CHR 287821; Tarndale, *D. Sinclair*, Jan 1861, WELT 47870; Wairau Gorge, *Captain Rough*, WELT 47869; Tapuaenuku, *B. C. Aston*, Dec 1915, WELT 47866, 47871; Mt Southey nr Lake Tennyson, *Y. Cave*, 19 Jan 1976, MPN 68.

**HYBRIDISM:** *W. cartilaginea* hybridises occasionally with *W. albomarginata* where they grow close together. One hybrid seen alive had the leaves of *W. cartilaginea* and the calyx and corolla of *W. laxa*, e.g., CHR 287824–6, fine scree on Mt. Southey, near Lake Tennyson, *J. A. Petterson*, Jan 1976.

**Table 7** Typical corolla, calyx, and capsule dimensions of *W. cartilaginea*. All measurements in mm from living plants.

Diam.	length	tube	lobe	calyx	capsule
10	12	5 × 6	7 × 5	12 × 3	10 × 10

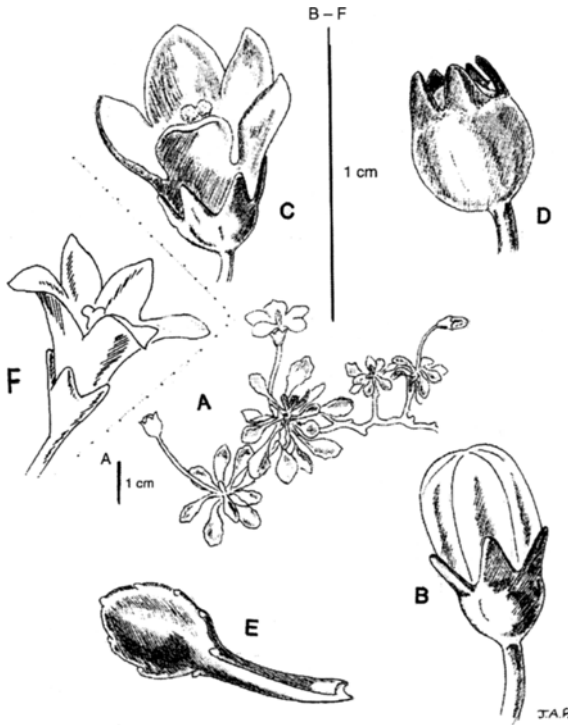
**8. *W. congesta*** (Cheeseman) N.E.Br., *Gardeners' Chronicle* 54: 336 (1913) Fig. 17  
*W. saxicola* var. *congesta* Cheeseman *Man. N.Z.Fl.:* 403, (1906).  
*W. morgani* Petrie in *Trans.N.Z.Inst.* 46: 34, (1914).  
**LECTOTYPE:** Cape Foulwind, near Westport, *T. F. Cheeseman*, AK 9257 (here chosen). **ISOLECTOTYPES:** Cape Foulwind, near Westport, AK 9258, 209535 (*T. F. Cheeseman Herbarium*).

**Key to subspecies**

Capsules 6 mm diam., flowers broadly campanulate, wide-open, 12–15 mm diam. .... subsp. ***congesta***  
 Capsules half the size of var. *congesta*, and smaller funnel-form flowers 8–10 mm diam. .... subsp. ***haastii***

Table 8 shows the flower and capsule proportions in *W. congesta* ssp. *congesta* and ssp. *haastii*.





**Fig. 17** *W. congesta*, Cape Foulwind. A, habit; B, bud near anthesis; C, flower; D, capsule; E, leaf; F, flower of subsp. *haastii*, cult. from Ship's Creek beach, coast north of Haast.

#### Subspecies *congesta*

**DESCRIPTION:** Mat-forming plant with sessile rosulate tufts of glossy glabrous leaves and subsessile white flowers. Leaves orbicular spatulate, 8–25 mm long, shallowly crenate-serrate, undulate or flat, narrowed to a thin flat petiole. Scape solitary from each rosette, 1–2 cm long in flower, elongating up to 5 cm in fruit. Flowers solitary, terminal, erect, white or palest blue, 12–15 mm diam. Corolla rotate-campanulate, 9–12 mm long, tube bowl-shaped, c. 4 × 5 mm, lobes 7 × 5 to 8 × 5 mm, ovate, obtuse. Calyx lobes 2 × 1 mm wide at base, triangular. Capsule globose, 6 mm diam. when mature. Seeds ellipsoid, glossy brown. Self-fertile in cultivation. FL Nov–Mar, FT Dec–Apr. Chromosome number:  $2n = 36$  (Pettersen et al. 1995), vouchers CHR 79193, MPN 14330; Beuzenberg & Hair (1983, fig. 35), voucher CHR 100206.

**DISTINCTIVE FEATURES:** Coastal habitat, sessile glossy spatulate leaves, subsessile flowers, round capsules.

Fig. 17 A–E

**DISTRIBUTION:** South Island, west coast from Cape Farewell to Invercargill coast (Fig. 9). Endemic.

**HABITAT:** Coastal rocky bluffs, cliffs, and beaches, often in places exposed to southerly gales and salt spray.

**CONSERVATION STATUS:** Not at risk.

**REPRESENTATIVE SPECIMENS:** NELSON: Wharariki (nr Cape Farewell), *A. P. Druce*, cult., Jan 1985, CHR 394308; Nguroa Bay, *D. R. Given* 14096, 8 Jan 1986, CHR 420342; Ferguson's Beach nr Bar Point, *D. R. Given*, 7 Jan 1986, CHR 420333; NW Nelson, between Kahurangi River mouth and Big River, in sand, *G. Collett*, Apr 1965, CHR 177546; Coast S of Heaphy River, *L. B. Moore*, 1 Jan 1958, CHR 123829. WESTLAND: Cytology voucher  $2n = 36$ , Cape Foulwind, coastal rocks, *W. B. Brockie*, 1951, ex cult. *J. A. Petterson*, 1 Feb 1967, CHR 79193, MPN 14330; Charleston, *D. Petrie*, 7 Feb 1913 (as "*W. morgani*"), CHR 297425; Gillespies Beach, *P. Wardle & J. Fryer*, CHR 179184; South Westland, N of Cascade River mouth, coastal cliff, *P. Wardle*, 31 Mar 1977, CHR 228404. FIORDLAND: Yates Point, Madagascar Beach, sea-level, *A. F. Mark & G. T. S. Baylis*, 3 Mar 1977, OTA 37527; Poison Bay, "locally common on sand-dunes at head of bay", *A. F. Mark & P. Wardle*, 1977, OTA 35067; Waitutu River mouth, *P. N. Johnson*, 25 Feb 1976, CHR 261949; Omaui Peninsula, SSW of Invercargill, *A. P. Druce*, Mar 1991, CHR 469330; Fortrose, *D. Petrie*, 4 Jan 1913, WELT 47858.

subsp. *haastii* J.A.Pettersen subsp. nov. Fig 17 F

**DIAGNOSIS:** *W. congestae* similis, differt floris infundibuliformis, parvi, capsulus parvulus, 3 mm diam. Similar to *W. congesta*, but flowers funnel-shaped, small. Capsules very small, 3 mm diam.

**HOLOTYPE:** Ship's Creek, N of Haast, in sand close to sea, *J. A. Petterson*, Jan 1992, MPN 14920, ex cult. 12 Dec 1993. (All pieces are from one matted plant.) Isotype: CHR 201850.

**Table 8** Typical corolla, calyx, and capsule dimension of the two subspecies of *W. congesta*. All measurements in mm from living plants.

Diam. length tube		lobe	calyx	capsule	ssp.	
15	10	4 × 5	7 × 5	2 × 1	6 × 6	<i>congesta</i>
9	8	2 × 3	6 × 2	1.5 × 1	4 × 4	<i>haastii</i>

**DESCRIPTION:** Mat-forming plant with flowers much smaller than subsp. *congesta*, sessile or subsessile, corolla funnel-shaped, erect, white, c. 9 mm diam., 8 mm long, tube 2 × 3 mm, lobes strap-shaped, 6 × 2 mm. Capsules globular, 4 mm diam., fruiting scapes 1–2 cm long. FL Nov–Apr, FT Dec–Apr. Chromosome number:  $2n = 36$  (Petterson et al. 1995, fig. 3), voucher CHR 483566.

**DISTRIBUTION:** Known only from a short area of coastal sandy beach between Whakapohai River and Haast River, South Westland (Fig. 9). Endemic.

**HABITAT:** Partly consolidated sand at back of beach, where it forms extensive mats, the stems and leaves often covered by drifting sand.

**CONSERVATION STATUS:** Rare; further searching along the Westland beaches will help determine the range of this taxon.

**ETYMOLOGY:** The epithet *haastii* refers to the Haast River near where the taxon was first recognised.

**REPRESENTATIVE SPECIMENS:** WESTLAND: nr Whakapohai River mouth, *W. R. Sykes*, 6 May 1970, CHR 205904; sand-dunes north of Haast River, sea-level, *G. T. S. Baylis*, 9 Jan 1966, CHR 13645, 13646; Ship Creek, N of Haast, *P. Wardle*, 7 Jan 1977, CHR 228326; Cytology voucher  $2n = 36$ , Ship Creek, N of Haast River mouth, *J. A. Petterson*, ex cult., Jan 1992, CHR 483566.

A good living plant is CHR garden no. 15711, *Bruce Given*, 1984, Ship Creek, Haast, in the Landcare Research rockery at Lincoln.

**NOTE:** *W. congesta* Thulin (1975, Zaire) is predated by *W. congesta* N.E.Br. (1913, New Zealand).

**9. *W. albomarginata*** Hook. *Icones Plantarum* 9: t. 818 (1852)

Type Sheet: K Negative No. 1107, Herbarium Hookerianum. Fig. 18. (Three collections on this sheet.)

**LECTOTYPE:** *Bidwill* n. 68, K, two pieces marked X in Fig. 18 (here chosen).

**DESCRIPTION:** Perennial herb with radical, rosulate tufts of leaves, sometimes alternate on elongated stems (shade form). Leaves more or less petiolate, entire or dentate or undulate, lamina 10 × 2 to 40 × 10 mm, linear to elliptic or ovate to obovate, gradually narrowed to petiole as long as the lamina or longer. Flowers narrowly campanulate-rotate, corolla pale flax blue to pale blue-violet, often with white zoning and deeper coloured veins, or all white, 10–25 mm diam., 10–20 mm long, corolla tube 4 ×

3 to 10 × 6 mm, lobes 6 × 3 to 12 × 5 mm; style equal in length to corolla tube, lobes 2 or 3. Calyx lobes less than ¼ corolla length; capsule domed cylindric, 6–8 × 4 mm. Seeds 0.5 mm long, ellipsoid, smooth, glossy brown when mature. Usually insect-pollinated in natural habitat, seldom sets seed in cult. FL Nov–Apr, FT Dec–Apr.

**DISTINCTIVE FEATURE:** Narrow-campanulate-rotate corolla, with tube distinctly longer than broad. This feature unites the five subspecies listed below, three of which have been described as species in the past. Spring flowers may have shorter corollas, but later flowers in the same plant are long-tubed.

The five subspecies are distinguished by leaf characters combined with geographical and geological separation.

### Synopsis of subspecies

- 1 Inland eastern South Island low-rainfall regions, from east of the Wairau River to Central Otago; leaves linear to elliptic, entire, often white-margined ..... subsp. *albomarginata*
- 2 Kaikoura limestone, leaves ovate, entire ..... subsp. *flexilis*
- 3 Western South Island, serpentine substrate, leaves dark olive-green, entire, white-margined ..... subsp. *olivina*
- 4 Western South Island, high rainfall regions from west of Wairau River to North West Nelson and south to Fiordland and Stewart Island; leaves oblanceolate, dentate, undulate, not white-margined ..... subsp. *laxa*
- 5 Nelson Lakes National Park, screes and rocks above 4000 ft, leaves dentate, undulate, flower scented ..... subsp. *decora*

Table 9 shows the flower and capsule proportions in the five subspecies of *W. albomarginata*.

**TYPIFICATION:** The Type sheet in Kew (Fig. 18) has three collections mounted on the page, one set collected by Bidwill n. 68 (no date), and two sets by D.

**Table 9** Typical corolla, calyx, and capsule dimensions for subspecies of *W. albomarginata*. All measurements in mm from living plants.

	Diam.	length	tube	lobe	calyx	capsule	ssp.
35	25	10 × 7	15 × 6	5 × 1	8 × 4	<i>laxa</i>	
25	20	8 × 5	12 × 5	4 × 1	8 × 5	<i>laxa</i>	
18	14	6 × 5	8 × 4	4 × 1.5	7 × 4	<i>flexilis</i>	
20	14	5 × 4	9 × 5	2 × 1	6 × 4	<i>decora</i>	
17	15	7 × 4	8 × 3	2 × 0.5	6 × 4	<i>albomarginata</i>	
12	10	4 × 3	6 × 4	3 × 1	8 × 3	<i>olivina</i>	



**Fig. 18** K 1107: Type specimens of *W. albomarginata* Hook. in *Icones Plantarum* 1852. Three collections on the sheet. Lectotype here chosen, pieces marked X.

Monro, "81, Manuku Island, Upper Wairau, *D. Monro* 1850" and "Aglionby Plains, *D. Monro*, 1851". Bidwill was in the Nelson region in March 1848, the first botanical explorer there. The seven specimens at the top of the page with entire leaf-margins and pale laminae are typical *W. albomarginata* subsp. *albomarginata* as described below. They belong to the label with a sketch of the

flower and "Bidwill n. 68" and "*W. albomarginata* Hook Ic.Pl.t. 818." The sketch and the two specimens marked X are recognisable as those used for the drawing in *Icones Plantarum* t. 818.

Monro's "81" label probably belongs to the single specimen at lower left. The top label "135 Aglionby Plains N. Zealand 1851 D.Monro" probably applies to the rest, which appear to have dark

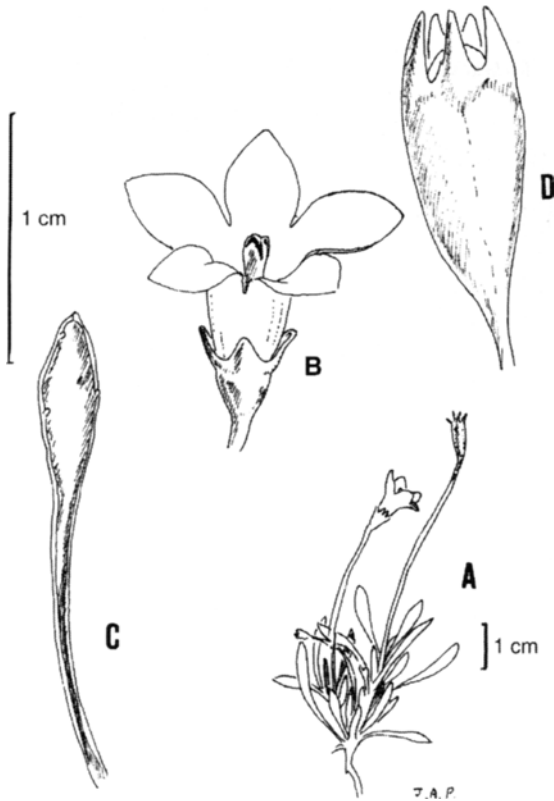


Fig. 19 *W. albomarginata*, cultivated from Fox's Peak, Canterbury. A, habit; B, flower; C, leaf; D, capsule.

leaves with toothed margins and may be subsp. *laxa*. "Aglionby Plains" is an obsolete name for the Matakītaki Valley, near Murchison, a region of high rainfall.

subsp. *albomarginata*

Fig. 19

= *W. brockiei* Hay in Allan, *Flora of New Zealand* 1: 792 (1961).

DESCRIPTION: Leaf lamina elliptic to linear, entire or subentire, often glaucous when dried, often with conspicuous thickened margin. Marginal teeth few, inconspicuous. Flowers 12–17 mm diam. Chromosome number:  $2n = 36$  (Petterson et al. 1995), vouchers CHR 76404; 79075; 79094).

DISTRIBUTION: Low rainfall areas of the eastern South Island: Marlborough east of the Wairau River, Canterbury, and Central Otago (Fig. 20). Endemic.

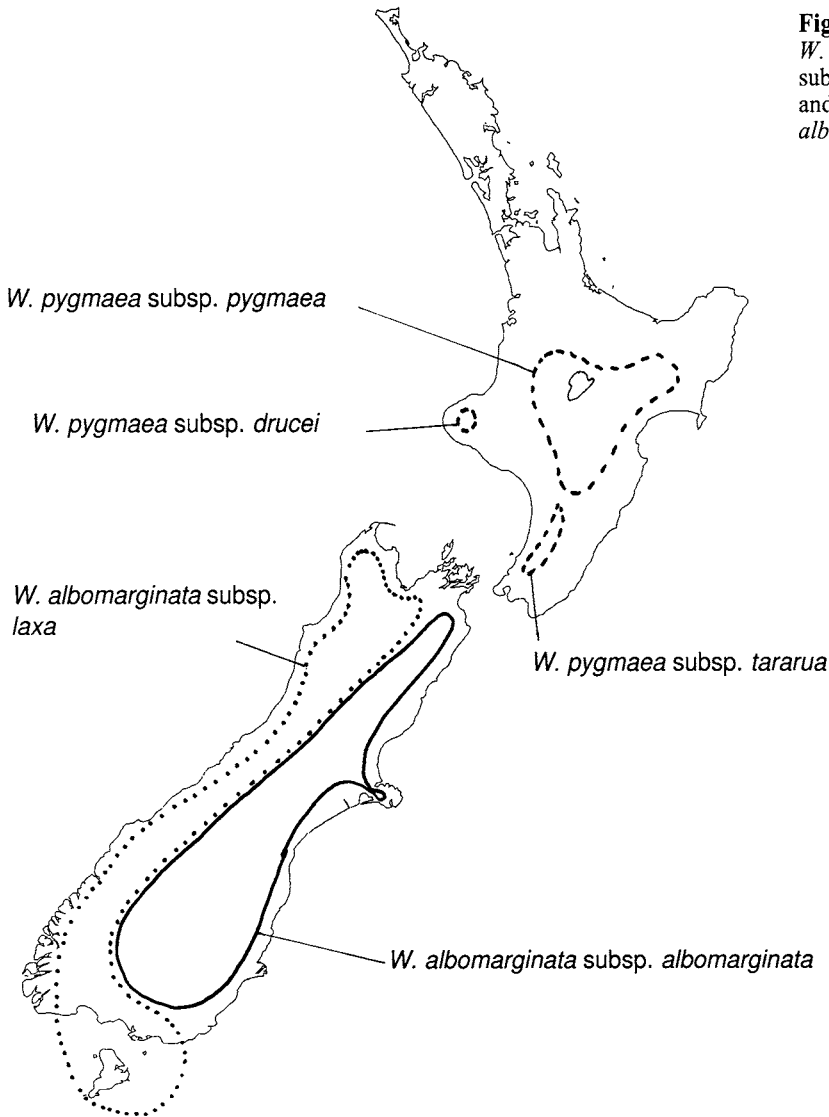
HABITAT: Lowland tussock-grassland, river terraces and rocks, usually 500 to 2000 ft.

CONSERVATION STATUS: Not at risk.

REPRESENTATIVE SPECIMENS: MARLBOROUGH: Cytology voucher  $2n = 36$ , Awatere, Altamarloch, *J. A. Petterson*, 28 Mar 1967, CHR 79075, 79094; Williams valley, Mt St Patrick, *J. A. Petterson*, 20 Jan 1976, CHR 287837, MPN 428; Tapuaenuku, *B. C. Aston*, 1915, WELT 47906; Molesworth Station, upper Awatere, *L. B. Moore*, 1952, CHR 76361; Ridge east of Carters Saddle, *L. B. Moore*, 1952, CHR 76365, CHR 76366; upper Wairau Valley, *A. G. Hutson*, 20 Apr 1965, MPN 426. NELSON: Mt Owen, marble scree, 5000 ft, *J. A. Petterson*, 20 Jan 1972, CHR 287846, MPN 14904. CANTERBURY: Cytology voucher  $2n = 36$ , foot of Porters Pass, Christchurch side, *Y. Elder*, 16 Dec 1967, CHR 76404; Cytology voucher  $2n = 36$ , Maryburn Station, *K. Forde*, Nov 1993, ex cult. Landcare Lincoln garden no. 370/93, *M. Dawson*, May 1994, CHR 483565; Lindis Pass, *Y. & R. Elder*, 14 Jan 1968, CHR 201813; Cass River bed, *W. R. Philipson*, 20 May 1957, CANU 25536; Porters Pass, *M. T. Kalin*, Nov 1964, CANU 12437; South Canterbury, Fox's Peak, *A. E. Esler*, Jan 1956, AK 214142; South Canterbury, Hakataramea, *A. T. Dobson*, 9 Dec 1975, CANU 21881; Banks Peninsula, Herbert Peak summit, *B. P. Molloy*, 22 Jan 1970, CHR 201533. CENTRAL OTAGO: Kawarau River terrace, between Queenstown and Arrowtown, *J. A. Petterson*, 7 Jan 1992, MPN 15041; Shotover River bed, *J. A. Petterson*, 6 Jan 1992, MPN 15043; Lower slopes of Remarkables, on Wye track, 2000–2500 ft, *J. A. Petterson*, 30 Dec 1991, MPN 15044; nr Lake Wakatipu, Nevis Valley, 2000 ft, *J. A. Petterson*, 31 Dec 1991, MPN 15054; Shotover summit, 3200 ft, *J. A. Petterson*, 25 Dec 1973, CHR 287843.

Narrow-leaved form, formerly referred to *W. brockiei*: CANTERBURY: Type, Castle Hill, *H. Talbot*, 24 Apr 1954, CHR 77811; Cytology voucher  $2n = 36$ , Castle Hill, *Y. Elder*, 1967, CHR 79083; Castle Hill, *D. Urquhart*, 21 Mar 1961, MPN 14327. OTAGO: hills above Lake Tekapo, dry grassland, *R. G. Petterson*, 22 Dec 1973, CHR 287839, MPN 316; Lake Pukaki, roadside rubble, *J. A. Petterson*, 22 Dec 1973, MPN 59; Kurow, *J. A. Petterson*, 23 Dec 1973, CHR 201816, 201817; Twizel, *J. A. Petterson*, 22 Dec 1973, CHR 287828. FIORDLAND: Green Lake, 2700 ft, *Ward & Kalin*, 11 Jan 1967, CANU 10488, 10489.

DISCUSSION: *W. brockiei* is a dry habitat form of *W. albomarginata*. My cultivated specimens from screes on Castle Hill and Prebble Hill, and from Landcare Lincoln (CHR garden no. 17903, *P.*



**Fig. 20** Natural distribution of *W. pygmaea* subsp. *pygmaea*, subsp. *drucei*, and subsp. *tararua*, and of *W. albomarginata* subsp. *albomarginata* and subsp. *laxa*.

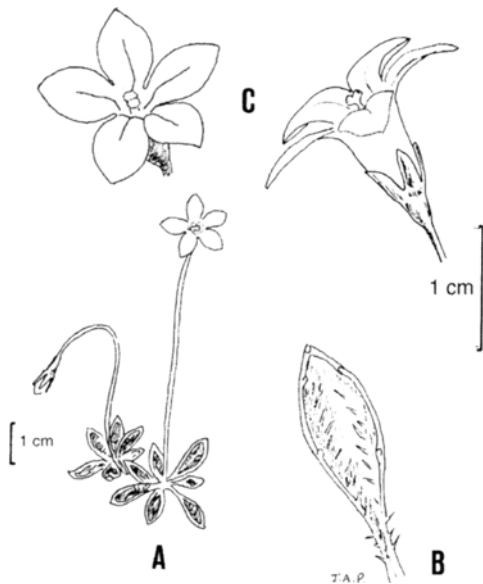
Heenan, 1989, at Castle Hill), developed broader leaves in spring and autumn and cannot be distinguished in life from cultivated specimens of *W. albomarginata* from other Canterbury sites. In the heat of summer the reverse took place – all my specimens of *W. albomarginata* and *W. "brockiei"* lost the larger leaves of spring and had small narrow channelled leaves. CHR 483565 (garden no. 370/93, from Maryburn Station) in the Landcare Research glasshouse at Lincoln did the same (v.v. Nov 1994). CHR 76373 (Allan 1961) was cultivated at Otari, and may have been a rare hybrid of *W. albomarginata* and *W. matthewsii*. The leaves are longer and narrower than the normal *W. albomarginata* (see Petterson 1953: 93).

subsp. *olivina* J.A.Petterson subsp. nov. Fig. 21  
 DIAGNOSIS: *W. albomarginatae* similis, differt foliae marginis incrassatis, foliis supra atroviridis, hispidis, subtus purpurescens, glabris.

Similar to *W. albomarginata*, differs in having the leaf margins much thickened, the leaves dark green and hispid above, purplish and glabrous below.

HOLOTYPE: Nelson, Roding River, Hackett Creek, A. P. Druce, Apr 1992, MPN 14900. Specimen ex cult. J. A. Petterson, 20 Aug 1994.

DESCRIPTION: Similar to subsp. *albomarginata*, but leaves dark olive green, with white, stiff bristly hairs above, often purple on the back, and with prominent cartilaginous margins. Plants retain these characters



**Fig. 21** *W. albomarginata* subsp. *olivina*, cultivated from Dun Mountain, Nelson. A, habit; B, leaf; C, flower in profile and full-face.

in cultivation. Flowers range from very small (10 mm diam.) to very large (30 mm diam.) in different sites. Chromosome number:  $2n = 36$  (Petterson et al. 1995, fig. 2), voucher CHR 494716.

**KNOWN DISTRIBUTION:** Serpentine areas of South Island from Dun Mountain, Nelson, to Red Hills, near Lake Rotoiti (Fig. 16). Endemic.

**HABITAT:** Serpentine scrub.

**CONSERVATION STATUS:** Not at risk.

**ETYMOLOGY:** The name *olivina* refers to the dark olive-green of the leaves, and the fact that this species grows in olivine (serpentine) ultramafic substrate.

**REPRESENTATIVE SPECIMENS:** NELSON: Cytology voucher  $2n = 36$ , Roding River, Hackett Creek, *M. Dawson*, 1994 (same clone as the holotype), CHR 494716; Maitai Track to Dun Mountain, serpentine scrub, 2000 ft, *J. Rattenbury*, 16 Dec 1952, AKU 5665; Roding River, Hackett Creek, *W. B. Brockie*, Feb 1969, CHR 208222; Dun Mountain, *J. A. Petterson*, Apr 1953, CHR 77918; Dun Mountain, Coats Creek to Coppermine Saddle, *J. A. Petterson*, 19 Dec 1969, CHR 453029; Dun Mountain, Rush Pools, *J. A. Petterson*, 16 Dec 1988, MPN 15038; Richmond Range, left branch Motueka River,

*Leptospermum* scrub on Red Hills clay, *E. A. Brown*, 17 Jan 1985, AKU 18133; Red Hills, 2400 ft, *C. J. West*, 19 Jan 1985, AKU 18221.

**DISCUSSION:** Although quite common in the Nelson Mineral Belt, no specimens of this taxon are yet recorded from the Southland olivine areas.

subsp. *flexilis* (Petrie) J.A.Petterson comb. nov.

Fig. 22

*W. flexilis* Petrie *Trans. N. Z. Inst.* 49: 51 (1917).  
= *W. simpsonii* Hay in Allan, *Flora of New Zealand* 1: 793 (1961).

**LECTOTYPE:** (here chosen) Inland Kaikouras, Clarence River valley, *B. C. Aston*, Dec 1916, WELT 4706. Syntype: AK 9256.

**Lectotype of *W. simpsonii*:** Provenance Rag Saddle, between Keckerengu and the inner Clarence Basin, ex garden of G. Simpson, 19 Mar 1950, CHR 76400a.

**DESCRIPTION:** Similar to subsp. *albomarginata*, but with prostrate leaves ovate to orbicular-spathulate, sometimes tufted along the elongating ascending stems in shade forms. Usually entire-margined, except in deep shade when they may become dentate. Flowers larger than *W. albomarginata*, creamy-white to bluish white, 18–25 mm diam. in life. Calyx lobes toothed and recurved in ripe capsules in Simpson's specimens (Fig. 22). Chromosome number:  $2n = 36$  (Petterson et al. 1995), voucher CHR 179478.

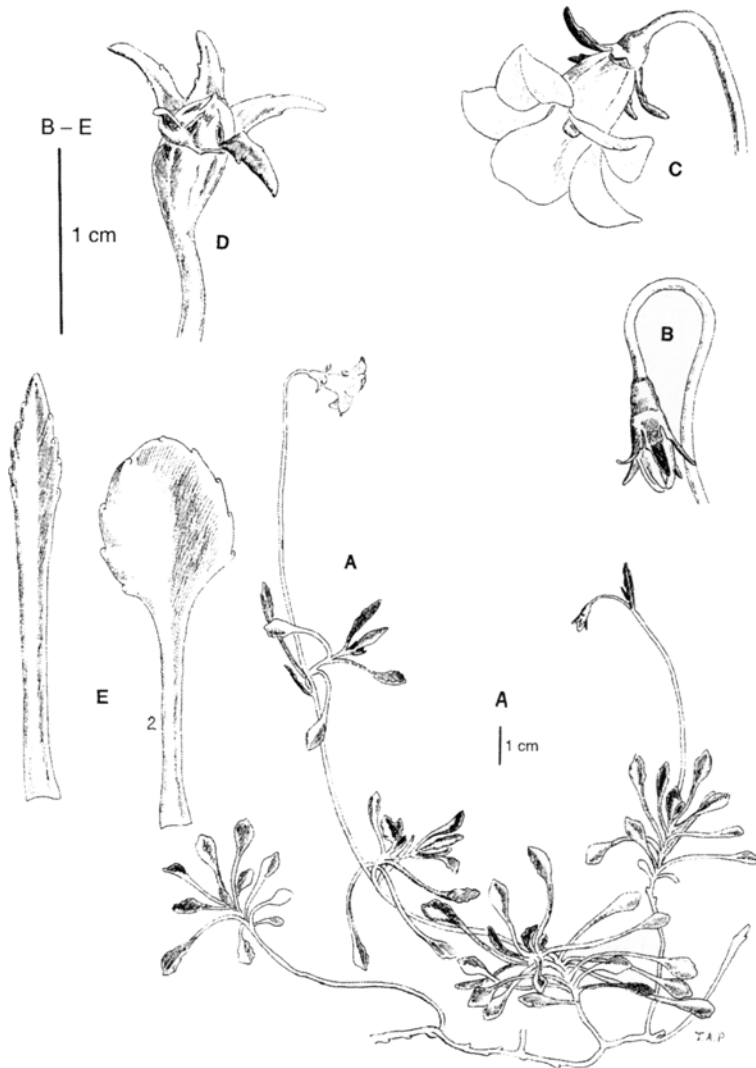
**DISTRIBUTION:** Eastern Marlborough: beaches from south of Cape Campbell to just south of Kaikoura Peninsula, and from the coast to the Clarence Fault (Fig. 16). Endemic.

**HABITAT:** Beach gravel and limestone hills, sea level to 3000 ft.

**DISCUSSION:** One living specimen (CHR garden no. 17896 coll. *P. Heenan* at Flaxbourne River mouth) in the limestone rockery at Landcare Research has sessile ovate yellow-green leaves in open ground, and is self-seeding there. In semi-shade at Waikanae plants of the same clone have become drawn-up like the type specimens of *W. simpsonii*. Similar drawn-up specimens from Mead Gorge and Nidd Valley in the inner Clarence basin and Isolated Hill (upper Waima valley) were named *W. flexilis* by Petrie (1917). This epithet has priority over *W. simpsonii* Hay (1961), and is reinstated.

**CONSERVATION STATUS:** Rare (Cameron et al. 1995). Much of the former habitat area is in pasture.

**REPRESENTATIVE SPECIMENS:** MARLBOROUGH:



**Fig. 22** *W. albomarginata* subsp. *flexilis*, cultivated from Kekerangu, Marlborough. A, habit; B, bud; C, flower; D, capsule; E1 cauline leaf, E2 rosette leaf.

Cytology voucher  $2n = 36$ , Flaxbourne, Weld Cone, A. P. Druce, 1966, CHR 179478; Kaikoura, Kowhai Bush, "dry margins of *Leptospermum* scrub", A. T. Dobson, 2 Jan 1975, CANU 21342; Flaxbourne River mouth, limestone cliffs, W. R. B. Oliver, 19 Dec 1949, WELT 8311; Flaxbourne River mouth, "limestone hills facing sea", D. R. Given, 31 Jan 1966, CANU 10490, CHR 175161; Nid (sic) Valley, limestone hills, c. 3000 ft, B. C. Aston, Dec 1915, WELT 47889; Ward Beach, on gravel beach, sealevel, P. Wardle, Dec 1952, OTA 2678; Upper Clarence River, Simpson & Scott Thomson, OTA 2677; Lincoln Landcare Research limestone rockery, (CHR garden no. 12313, D. Given, 1979), ex cult.

J. A. Petterson, 8 Jan 1994, MPN 15115; (Label in Petrie's hand) "*W. flexilis*, Isolated Hill Creek basin, Marlborough, B. C. Aston, 24 Apr 1915", WELTU 5809; Ure (Waima) River, Isolated Creek, J. A. Petterson, 15 Jan 1977, MPN 15135.

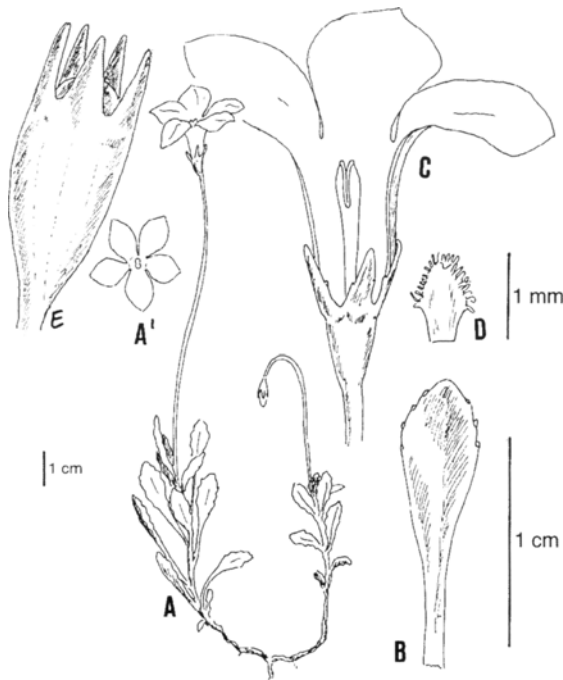
subsp. *laxa* (Simpson) J.A.Petterson comb. nov.

Fig. 23

*W. laxa* Simpson *Trans. Roy. Soc. N.Z.* 79: 430 (1952).

HOLOTYPE: Hanmer, Banks of the Doubtful River, cult. G. Simpson, CHR 50061. The type specimen is a shade form from cultivation, in poor condition.

A good typical shade specimen from near the type



**Fig. 23** *W. albomarginata* subsp. *laxa*, Arthur's Pass, Southern Alps. A, habit; A 1, corolla, natural size; B, leaf; C, flower dissected to show long corolla tube; D, staminal filament; E, capsule.

locality is CHR 171622 (Hope River Bridge, *B. H. Macmillan*, 1962).

**DESCRIPTION:** Similar in flowers to *W. albomarginata*, but with leaf laminas obovate to oblanceolate, dentate to serrate, with rather conspicuous marginal teeth; not glaucous, not margined, not entire. Flowers long-tubed, often much larger than in subsp. *albomarginata*, and calyx lobes longer. The measurements for subsp. *laxa* in Table 9 were recorded from living flowers cultivated from Temple Track and Caseys Pass, in Arthur's Pass National Park. Chromosome number:  $2n = 36$  (Pettersson et al. 1995, fig. 5), vouchers CHR 79006–8, 79019, 79022, 79079; MPN 15120.

**DISTRIBUTION:** High rainfall areas of South Island: west of the Wairau River, Richmond, Arthur, and Tasman Ranges; Nelson Lakes National Park, Spenser Mountains, Hanmer, Buller; Arthur's Pass National Park, Lake Sumner National Park, Westland ranges, Fiordland (Fig. 20). Endemic.

**HABITAT:** Mountain valleys, lake shores, and

herbfield, generally 1500–3000 ft in the northern South Island, down to sea-level at Stewart Island.

**CONSERVATION STATUS:** Not at risk.

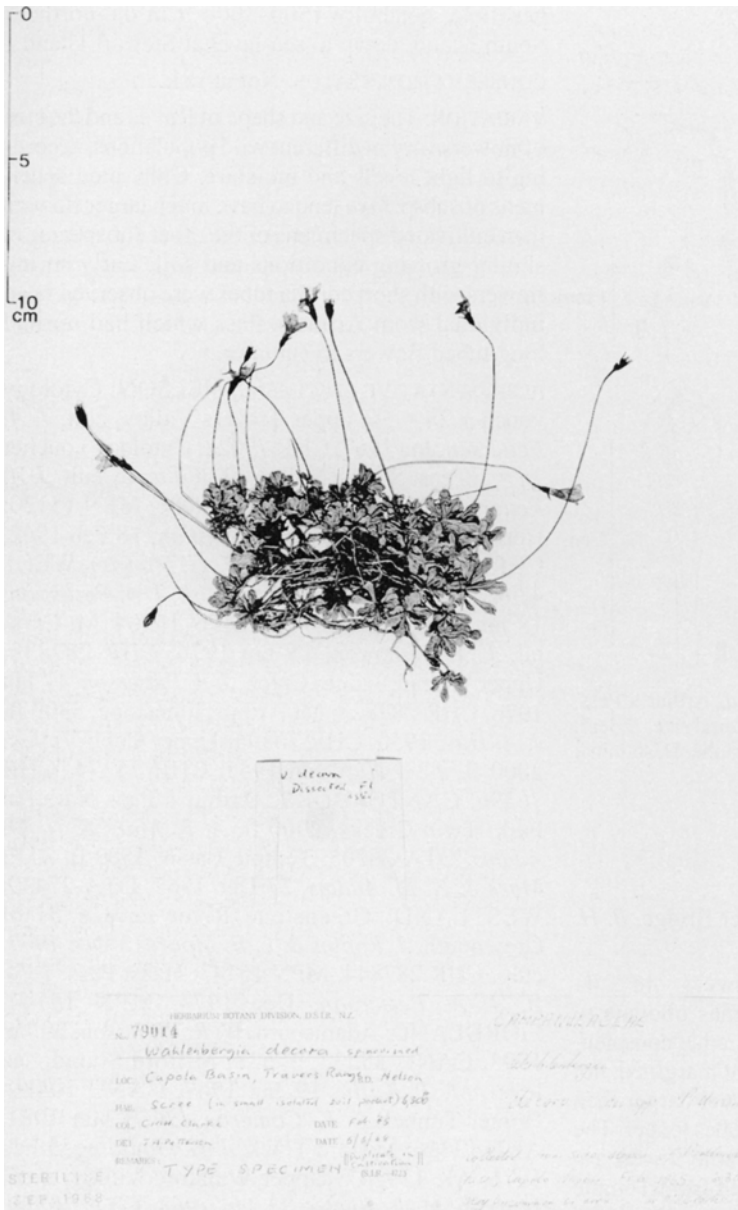
**VARIATION:** The size and shape of leaves and the size of flowers vary in different wild populations, according to light levels and moisture. Cultivated specimens of subsp. *laxa* tend to have much larger flowers than cultivated specimens of the other subspecies in similar growing conditions and soil. Early spring flowers with short corolla tubes were observed in an individual from Arthur's Pass which had normal long-tubed flowers in summer, v.v.

**REPRESENTATIVE SPECIMENS:** NELSON: Cytology voucher  $2n = 36$ , upper Travers Valley, cult. *J. A. Pettersson*, Jan 1967, CHR 79022; Cytology voucher  $2n = 36$ , east Sabine Valley, *D. Wilde*, ex cult. *J. A. Pettersson*, 21 Feb 1970, CHR 79006, MPN 15120; Hope River bridge, *B. H. Macmillan*, 18 Feb 1962, CHR 171622; Buller Gorge, *P. G. Morgan*, WELT 47949; Lake Tennyson, lake shore, *J. A. Pettersson*, 18 Jan 1976, CHR 287836, MPN 15504; Mt Crystal, *J. A. Pettersson*, 15 Jan 1976, CHR 287838; Upper Wairau, Judges Creek, *J. A. Pettersson*, 17 Jan 1976, CHR 287823; Mt Arthur, limestone, 5300 ft, *J. A. Hay*, 1950, CHR 76394; Upper Cobb Valley, 2000 ft, *J. A. Hay*, Jan 1951, CHR 75374, CHR 76396. CANTERBURY: Arthur's Pass National Park, Twin Creeks, 2900 ft, *A. F. Mark & N. M. Adams*, OTA 26205; Temple Basin, 3500 ft, *A. F. Mark & N. M. Adams*, 27 Dec 1967, OTA 27439. WESTLAND: Greenstone River terrace, N of Greymouth, *J. Robins & L. B. Moore*, 3 Dec 1967, cult., CHR 287844, MPN 15143; Haast Pass, 1850 ft, *J. A. Pettersson*, Dec 1974, MPN 15147. FIORDLAND: Adamsburn, *W. R. Philipson*, 29 Jan 1993, CANU 35537, 35538; Milford Sound, sea level, *M. T. Kalin*, 19 Jan 1967, CANU 10489; Homer Tunnel, *E. K. Cameron* 426, 3 Mar 1981, AKU 13396; Milford Track, *J. H. Goulding*, 5 Feb 1976, AK 139247; Upper Waiatoto Valley, *A. F. Mark & M. L. Burke*, 22 Jan 1968, OTA 20859; Murchison Mountains, above Lake Eyles, *A. F. Mark*, 12 Jan 1973, OTA 33876; Upper Arahata Valley, 4000 ft, *A. F. Mark*, 16 Jan 1968, OTA 21870; Arahata River, Williamson Flat, 1500 ft, *A. F. Mark & M. L. Burke*, Jan 1968, OTA 20697. STEWART ISLAND: Mason Bay, *D. Leask*, Feb 1960, WELT 64134.

subsp. *decora* J.A.Pettersson subsp. nov.

**DIAGNOSIS:** Subsp. *laxae* similis, differt floris fragrans, alpinis.





**Fig. 24** CHR 79014, Holotype of *W. albomarginata* subsp. *decora*.

Similar to subsp. *laxa*, differs in the fragrant flower and high altitude habitat.

**HOLOTYPE:** [Nelson, Travers Range] "scree slopes of Badlands face, Cupola Basin, 6,300 ft", C. M. H. Clarke, Feb 1965, CHR 79014. Fig. 24

**DESCRIPTION:** Similar to subsp. *laxa*, but develops a strong taproot and short crowded rosettes in scree habitat, scapes slender, short, 3–10 cm long, flowers fragrant, 15–20 mm diam, 10–15 mm long.

Chromosome number:  $2n = 36$  (Pettersen et al. 1995, fig. 1), voucher CHR 79081.

**DISTRIBUTION:** Nelson Lakes National Park; perhaps extending to North-west Nelson and Fiordland (Fig. 16). Endemic.

**HABITAT:** Scree margins and rock crevices 4000–6500 ft.

**CONSERVATION STATUS:** Range of subspecies not known, but not considered at risk.

ETYMOLOGY: *Decora* from Latin *decorus* “ornamental”, referring to the charm of this pretty little plant growing in naked rock or scree-margins close to the upper limits of vegetation. (cf. Bulfin 1965: 87).

DISCUSSION: Subsp. *decora* grows in high-altitude sites, separated from subsp. *laxa* of the lake margins and valleys by 1000–2000 ft of beech forest. The taxon needs further study, as the range may be more extensive, into North-west Nelson, the Southern Alps, and Fiordland. Some of the specimens listed below have similar corolla dimensions to those given in Table 9, but others have the corolla tube almost equal in length and breadth.

REPRESENTATIVE SPECIMENS: NELSON: Cytology voucher  $2n = 36$ , summit of St Arnaud Range, *A. P. Druce* cult., Jan 1967, CHR 79081; St Arnaud Range, south end, rocks at head of scree, 5700 ft, *M. J. A. Simpson* 173, 31 Dec 1958, CHR 110618; Mt Misery, summit rocks, 5200 ft, *M. J. A. Simpson* 2767, 9 Feb 1961, CHR 120412; Ridge to Mali Tops, grassland, 5000 ft, *M. J. A. Simpson* 4123, 14 Feb 1964, CHR 148762; Mt Robert, solifluction terrace, c. 5100 ft, *M. J. A. Simpson* 6885, 23 Feb 1972, CHR 227754; Mt Travers, 5500 ft, *M. J. A. Simpson* 3287, 25 Jan 1962, CHR 125440; Mt Travers, rocks, 5000 ft, *A. P. Druce*, Mar 1947, CHR 82200; Cupola West, amongst grass under trees, *J. R. Fryer*, 21 Mar 1964, CHR 150057; Travers Range, Fifth Basin, among rocks, 5000 ft, *M. J. A. Simpson* 6044, 13 Feb 1971, CHR 220329; Mt Benson, above Cobb Valley, limestone, *A. P. Druce*, 1980, ex cult. *J. A. Petterson*, 1993, CHR 287828, MPN 14902, 14903; Mt Benson, ex cult. *J. A. Petterson*, 25 Feb 1995, MPN 15230. OTAGO: Humboldt Mountains, Routeburn valley, Park Pass, 4000 ft. *A. F. Mark*, 18 Feb 1968, OTA 20642; Humboldt Mountains, Mt Savage, 4500 ft, *A. F. Mark*, 22 Feb 1968, OTA 20700; Five Fingers Range, Joe River, 3500 ft, *A. F. Mark* & *M. L. Burke*, 19 Jan 1968, OTA 22289; Rampart Range, Waiototo valley, 4200 ft, *A. F. Mark*, 26 Jan 1969, OTA 28793; Ida Range, 4000 ft, *J. Keogh* & *M. Heads*, 12 Jan 1985, OTA 41393. SOUTHLAND: Umbrella Mountains, Gem Lake catchment, 1120 m, *K. J. M. Dickinson* & *B. D. Rance*, 19 Dec 1985, OTA 43238.

**10. *W. pygmaea*** Colenso, *Tranz. N.Z.Inst.* 31: 273 (1899)

Type sheet: K negative no.1108. Fig. 25

TIPIFICATION: The type sheet is stamped “Herbarium Hookerianum”, and there are three collections on the sheet, with three labels:

(1) In Bidwill’s hand: “70 Tongadido, Campanula”.

Written above in J. D. Hooker’s hand: “Bidwill”

(2) In Colenso’s hand: “19 *Wahlenbergia* 1847”. Below in J. D. Hooker’s hand: “N. Zealand, Colenso”.

(3) In Colenso’s hand: “1026 *Wahlenbergia*”. On the back of the sheet is written: “19, 1847 Mountain top, Ruahine” and “1026, Mountains near Pareranui.”

TYPE LOCALITY: “Ruahine Mountain Range, west side, near summits, 1848, *W.C.*; East side 1898, Mr. A. Olsen” (Colenso 1899).

LECTOTYPE (here chosen): K neg. 1108 “1026 *Wahlenbergia*”, specimen marked X at bottom right corner of Fig. 25, with one capsule and one flower.

DESCRIPTION: Perennial rhizomatous herb with rosulate tufts of leaves at ground level. Leaves bright green, glossy, glabrous or with a few scattered hairs, oblong to oblanceolate to obovate to orbicular-spathulate,  $10 \times 3$  to  $20 \times 5$  mm, sessile or gradually narrowed to a flat petiole 2 mm wide. Leaf margin subentire to serrate or crenate-serrate, or dentate, often undulate, sometimes red, with 2–7 exserted glandular marginal teeth on each side. Flowers erect or nodding on short upright scapes, 4–10 cm tall, which may be naked or 1–2-bracted. Corolla soft blue and white, sometimes pure white or all blue, usually with deeper-coloured veins; up to 30 mm diam., up to 18 mm long, broadly campanulate with tube as broad as or broader than long, lobes c.  $9 \times 7$  mm, spreading, broadly elliptic-lanceolate, acute. Calyx lobes c.  $3 \times 1.5$  mm, glabrous, narrow-triangular. Capsule c.  $10 \times 6$  mm, glabrous, domed cylindrical to plump barrel-shaped. Seeds ellipsoid, glossy brown. Usually insect-pollinated, some forms self-fertile. FL Dec–May, FT Jan–May.

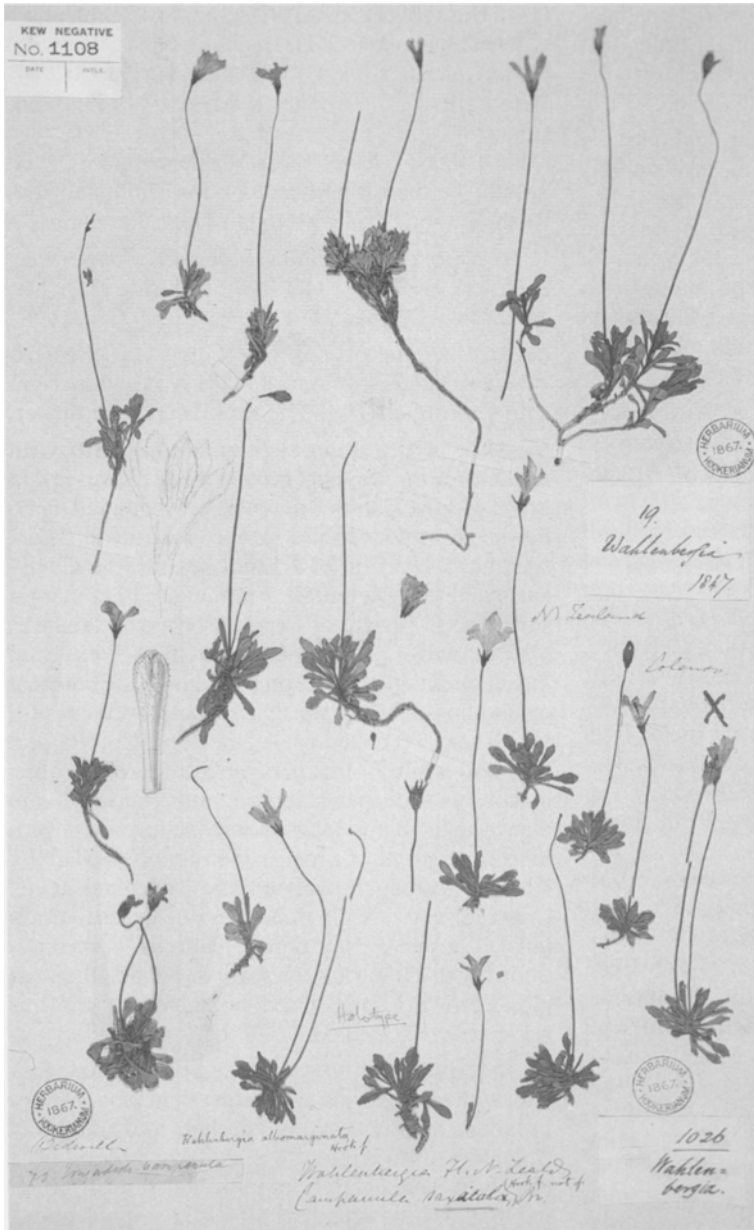
DISTINCTIVE FEATURES: Corolla broadly campanulate, with tube as wide as or wider than long. Leaves broadest at tips, usually toothed and undulate. Colenso (1899) wrote: “A peculiarly striking little plant with a rather large drooping bell-flower springing from its little squarrose moss-like tuft of leaves.”

Table 10 shows the flower and capsule proportions in *W. pygmaea*.

**Table 10** Typical corolla, calyx, and capsule dimensions of *W. pygmaea*. All measurements in mm from living plants.

	Diam.	long	tube	lobe	calyx	capsule
23	13	$5 \times 8$	$8 \times 5$	$2 \times 1$	$8 \times 6$	
26	15	$7 \times 8$	$9 \times 8$	$3 \times 1.5$	$10 \times 6$	
30	18	$8 \times 10$	$10 \times 9$	$3.5 \times 2$	$10 \times 6$	

**Fig. 25** K 1108, Type specimen sheet of *W. pygmaea* Colenso. Three collections. Lectotype here chosen, specimen at bottom right marked X, "1026 *Wahlenbergia*".



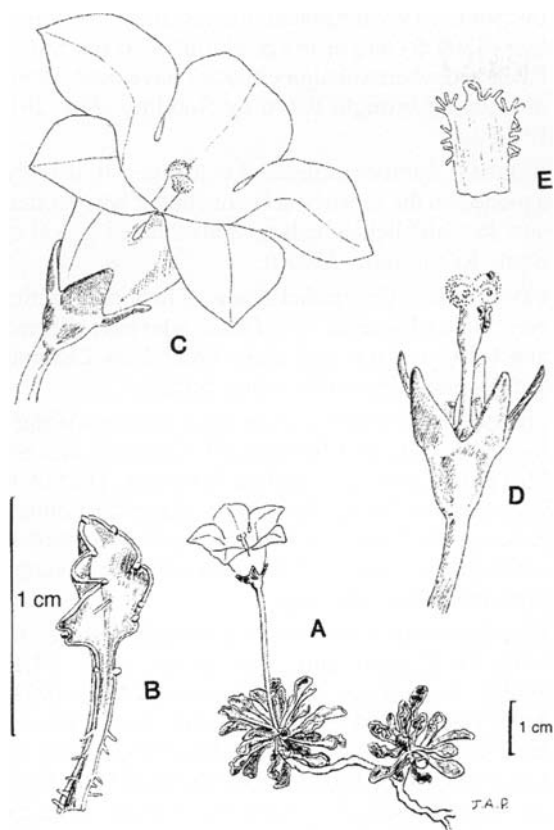
**VARIATION:** A variable species, varying slightly throughout its range. Three subspecies are defined by geographic separation and floral and foliar differences.

**Synopsis of subspecies**

Leaves petiolate, spatulate, often red-margined with few teeth. Flowers soft blue or blue and white ..... subsp. *pygmaea*

Leaves sessile, oblanceolate, margins flat, serrate, with many teeth. Flowers opaque white ..... subsp. *tararua*

Leaves petiolate, orbicular-spathulate, margins undulate, crenate-dentate, with many teeth. Flowers pale blue with creamy-white central band in each petal ..... subsp. *drucei*



**Fig. 26** *W. pygmaea*, Kaimanawa Range. A, habit; B, leaf; C, broad-tubed flower; D, dissected flower to show style and open stigma; E, staminal filament.

**subsp. *pygmaea***

Fig. 26

**DESCRIPTION:** Leaves petiolate, spatulate, margins often red, flat or undulate, entire or with 2–4 teeth on each side; flowers soft blue or blue and white. Capsules domed cylindric, 6 × 4 to 10 × 6 mm. v.v. Chromosome count:  $2n = 36$  (Petterson et al. 1995), voucher CHR 79197, MPN 14901.

**DISTRIBUTION:** North Island: throughout the Kaimanawa, Kaweka, Ruahine, and Maungaharuru Ranges, also the Rangipo Desert, Mt. Ruapehu, and Mt. Tongariro, local on emergent peaks in the Huiarau range (A. P. Druce pers. comm.) (Fig. 20). Endemic.

**HABITAT:** Herbfield, tussock-grassland, and rocks above the forest line, 5000–6000 ft, down to 3000 ft in the Rangipo Desert.

**CONSERVATION STATUS:** Not at risk.

**REPRESENTATIVE SPECIMENS:** NORTH ISLAND:

Cytology voucher  $2n = 36$ , Ruahine Range, A. E. Esler, 1967, CHR 79197, MPN 14901; Ruahine Range, Rongotea, 5000 ft, A. P. Druce, 21 Dec 1951, CHR 76383; Ruahine Range, Mt Colenso, 1406 m, J. Ogden, 19 Jan 1973, MPN 13924; NW Ruahines, Makirikiri, A. P. Druce, Jan 1977, ex cult. J. A. Petterson, 12 Dec 1993, MPN 15105; Mt Tongariro, 4000 ft, J. A. Petterson, 1 Jan 1981, MPN 62; Ruapehu, 4800 ft, R. Melville, 17 Mar 1962, CHR 140089; Ruapehu, F. M. Warren, Jan 1962, AKU 10467; Waiouru, D. Petrie, Jan 1917, WELT 47912; Waihohonu, W. R. B. Oliver, 1 Mar 1936, WELT 8352; Desert Rd, M. Gordon, 15 Jan 1966, MPN 686; Kaimanawa Mountains, Patutu, B. H. Macmillan, 31 Mar 1959, CHR 171624; Waikaremoana, Panekiri Bluff, A. P. Druce, Jan 1954, MPN 77; Urewera National Park, Mt Manuoha, P. J. de Lange, 18 Nov 1985, WAIK 5217.

**subsp. *tararua*** J.A.Petterson subsp. nov.

**DIAGNOSIS:** *W. pygmaea* similis, flora alba opaqua, folia serrata, dentibus 9–15.

Similar to *W. pygmaea*, flowers opaque white, leaves serrate, with 9–15 teeth.

**HOLOTYPE:** Tararua Ranges, Mitre Peak, A. P. Druce, 1956, CHR 494717, ex cult. J. A. Petterson, 1994.

**DESCRIPTION:** Similar to *W. pygmaea*, but with leaves sessile, laminas elliptic to oblanceolate, flat, evenly serrate with 4–7 marginal teeth on each side, narrowed slightly at base, forming distinctive neatly radiating rosettes in cultivation. Leaf margins not red. Flowers opaque white with one fine blue vein beneath each petal. Capsules domed cylindric, mature capsules not seen. Not self-fertile in cult. v.v. Chromosome count:  $2n = 36$  (Petterson et al. 1995), voucher CHR 494717.

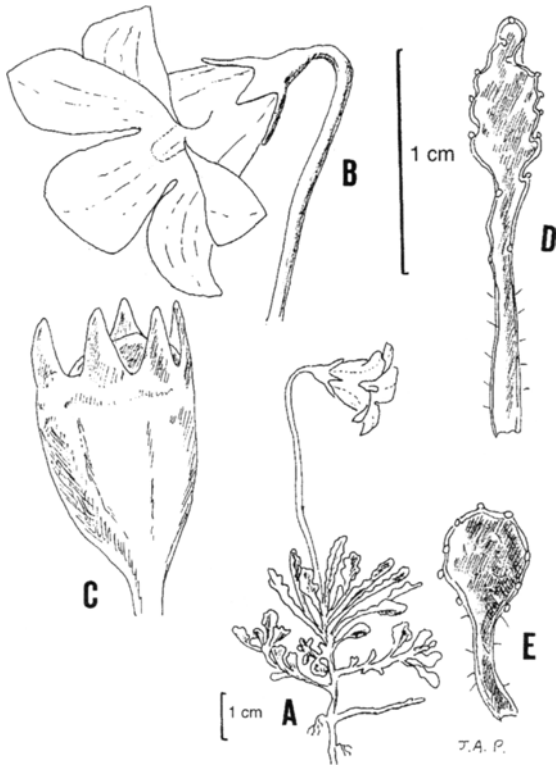
**DISTRIBUTION:** Restricted to Mitre Peak and Mt Holdsworth in the Tararua Ranges, 4000–5000 ft (A. P. Druce pers. comm. 1994) (Fig. 20). Endemic.

**HABITAT:** Herbfield, rocks above the forest line.

**CONSERVATION STATUS:** Local.

**DISCUSSION:** Although quite common in the sites named, very few herbarium specimens exist. A. P. Druce has had this taxon in cultivation for 40 years. It is easy to propagate from tip cuttings. Further collections from the wild are desirable.

**REPRESENTATIVE SPECIMENS:** Cytology voucher  $2n = 36$ , Mitre Peak, A. P. Druce, ex cult. J. A. Petterson, 1994, CHR 494717; Mt Mitre, 5000 ft,



**Fig. 27** *W. pygmaea* subsp. *drucei*, Mt. Egmont. A, habit; B, flower; C, barrel-shaped capsule; D, old leaf; E, young leaf.

*A. P. Druce*, 1956, MPN 14324; Mt Holdsworth, ex cult. *A. P. Druce*, MPN 73.

**subsp. *drucei*** J.A.Petterson subsp. nov. Fig. 27

**DIAGNOSIS:** *W. pygmaea* similis, differt foliis petiolatis, lamina spathulata, dentata, dentibus 9–15; capsula lata.

Similar to *W. pygmaea*, differs in having spathulate, petiolate, dentate leaves, with 9–15 teeth; capsules broad.

**HOLOTYPE:** Mt Egmont, Stony River, *J. A. Petterson*, 20 Dec 1993, MPN 15014. Fig. 28

**DESCRIPTION:** Leaves petiolate, petioles 3–15 mm long, laminas orbicular- to oblong-spathulate, margins with 4–7 teeth on each side, undulate. Corolla pale blue-violet with broad creamy-white central band in each lobe. Mature capsules domed and broadly barrel-shaped, 8 × 5 to 10 × 6 mm. Self-fertile, sets seed in cultivation. v.v. Chromosome count:  $2n = 36$  (Petterson et al. 1995, fig. 6), voucher CHR 79084.

**DISTRIBUTION:** Mt Egmont, mainly above the forest line (3700 ft) and at lower altitudes on the Stony River bed where subalpine species have established after being brought down by flooding (Fig. 20). Endemic.

**HABITAT:** Semi-consolidated volcanic grit, usually a pioneer at the foot of a scree or similar bare eroded site. In white lichen beds on consolidated gravel at Stony River. 3000–5500 ft.

**ETYMOLOGY:** The epithet *drucei* is in honour of the New Zealand botanist A. P. Druce, who has collected and cultivated this and many other New Zealand species and varieties for many decades.

**CONSISTENCY:** Twelve collections were made during 1992–1993 at different well-separated sites on Mt Egmont, and cultivated for 3–4 years. The taxon is constant in foliage from every place; the colour-pattern of the flowers is distinctive, pale blue banded with opaque creamy-white, with only slight variations throughout the range.

**REPRESENTATIVE SPECIMENS:** Cytology voucher  $2n = 36$ , Mt Egmont, cult. *A. P. Druce*, 1958, CHR 79084; Stony River, *J. A. Petterson*, 24 Jan 1993, MPN 14944, 14945; North Egmont, foot of Razorback Ridge, *J. A. Petterson*, 23 Jan 1993, ex cult. 15 Mar 1993, MPN 15012; above Dawson Falls Hostel, Wilkies Pools, *J. A. Petterson*, 30 May 1992, ex cult. 15 Mar 1993, MPN 15013; Mangonui Gorge, *M. B. Ashwin*, 19 Apr 1957, MPN 1252; Mt Egmont, 3800 ft, *D. Petrie*, Feb 1912, WELT 47914; Dawson Falls 5500 ft, *H. Murray* 18 Jan 1933, WELT 47958.

### ***Wahlenbergia* species from other countries**

Three species, *W. marginata* from Japan, *W. gracilis* from New Caledonia, and *W. dehiscens* from West Bengal, have been cultivated in New Zealand and their chromosomes counted (Petterson et al. 1995). The original protologue of each was inadequate. The chromosome counts and floral characters of these three species have proved vital to the delimitation of New Zealand, Australian, and Pacific radicate taxa which have in the past been included in "*W. gracilis*" or "*W. marginata*" (Petterson 1997). They are here described from living specimens.

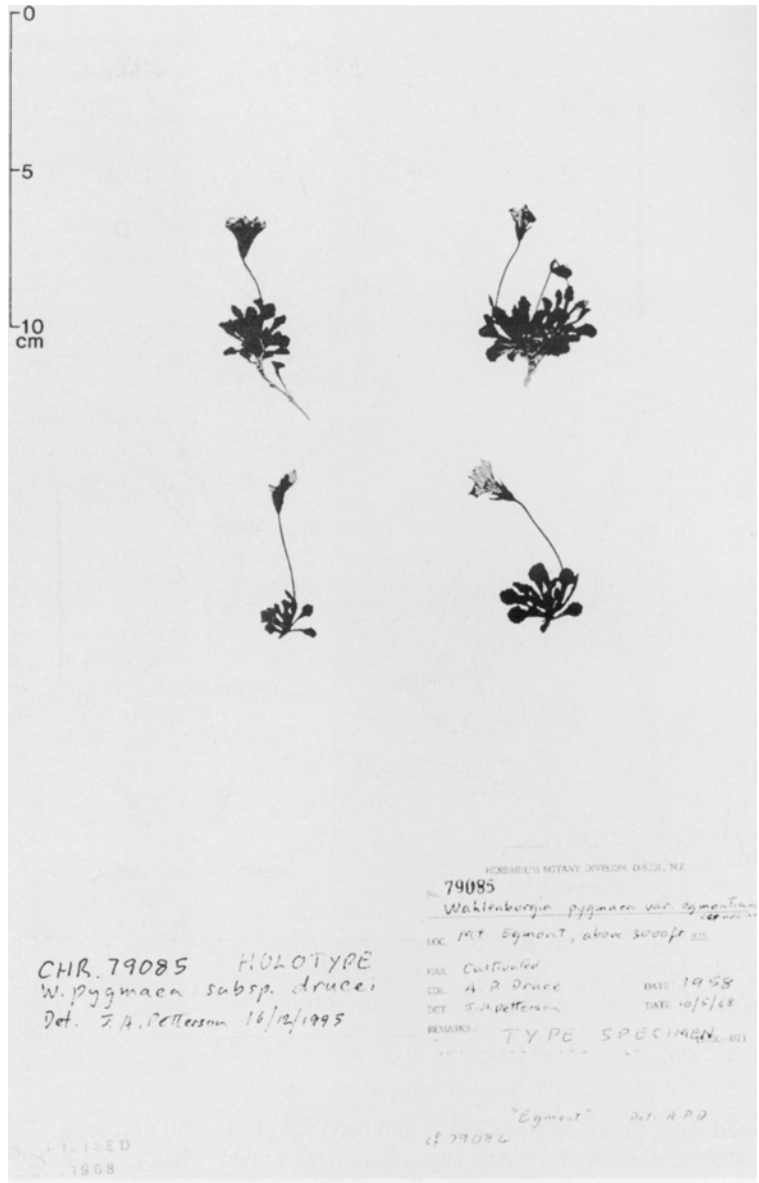
#### **11. *W. marginata* (Thunberg) A.DC.**

Monographie des Campanulees 1830. Fig. 29 A-D  
*Campanula marginata* C.P.Thunberg in *Flora Japonica* 1784.

*Wahlenbergia marginata* Tuyn *Fl. Malesiana* 1960 p.p.

*W. marginata sens. strict.* Petterson et al. 1995.

**Fig. 28** CHR 79085, Holotype of *W. pygmaea* subsp. *drucei*.



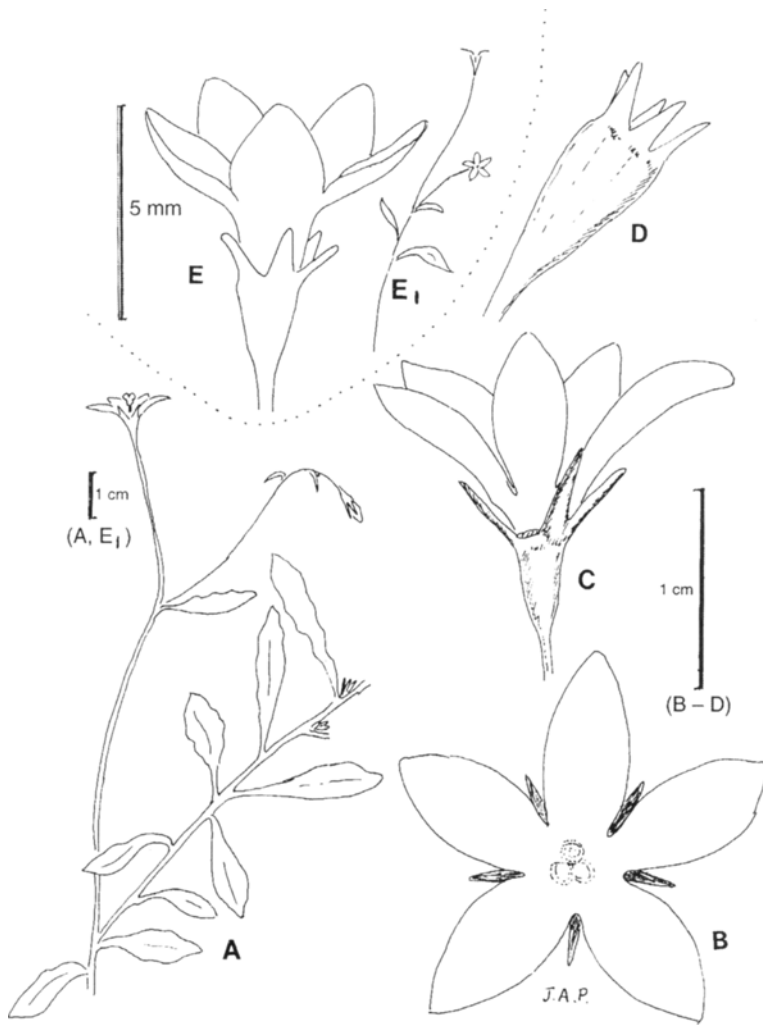
non *W. marginata* sens. lat. Petterson et al. 1995.  
 HOLOTYPE: UPS Campanula marginata; e japonica  
 C.P. Thunberg.

This specimen was collected by Thunberg in May 1776: “in marginibus viarum inter Arai et Quana” (Thunberg 1784). The specimen is in poor condition, having shrivelled before pressing (Petterson 1997, fig. 2).

Thunberg’s description is short, without details of the flowers. In November 1993, fresh specimens and

**Table 11** Typical corolla, calyx, and capsule dimensions for *W. marginata*. All measurements in mm from living plants.

Diam.	length	tube	lobe	calyx	capsule	HCC
18	9	2 × 4	7 × 4	4 × 1	7 × 4	41/1
20	16	2 × 4	14 × 5	5 × 1	8 × 5	



**Fig. 29** A–D, *W. marginata*, cultivated from Honshu, Japan. A, habit; B, rotata starry corolla; C, flower in profile, one sepal removed to show sinus of corolla, and corolla tube shorter than sepals; D, capsule. E, *W. gracilis*, cultivated from New Caledonia. Campanulate corolla with longer corolla tube and shorter corolla lobes; E<sub>1</sub>, branch showing tiny flower.

seed were obtained from Japan and used for chromosome counts, and living specimens were grown which came into flower in October and November 1994. The description below is made from vigorous, young, live flowering plants, glasshouse-grown in New Zealand, originating from two well-separated sites in Honshu. It is likely that in wild conditions, *W. marginata* would vary greatly in vigour and flower size, depending on nutrients and season, as do related New Zealand species.

**DESCRIPTION:** Taprooted, stems slender, erect or decumbent, 20–50 cm tall, 1–3 mm diam., hispid or sparsely hairy in lower parts, glabrous in the upper parts, hairs 1–2 mm long; leaves alternate, 20–

50 mm long, 2–8 mm wide, basal leaves sparsely hairy, spatulate to oblanceolate, margins flat or undulate, upper leaves and bracts lanceolate to linear, glabrous. Flowers rotate, glabrous, bright blue-violet, 18–20 mm diam., corolla tube pale, shallow saucer-shaped, 2 mm long, 4 mm diam., lobes elliptic, separate almost to the base, 7 × 4 to 15 × 5 mm; style strongly constricted beneath the stigma lobes, stigmas large, white; calyx lobes narrowly triangular, 4–5 mm long, 1 mm wide at base, visible from above between the corolla lobes. Capsules glabrous, obconic, 7 × 4 to 8 × 5 mm. Seeds glossy, dark brown, ellipsoid c. 0.5 mm long. FL Oct–Mar, FT Nov–Apr. Chromosome count:  $2n = 72$  (Pettersson et al. 1995), voucher CHR 483564.

**DISTINCTIVE FEATURES:** Alternate leaves, blue-violet rotate flowers, petals elliptic, separate to base giving the flower a starry appearance; sepals much longer than the shallow corolla tube, visible between the corolla lobes.

Table 11 shows flower and capsule proportions in *W. marginata*.

**DISTRIBUTION:** Honshu, Japan, northern limit 37°N (H. Kanai pers. comm.)

**CONSERVATION STATUS:** Not assessed.

**REPRESENTATIVE SPECIMENS:** Japan, Honshu, Hyogo Pref., Usazaki, 100 m from seashore of Seto Naikai, *T. Totuoka*, 17 Sep 1993, CHR 454235; Cytology voucher  $2n = 72$ , seedling of CHR 454235, *M. I. Dawson*, Aug 1994, v.v., CHR 483564; Japan, Honshu, Wakayama Pref., Fukatani, 150 m, *T. Fukuhara*, 14 May 1994, MPN 15113, MPN 15114; seedling of MPN 15113, v.v., *J. A. Petterson*, ex cult. Waikanae, Nov 1994, MPN 19117.

**NOTE:** *W. marginata sens. lat.* has been reported from most of Asia and several Pacific islands (Tuyn 1960). Some of these reportings have a different chromosome count,  $2n = 18$  or  $36$  (Hsu 1967, 1968; Ono & Masuda 1981), and need further study.

**12. *W. gracilis*** (G.Forst.) A.DC. *Monographie des Campanulees* (1830): 142 Fig. 29 E

*Campanula gracilis* G.Forst. *Prodromus* 1786, no. 84.

*W. gracilis* N.E.Br., *Gardeners' Chronicle* 54: 316 (1913).

≡ *W. marginata* var. *neo-caledonica* Lothian *Proc. Linn. Soc. N.S.W.* 71 (3–4): 214, 1947.

= *W. marginata* (Thunberg) A.DC (Tuyn 1960) p.p.

**LECTOTYPE:** *K. C. gracilis* Forst. "The Forster Herbarium, presented by the Corporation of Liverpool, August 1885". "Habitat in N. Zealand et N. Caladonia" (label written by the curator, J. Shepherd c. 1808). No original provenance. This specimen was chosen and described by Brown (1913). There are three pieces mounted on the sheet, apparently branches from one large plant. All three pieces are the lectotype. Flowers present (Petterson 1997, fig. 9).

Probable Isolectotypes (cf. Petterson 1997): BM *Campanula gracilis* Forst. "Nova Caledonia *W. Anderson* 1774". Provenance pencilled on the back of the sheet by the collector. Flowers present. P *Campanula gracilis* "Forster 37". No original provenance. Cited by Richard (1832) as a New Zealand specimen; cited by Guillaumin (1911) as

collected at Balade, north-east New Caledonia, near where Cook's party landed 1774. No flowers. GOET "52 *Campanula gracilis* Prodr. 84" (original label probably in Forster's hand). 2nd label: "*Wahlenbergia gracilis* DC. In Nova Zeelandia, leg Forster, D.d. Forster" (label written by the curator, F. G. Bartling c. 1836). No original provenance written by Forster, and no flowers. This appears to be part of the same gathering. v.s.

**DISCUSSION:** Confusion has surrounded the true identity of Forster's *C. gracilis*, since Forster (1786) cited both New Zealand and New Caledonia in his brief diagnosis, and no original provenance is written on his three extant specimen sheets. This is a common fault in Forster specimens (Merrill 1954). The only genuine provenance is that provided by W. Anderson, who accompanied the Forsters. Anderson wrote on his specimen sheet "*W. Anderson*, Nova Caledonia 1774".

All these specimens are tall, stiff xerophytic specimens with hispid crimped leaves, and have the appearance of being pieces from one large plant, or a colony of equal-aged plants from one parent (Petterson 1997).

**DESCRIPTION:** Habit of radicate group. Closely similar in vegetative habit to *W. marginata*. Differs in the flowers which are very small, light blue-violet, campanulate to deeply campanulate, with narrow lobes; corolla 4–9 mm diam., 4–7 mm long, with tube  $2 \times 2$  to  $3 \times 2$  to  $3 \times 3$  mm, lobes  $2 \times 1.5$  to  $4 \times 2$  mm. Style blue, unconstricted. Calyx glabrous, lobes erect, narrow-triangular, very small, distinctly shorter than corolla tube,  $1-2.5 \times 0.5$  mm. Capsule glabrous,  $4 \times 3$  to  $6 \times 4$  mm, ellipsoid to obconic. Self-fertile. Seeds 0.5 mm long. FL Oct–Mar, FT Nov–Apr. Chromosome number:  $2n = 72$  (Petterson et al. 1995, fig. 4), vouchers CHR 79099, CHR 79100. Fig. 30.

**DISTINCTIVE FEATURES:** Alternate leaves, tiny light blue-violet long-tubed flowers, with corolla lobes scarcely longer than the tube, and calyx lobes much shorter than the corolla tube (Fig. 29 E).

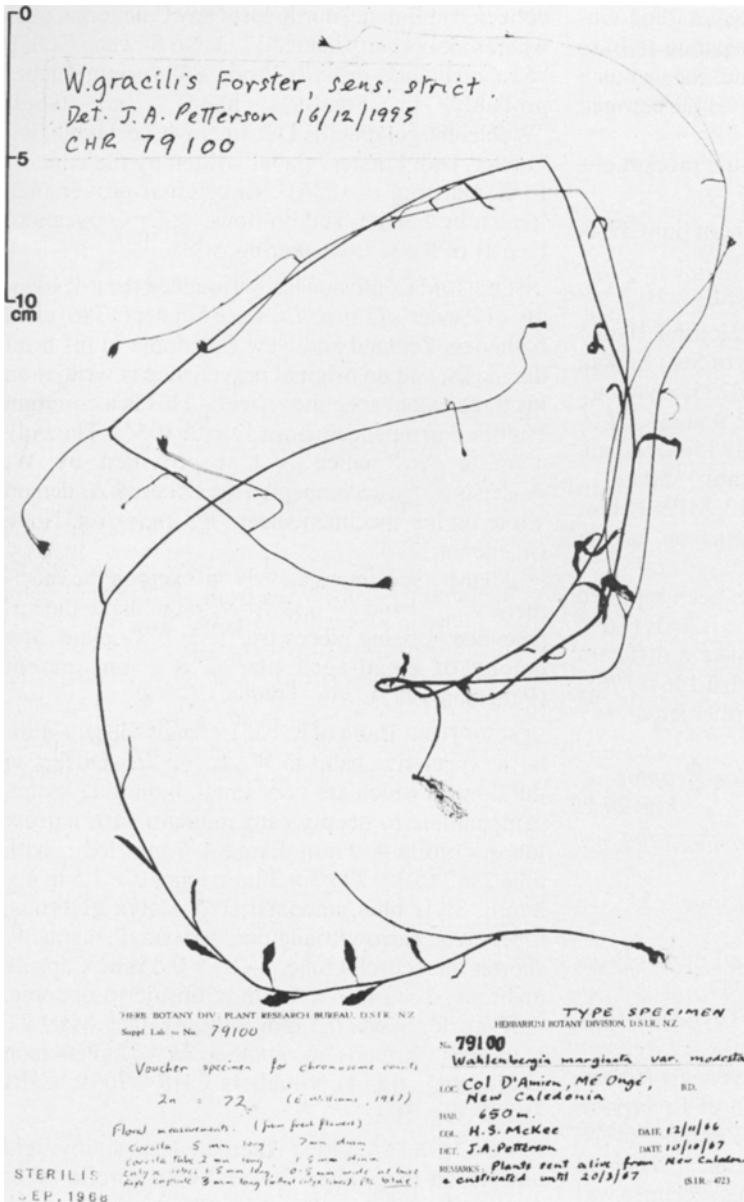
Table 12 shows the flower and capsule proportions in *W. gracilis*.

**DISTRIBUTION:** New Caledonia v.v., Norfolk Island v.v., Lord Howe Island (fide Green 1994). Possibly also on 'Eua, Tonga v.s.

**HABITAT:** "Not common. It occurs in disturbed situations, but never seems to be associated with cultivation or human habitation. Typical habitats are landslips, burnt areas, or road banks not yet invaded by the common weeds. It does not occur on the coast,



**Fig. 30** CHR 79100, *W. gracilis* sens. strict.



but in the lower hills, 400–500 m” (H. S. McKee pers. comm. July 1967, referring to New Caledonian specimens). Norfolk Island specimens that I saw in November 1996 were growing in similar sites at 200–300 m.

CONSERVATION STATUS: Not known.

REPRESENTATIVE SPECIMENS: Cultivated specimens, v.v.: Fig. 30, cytology voucher  $2n = 72$ , New Caledonia, Me’Onge, Col d’Amieu, 650 m, H. S.

McKee, 12 Nov 1966 (a rooted plant sent alive and grown on at Massey University, New Zealand), J. A. Petterson, 20 Mar 1967, CHR 79100; seedlings from CHR 79100, J. A. Petterson, 1967, CHR 79101–4; cytology voucher  $2n = 72$ , New Caledonia, wooded gully N of La Conception, seedlings cult. from seed from this locality, J. A. Petterson, 1967, CHR 79099; New Caledonia, Col de Massirah, 400 m, seedlings cult. from seed from this locality, J. A. Petterson, 1967, CHR 79105.

Specimens collected in the wild, v.s.: NEW CAL-  
EDONIA: New Caledonia, auf den Hulgen bei  
Yahoue, *Schlechter*, 1902, NSW 14739 [This is a  
juvenile shade form, with broad membranous  
leaves.]; *Compton* 676, 1914, NSW; New Caledo-  
nia, Plateau de Dogny, *H. S. McKee*, 18 Jan 1961,  
NSW 94101; Ravine nr La Conception, 100 m,  
*McKee* 16332, 23 Jan 1967, NOU; Col D'Amieu,  
450 m, *McKee* 18070, 5 Dec 67, NOU; Col  
D'Amieu, 300 m, *McKee* 44991, 26 Jul 1990, NOU;  
Haute Tipinje, 400 m, *McKee* 2216, 28 Jun 1970,  
NOU; Noumea, *McKee* 34079, 9 Oct 1977, NOU.  
NORFOLK ISLAND: *J. D. McComish* 53, 24 Sep  
1937, WELT 74104; *Dr. Metcalfe*, WELT 74120;  
"abundant in pasture (recently ripped secondary  
scrub)", *R. O. Gardner* 5939, 13 Oct 1989, AK  
199874; Mt Pitt, roadside near summit, 300 m, *J. A.*  
*Petterson*, 13 Nov 1996, WELT 74519; Palm Glen  
Track, 200 m, *J. A. Petterson*, 13 Nov 1996, WELT  
74518.

Insertae Sedis: TONGA: Forest Farm area, 'Eua,  
Tonga, *W. S. Sykes* 732/T, 14 Jul 1977, CHR 318167.  
With young buds only.

DISCUSSION: *W. gracilis* is clearly related to *W.*  
*marginata* of Honshu, Japan, which has the same  
chromosome number,  $2n = 72$ , and the same general  
appearance of vegetative parts and capsules. Only  
the floral size and proportions are different.

NOTE: Smith (1992) included one similar small-  
flowered Australian species in *W. gracilis* (G.Forst)  
A.DC, but this Australian taxon has  $2n = 54$ , so is  
unlikely to be the same species. Its prior name was  
*W. quadrifida* (R.Br.) A.DC. However, the original  
specimens of Robert Brown were false annuals  
(Petterson 1997, fig. 15), and are therefore not typi-  
cal. I have examined the vouchers for Smith's "*W.*  
*gracilis*" and they appear closely similar to most of  
his vouchers for *W. tumidifruca*, which also has  $2n$   
 $= 54$ . Analysis of Smith's descriptions of his "*W.*  
*gracilis*" and *W. tumidifruca* show them to be prac-  
tically identical, apart from distribution. *W.* "*gracilis*"  
is common in the gardens and parks of eastern Aus-  
tralia while *W. tumidifruca* is scattered all over the  
relatively uninhabited interior. They are closely

related. Neither should be included in *W. gracilis*  
*sens. strict.*

**13. *Wahlenbergia dehiscens* (Roxb.) A.DC 1830**

Fig. 31

*Campanula dehiscens* Roxburgh in *Hortus*  
*Bengalensis*: 85 (1814) ed. W. Carey, Serampore,  
The Mission Press. *Flora Indica* 2: 96 (1820–24),  
ed. William Carey, Serampore, The Mission Press  
1824.

*W. marginata* sensu Tuyn (1960) p.p.

Type specimens: West Bengal, *Roxburgh* (before  
1814), K, BM.

DESCRIPTION: Slender branching taprooted annual or  
perennial, with the habit of the radicate group. Co-  
rolla palest lilac fading to white, 10–15 mm. diam.,  
7–9 mm long, deeply campanulate with inflated tube  
c. 4 × 5 mm, lobes ovate, 5 × 4 mm. Ovary globose  
in flower, 5 × 4 mm, becoming barrel-shaped in fruit,  
8 × 7 mm. Calyx lobes short, broadly triangular, 1 ×  
1 mm. Seeds ellipsoid, glossy brown, 0.5 mm long.  
Chromosome number:  $2n = 18$  (Petterson et al.  
1995), vouchers CHR 201808–9. Fig. 31D

DISTINCTIVE FEATURES: Pale lilac flowers with in-  
flated corolla tube, globose ovary, and barrel-shaped  
capsule.

Table 13 shows flower and capsule proportions  
of *W. dehiscens*.

REPRESENTATIVE SPECIMENS: Banichi, Houghley  
District, West Bengal, *Subir Sen*, Apr 1969, CHR  
201807; cultivated seedlings from the same, *J. A.*  
*Petterson*, 1970, CHR 201808, 201809.

DISCUSSION: De Candolle (1830) described *W.*  
*dehiscens*, *W. agrestis*, and *W. indica*. Of these only  
*W. dehiscens* is described with white flowers. The  
others have blue flowers.

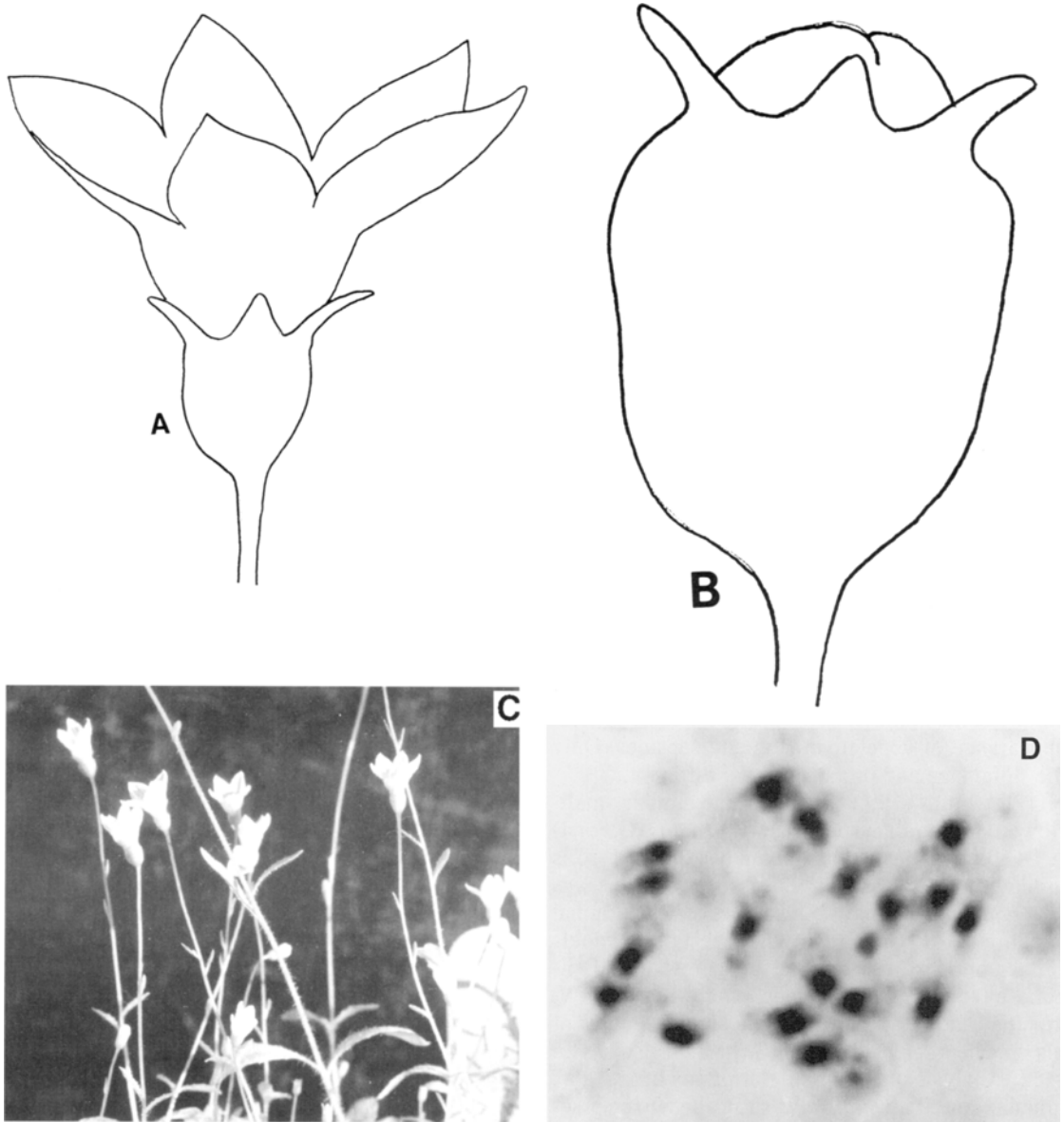
Tuyn (1960) included this species in the syn-  
onymy of *W. marginata* (Thunb.) A.DC., working  
from dried specimens. However, living specimens  
of *W. dehiscens* differ markedly from *W. marginata*  
in chromosome count and floral and capsule char-  
acters.

**Table 12** Typical corolla, calyx, and capsule dimensions  
of *W. gracilis*. All measurements in mm from living  
flowers.

diam	length	tube	lobes	calyx	capsule	HCC
6	4	2 × 2	2 × 2	1 × 0.5	4 × 3	41/1
9	6	3 × 3	4 × 2	2 × 0.5	5 × 4	

**Table 13** Typical corolla, calyx, and capsule dimensions  
of *W. dehiscens*. All measurements in mm from living  
flowers.

Diam.	length	tube	lobes	calyx	capsule	HCC
10	7	3 × 4	4 × 3	1 × 1	8 × 7	437/3
15	9	4 × 5	5 × 4	1 × 1	8 × 7	



**Fig. 31** *W. dehiscens* (Roxb.) A.DC, cultivated from Banichi, Houghley District, West Bengal. A, flower in profile, showing slightly inflated corolla tube and globose ovary; B, barrel-shaped capsule; C, photograph of living plant showing habit (Photo G. B. Petterson); D, chromosomes,  $2n = 18$ , (Photomicrograph, G. de Lautour), voucher CHR 201808.

#### RELATIONSHIPS OF NEW ZEALAND WAHLENBERGIA SPECIES WITH AUSTRALIAN SPECIES

Here I am quoting haploid (pmc) numbers to agree with Smith's (1992) treatment, as well as the diploid (somatic) numbers used elsewhere in this paper.

Vouchers quoted by Smith (1992) have been examined for comparisons with New Zealand material.

#### Species with $n = 27$ , $2n = 54$

New Zealand's *W. vernicosa* ( $2n = 54$ ) has completely glabrous campanulate corollas with the tube length = width, and lobes less than twice as long as

the tube. The flat-topped obconic capsule with patent calyx lobes is distinctive. The lobes appear twisted in dried specimens. The leaves are usually regularly and conspicuously serrate, but linear entire leaves are found in starved specimens from scrubland. The lowermost leaves are opposite.

Of the five Australian species recorded with  $n = 27$ , all have flowers that are recorded as puberulous inside at the base. I could not see this in dried specimens.

*W. multicaulis* has small, short-petalled rotate flowers. *W. "gracilis"* as defined by Smith (1992) and *W. tumidifruca* both have very small deeply campanulate flowers with short petals, while *W. littorcola* has rotate flowers varying in size and shape from rotate to campanulate, and with capsules varying from elongated erect obconic to shortly obconic. All have straight erect calyx lobes. None of these is conspecific with *W. vernicosa* or any other New Zealand species. One voucher of *W. planiflora* (Carolyn W 199, SYD) has  $n = 27$ , but may represent a different taxon since it has large, shortly campanulate flowers similar to those of *W. littorcola* or *W. victoriensis*.

### Species with $n = 18$ , $2n = 36$

Australian species with this count are without exception radicate in habit. They are therefore unrelated to New Zealand's endemic  $n = 18$  ( $2n = 36$ ) rhizomatous series.

*W. planiflora* (4 counts of  $n = 18$ ) has large rotate flowers and short obconic capsules.

*W. gracilentia* (2 counts of  $n = 18$ ) is a desert annual or ephemeral of inland Australia. I have seen Smith's two vouchers in SYD and 12 other specimens from NSW and PERTH. All have consistently very small campanulate flowers, small globular capsules, and distinctive oblong hispid calyx lobes. From the descriptions and maps in Smith (1992), I suspect *W. gracilentia* to be conspecific with *W. preissii* Vriese, which shares its range, the globular capsule, and the oblong calyx lobes. I can detect no significant difference in dried specimens. There are no recorded chromosome data for *W. preissii*.

*W. gracilentia* has been tentatively identified in northern New Zealand (Gardner 1994). The resemblance is superficial, as the specimens concerned (*A. E. Wright* 9510, 30 Nov 1989, AK 189997) are sympatric with *W. vernicosa* and are more likely to be false annuals of that species.

*W. stricta* subsp. *stricta*,  $n = 9$  or 18, is unlike any New Zealand species. The flowers are large and deeply campanulate, and the specimens found in

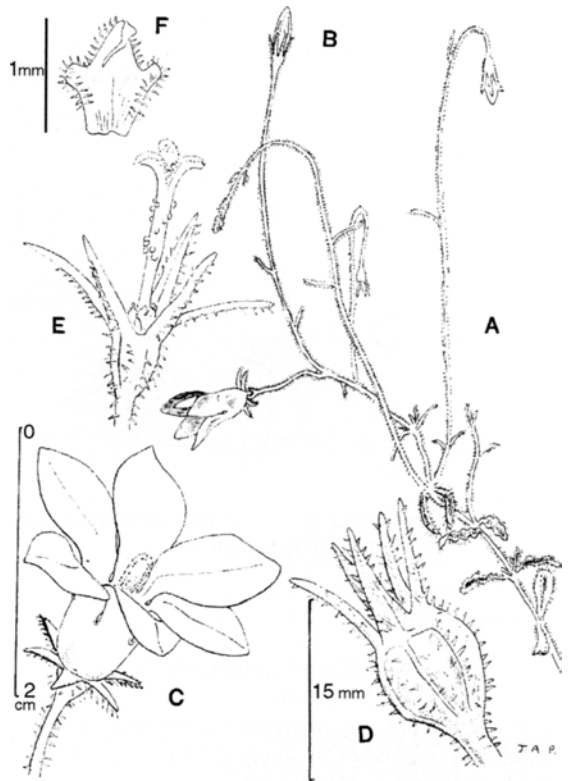


Fig. 32 *W. stricta* subsp. *stricta* from Rarangi, Cloudy Bay, New Zealand, c. 1950. A, habit; B, bud; C, 6-lobed flower; D, ripe capsule; E, dissected flower with corolla removed to show straight style and receptive stigmas; F, staminal filament.

New Zealand have bristly capsules and calyces. It was first collected at Rarangi, Cloudy Bay, in 1920, is now regarded as adventive to New Zealand, and is almost extinct in this country. It is native to New South Wales, where it is abundant (Fig. 32).

### Species with $n = 36$ , $2n = 72$

*W. saxicola* ( $n = 36$ ) is endemic to Tasmania, a completely glabrous, rhizomatous perennial with small campanulate blue-violet flowers solitary on short erect scapes, followed by globular capsules. v.v. It is unrelated to any other Australian species. No voucher was kept by Gulline, but the living plants she sent me from Mt. Rufus, Tasmania, in 1950 matched the descriptions in Lothian (1947) and Smith (1992). It is occasionally found in cultivation in New Zealand, under a variety of wrong names ("*W. tasmanica*" and "*W. congesta* hybrid") and is unlike any New Zealand species (Fig. 33).



swarms are sometimes observed. This agrees with my observations in New Zealand.

Published chromosome counts of *Wahlenbergia* in India, Africa, and the Pacific basin countries are compared in Table 15 (Petterson et al. 1995).

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## REFERENCES

- Allan, H. H. 1961: Flora of New Zealand. Vol. 1. Wellington, Government Printer.
- Beuzenberg, E. J.; Hair, J. B. 1983: Contributions to a chromosome atlas of the New Zealand Flora—25. Miscellaneous species. *New Zealand journal of botany* 21: 13–20.
- Brown, N. E. 1913: The wahlenbergias of Australia and New Zealand. *The gardeners' chronicle* 54 (ser. 3): 316–317.
- Brown, R. 1810: Prodrum florae Novae Hollandiae et insulae Van-Diemen. London.
- Bulfin, M. J. A. 1965: Nelson Lakes National Park, a handbook for visitors. Host, E. ed. Nelson, Nelson Lakes National Park Board.
- Borgmann, E. 1964: Anteil der polyploiden in der Flora des Bismarckgebirges von Ostneuguinea. *Zeitschrift für Botanik* 52 (2):118–172.
- Cameron, E. K.; de Lange, P. J.; Given, D. R.; Johnson, P. N.; Ogle, C. C. 1995: Threatened and local plant lists (1995 revision). *New Zealand Botanical Society newsletter* 39: 1528.
- Carolin, R. C. 1964: Critical and taxonomic notes on the genus *Wahlenbergia* in Australia. *Proceedings of the Linnean Society of New South Wales* 89 (2): 240.
- Colenso, W. 1899: *Wahlenbergia pygmaea* sp. nov. W. Colenso. *Transactions of the New Zealand Institute* 31: 273.
- Darlington, C. D.; Wylie, A. P. 1955: Chromosome atlas of flowering plants. London, Allen & Unwin.
- de Candolle, A. L. P. P. 1830: Monographie des Campanulees. Paris, Veuve Desray.
- Forster, J. G. A. 1786: Florulae insularum australium prodromus. Goettingen, Germany.
- Gardner, R. 1994: *Wahlenbergia gracilentia* (Campanulaceae). *Auckland Botanical Society journal* 49 (1): 40–41.
- Green, P. S. 1994: Flora of Australia. Vol. 49. Oceanic Islands 1. Canberra, Australian Government Printing service. Pp. 345–346.
- Guillaumin, A. 1911: Catalogue des plantes phanerogames de la Nouvelle-Calédonie et dépendances. *Annales du Musée Colonial de Marseille* 19.
- Hatch, E. D. 1952: A new species of *Corybas* Salisbury, and a note on some name changes in *Wahlenbergia* Schrad. *Transactions of The Royal Society of New Zealand* 79: 366–369.
- Holmgren, P. K.; Holmgren, N. H.; Barrett, L.C. 1990: Index herbariorum. *Regnum vegetabile* 120. 693 p.
- Horticulture Colour Chart 1942. Henry Stone & Son Ltd.
- Hsu, C.-C. 1967: Preliminary chromosome studies on the vascular plants of Taiwan, 1. *Taiwania* 13: 117–130.
- Hsu, C.-C. 1968: Preliminary chromosome studies on the vascular plants of Taiwan, 2. *Taiwania* 14: 11–27.
- Lothian, N. 1947: Critical notes on the genus *Wahlenbergia* Schrader; with descriptions of new species in the Australian region. *Proceedings of the Linnean Society of New South Wales* 71 (3–4): 212–214.
- Merrill, E. D. 1954: The botany of Cook's voyages. *Chronica botanica* 14: 161–384.
- Ono, M.; Masuda, Y. 1981: Chromosome numbers of some endemic species of the Bonin Islands II. *Ogasawara Research* 4: 1–24.
- Petrie, D. 1917: *Wahlenbergia flexilis* sp. nov. *Transactions of the New Zealand Institute* 49: 51.
- Petterson, J. A. 1953: The genus *Wahlenbergia* in New Zealand. Unpublished MSc thesis, Victoria University College, University of New Zealand.
- Petterson, J. A. 1993: Progress toward a revision of New Zealand harebells (*Wahlenbergia*). *New Zealand Botanical Society newsletter* 34: 11–18.

- Petterson, J. A. 1997: Identity of the original *Wahlenbergia gracilis* (Campanulaceae) and allied species. *New Zealand journal of botany* 35: 55–78.
- Petterson J. A.; Williams, E. G; Dawson, M. I. 1995: Contributions to a chromosome atlas of the New Zealand flora – 34 *Wahlenbergia* (Campanulaceae). *New Zealand journal of botany* 33: 489–496.
- Richard, A. 1832: Essai d'une flore de la Nouvelle Zélande. Paris.
- Roth, A. W. 1821: Novae plantarum species praesertim Indiae orientalis.
- Salmon, J. T. 1967: New Zealand flowers and plants in colour. 2nd ed. Wellington, A. H. & A. W. Reed.
- Salmon, J. T. 1985: Collins guide to the alpine plants of New Zealand. 2nd ed. Auckland, Collins.
- Schrader, H. A. 1814: Plantarum semina in Horto Academico Gottingensi, Anno 1814 collecta.
- Schrader, H. A. 1828: Blumenbachia, novum et losearum familia genus: 123.
- Smith, P. J. 1992: A revision of the genus *Wahlenbergia* in Australia. *Telopea* 5 : 91–175.
- Stearn, W. T. 1992: Botanical Latin. 4th ed. Devon, David & Charles.
- Thulin, M. 1975: The genus *Wahlenbergia* s. lat. (Campanulaceae) in tropical Africa and Madagascar. *Symbolae botanicae Upsalienses* 21 (1): 1–210.
- Thunberg, C. P. 1784: Flora Japonica. Liepzig.
- Tuyn, P. 1960: Campanulaceae. In: van Steenis, C. C. G. J. ed. *Flora Malesiana ser 1*, 6: 107–141.
- van Steenis C. G. G. J. 1960: Original generic description and typification of the genus 8668 *Wahlenbergia* Schrad. ex Roth (1821) Campanulaceae. *Taxon* 9: 122.
- von Brehmer, W. 1915a: Ueber die systematische gliederung und entwicklung der gattung *Wahlenbergia* in Afrika. *Botanische Jahrbucher fur Systematik, Pflanzengeschichte und Pflanzengeographie* 53: 9–71.
- von Brehmer, W. 1915b: Aufzählung der afrikanischen arten von *Wahlenbergia* nebst diagnosen der neuen arten. *Botanische Jahrbucher fur Systematik, Pflanzengeschichte und Pflanzengeographie* 53: 72–143.
- Webb, C. J.; Sykes, W. J.; Garnock-Jones, P. J. 1988: Flora of New Zealand. Vol. IV. Christchurch, Botany Division, Department of Scientific and Industrial Research.
- Wilson, H. D, 1987: Fieldwork: Banks Peninsula. *New Zealand Botanical Society newsletter* 8: 6–8.