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Mesembryanthemum section *Geniculiflora* in Aotearoa New Zealand and genetic confirmation of the hybrid origin of *Mesembryanthemum* ×*vascosilvae* (Aizoaceae)

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Abstract

Mesembryanthemum cordifolium L.f. and *M.* ×*vascosilvae* (Gideon F.Sm., E.Laguna, F.Verloove & P.P.Ferrer) L.Sáez & Aymerich are succulent ornamentals of southern African origin that have become naturalised in several regions of the world. Although both taxa are recorded from Aotearoa New Zealand, they have frequently been confused because of their similar appearance and the relatively recent formal recognition of *M.* ×*vascosilvae*. Herbarium specimens and iNaturalist observations were examined to determine the distribution of each taxon in New Zealand. *Mesembryanthemum* ×*vascosilvae* was found to be more common than previously recognised and should be considered fully naturalised. Both taxa are widely distributed, particularly in coastal and urban environments where they have been recorded as spreading vegetatively, although *M. cordifolium* is substantially more abundant and widespread and is producing seedlings in some locations. This contrasts with reports from parts of Europe that the more vigorous *M.* ×*vascosilvae* has largely replaced *M. cordifolium*. Continued monitoring of both taxa is warranted because of their ability to form a dense groundcover that displaces indigenous vegetation, particularly in coastal habitats. In addition, nuclear ITS and chloroplast *trnL-trnF* DNA sequences were generated to investigate the parentage of *M.* ×*vascosilvae*. The nuclear ITS sequence of *M.* ×*vascosilvae* contained additive polymorphisms consistent with it being a hybrid between *M. cordifolium* and *M. haeckelianum* A.Berger, while chloroplast data indicate that *M. cordifolium* was the maternal parent. These results provide the first molecular evidence supporting the proposed hybrid origin of *M.* ×*vascosilvae*.

Keywords

Biological invasions, citizen science, DNA sequencing, iNaturalist, naturalised plants

Introduction

Mesembryanthemum L. (Aizoaceae) is a genus of succulent plants containing over 100 species, many of which are popular in cultivation around the world. The genus is morphologically variable, including leaf- and stem-succulents, annuals and perennials, and dwarf shrubs, as well as woody shrubs exceeding 1 m in height (Klak and Bruyns 2013). Klak and Bruyns (2013) recognised five subgenera and 13 sections within the genus. One of the sections, *Mesembryanthemum* section *Geniculiflora* DC., contains four species (*M. cordifolium*, *M. geniculiflorum* L., *M. haeckelianum* and *M. lancifolium* (L.Bolus) Klak.) that are indigenous to southern Africa. The species in this section were formerly recognised in the genus *Aptenia* N.E.Br. (Gerbaulet 2017).

Mesembryanthemum cordifolium was introduced into cultivation in 1774, becoming naturalised in multiple regions worldwide by 1925 (Brown 1925). In 1995, Brown Folsom et al. (1995) published the first record of a cultivar they named ‘Red Apple’, suggesting that it was likely to be a hybrid between *M. cordifolium* and *M. haeckelianum*. Despite these two species occurring in sympatry in several areas of South Africa’s Eastern Cape Province, no wild hybrids are known (Smith et al. 2019a). However, they commonly hybridise with each other in cultivation, as well as with other species in the genus, and ‘Red Apple’ is assumed to have arisen in cultivation (Smith et al. 2019a).

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Smith et al. (2020) provided a formal name for 'Red Apple', *Aptenia* ×*vascosilvae*, and it was later moved to *Mesembryanthemum* (*M.* ×*vascosilvae*) by Sáez and Aymerich (2020). *Mesembryanthemum cordifolium* and *M.* ×*vascosilvae* are often confused (Smith et al. 2019b; Cerrato et al. 2024; Stajsic in Kodela and Venning 2026). For example, on iNaturalist (https://www.inaturalist.org; accessed 19 August 2026), only 188 observations are ascribed to *M.* ×*vascosilvae*, but the majority of the 8,600 observations worldwide identified as *M. cordifolium* are also *M.* ×*vascosilvae*. *Mesembryanthemum cordifolium* and *M.* ×*vascosilvae* can be distinguished by the basally cordate leaves with obvious papillae and pinkish-purple flower colour of the former compared with the basally cuneate leaves with less conspicuous papillae and bright strawberry-red flowers of the latter (Fig. 1; Smith et al. 2019a).

Mesembryanthemum ×*vascosilvae* is more vigorous than either parent (Brown Folsom et al. 1995) and has largely replaced *M. cordifolium* in cultivation in Europe (Smith et al. 2019b; Galasso et al. 2022; Cerrato et al. 2024). *Mesembryanthemum cordifolium* reproduces by seeds (Preston and Sell 1988; Guillot Ortiz et al. 2008), which are dispersed by rain from multi-seeded capsules that dehisce when wet (Sukhorukov et al. 2023). The reproductive mode of *M.* ×*vascosilvae* is less certain, with Guillot Ortiz et al. (2008) noting that some forms are sterile, although it has also been reported to occasionally hybridise with other species or be self-fertile (Steven Hammer, pers. comm. in Smith et al. 2019a). Both taxa also spread vegetatively, rooting easily from stem cuttings (Guillot Ortiz et al. 2008), and wild plants often appear to be derived from dumped garden waste (Smith et al. 2019b).

Mesembryanthemum section *Geniculiflora* in Aotearoa New Zealand

Mesembryanthemum cordifolium is a popular garden plant in New Zealand, with the earliest record being a specimen collected by Thomas Kirk near the Wellington Botanic Gardens (Wellington, *Kirk s.n.*, no date, WELT SP002201). While this specimen is undated, Kirk's death in 1898 logically places an upper limit on its collection. The species was first recorded as naturalised in New Zealand in 1959 (Webb et al. 1988). In contrast, *M.* ×*vascosilvae* (as "Red Apple") has few records in New Zealand. Sykes (2004) recorded that he was growing two forms of *M. cordifolium* with different coloured flowers, which is consistent with both *M. cordifolium* and *M.* ×*vascosilvae* being present. He noted that one of these forms had come to him from the Auckland Botanic Gardens, and a specimen collected earlier from there by the same author in 1994 is lodged in the Allan Herbarium as *Aptenia* 'Red Apple' (*Sykes WR 679/94*, 5 Dec. 1994, CHR 500525). The collection notes record it as having crimson-rose flowers but state that 'the usual form of this species in New Zealand has pink flowers', indicating that *M. cordifolium* was more common at that time.

Although there are numerous New Zealand iNaturalist observations that match the description of *M.* ×*vascosilvae*, none were identified as that taxon as of 19 August 2026. One plant observed in 2013 from Koitiata, Manawatū, by Colin Ogle was suggested to possibly be the cultivar 'Red Apple' in the notes (https://www.inaturalist.nz/observations/196316427), and a herbarium specimen was collected at the same time (*Perrie 6827 & Ogle*, 30 Mar. 2013, WELT SP103664).

Figure 1. Taxa of *Mesembryanthemum* section *Geniculiflora* present in New Zealand **A.** *Mesembryanthemum cordifolium*. Photo by Stephen Thorpe, via iNaturalist CC-BY-NC. **B.** *M.* ×*vascosilvae*. Photo by Peter Langlands, via iNaturalist CC-BY-NC.

Mesembryanthemum cordifolium and *M. ×vascosilvae* are both recorded in the Biota of New Zealand database (https://biotanz.landcareresearch.co.nz/scientific-names/6bd04beb-fb71-47cc-afe4-df184f667206), with the former noted as wild and the latter as casual. However, only *M. cordifolium* is recorded on the New Zealand Plant Conservation Network (NZPCN) website (https://www.nzpcn.org.nz/; accessed 1 September 2026). A good understanding of which taxa occur in New Zealand and their distributions is important for their management and potential control (e.g., with biocontrol agents).

This study had two aims:

(1) Identify herbarium and iNaturalist observations of *Mesembryanthemum* section *Geniculiflora* in New Zealand and map their distributions.
(2) Examine the hybrid ancestry of *M. ×vascosilvae* using DNA sequencing. A phylogeny of the genus has been published and includes sequences of the putative parents (Klak et al. 2007), but to date, no sequences are available for *M. ×vascosilvae*.

Materials and methods

Herbarium specimens (from AK, CHR, and WELT; *n* = 55) and iNaturalist observations (https://www.inaturalist.org; accessed 20 August 2026; *n* = 229) were identified, where possible, based on flower colour and leaf shape, and then each taxon was mapped. Herbarium codes follow Thiers (2026). Flowering times of both taxa were determined based on iNaturalist observations. The number of observations of plants with at least a single flower was recorded per month, but observations made during the four-day period of the annual City Nature Challenge were excluded owing to the artificial spike in observations caused by this event.

Samples of *Mesembryanthemum cordifolium* (*Perrie 9601 & Shepherd*, 8 Jan. 2021, WELT SP111614) and *M. ×vascosilvae* (*Shepherd 4159*, 15 Jun. 2026, WELT SP134285) were collected from Wellington for DNA analysis. The former was growing on a steep bank and was likely wild, and the latter was present in a suburban garden. These plants had been previously recorded on iNaturalist (https://www.inaturalist.nz/observations/67718866, https://www.inaturalist.nz/observations/275399717). DNA was extracted from fresh leaf material using a modified-CTAB extraction method (steps 1, 3–7 from table 1 in Shepherd and McLay 2011).

Two loci were sequenced: the nuclear internal transcribed spacer (ITS) and the chloroplast *trnL-trnF* locus, which encompasses the *trnL*-intron, *trnL*-3-exon, and the *trnL-trnF* intergenic spacer. The ITS locus was amplified using the primers and PCR protocol reported in Klak et al. (2007). The *trnL-trnF* locus was amplified with the C and F primers (Taberlet et al. 1991), and PCR thermocycling followed the "slow and cold" conditions from Shaw et al. (2007). Both loci were PCR amplified in 12 µL reactions containing 1× Mytaq reagent buffer (Bioline, Australia), 5 ρmol of each primer, 0.04 µg of bovine serum albumin (BSA) and 0.1 M betaine.

PCR products were purified by digestion at 37°C for 15 min with 2.5 U of exonuclease I (ExoI; New England Biolabs, Massachusetts, USA) and 0.5 U of shrimp alkaline phosphatase (rSAP; New England Biolabs, Massachusetts, USA), followed by inactivation of the enzymes at 80°C for 15 min. DNA sequencing was performed in both directions by capillary separation at Macrogen (Seoul, South Korea).

Sequencher v. 5.4.6 (Gene Codes Corporation, Ann Arbor, MI, USA) was used for sequence editing, and ambiguous nucleotide positions were coded with IUPAC ambiguity codes. Sequences were aligned manually with published sequences from GenBank, with BLAST searches (Altschul et al. 1990) used to determine the closest available sequences. Collection details and GenBank numbers for the samples included in the analysis are given in Appendix 1. Indels were coded with the simple coding technique of Simmons and Ochoterena (2000).

For the ITS alignment, a network was constructed using the NeighborNet algorithm (Bryant and Moulton 2004) implemented in SplitsTree4 v. 4.14.8 (Huson and Bryant 2006). *Mesembryanthemum geniculiflorum* was excluded from this analysis owing to only half the sequence length of the other species being available. For the *trnL-trnF* alignment, phylogenetic analyses were performed using maximum parsimony (MP), maximum likelihood (ML, with the GTR + I model of sequence evolution), and Bayesian inference (BI) following Perrie et al. (2020).

Results

Of the 229 iNaturalist observations recorded as *M. cordifolium*, 179 were confirmed as this species (one of these was a variegated form: https://www.inaturalist.nz/observations/77992353), 44 were identified as *M. ×vascosilvae*, one observation contained photographs of both taxa, and five could not be identified based on the provided photographs. These identifications are provided in Appendix 1). Flower colour was uniform within each taxon.

Herbarium specimens were more difficult to identify. The succulent leaves of some specimens had not dried flat, so determining their shape was not possible, and the colour of the flowers had faded (although flower colour was recorded in the collection notes of some specimens; see Discussion). Of the 55 herbarium specimens, 48 were *M. cordifolium*, three were *M. ×vascosilvae*, and four could not be identified.

The distribution of each species is mapped in Figs 2, 3. Both herbarium specimens and iNaturalist observations were largely clustered around urban and coastal areas, but there were a few records from inland areas (e.g., *M. cordifolium* from Bulls (https://www.inaturalist.nz/observations/57584928 and

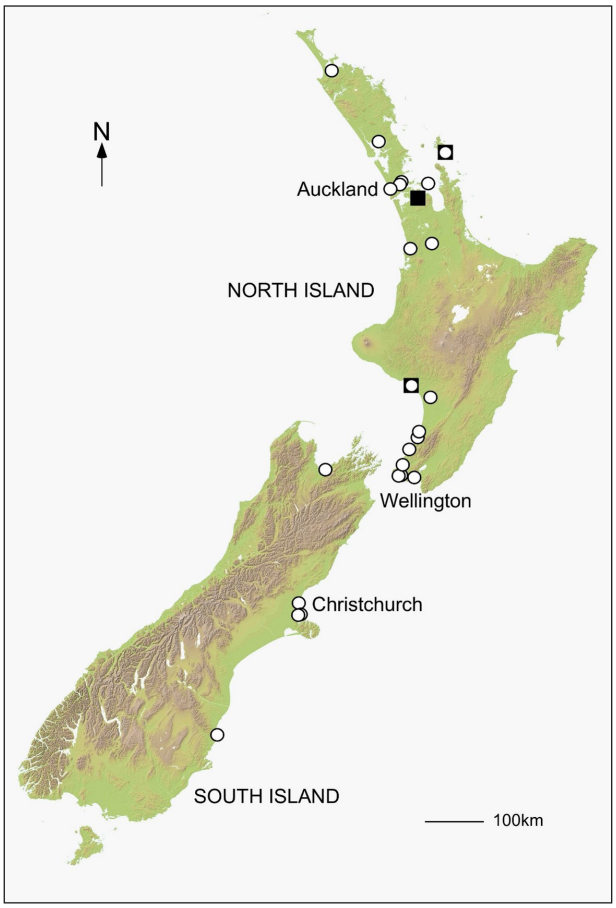

Figure 2. Distribution of *Mesembryanthemum* ×*vascosilvae* in New Zealand. Open circles represent iNaturalist observations (n = 45), and black squares indicate herbarium vouchers (n = 3).

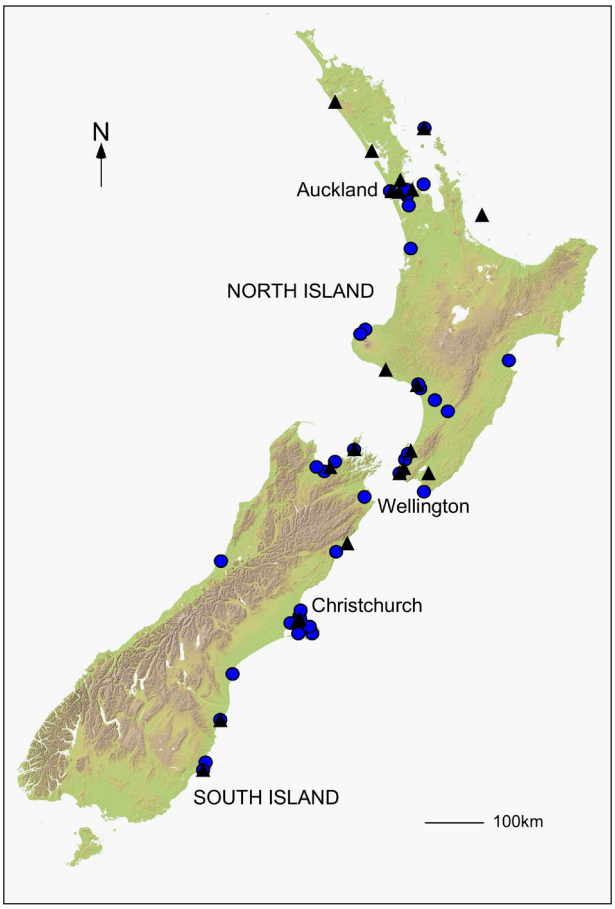

Figure 3. Distribution of *Mesembryanthemum cordifolium* in New Zealand. Black triangles represent herbarium vouchers (n = 48), and blue circles indicate iNaturalist observations (n = 180).

M. ×*vascosilvae* from Hamilton (https://www.inaturalist.nz/observations/151561150) and remote regions (e.g., for *M. cordifolium*, there were several records from French Pass and numerous records from Pokohinu (Burgess), Mokohinau Islands group). It was often unclear whether individual plants were cultivated or wild, particularly for iNaturalist observations. However, the notes of some records indicate that *M. cordifolium* is naturalising locally across much of the country, e.g., Pokohinu (Burgess), Mokohinau Islands group (https://www.inaturalist.nz/observations/335341828), Timaru (https://www.inaturalist.nz/observations/51268593), Christchurch (*Garnock-Jones 528*, 7 Aug. 1976, CHR 286309) and Wellington (*Muir s.n.*, 13 Apr. 1970, CHR 220880). Seedlings of this species have also been recorded, e.g., from Bulls (https://www.inaturalist.nz/observations/57584928), Auckland (https://www.inaturalist.nz/observations/288941128), Kaikoura (https://www.inaturalist.nz/observations/231576148) and Oamaru (*Healy 54/404*, 28 Aug. 1954, CHR 91424 and *Sykes 33/04*, 6 Mar. 2004, CHR 605133).

In contrast, seedlings of *M.* ×*vascosilvae* have not been noted on herbarium vouchers or in iNaturalist observations. *Mesembryanthemum* ×*vascosilvae* is noted as spreading vegetatively from a nearby garden in Auckland (https://www.inaturalist.nz/observations/263113479), assumed to be growing from dumped garden waste on Great Barrier Island (*Kilgour s.n.*, 20 Mar. 2003, AK 280548) and naturalising in a few places around Piha (https://www.inaturalist.nz/observations/24355284).

As shown in Fig. 4, flowering occurred throughout the year for *M. cordifolium* (n = 142, with City Nature Challenge observations excluded). The flowering of *M.* ×*vascosilvae* peaked between spring and autumn, although this is based on a relatively small number of records (n = 36, with City Nature Challenge observations excluded).

The ITS alignment was 588 base pairs (bp) in length and contained a single 2 bp indel. The ITS sequence of the specimen of *M. cordifolium* from New Zealand (GenBank accession PZ956031) differed by a single nucleotide substitution from the sequence of this species sourced from South Africa (GenBank accession AM162352). The *M.* ×*vascosilvae* ITS sequence (GenBank accession PZ956032) had double peaks at five nucleotide sites, suggesting contributions from two divergent parent taxa. These five sites were the only ones that differed between *M. haeckelianum* and the New Zealand specimen of *M. cordifolium*, consistent with these two species being the parents of *M.* ×*vascosilvae*. The *M.* ×*vascosilvae*

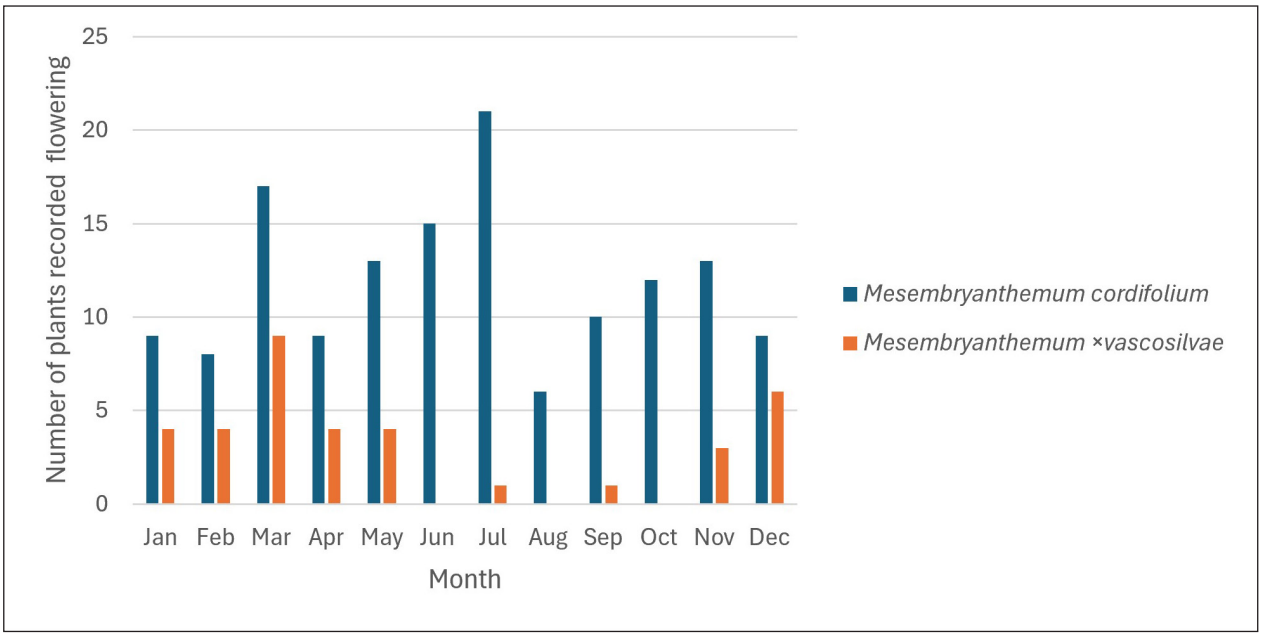

Figure 4. Flowering times for *Mesembryanthemum* section *Geniculiflora* in New Zealand based on iNaturalist records as of 20 August 2026. The four-day periods of the City Nature Challenge were excluded.

ITS sequence was also compared to a short 266 bp ITS sequence from *M. geniculiflorum* (GenBank accession AJ532602), another species in *M.* section *Geniculiflora* (the fourth species, *M. lancifolium*, has no ITS sequence available). The *M. geniculiflorum* ITS sequence had three unique substitutions and one 1 bp indel compared to *M. ×vascosilvae* and the other two sequenced species of *M.* section *Geniculiflora*, indicating that *M. geniculiflorum* is not involved in the parentage of this hybrid. The internal position of *M. ×vascosilvae* in the NeighborNet graph, between *M. haeckelianum* and *M. cordifolium*, also supports a hybrid origin for this taxon (Fig. 5).

The full-length *trnL-trnF* locus alignment was 959 bp in length, with 893 bp following the recoding of 12 indels. The newly-generated *M. cordifolium* and *M. ×vascosilvae* sequences (GenBank accessions PZ972683 and PZ972684, respectively) were identical to a sequence of *M. cordifolium* of unknown origin (GenBank accession OR804507) and differed by two nucleotide substitutions from a *M. cordifolium* sequence from South Africa (GenBank accession KM262026). The *trnL-trnF* sequence of *M. haeckelianum* differed from the *M. cordifolium* and *M. ×vascosilvae* sequences by two substitutions and two indels. MP analysis of the *trnL-trnF*

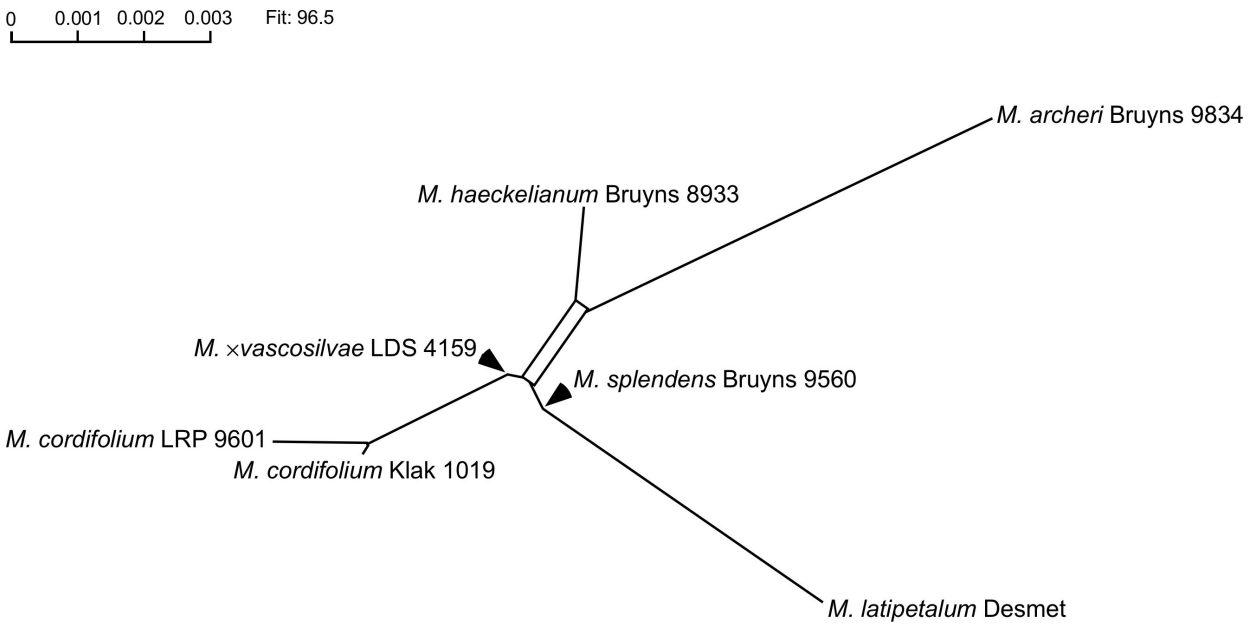

Figure 5. NeighborNet graph of selected *Mesembryanthemum* internal transcribed spacer (ITS) sequences.

sequences recovered nine most parsimonious trees (score = 26), all of which recovered a clade containing the *M. cordifolium* and *M. ×vascosilvae* sequences. This clade was also recovered in the ML and BI phylogenies and received moderate to high support in all analyses (92% ML bootstrap (BS)/87% MP BS/0.94 BI posterior probability). The ML phylogram, with support values from all analyses, is shown in Fig. 6.

Discussion

Both *M. cordifolium* and *M. ×vascosilvae* occur in New Zealand and are relatively straightforward to identify, but *M. cordifolium* is more common and has a more extensive distribution than *M. ×vascosilvae*, based on both herbarium specimens and iNaturalist observations. This finding

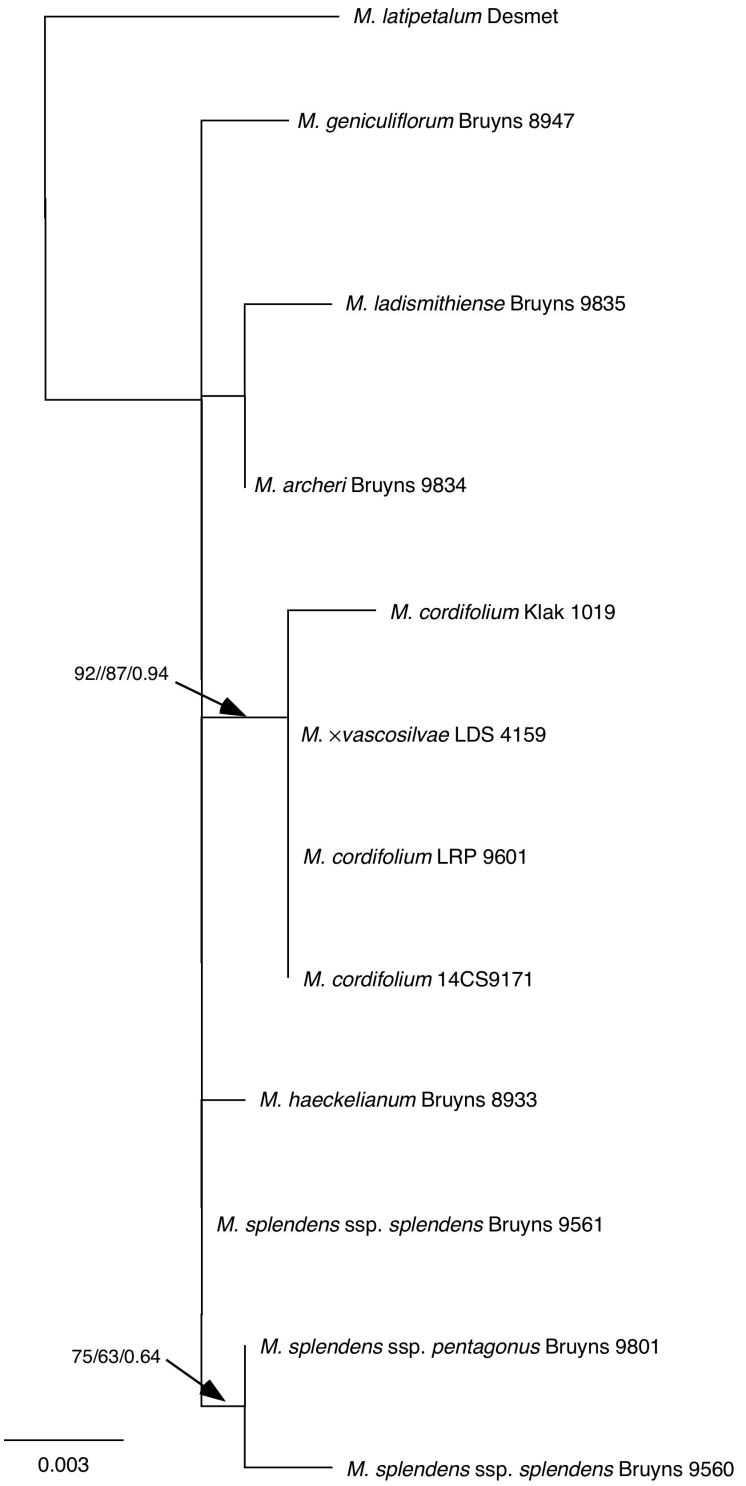

Figure 6. Maximum likelihood phylogeny of selected *Mesembryanthemum trnL-trnF* region sequences. Support values are given in the order of maximum likelihood bootstrap, maximum parsimony bootstrap, and Bayesian posterior probabilities.

is consistent with the longer history of *M. cordifolium* in New Zealand (~120 years compared with ~30 years for *M. ×vascosilvae*) but contrasts with findings from a number of locations overseas, such as Portugal and the Balearic Islands, where the hybrid is suggested to have recently largely replaced *M. cordifolium* (Smith et al. 2019a, 2019b; Serapio et al. 2023; Cerrato et al. 2024).

In New Zealand, both taxa appear to be centred around urban locations, reflecting their likely spread from cultivation and limited natural dispersal abilities. Experiments measuring the dispersal distance of seeds of other *Mesembryanthemum* species indicate only short-distance movements (of up to 1.64 m; Parolin 2001) during rainfall events, although further dispersal is possible by running water once the seed hits the ground (Parolin 2006). *Mesembryanthemum cordifolium* has only rarely been recorded as producing seedlings in New Zealand, and it is not known whether *M. ×vascosilvae* produces seeds here at all. It seems likely that the spread of both taxa in New Zealand is largely occurring vegetatively, with garden waste a likely source of spread.

Both taxa should be considered fully naturalised in New Zealand. *Mesembryanthemum ×vascosilvae* is currently classed as casual in the Biota of New Zealand database but meets the criteria for being naturalised because it has multiple populations that are self-maintained by vegetative reproduction (Heenan et al. 2004). Both taxa have the potential to become problematic weeds in New Zealand. Once established at a site, they can smother the surface and displace indigenous species, as has been observed overseas (Smith et al. 2019b). *Mesembryanthemum cordifolium* has already become well established locally in several New Zealand regions, such as Pokohinu (Burgess), Mokohinau Islands group, New Plymouth, Kaikoura, and Timaru, and based on its preferred habitat overseas, dry coastal sites are likely to be particularly vulnerable.

Continuing to record both taxa is important for tracking their spread. Flowering of both taxa occurs throughout much of the year (Fig. 4), aiding identification. Flower colour fades when the plants are dried for herbarium specimens, so iNaturalist observations have the advantage of flower colour being recorded in photographs. Flower colour was recorded in the collection notes of many of the herbarium specimens examined, but the described colour varied considerably, even among specimens collected by the same collector (for *M. cordifolium*, flower colour descriptors ranged from cerise, purple, pink, mauve-pink, mauve, rose, and deep rose to pink-purple). Leaf shape is another important identification feature. The succulent leaves are difficult to dry, so freezing specimens or bathing them in alcohol or boiling water prior to drying is recommended (Leon Perrie, pers. comm.).

The additive nucleotides in the ITS sequence of *M. ×vascosilvae* support the hypothesis that this taxon is a hybrid between *M. cordifolium* and *M. haeckelianum* (Brown Folsom et al. 1995; Smith et al. 2019a). The chloroplast *trnL-trnF* sequence from *M. ×vascosilvae* indicates that its chloroplast donor is *M. cordifolium*. DNA sequences are not currently available for *M. lancifolium*, the only unsequenced species in *M.* section *Geniculiflora*. However, the leaf morphology and flower colour of that species (Bolus 1959) are less consistent with it being a parent of *M. ×vascosilvae*, and *M. lancifolium* is uncommon in cultivation (Stajsic in Kodela and Venning 2026), where the hybrid likely arose.

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Appendix 1

Herbarium specimens and iNaturalist observations used for determining the distributions of *Mesembryanthemum cordifolium* and *M.* ×*vascosilvae*. The iNaturalist observations can be viewed by appending each number to the weblink https://www.inaturalist.nz/observations/

***M. cordifolium* – herbarium specimens:** South Head, Hokianga, *Gardner 6976*, 19 Sep. 1993, AK 221534; Pokohinu (Burgess), Mokohinau Islands group, *Wright s.n.*, 1 Jan. 1984, WELT SP071231; Pokohinu (Burgess), Mokohinau Islands group, *Collett s.n.*, Aug. 1965, CHR 183355; Pokohinu (Burgess), Mokohinau Islands group, *Wright 6171*, 1 Jan. 1984, AK 165097; Pokohinu (Burgess), Mokohinau Islands group, *Wilson s.n.*, 27 Sep. 2002, AK 258828; Pokohinu (Burgess), Mokohinau Islands group, *Cameron 2657*, 1 Jan. 1984, AK 273229, CHR 408941; Pouto, Kaipara, *Cooper s.n.*, 8 Aug. 1968, AK 119956; Auckland, *Cameron 5659*, 30 Sep. 1989, AK 241399; Auckland, *Cameron 7405*, 27 Dec. 1993, AK 218634; Auckland, *Harre s.n.*, 21 Apr 1998, AK235666;

Karekare, *Brownsey s.n.*, 10 Feb. 1978, WELT SP059827; Karekare, *Wright 2632*, 10 Feb. 1978, AK 143548, CHR 345319; Karekare, *Cooper s.n.*, 16 Nov. 1965, AK 109047; Mayor Island, *Sykes 214/92*, 27 Nov. 1992, CHR 479997; Patea, *Ogle s.n.*, 17 Apr. 2002, CHR 565414; Whanganui, *Sigley s.n.*, 2 Nov. 1996, CHR 511401; *Ogle 3294*, 21 Oct. 1997, CHR 514139; Paekākāriki, *Bryant s.n.*, Oct. 2018, WELT SP108556; Martinborough, *Irvine s.n.*, 14 Apr. 1983, AK243274; Wellington, *Sykes s.n.*, 24 Feb. 1987, WELT SP070922; Wellington, *Kirk s.n.*, no date, WELT SP002201; Wellington, *Perrie 9601 & Shepherd*, 8 Jan. 2021, WELT SP111614; Wellington, *Sykes s.n.*, 21 Aug. 1976, CHR 286322; Wellington, *Ogle s.n.*, 17 Jan. 1978, CHR 312895, CHR 324065; Wellington, *Muir s.n.*, 13 Apr. 1970, CHR 220880; Wellington, *Healy s.n.*, 9 Dec. 1953, CHR 85716; Wellington, *Mason 2560*, 12 Nov. 1953, CHR 85349; French Pass, *Cameron 17568*, 16 Dec. 2020, AK 381674; Nelson, *Sykes 133/86*, 31 Oct. 1986, AK 177353, CHR 437447; Nelson, *Healy 71/57*, 25 Apr. 1971, CHR 196999; Nelson, *Healy s.n.*, 6 May 1959, CHR 118229; Kaikōura, *Chinnock s.n.*, 14 Dec. 1969, CHR 219988; Kaikōura, *Healy s.n.*, 19 Sep. 1966, CHR 152499; Christchurch, *Cameron & Bellingham s.n.*, 2 Jan. 2016, AK 359987; Christchurch, *Healy 54/133*, 12 May 1954, CHR 88959; Christchurch, *Garnock-Jones 528*, 7 Aug. 1976, CHR 286309; Christchurch, *Garnock-Jones 523*, 30 May 1976, CHR 280497; Christchurch, *Meurk s.n.*, 26 May 1999, CHR 536512; Oamaru, *Sykes 33/04*, 6 Mar. 2004, CHR 605133; Oamaru, *Healy 54/404*, 28 Aug. 1954, CHR 91424, CHR 88470; Oamaru, *Healy 54/406*, 28 Aug. 1954, CHR 91425; Dunedin, *Johnson s.n.*, 11 Mar. 1982, CHR 353878. **iNaturalist observations:** 335341828 Pokohinu (Burgess), Mokohinau Islands group; 232141638, 288941115, 288941128, 289141826, 126440861, 138097886, 51633808, 380205957, 77992353, 9342768, 9342779, 2745754, 14599012, 5448857 Auckland; 380618159 Karekare; 261077646 Raglan; 308530208, 243026608, 244369254, 197292338, 81655823, 57965971, 57965962, 57965960, 57965959, 57965972, 277318124 New Plymouth; 4861669, 19147344 Oakura; 76277787 Napier; 381513358, 274208500, 196316124 Whanganui; 57584928 Bulls; 34984513 Palmerston North; 17200566 Paekākāriki; 25717746, 107444732, 108224372, 122122315, 210687012 Plimmerton; 289761207, 289762339, 292523279, 295024482, 301687871, 220174353, 226849999, 267430599, 267621669, 289752746, 209547776, 182920958 165265278, 42631213, 190713366, 117833357, 56885289, 96865479, 155841786, 148349451, 67718866, 239893735, 251830248, 84634776, 10388548 Wellington; 62597403 Cape Palliser; 67232272 French Pass; 151704553 Tawero Point; 304362223 Cable Bay; 328678057, 225028808, 229446898, 161711437, 129315852 Nelson; 22278025, 139691521 Seddon; 231576148, 205990935, 361094576 Kaikoura; 256244811 Oaro; 195879699 Hokitika; 236670326, 301435648, 313969580, 322648583, 332819579, 357114884, 357119673, 357784769, 358546152, 359175015, 359410855, 359463513, 255109701, 255109710, 277627748, 277925080, 283861679, 284129858, 275340494, 199636992, 285547443, 185071187, 185850399, 190526059, 195996851, 160229366, 150374561, 116027433, 116027435, 116064021, 64552500, 65954580, 94191816, 35632755, 23099230, 24573523, 31375363, 962430, 990980, 1338558, 1620703, 9027534, 16561775, 17476872, 22528265, 10689005, 7099839, 1017432, 82503624, 35682980 Christchurch; 142788414, 165631447, 211929847, 103726520, 66629956, 68193558, 77723349, 23311338, 23281241, 970002, 972339, 4070438, 4234255, 9177298, 13068194, 23084327, 211930192, 211930305, 356313927, 355854470, 198313733, 210530186, 201893323, 386203499, 386204259, 387696996, 217621836, 218001927, 222138527, 1054221 Banks Peninsula; 266864639 Canterbury (imprecise location) 51268593, 21100735 Timaru; 137185557, 144773553, 1584422, 349613644 Oamaru; 111883663, 64422407, 41279062, 956210, 1941111, 260662138, 200686983, 70640041 Dunedin.

***M.* ×*vascosilvae* – herbarium specimens:** Koitiata, *Perrie 6827 & Ogle*, 30 Mar. 2013, WELT SP103664; Great Barrier Island, *Kilgour s.n.*, 20 Mar. 2003, AK 280548; Auckland (cult.), *Sykes WR 679/94*, 5 Dec. 1994. CHR 500525. **iNaturalist observations:** 105201684 Kaitaia; 195024497 Pahi; 216232009 Great Barrier Island; 204114395, 239570169, 263113479, 265511652, 92422932, 152571440, 21965631 Auckland; 171102899 Waiheke Island; 24206027, 24355284, 42291952, 43236506 Phia; 146497670 Raglan; 151561150 Hamilton; 196316427 Koitiata; 52347448 Parewanui; 39477980, 66909621 Waikawa Beach; 39031568 Te Horo Beach; 195704746 Raumati; 209557743, 213932222, 260211317, 275399717, 342195389, 359380983, 71189603, 75741896, 157458561 Wellington; 108145214, 143615602 Wharekauhau; 328678057 Nelson; 64091682, 199529704, 212479162, 272868011, 331753242, 165865902, 9502142, 195146948, 356385873 Christchurch; 66994864 Moeraki.

Additional information

Conflict of interest

The author has declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.