Colin, Thanks for your considerable assistance with the later. Regards Pete P.S. and debate!!

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Mazus novaezeelandiae (Scrophulariaceae): taxonomy, distribution, habitats, and conservation

P. B. HEENAN
Landcare Research
P. O. Box 69
Lincoln, New Zealand

Abstract *Mazus novaezeelandiae* subsp. *impolitus* is a new subspecies distinguished from *M. novaezeelandiae* subsp. *novaezeelandiae* by dull or matt leaves with a prominent brown margin. It occurs on alluvial and sand soils. A form with distinct hairy margins and a restricted distribution is described as *M. novaezeelandiae* subsp. *impolitus* f. *hirtus*. *Mazus novaezeelandiae* subsp. *novaezeelandiae* has shiny leaves and is associated with lowland kahikatea-hardwood forest, or the sites of former kahikatea forest, and is known from few locations. The distribution, habitats, reproductive biology, and conservation status of the taxa are assessed, and a key is provided to the species of *Mazus* in New Zealand.

Keywords Scrophulariaceae; *Mazus*; *M. novaezeelandiae*; *M. novaezeelandiae* subsp. *impolitus*; *Mazus novaezeelandiae* subsp. *impolitus* f. *hirtus*; new subspecies; taxonomy; conservation; New Zealand flora

INTRODUCTION

Mazus is represented in New Zealand by the endemic *M. radicans* (Hook.f.) Cheeseman, *M. novaezeelandiae* W.R.Barker, and *M. arenarius* Heenan, P.N.Johnson, et C.J.Webb (Barker 1991; Heenan et al. 1996), and *M. pumilio* R.Br. which is shared with Australia (Heenan & Forester 1997). In North Island, *M. novaezeelandiae* (*sensu* Barker 1991) exhibits considerable variation in leaf size, coloration, and hairiness, flower size and colour, and habitats.

To assess the taxonomic implications of variations in morphology and habitat, a living collection of *M. novaezeelandiae* from known wild accessions has been established at the Landcare Research experimental nursery, Lincoln. Cultivation in uniform growing conditions significantly reduces the influence of natural environmental conditions on variation in morphological characteristics, and allows for the recognition of genotypic characteristics. A result of this cultivation study is recognition of a new subspecies of *Mazus novaezeelandiae* that is here named and described.

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TAXONOMY

Mazus Lour., *Fl. Cochinch.*, 385 (1790)

TYPE: *M. rugosus* Lour. (*fide* Greuter et al. 1993).

Mazus novaezeelandiae W.R.Barker, *Roy. Soc. Tasm. 31*, 89–91 (1991)

DESCRIPTION (Fig. 1–10): Perennial, creeping herb. Main branches 1.0–2.0 mm diameter, fleshy, white. Lateral shoots up to 20(–40) mm tall, white. Leaves up to 80 mm long, alternate; lamina 10–45 × 4–16 mm, elliptic, narrow-elliptic, or narrow-obovate, thin, surface undulate, spreading or weakly ascending, adaxial surface green to green-brown, abaxial surface pale green, midrib and main lateral veins raised on abaxial surface, red-green or green midrib raised on adaxial surface, base attenuate, margin undulate and with 6–7 pairs of teeth; petiole 5–40 mm long, subterete, white glabrous or with a few hairs. Inflorescences lateral on short branches, 2–8-flowered, flowers held just above to well above the leaves. Peduncle 20–60 mm long, glabrous, pale green, green, to brown-green. Bracteoles 2.0–4.5 × 0.2–0.5 mm, narrow-linear, glabrous, green, solitary, apex acute, inserted below calyx. Pedicel 4.5–40 mm long, pale green to green. Calyx 3.0–5.0 mm long, campanulate, green or brown-green, glabrous or hairy on margin, with prominent ridges on adaxial

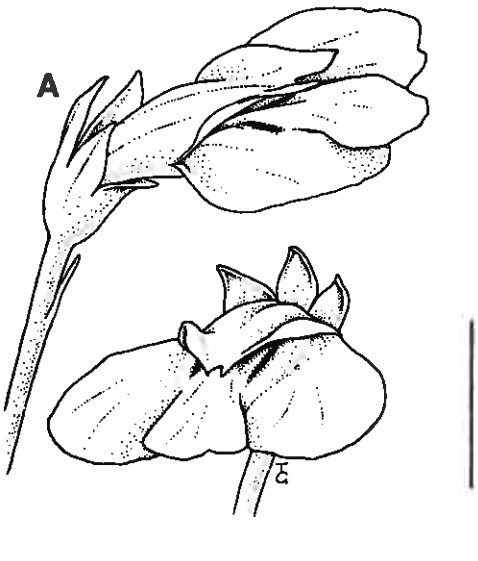

Fig. 1 Variation in flowers. **A**, *M. novaezeelandiae* subsp. *impolitus* from the Whangaehu River mouth with rounded and overlapping corolla lobes; **B**, *M. novaezeelandiae* subsp. *novaezeelandiae* from Marangai, near Wanganui, with square and spreading lobes. Scale bar = 5 mm.

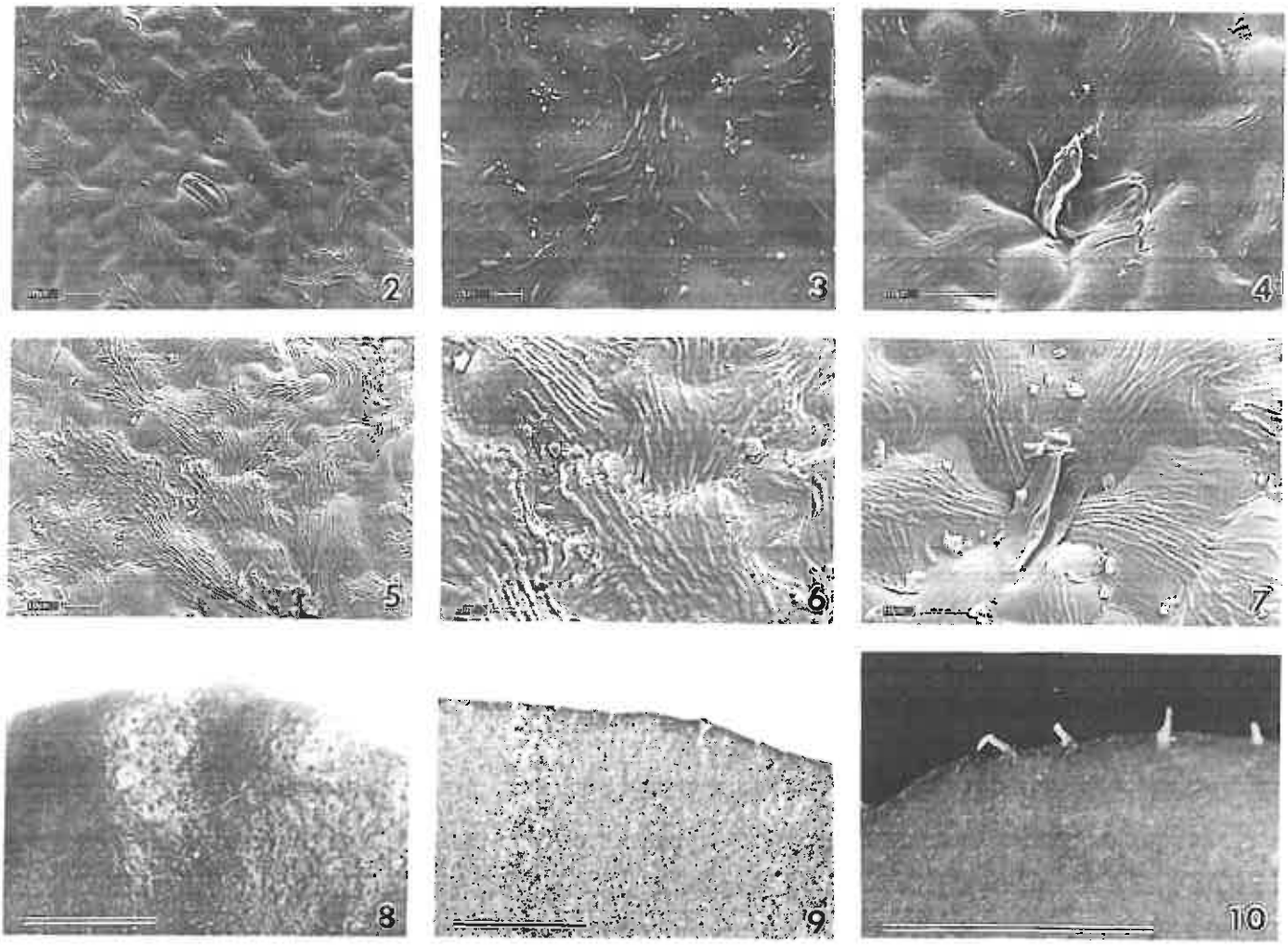

Fig. 2–10 Leaf surfaces. **Fig. 2, 3, 4** *M. novaezeelandiae* subsp. *novaezeelandiae* with weak sculpturing on the adaxial surface; note stomata in Fig. 2 (arrow) and pit in Fig. 4. **Fig. 5, 6, 7** *M. novaezeelandiae* subsp. *impolitus* with bold sculpturing on the adaxial surface; note pit in Fig. 7. **Fig. 8** *M. novaezeelandiae* subsp. *novaezeelandiae* uniformly coloured lamina and margin; note the reflected light. **Fig. 9** *M. novaezeelandiae* subsp. *impolitus* brown marginal band. **Fig. 10** *M. novaezeelandiae* subsp. *impolitus* f. *hirtus* leaf margin. Scale bars: Fig. 2, 4, 5, 7 = 10 μm; 3, 6 = 3 μm; 8–10 = 2 mm.

surface; teeth 1.5–2.5 mm long, narrow-triangular. Corolla 7.0–14.5 × 7.8–14.0 mm, white, but often opening pale yellow or flushed pale lavender then fading to white, palate yellow, glabrous apart from papillae and few scattered hairs on palate and corolla tube. Tube 3.0–5.0 mm long. Lower lobes 2.0–6.0 × 3.0–5.0 mm, rounded to praemorse, spreading to overlapping; middle lobe smaller than lateral lobes, sometimes square, apex sometimes retuse; palate comprising 2 longitudinal elevations extending from point of filament fusion to base of lower lobes. Upper lobes 1.0–6.5 mm long, narrow-triangular, horizontal, apex subacute. Stamens 4, white, glabrous, inserted at same level in middle of tube; filaments 1.2–3.0 mm long, curved; anthers 0.7–0.9 mm long. Ovary 1.0–1.8 mm long, glabrous, ovoid; style 2.3–4.5 mm long, positioned ± symmetrically on summit of ovary; stigmatic lobes 1–1.2 × 0.7–0.8 mm, rhomboid to praemorse. Fruit 5.9–6.5 × 2.5–3.5 mm, ovoid, green, bilaterally compressed, persistent, indehiscent; apex subacute. Seeds 0.4–0.8 × 0.4–0.5 mm, brown to purple-brown, surface reticulate. FL Dec–Jan(–Oct), FT Jan–Mar.

Key to *Mazus novaezeelandiae* subspecies

1 Lamina shiny, glossy, usually without a brown marginal band, margin glabrous..... .....**subsp. *novaezeelandiae***

1 Lamina dull, matt, and usually with a prominent brown marginal band, margin glabrous or hairy .....**subsp. *impolitus***

subsp. *novaezeelandiae* Fig. 2–4, 8

Lamina shiny, glossy, usually without a prominent brown marginal band, but occasionally a thin brown marginal line is present.

HOLOTYPE (*fide* Barker 1991): Hawkins Gully Stream, *B. V. Sneddon & T. Moss*, 8 Dec 1966, AD 99001047.

ISOTYPES: Hawkins Gully Stream, *B. V. Sneddon & T. Moss*, 8 Dec 1966, CHR 454460!, WELT 79241!

REPRESENTATIVE SPECIMENS: WELLINGTON: Marangai, *C. C. Ogle 1923*, 30 Sep 1989, CHR 468579; Kauangaroa, *C. C. Ogle 2100*, 29 Jun 1991, CHR 473937; Marangai, *P. B. Heenan 78/95*, 11 Oct 1995, CHR 500575; Kauangaroa, *P. B. Heenan 6/96*, 30 Jan 1996, CHR 507537; upper Wainuiora River, *P. J. de Lange*, 19 Oct 1995, AK 228218. CULTIVATED SPECIMENS: ex N. Singers, Turakina River valley, *P. B. Heenan 15/96*, 14 Jun 1996, CHR 507552; ex C. C. Ogle, Waireka Road, Wanganui, *P. B. Heenan 16/96*, 14 Jun 1996, CHR 507553; ex Gisborne Bowling Club green, Gisborne, *G. Loudon*, 17 Jan 1997, CHR 487328; ex C. C. Ogle, Kawhatau River near Mangaweka, *P. B. Heenan*, 5 Jun 1997, CHR 512614; ex C. C. Ogle, Whanganui River, *P. B. Heenan*, 5 Jun 1997, CHR 512613; ex bowling green, Havelock North, *D. Clapperton*, Feb 1984, CHR 419963; ex bowling green, Havelock North, *W. R. Sykes*, 13 Nov 1984, CHR 416567; ex C. C. Ogle, Waiwhero Stream, Waipawa, *P. B. Heenan 9/97*, 22 Jan 1997, CHR 511037.

The loss of critical diagnostic characters on dried plant material, which usually turns brown, inhibits accurate identification of the two *M. novaezeelandiae* subspecies from herbarium specimens. However, dried leaves on some herbarium specimens from the central and lower North Island do have a rather glossy sheen. The following specimens are provisionally considered to be *M. novaezeelandiae* subsp. *novaezeelandiae*: Lake Wairarapa, *W. R. B. Oliver*, WELT 8432; Lake Wairarapa, *R. Mason 564a*, 8 Feb 1950, CHR 65659; Lake Wairarapa, *L. B. Moore*, 5 Dec 1959, CHR 141872; Wairarapa, *A. P. Druce*, Dec 1970, CHR 210796; Carter's Bush, Wairarapa, *A. P. Druce*, Jun 1967, CHR 165615; Hunterville, *C. C. Ogle 2557*, 3 Apr 1993, CHR 481811; lower Waikato, *H. Carse*, 17 Feb 1900, CHR 328404; Paekakariki, *C. C. Ogle*, 15 Mar 1980, WELT 68843; Pencarrow Lagoon, *T. Kirk*, Nov 1889, WELT 59896; Paraparaumu, *B. C. Aston*, Jan 1912, WELT 59913.

subsp. *impolitus* Heenan, subsp. nov. Fig. 5–7, 9

DIAGNOSIS: Ab *Mazo novaezeelandiae* subsp. *novaezeelandiae* foliis impolitis atque plerumque vitta marginali ornatis removenda.

Differs from *Mazus novaezeelandiae* subsp. *novaezeelandiae* by leaves that are dull and usually have a brown marginal band.

HOLOTYPUS: Foxton dunes, sand hollow, *H. H. A*[llan], 6 Dec 1939, CHR 23178.

DESCRIPTION: Lamina dull, matt, with a prominent brown marginal band, margin glabrous or hairy.

REPRESENTATIVE SPECIMENS: NORTH AUCKLAND: Te Werahi Swamp, *G. C. Kelly*, Dec 1966, CHR 178276; Reef Point, *T. F. Cheeseman*, Jan 1896, WELT 59908; north Woodhill Forest, *E. K. Cameron*, 16 Feb 1995, AK 221756. GISBORNE: Bay of Plenty, *A. P. Druce*, CHR 100151; East Cape, *S. Courtney*, 3 Dec 1984, CHR 417583. WELLINGTON: Whangaehu River, *J. Liddell 1654*, 23 Jan 1989, CHR 462446; Rangitikei, *C. C. Ogle 1747*, 11

Oct 1988, CHR 464145; Turakina beach, *A. P. Druce*, Mar 1975, CHR 275030; Himatangi, *V. D. Zotov*, CHR 4418; Foxton, *H. H. Allan*, 1 Jan 1932, CHR 4031; Hokio, *L. B. Moore*, 17 Nov 1946, CHR 77221. NELSON: Nile River, *D. & G. C. Kelly*, Nov 1973, CHR 250117. CANTERBURY: Canterbury plains, *J. von Haast*, CHR 328119; Mt Grey, *A. Wall*, Dec 1930, CHR 328118; Leithfield beach, *J. Thompson*, 8 Mar 1980, CHR 454180; Chaney's Forest, *J. Thompson*, 28 May 1980, CHR 369119; Waimakarari mouth, *W. R. B. Oliver*, 27 Nov 1910, WELT 8433. OTAGO: Lowburn, *P. N. Johnson*, 6 Mar 1980, CHR 363614; Earnscleugh, *I. A. McNeur*, 2 Jan 1950, CHR 68584; Luggate, *B. Campbell*, 14 Jan 1969, CHR 188742.

ETYMOLOGY: The epithet *impolitus* refers to the dull, unpolished, and matt leaf surface (Stearn 1993).

subsp. *impolitus* f. *hirtus* Heenan, forma nov.
Fig. 10

DIAGNOSIS: A subsp. *impolito* marginibus foliorum pilosis recedit.

Differs from subsp. *impolitus* by its hairy leaf margins.

HOLOTYPE: North Auckland, Awanui Straight, Foley's Bush, *P. J. de Lange 454 & G. M. Crowcroft*, 10 Oct 1990, CHR 472872.

REPRESENTATIVE SPECIMENS: NORTH AUCKLAND: Waihopai Stream, *R. Mason & N. T. Moar 140*, 25 Nov 1949, CHR 65869; Scott's Point, *H. Carse*, Feb 1928, CHR 328095; Mangonui Co., *H. Carse*, Jan 1912, CHR 280118; Reef Point, *H. Carse & H. B. Matthews*, Jan 1912, CHR 328098; Kaitaia, *H. B. Matthews*, CHR 328096; Kaitaia, *H. B. Matthews*, Jan 1898, CHR 328097. SOUTH AUCKLAND: Mercer, lower Waikato, *D. P*[etrie], 1 Nov 1913, WELT 59912 lower left piece. GISBORNE: Hautai Beach, *S. Courtney*, 3 Dec 1984, CHR 417584; Karakatuwhero River, *S. Courtney*, 22 Nov 1984, CHR 417570; Waipapa Stream, *P. B. Heenan*, 11 Jun 1997, CHR 512624.

A single specimen in the Kirk herbarium (WELT 59894) labelled "Dunedin Feb 1871 W. L. Williams" is likely to be a misleading locality for three reasons. Firstly, W. L. Williams resided in the Hawke's Bay area (Orange 1993); secondly, no other *M. novaezeelandiae* collections are known from Dunedin; and thirdly, the specimen has hairy leaf margins and is therefore consistent with forma *hirtus* which occurs from Northland to the East Cape area. Furthermore, in an account of the flora of the East Cape district Kirk (1897) lists *M. novaezeelandiae* (as *M. pumilio*) and cites a specimen collected by "W.L.W."

ETYMOLOGY: The epithet *hirtus* refers to the hairy leaf margins.

NOTES: The matt leaf surface is the main character that reliably and consistently separates the new taxon *M. novaezeelandiae* subsp. *impolitus* from *M. novaezeelandiae* subsp. *novaezeelandiae*. The two subspecies are almost separated by their ecology but the presence of some plants of *M. novaezeelandiae* subsp. *impolitus* f. *hirtus* in kahikatea forest weakens this distinction. Because of the single character support, the rank of subspecies was preferred over species.

The taxon f. *hirtus* is named as it is a constant form with a well defined distribution. The rank of f. *hirtus* is preferred over that of "variety hirtus" as the taxon is sympatric, rather than allopatric, with the typical species.

CHROMOSOME NUMBERS

Mazus novaezeelandiae, $n = 19$ (CHR 100151, glasshouse, Nov 1954, col. *A. P. Druce*, loc. Bay of Plenty). The dried herbarum voucher is difficult to assign to either subspecies with confidence, but the narrow and matt leaves and distribution are certainly more suggestive of subsp. *impolitus*.

The three taxa here placed in *Mazus novaezeelandiae* and New Zealand material of *M. pumilio* (Heenan & Forester 1997) have been counted by B. Murray (pers. comm.). The chromosome numbers are all $2n = 38$. The following are the herbarium vouchers for each of the taxa: *M. novaezeelandiae* subsp. *novaezeelandiae* (CHR 507551); *M. novaezeelandiae* subsp. *impolitus* (CHR 513357); *M. novaezeelandiae* subsp. *impolitus* f. *hirtus* (CHR 472872); *M. pumilio* (CHR 510594).

DISTRIBUTION

Mazus novaezeelandiae subsp. *novaezeelandiae* is known with certainty only in the lower and central North Island from several areas near Wanganui, a single site in the upper Wainuiora River (south-east of Carterton), near Waipawa (Hawke's Bay), near Gisborne, and the type locality at Makara (Fig. 11).

Two gatherings (CHR 419963, 487328) of *M. novaezeelandiae* subsp. *novaezeelandiae* have been made from bowling greens at Havelock North and Gisborne, and another (CHR 258041) from turf plots in Palmerston North.

Mazus novaezeelandiae subsp. *impolitus* occurs in mainly coastal and lowland regions of North and

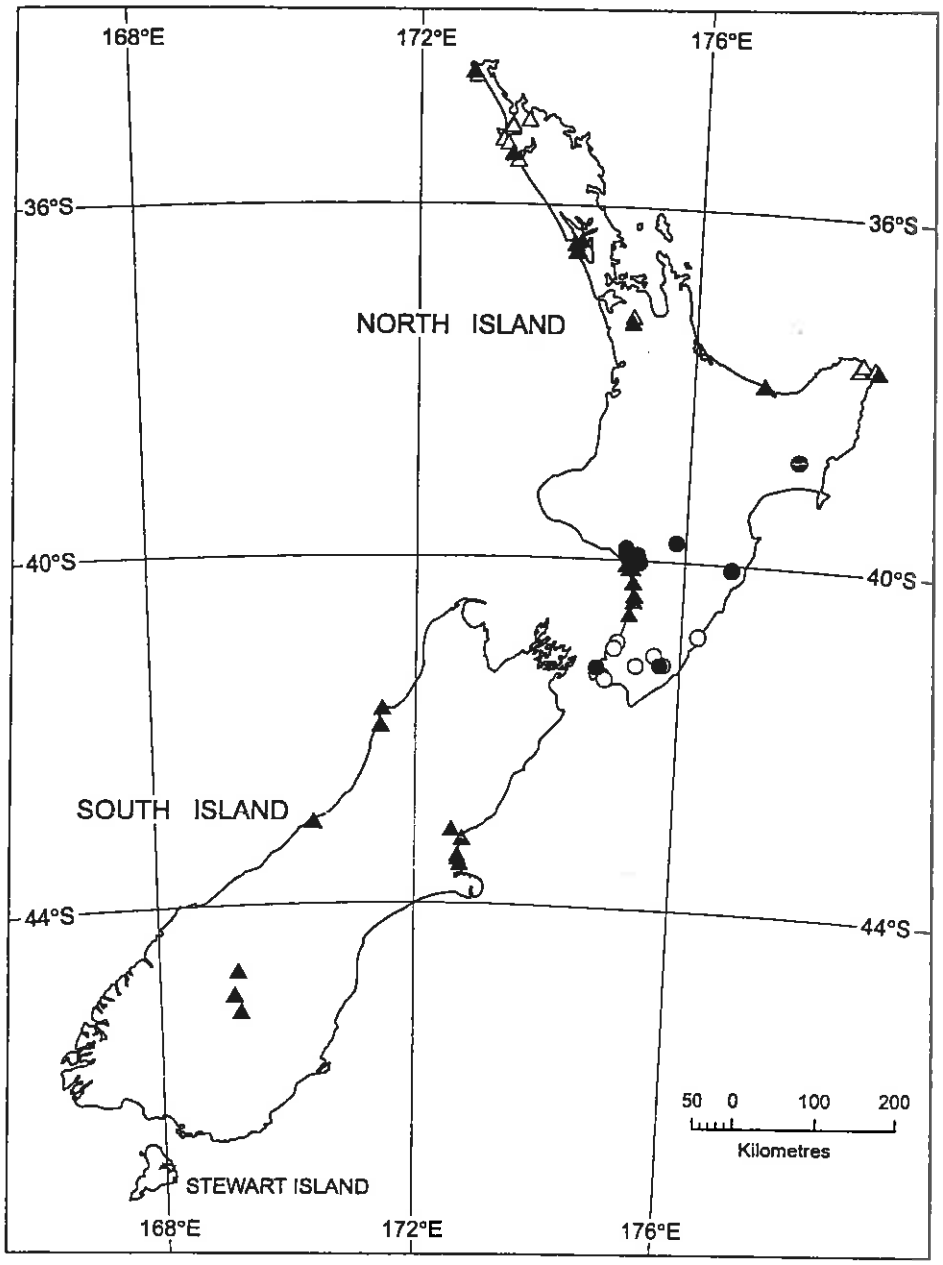

Fig. 11 Distributions. ●, *M. novaezeelandiae* subsp. *novaezeelandiae*; ○, probable *M. novaezeelandiae* subsp. *novaezeelandiae*; ▲, *M. novaezeelandiae* subsp. *impolitus*; △, *M. novaezeelandiae* subsp. *impolitus* f. *hirtus*.

South Islands (Fig. 11). In the South Island it occurs in Central Otago. A single collection has been made from a lawn in Christchurch (CHR 369120). *Mazus novaezeelandiae* subsp. *impolitus* f. *hirtus* has a restricted distribution in the north and north-eastern areas of the North Island (Fig. 11). It is notable that f. *hirtus* occurs only north of about 38°S, which is the southern limit for a number of northern New Zealand species (e.g., McGlone 1985, fig. 2).

de Lange (1988) records *M. novaezeelandiae* (as *M. pumilio*) from Rakaunui Peninsula, Kawhia. The distributions of the taxa described here do not include all specimens from AK as these have been unavailable.

HABITATS AND ASSOCIATED VEGETATION

Mazus novaezeelandiae subsp. *novaezeelandiae* is associated with kahikatea-hardwood forest, or farmland where kahikatea-hardwood was formerly present.

At Marangai, near Wanganui, *M. novaezeelandiae* subsp. *novaezeelandiae* grows in three situations, two of which are directly associated with remnant kahikatea forest (Fig. 12). The forest at Marangai covers about 7 ha and is fenced to exclude stock. The dominant tree species are *Dacrycarpus dacrydioides*, *Prumnopitys taxifolia*, *Alectryon excelsus*, *Beilschmiedia tawa*, and *Pennantia*

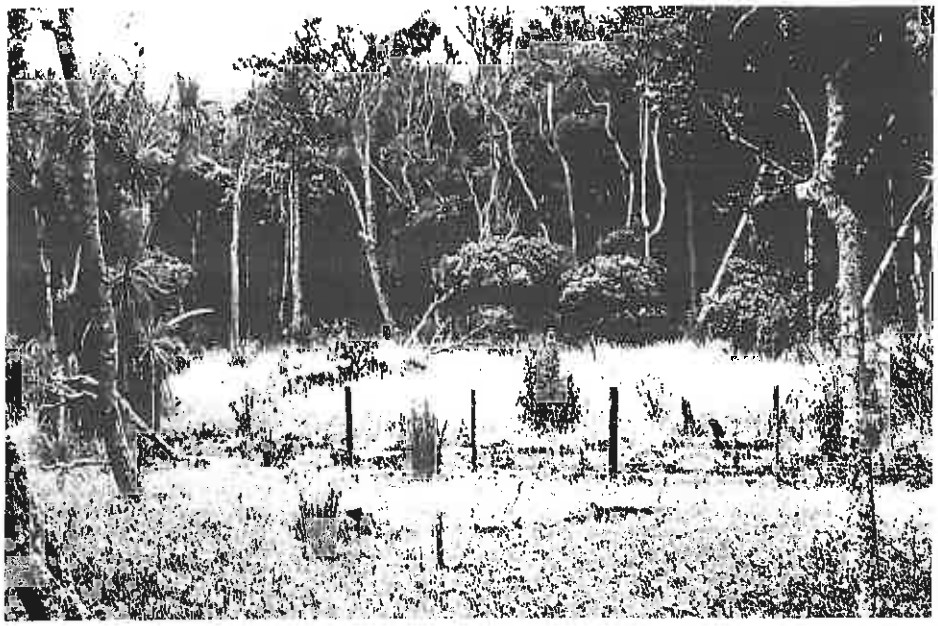

Fig. 12 Habitat of *M. novaezeelandiae* subsp. *novaezeelandiae* at Marangai. The *Mazus* occurs in the grazed turf in the foreground, around the forest margin, and in light gaps. It is absent from the dense sward of grasses in the central foreground.

corymbosa, and the most conspicuous understorey species include *Coprosma rhamnoides*, *Macropiper excelsum*, *Melicytus ramiflorus*, and *Parsonsia capsularis*. *Mazus novaezeelandiae* grows within the forest in several light gaps and around the forest margin. In a small light gap of 1 m × 1 m, *M. novaezeelandiae* occupies about 10% of the ground cover and is associated with *Stellaria parviflora*, *Dichondra brevifolia*, *Cardamine* sp. (CHR 507544), *Oxalis exilis*, and several 50-mm-high seedlings of *D. dacrydioides*. A larger light gap, of approximately 10 m × 5 m, has a moderate covering of introduced grasses and several scattered 1–2 m tall shrubs of *Melicytus ramiflorus*, *Pennantia corymbosa*, and *Lophomyrtus obcordata*. Here *M. novaezeelandiae* is the dominant herb around the margins of the gap and under the shrubs, but it is competing very poorly with the grasses where it only occurs as isolated and etiolated tufts. Around the forest margins *M. novaezeelandiae* grows in a few places at the bases of trees and among adjacent short and rather open herbs and grasses. It is absent from a dense sward of grasses and herbs and a thicket of *Macropiper excelsum* on the forest margin.

The third habitat at Marangai is farmland which has been developed by clearing the mixed kahikatea-hardwood forest. In this situation *M. novaezeelandiae* subsp. *novaezeelandiae* grows in lightly grazed and trampled pasture with introduced grasses and other low herbs. The grazing regime prevents excessive shading and competition with vigorous weeds, but is not so heavy that trampling and damage to the turf and *Mazus* occurs. In contrast, at nearby Kauangaroa heavy grazing and severe trampling by cattle has eliminated or prevented *M. novaezeelandiae* subsp. *novaezeelandiae* from establishing in pasture under scattered kahikatea. Here *M. novaezeelandiae* subsp. *novaezeelandiae* occurs in small tufts only where it has protection around the base of *Melicope simplex* and *Coprosma rhamnoides*.

N. Singers (pers. comm.) has observed *M. novaezeelandiae* subsp. *novaezeelandiae* in the Turakina River valley and near Waireka Road, Wanganui. These sites were almost certainly dominated by *Dacrycarpus dacrydioides* and *Laurelia novae-zelandiae* forest, but today the forest has been cleared and the *Mazus* persists in moist hollows and damp seepages in pasture. On a river terrace beside the Whanganui River, C. C. Ogle (pers. comm.) has collected *M. novaezeelandiae* subsp. *novaezeelandiae* in rough damp pasture among *Schoenoplectus tabernaemontani*, *Eleocharis acuta*, *Agrostis stolonifera*, and *Trifolium repens*; this site would have formerly been kahikatea forest. In the upper Wainuioru River, *M. novaezeelandiae* subsp. *novaezeelandiae* grows in matai-kahikatea forest under *Coprosma* sp. "v" (Eagle 1982, fig. 211), and it is associated with *Crassula ruamahanga*, *Urtica linearifolia*, *Isolepis inundatus*, and *Leptinella tenella* (P. J. de Lange pers. comm.).

Mazus novaezeelandiae subsp. *impolitus* occurs in mainly coastal sites, particularly damp sand hollows and sand flats (Fig. 13), but several collections have been made on river gravel alluvium in inland Otago. *Mazus novaezeelandiae* subsp. *impolitus* f. *hirtus* occurs in kahikatea forest at Foley's Bush (CHR 472872) and Kaitaia (CHR 328096), North Auckland, and near Te Araroa, East Cape (AK

Fig. 13 *Mazus novaezeelandiae* subsp. *impolitus* in full flower among *Leptocarpus similis* and *Isolepis nodosa* at the Whitiau Scientific Reserve, Whangaehu River mouth.

14140). These kahikatea forest remnants are only slightly inland and often have other coastal plants present. For example, at Foley's Bush, in addition to *M. novaezeelandiae* subsp. *impolitus* f. *hirtus*, are *Myoporum laetum* and *Coprosma repens* (P. J. de Lange pers. comm.).

At Woodhill, Waionui Inlet, west Auckland, *M. novaezeelandiae* subsp. *impolitus* grows in open areas, in particular along tracks and in sand hollows that are periodically inundated. In some places the *Mazus* forms a dense mat of coalescing rosettes over several square metres, and in others it occurs sparingly among other small herbs. The overhead canopy includes *Leptospermum scoparium*, *Coprosma crassifolia*, *Macropiper excelsum*, *Phormium tenax*, *Cordyline australis*, *Leptocarpus similis*, *Carex virgata*, *Baumea juncea*, *B. articulata*, and *Ageratina adenophora*, and associated herbs and other plants include *Hydrocotyle novae-zeelandiae*, *Lobelia anceps*, *Galium trilobum*, and *Schoenus maschalinus*. At the Whangaehu River mouth the dominant cover is *Leptocarpus similis*, with the occasional *Cordyline australis*, *Phormium tenax*, and *Baumea juncea* (C. C. Ogle pers. comm.).

Near East Cape, at Waipawa Stream mouth, *M. novaezeelandiae* subsp. *impolitus* f. *hirtus* is sparsely distributed in a damp seepage that is dominated by kikuyu grass (*Pennisetum clandestinum*). Other species present, although in small numbers, include *Leptocarpus similis*, *Centella uniflora*, *Nertera depressa*, *Gunnera monoica*, *Sagina procumbens*, and *Prunella vulgaris*.

VARIATION

The shape of the lower three lobes of the corolla varies within and between the two subspecies (Fig. 1), with no apparent pattern. Some plants have rounded lobes with obtuse apices and the lobes overlap, while other forms have squarish lobes with praemorse apices and the lobes spreading. Variation in the shape of the stigmatic lobes and the degree of leaf undulation was also observed. The apices of the stigmatic lobes of *M. novaezeelandiae* subsp. *novaezeelandiae* are inclined to be obtuse, whereas those of *M. novaezeelandiae* subsp. *impolitus* are more acute. Although this variation appears to be correlated with the two subspecies it is not exclusive to either and is therefore of limited taxonomic value. The leaves of *M. novaezeelandiae* subsp. *novaezeelandiae* generally appear to be slightly more undulate than the leaves of *M. novaezeelandiae* subsp. *impolitus*; this difference is also extremely difficult to quantify.

At Marangai *M. novaezeelandiae* subsp. *novaezeelandiae* differs from other collections in the leaf midrib being green rather than red or red-green, and the flower is pale lemon rather than white. In cultivation, plants from all populations sometimes produce flowers which have six petals because of the lower middle lobe splitting into two, others have a small extension from the sinus between the lower three lobes, and one six-petalled actinomorphic flower has been recorded. Actinomorphic flowers have also been recorded in *M. arenarius* by Heads (1994).

Mazus novaezeelandiae subsp. *impolitus* f. *hirtus* recognises a form with distinctive and consistently hairy leaf margins (Fig. 10). Although this hairy margin may be the result of a single gene, it is named as it is a distinctive morph with a well defined distribution. *Mazus novaezeelandiae* subsp. *impolitus* f. *hirtus* from Foley's Bush has brown-green leaves

rather than green leaves which are typical of other *M. novaezeelandiae* subsp. *impolitus* collections. The Foley's Bush plants also have petals with a distinct lilac flush.

The difference in leaf glossiness of the two subspecies of *M. novaezeelandiae* has been shown by SEM investigation to be caused by epicuticular wax sculpturing. The lamina of *M. novaezeelandiae* subsp. *novaezeelandiae* has weak striae on the adaxial surface (Fig. 2–4, 8) which results in reflected light and a shiny leaf surface. In comparison, *M. novaezeelandiae* subsp. *impolitus* has well developed and more pronounced striae and light is scattered rather than reflected, causing the lamina to appear dull (Fig. 5–7, 9).

RECOGNITION

Mazus novaezeelandiae and *M. pumilio* are distinguished from *M. radicans* and *M. arenarius* by their slender calyx, which is usually glabrous or only sparsely covered with eglandular hairs; horizontal rhizomes without distinct nodes and the leaves in close packed terminal rosettes; the palate glabrous or sparsely papillose only in the throat; a narrow fruit; and the seed dark purple-brown and with a reticulate testa of distinct thin-walled cells. *Mazus pumilio* differs from *M. novaezeelandiae* in having hairy leaves, the lower part of the lamina being distinctly serrated, and in having purple, pale blue, or lilac flowers. *Mazus novaezeelandiae* subsp. *impolitus* has dull and matt leaves with a prominent brown margin, whereas *M. novaezeelandiae* subsp. *novaezeelandiae* leaves have a glossy appearance and usually a green margin.

Field identification of *M. novaezeelandiae*, like that of many other small herbs, is often extremely difficult as the two subspecies often grow in disturbed and unfavourable conditions. In such sites the leaves can be very small and it is often difficult to determine whether the leaves have a dull or glossy appearance.

REPRODUCTIVE BIOLOGY

In cultivation only a few plants of *M. novaezeelandiae* developed fruit. The plants that form fruit have dehiscent anthers and receptive stigmas held at a similar height at the same time (Fig. 14). In these plants the self-pollen is frequently deposited directly on to the stigmatic lobes. These observations suggest that *M. novaezeelandiae* can be self-pollinated and that it is self-compatible. Barker (1991) also reported fruit on a cultivated plant of *M. novaezeelandiae* and concluded that the species was self-compatible.

KEY TO THE NEW ZEALAND SPECIES OF *MAZUS*

1 Leaves distant and with obvious internodes, yellow-green, yellow-brown, brown, brown-green, or purple-brown, often with darker blotches or marginal stitch marks; calyx stout–broadly campanulate; capsule apex truncate; seeds henna *2*

1 Leaves in rosettes and without obvious internodes, green, sometimes with a narrow brown margin; calyx slender–narrowly campanulate; capsule apex acute; seeds purple-brown *3*

2 Leaves purple-brown, brown-green, or green, without mottling; peduncle 5–8 mm long; apex of lower corolla lobes rounded; fruit usually enclosed within a fleshy calyx ..... ***M. arenarius***

2 Leaves yellow-green or yellow-brown, usually with mottling or stitch marks; peduncle 10–70 mm long; apex of lower corolla lobes retuse; fruit often protruding from fleshy calyx ..... ***M. radicans***

3 Leaves with serrate–dentate margin, hairs present on upper lamina; corolla pale blue, lilac, or purple ..... ***M. pumilio***

3 Leaves with entire or weakly serrate margin, hairs confined to margin, or absent; corolla white, rarely pale yellow or with a weak mauve flush *4*

4 Leaves with a shiny and glossy lamina and margins, margins glabrous and usually the same colour as the lamina..... ***M. novaezeelandiae*** subsp. ***novaezeelandiae***

4 Leaves with a dull and matt lamina, margin glabrous or hairy and with a narrow brown band *5*

5 Leaf margin glabrous ..... ***M. novaezeelandiae*** subsp. ***impolitus***

5 Leaf margin hairy..... ***M. novaezeelandiae*** subsp. ***impolitus*** f. ***hirtus***

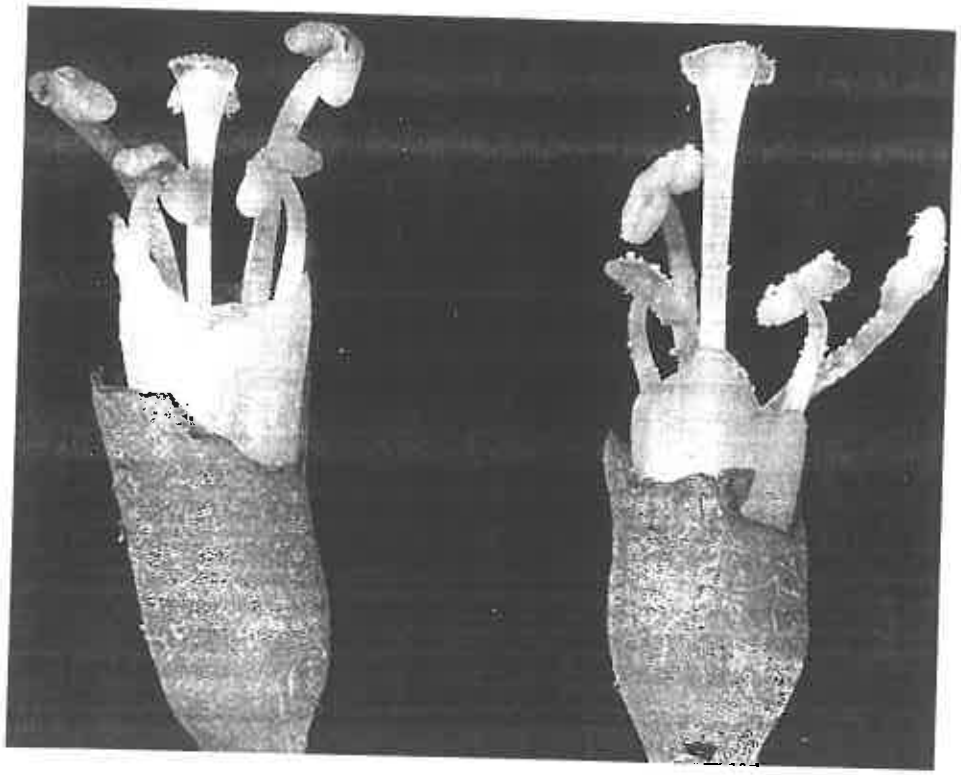

Fig. 14 Variations in style length in *Mazus novaezeelandiae*. Left, stigma held at a similar height to the anthers; this plant self-pollinating. Right, stigma held beyond the anthers; this plant does not self-pollinate.

In the non-fruiting plants the receptive stigma is held beyond the dehicent anthers, and direct contact is avoided (Fig. 14). In these flowers an incoming pollinator would deposit pollen on to the stigma, thereby facilitating outcrossing. The variation of anther and stigma heights varies on different plants of *M. novaezeelandiae*, and shows no correlation with either subspecies. No flower visitors were observed visiting flowers over the three year period the plants have been cultivated at Lincoln.

CONSERVATION

Mazus novaezeelandiae has a fragmented distribution and at each locality is known from small populations. *Mazus novaezeelandiae* is very susceptible to habitat disturbance and has a low tolerance to excessive trampling and competition from aggressive herbs and grasses. At some localities, over collecting by rare plant enthusiasts also has the potential to adversely affect plant numbers.

Lowland kahikatea forest, the habitat of *M. novaezeelandiae* subsp. *novaezeelandiae*, has been eliminated from much of its former range and is now known from small, isolated, and often disturbed remnants (Esler 1978; Molloy 1995; Park 1995; Grant 1996). In the central and lower North Island this reduction of kahikatea forest has almost certainly resulted in the loss of suitable habitat for *M. novaezeelandiae* subsp. *novaezeelandiae*. The strongly rhizomatous growth habit of subsp. *novaezeelandiae* ensures that it is one of the most persitent native herbs in some cattle-trampled wet pastures (C. C. Ogle pers. comm.). Nevertheless, it is susceptible to excessive trampling.

Mazus novaezeelandiae subsp. *impolitus* occurs in mostly coastal or lowland sites that are highly modified by farming and forestry practices, weeds, and land drainage. These activities have severely impacted on this subspecies. For example, in the North Island the thickly swarding and rhizomatous kikuyu grass (*Pennisetum clandestinum*) smothers out mazus plants.

To retain *M. novaezeelandiae* its current grassland habitats need to be carefully managed. Excessive trampling by stock will damage plants and churn the soil, and a light grazing regime could enable the rank growth of other grasses and herbs to shade out *M. novaezeelandiae*. In fenced forest remnants such as at Marangai, the regeneration of the forest could also fill in light wells and forest margins where *Mazus* occurs.

Mazus novaezeelandiae subsp. *novaezeelandiae* is considered to be critically endangered and *M. novaezeelandiae* subsp. *impolitus* is regarded as vulnerable following the definitions of Cameron et al. (1995) (P. J. de Lange pers. comm.). The geographically restricted *Mazus novaezeelandiae* subsp. *impolitus* f. *hirtus* is considered to be endangered.

These ranks differ from Cameron et al. (1995) who considered *M. novaezeelandiae* (sensu Barker 1991) to be vulnerable.

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