



FLORA OF NEW ZEALAND
SEED PLANTS

ALISMATACEAE



K.A. FORD & P.D. CHAMPION

Fascicle 7 – DECEMBER 2020

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Cover image: *Alisma lanceolatum*. Flower showing acute petal apices.

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Introduction

The water-plantains are an aquatic and semi-aquatic family of about 113 species of herbs in 17 genera (Les & Tippery 2013) with a near cosmopolitan distribution. The Alismataceae are represented in New Zealand by three genera, *Alisma*, *Hydrocleys* and *Sagittaria*, and seven species, all of which are naturalised. Three species of *Sagittaria* and *Hydrocleys nymphoides* are classified as unwanted organisms. All are plants of lowland ponds, drains, ditches, streams and other waterways.

***Alismataceae* Vent., *Tabl. Regn. Vég.* 2, 157 (1799)**

Type taxon: *Alisma* L.

Aquatic (freshwater) emergent or floating-leaved herbs, perennial or annual (rarely), with milky sap; rhizomatous or stoloniferous; vessels absent. Roots adventitious, fibrous. Hermaphrodite, monoecious, polygamomonoecious, or dioecious (rarely). Leaves basal, sheathing, simple, petiolate or sessile, floating, often heterophyllous. Leaf-lamina lobed or non-lobed, margin entire, an apical pore present; venation reticulate, prominent primary veins parallel, secondary veins reticulate. Inflorescence a whorled scape, raceme, panicle, umbel (rarely) or solitary, bracteate, erect or rarely floating. Flowers perfect or imperfect, actinomorphic; perianth hypogynous in two alternate whorls, sepals 3 persistent, petals 3 deciduous. Androecium 0–6–9 to many stamens in 1 or more whorls, free; anthers tetrasporangiate, 2-loculed, basifixed or versatile, extrorse or latrose dehiscence, opening by longitudinal slits; pollination syndrome entomophilous. Gynoecium 0–3–6 to many, ovary superior; carpels free or united at base, in 1 whorl or spiralled, apocarpic or occasionally with two anatropous ovules, or many (*Hydrocleys*), placentation basal or laminar, styles apical or lateral, persistent; carpel nectariferous region or septal nectaries present. Fruit a single whorl of laterally compressed achenes (forming a ring or cluster), or a follicle. Seeds uncinat-curved, with a horseshoe-shaped embryo, non-endospermic; starch.

Taxonomy: Alismataceae is part of a group of families known as the alismatids, a large radiation of plants exhibiting numerous adaptations for life in water, both fresh and marine. This treatment follows Les & Tippery (2013) by including *Hydrocleys* in the Alismataceae, giving a total of about 113 species of herbs in 17 genera. The latter genus was previously placed by Healy & Edgar (1980) in the Butomaceae and by some recent floras in the Limnocharitaceae (Haynes & Holm-Nielsen 1992, Jacobs & McColl 2011).

Based on molecular phylogenies (Les & Cleland 1997, Iles et al. 2013, Ross et al. 2016) the Alismataceae are placed in a well-supported clade known as the 'petaloid clade', also including Butomaceae and Hydrocharitaceae; this clade is recognised by Les & Tippery (2013) at the ordinal level as the Alismatales, with its sister clade the 'tepaloid clade' named Potamogetonales Dumort. (= Zosteriales Nakai).

1	Flowers unisexual.....	<i>Sagittaria</i>
1'	Flowers bisexual.....	2
2	Inflorescence an erect, whorled panicle, corolla pale pink or lilac.....	<i>Alisma</i>
2'	Inflorescence a lax scape, appearing solitary on long peduncles, corolla yellow.....	<i>Hydrocleys</i>

Distribution: Pantropical, temperate; almost cosmopolitan (Haynes & Holm-Nielsen 1992, Haynes & Holm-Nielsen 1994, Wang et al. 2010); 113 species in 17 genera (Les & Tippery 2013).

Biostatus: Exotic; fully naturalised.

Table 1: Number of species in New Zealand within *Alismataceae* Vent.

Category	Number
Exotic: Fully Naturalised	6
Total	6

Recognition: Plants have milky sap, the flowers are petaloid, and the petals are crumpled in bud and delicate. The seeds are uncinat-curved, with the embryo strongly bent to a horseshoe shape.

***Alisma* L., *Sp. Pl.* 342 (1753)**

Type taxon: *Alisma plantago-aquatica* L.

Etymology: Classical Greek name originating from Dioscorides.

Perennial, mostly emergent glabrous aquatic herbs, rhizomes short, stout, bulb-shaped; leaves from a basal rosette. Hermaphrodite. Stolons absent. Roots fibrous, non-septate. Leaves petiolate, erect, floating or submersed; leaf-bases cuneate or weakly lobed. Petioles open-sheathing, adaxially winged. Inflorescence a whorled panicle of many flowers, bracteate. Flowers perfect, pedicellate. Androecium 6(–9) stamens in pairs in one whorl; filaments filiform, glabrous; anthers basifixed, latrose dehiscence; staminodes absent. Gynoecium with many free carpels in a single whorl on a flattened receptacle;

style gynobasic (appearing lateral on the ventral side); ovule placentation basal. Fruit a laterally compressed obovate achene, dorsally 1–2 ribbed, beaked, without wings. Seed uncinata, surface smooth to rugose, non-glandular, without hairs.

- 1 Leaf-laminae broad-ovate or elliptic, base obtuse to cordate; petals rounded apically and denticulate; fruiting head cluster with a central gap *plantago-aquatica*
- 1' Leaf-laminae narrow lanceolate or elliptic, base cuneate; petals acute or acuminate apically; fruiting head cluster with no central gap..... *lanceolatum*

Distribution: About 11 species in temperate and subtropical regions of the world (Wang et al. 2010): Eurasia, Central Asia, China, Japan, north Africa, North America, Australia (Björkqvist 1968, Jacobs & McColl 2011, Conran 2012).

In New Zealand one species tends to predominate regionally, which cannot be entirely explained by latitude. Notable is the absence of *Alisma lanceolatum* from Northland, Gisborne, Taranaki and Waikato, as it is described in Europe as being more thermophilic than *A. plantago-aquatica* (Björkqvist 1967). Both species are widespread but scattered in distribution, *A. plantago-aquatica* occurs from Northland to the Clutha District in southern Otago, and *A. lanceolatum* recorded from Auckland to Southland. Also notable is the absence of records of either species from Westland, given the abundant habitat availability, open drains and ditches in lowland cultivated areas. The Taieri Plains in Otago appears to be the only location where both species are commonly present in the same water system.

Biostatus: Exotic; fully naturalised.

Table 2: Number of species in New Zealand within *Alisma* L.

Category	Number
Exotic: Fully Naturalised	2
Total	2

Recognition: The two species of *Alisma* in New Zealand have distinctive, plantain-like rosettes of erect leaves and a large, open, pyramid-shaped leafless inflorescence of many small, pale pink or lilac flowers.

Cytology: $n = 7$ is regarded as basic (Björkqvist 1968); there are diploid, tetraploid and hexaploid species. Björkqvist (1967, 1968) reported that stoma length equates to ploidy level.

Both species of *Alisma* in New Zealand are recorded by Björkqvist (1968) as cross-pollinating and self-fertile (facultative allogamic), reproducing by seed and vegetative by shoots and rhizomes. In Europe, natural hybrids have been documented between *Alisma plantago-aquatica* and *A. lanceolatum* and confirmed by progeny from artificial hybridisation with high but not absolute sterility (Björkqvist 1968). Pogan (1961, 1971) has reported various levels of fertility in hybrids. In New Zealand one instance of hybridisation (OTA 62553) has been reported from the Sinclair Wetlands in Otago, where both parent species occur.

Notes: Healy & Edgar (1980) treated *Alisma* in New Zealand. No additional species are reported here, and there has been little change in distribution since then.

***Alisma lanceolatum* With., Arr. Brit. Pl. ed. 3, 362 (1796)**

Lectotype: Illust. in Gerarde 1633 p. 337.2, cited by Withering (1796)

Etymology: From Latin lanceolatus, a reference to the lance-like leaves.

Vernacular names: lance-leaf water-plantain; narrow-leaf water plantain

Perennial, rhizome short; leaves erect (rarely floating or submerged) from a basal rosette 0.5–1.2 m tall. Leaves long, petiolate; lamina 60–260 mm long, 15–85 mm wide, lanceolate, elliptic, narrow-elliptic, oblanceolate, base cuneate, apex sub-acute to acuminate, margin entire. Petioles 55–260 mm long, 2.5–6.0 mm wide, D-shaped to more or less terete, septate. Inflorescence a whorled panicle of 3–6(–7) verticels, pyramidal, bracteate, 190–750 mm tall, 190–500 mm wide. Flowers 7.0–12 mm diameter, pedicels terete, 10–45 mm long, glabrous. Sepals green, 2.5–3.0 mm long, ovate. Petals pale pink or lilac with a yellow spot at the base, 4.0–6.0 mm long, 5.0–6.4 mm wide, broadly elliptic to rhombic, apices acute or acuminate, sometimes notched, margin entire to irregularly sub-dentate. Stamens 6, filaments membranous, 1.0–2.0 mm long, flattened, tapering, anthers yellow, 0.6–1.0 mm long, ellipsoid. Carpels 15 to 24 in a ring; styles 0.5–0.8 mm long, curved, lateral on the ventral side, attached from above middle; stigma over half the style region, papillose, papillae 40–70 µm long.

Fruiting head round to triangular, ventral sides of achenes meeting in the centre. Achenes 2.0–3.0 mm long, 1.2–2.0 mm wide, dorsal sutures (1)–2, straw coloured or light brown. Seeds 1.3–1.7 mm long, 0.4–0.6 mm wide, uncinata, rugose, red-brown. Dispersal units: achenes floating in water (hydrochory).

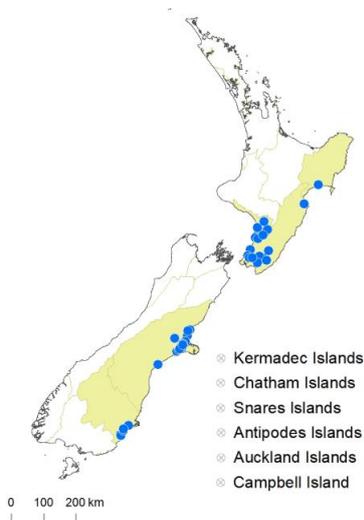


Fig. 1: *Alisma lanceolatum* distribution map based on databased records at AK, CHR, NZFRI, OTA, WAIK & WELT.

Habitat: Emergent or marginal in humus-rich soils in farm drains, roadside ditches, swamp drains, pools and ponds, and dune lakes, edges of slow-flowing streams and rivers, and at muddy river mouths. Recorded from eutrophic water bodies and some tolerance of brackish water evident.

Notes: Also exotic to Australia (Jacobs & McColl 2011, Conran 2012), particularly south-eastern Australia, where it is a weed of rice-producing areas, and where two distinct genetic groups have been identified using ISSR analysis (Ash et al. 2004).

Distribution: North Island: Gisborne – Wairoa; southern North Island – Havelock North, Tutaekuri, Pakowhai, Marton, Manawatu plains, Tangimoana, Hokianga Beach, Masterton, Pukera, southern Wairarapa, Waikanae, Pāuatahanui, Taupō Swamp, Hutt Valley. South Island: Canterbury – Kaiapoi, Canterbury plains, Lake Waihora, Christchurch City; Otago – Taieri Plains, Tokomairiro River.

Region of origin: Europe; northern Africa; western Asia

Biostatus: Exotic; fully naturalised.

Notes: Reported as calciphilous in its native European range and occurring in higher nutrient water than *Alisma plantago-aquatica*, but otherwise has a similar ecology (Björkqvist 1967). Reproducing by seed or vegetatively from side shoots of the rhizome. Seeds exhibit dormancy. In New Zealand, plants can survive the winter with submersed leaves in protected parts of water bodies such as shaded drains. Emergent leaves wither and die back over winter. Reported by Björkqvist (1967) to be a poor competitor and favoured by cultivation.

First record: AK 95163, *H. Hill*, Hawke's Bay [1892 or 1893] (cited in Healy & Edgar 1980, p. 33).

Recognition: This species can be distinguished from *Alisma plantago-aquatica* by its lanceolate or narrow-elliptic leaves with cuneate leaf-bases rather than the broad-elliptic or ovate leaves with obtuse to cordate leaf bases of the above (in emergent leaves). It can, however, be difficult to distinguish this species from young, non-flowering plants of *A. plantago-aquatica*. Although the flowers are very similar in the two species, petal colour is reported as usually pale pink in *A. lanceolatum* and pale lilac in *A. plantago-aquatica* (Healy & Edgar 1980). Of more diagnostic value are the petal apices, which in *A. lanceolatum* are often acute or acuminate and the margin irregularly toothed, whereas in *A. plantago-aquatica* they are rounded and the margin is often denticulate. In the fruiting heads of *A. lanceolatum* the ventral sides of the achenes meet in the centre and overlap, forming a tight cluster, whereas in *A. plantago-aquatica* they do not, and an obvious gap is left (as seen from above). The fruiting head-shape side-on is also different between the two species, with *A. lanceolatum* somewhat compressed and *A. plantago-aquatica* more cup-shaped.

Phenology: Flowering: Nov.–Jan. Fruiting: Feb.–Apr.

Cytology: $2n = 26, 28$ (Erlandsson 1946, Björkqvist 1968, Tschermak-Woess 1948). $2n = 26$ is an aneuploid number at the tetraploid level and is the commonest cytotype in Europe (Björkqvist 1968). It is hypothesised that the *Alisma lanceolatum* cytotypes have an autotetraploid or allotetraploidy origin derived from a diploid ancestor, either an autopolyploid origin from *A. plantago-aquatica* or an allotetraploid origin from *A. plantago-aquatica* crossed with an extinct species with a similar karyotype (Björkqvist 1968), or possibly with *A. gramineum* (Jacobson & Hedré 2007). Björkqvist (1968) reports a strong sterility barrier between the cytotypes and slight morphological differences, although of little diagnostic value. The common and widespread cytotype $2n = 26$ is most likely to be present in New Zealand, although this is presently unknown.



Fig. 2: *Alisma lanceolatum*. Whole plant.



Fig. 3: *Alisma lanceolatum*. A longitudinal section through a corm.



Fig. 4: *Alisma lanceolatum*. Emergent leaves.



Fig. 5: *Alisma lanceolatum*. The underside of two flowers showing the sepals.



Fig. 6: *Alisma lanceolatum*. Flower showing acute petal apices.



Fig. 7: *Alisma lanceolatum*. Two fruiting clusters showing for the most part achenes with two sutures on the dorsal edge.

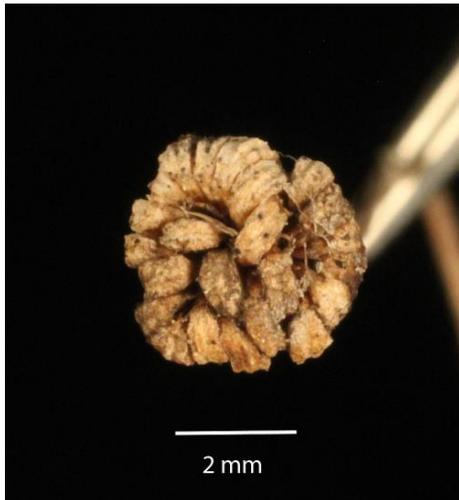


Fig. 8: *Alisma lanceolatum*. A fruiting cluster of achenes overlapping and leaving no gap in the centre.

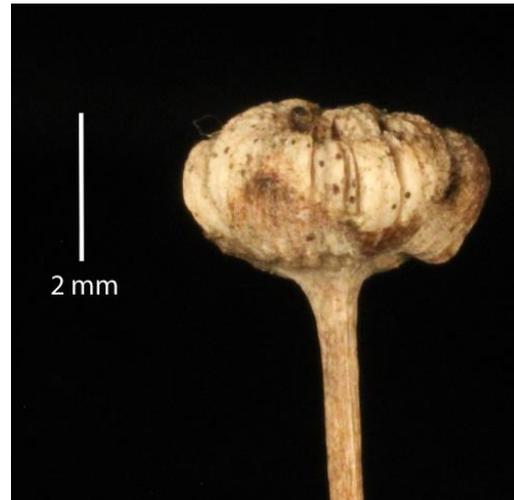


Fig. 9: *Alisma lanceolatum*. A compressed-shaped fruiting cluster from side-on.



Fig. 10: *Alisma lanceolatum*. Individual achenes showing the withered style base arising above the middle of the achene.



Fig. 11: *Alisma lanceolatum*. Typical population flowering and fruiting in a drainage ditch.

***Alisma plantago-aquatica* L., Sp. Pl. 342 (1753)**

Lectotype Linn-HL473-1, coll. Anon., s.n. designated by Carter, Fl. Trop. E. Africa, Alismataceae 5 (1960)

Etymology: An aquatic plantain like the true plantains of the genus *Plantago*.

Vernacular name: water plantain

Perennial, rhizome short; leaves erect (rarely floating or submerged) from a stout basal rosette 0.5–1.8 m tall. Leaves long petiolate; lamina 80–230 mm long, 30–100 mm wide, broad elliptic (emergent or terrestrial leaves), elliptic, ovate, base obtuse to cordate, apex acute or acuminate, margin entire. Petioles 50–420 mm long, 3.0–9.0 mm wide, D-shaped, septate. Inflorescence a whorled panicle of (3–)4–9 verticils, pyramidal, bracteate, 300–1080 mm tall, 230–600 mm wide. Flowers 4.0–10 mm diameter, pedicels terete, 14–35 mm long, glabrous. Sepals green, 3.0–4.0 mm long, ovate. Petals pale lilac or pale pink with a yellow spot at the base, 4.0–4.5 mm long, 4.0–6.4 mm long, 4.8–6.5 mm wide, broadly elliptic to rhombic, apices rounded, occasionally acute, margin denticulate. Stamens 6, filaments membranous, 1.4–2.5 mm long, flattened, tapering, anthers yellow, 0.8–1.2 mm long, ellipsoid. Carpels 18 to 23 in a ring; style 0.7–1.5 mm long, more or less straight, lateral on the ventral side attached below middle; stigma less than ½ the style region, papillose, papillae 20–45 µm long. Fruiting head more or less triangular, ventral sides of achenes not meeting in

the centre. Achenes 1.8–2.8 mm long, 1.2–1.6 mm wide, obovate (horseshoe-shaped), dorsal sutures 1–(2), straw coloured or light brown. Seeds 1.4–1.5 mm long, 0.5–0.6 mm wide, uncinata, smooth to faintly rugose, red-brown. Dispersal units: achenes floating in water (hydrochory).

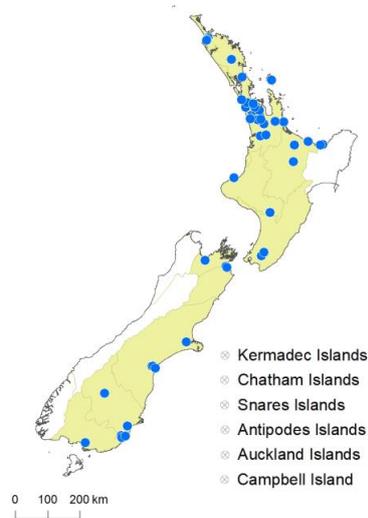


Fig. 12: *Alisma plantago-aquatica* distribution map based on databased records at AK, CHR, NZFRI, OTA, WAIK & WELT.

Distribution: North Island: Northland – Kaitaia, Awanui River, Waipapakauri, Mamaranui, Kaiwaka, Whangaroa, Aponga; Auckland – Waitakere, Kakamatua Estuary, Āwhitu, Great Barrier Island (Kaitoke Creek), Waikato River (near Elbow), Aka Aka, Wairoa River, Drury, Pukekohe, Mercer, Meremere, Waikato River near Orton, Pukekawa, Hauraki Plains, Whangamarino wetland, Lake Waikare, Lake Rotokawau, Hamilton City; Volcanic Plateau – Ōhau Channel near Lake Rotoiti, Matatā, Ōpōtiki; Taranaki – near Waitara; southern North Island – Featherston, Fernside.

South Island: Sounds-Nelson – Nelson City; Marlborough – Blenheim (Opawa River), Canterbury – Lincoln, Timaru, Levels, Washdyke, Winchester; Otago – Taieri Plains, Balclutha, Toko River, Lake Tuakitoto, Kaitangata; Southland – Invercargill.

iNaturalistNZ records:

<https://inaturalist.nz/observations/1121657>,
<https://inaturalist.nz/observations/4788352>,
<https://inaturalist.nz/observations/40555601>,
<https://inaturalist.nz/observations/37624948>,
<https://inaturalist.nz/observations/37624895>,
<https://inaturalist.nz/observations/36707943>.

Region of origin: Australia, Europe, west Asia, north & central Africa (Björkqvist 1968, Jacobs & McColl 2011, Conran 2012).

Biostatus: Exotic; fully naturalised.

Habitat: Emergent or marginal in humus-rich soils in farm drains, roadside ditches, swamps, swamp drains, pools and ponds, edges of slow-flowing streams and rivers, estuaries, marshy pasture. Recorded from oligotrophic and eutrophic water bodies, and some tolerance of brackish water evident.

Notes: Björkqvist (1967) reports that this species has the broadest ecological range of European *Alisma* species. It reproduces by seed, or vegetatively from side shoots of the rhizome. Seeds exhibit dormancy. In New Zealand, plants can survive the winter with submersed leaves in protected parts of water bodies such as shaded drains. Emergent leaves wither and die back over winter. Reported by Björkqvist (1967) to be a poor competitor and favoured by cultivation.

First record: CHR 1287, *E.B. Levy*, Waikato, March 1929 (cited in Healy & Edgar (1980), p. 34).

Recognition: This species can be distinguished from *Alisma lanceolatum* by its broader elliptic or ovate leaves with obtuse to cordate leaf-bases (in emergent leaves), rather than the lanceolate or narrow-elliptic leaves and cuneate leaf-bases of the above. It can, however, be difficult to distinguish young, non-flowering plants from *A. lanceolatum*. Although the flowers are very similar in the two species, petal colour is reported as pale lilac in *A. plantago-aquatica* and usually pale pink in *A. lanceolatum* (Healy & Edgar 1980). Of more diagnostic value are the petal apices, which in *A. plantago-aquatica* are usually more rounded and denticulate, whereas in *A. lanceolatum* they are often acute or acuminate and the margin entire or irregularly toothed. The fruiting head of *A. plantago-aquatica* has a distinctive gap in the centre (as seen from above), caused by the ventral edges of the achenes not meeting, whereas in *A. lanceolatum* there is no gap as the ventral sides of the achenes touch and overlap, forming a tight cluster. The fruiting head-shape side-on is also different in the two species, with *A. plantago-aquatica* cup-shaped and *A. lanceolatum* somewhat compressed.

Phenology: Flowering: Nov.–Feb. Fruiting: Dec.–Mar.

Cytology: $2n = 14$ (Erlandsson 1946, Björkqvist 1968).



Fig. 13: *Alisma plantago-aquatica*. Whole plant.



Fig. 14: *Alisma plantago-aquatica*. Emergent leaves.



Fig. 15: *Alisma plantago-aquatica*. Emergent leaf showing cordate leaf-base.



Fig. 16: *Alisma plantago-aquatica*. Flowers showing rounded petal apices with a denticulate margin.



Fig. 17: *Alisma plantago-aquatica*. The underside of a flower showing the sepals.



Fig. 18: *Alisma plantago-aquatica*. A fruiting cluster showing a whorl of achenes around a central gap, and one dorsal suture per achene.



Fig. 19: *Alisma plantago-aquatica*. A mature fruiting cluster showing with the central gap still visible.



Fig. 20: *Alisma plantago-aquatica*. Individual achenes showing the withered style base arising from about the middle of the achene or lower.



Fig. 21: *Alisma plantago-aquatica*. A conical-shaped fruiting cluster from side-on.



Fig. 22: *Alisma plantago-aquatica*. Seeds with a distinctive furrow on each side due to the bending of the embryo (uncinate or horseshoe-shaped).

***Hydrocleys* Rich., *Mém. Mus. Hist. Nat.* 1: 368 (1815)**

Type taxon: *Hydrocleys commersonii* Rich.

Etymology: From Greek *hudor* meaning water and *kleis* a key.

Perennial, glabrous aquatic herbs, with leaves proliferating from stolons. Roots fibrous, non-septate. Hermaphrodite. Leaves floating, emergent or submersed from a rosette; floating leaves long petiolate, leaf-bases cordate; submersed phyllodia non-petiolate, ribbon-like. Inflorescence a scape, bracteate. Flowers perfect, long pedicellate. Androecium 6–many stamens in whorls, the outer often sterile; filaments linear, flattened, glabrous; anthers basifixed, extrorse dehiscence; staminodes present. Gynoecium 3–8 with proximally coherent carpels attenuate to a curved terminal style; ovule placentation laminar, many per carpel. Fruit a follicle, more or less terete, dehiscent along the inner margin, beaked, without wings. Seeds uncinately with stalked, glandular hairs.

Taxonomy: The genus *Hydrocleys* was treated in the family Butomaceae by Healy & Edgar (1980) and in the Limnocharitaceae by recent floras (Haynes & Holm-Nielsen 1992, Jacobs & McColl 2011), but is here included in the Alismataceae (Les & Tippery 2013). The three genera of the Limnocharitaceae, *Butomopsis*, *Hydrocleys* and *Limnocharis*, share with Alismataceae s.s., milky sap, petiolate leaves with a terminal pore, a sepeloid calyx, thin and delicate petals that are crumpled in bud, and curved seeds and embryos (Haynes & Holm-Nielsen 1992).

Distribution: Five species in tropical and subtropical America, from Jamaica to southern Mexico and El Salvador, south to Bolivia and northeastern Argentina.

Biostatus: Exotic; fully naturalised.

Table 3: Number of species in New Zealand within *Hydrocleys* Rich.

Category	Number
Exotic: Fully Naturalised	1
Total	1

Recognition: *Hydrocleys* is easily distinguished from other genera in the Alismataceae, as species have relatively large, yellow (New Zealand) or white flowers on lax peduncles, and a mostly floating leaf habit rather than an erect, emergent habit. The leaves are round to oval in shape on long petioles, which, along with the pedicels, are conspicuously septate. The seed is released from relatively large, dehiscent follicles rather than indehiscent achenes, and the seeds have conspicuous, stalked, glandular hairs.

Cytology: $n = 8$ is regarded as basic (Rao 1953, Haynes & Holm-Nielsen 1992), $n = 7$ is hypothesised to have arisen through a Robertsonian translocation (Kenton 1981).

Notes: Healy & Edgar (1980) treated one species of *Hydrocleys* in New Zealand, *H. nymphoides*. No additional species are reported here.

***Hydrocleys nymphoides* (Humb. & Bonpl. ex Willd.) Buchenau, Index Crit. Butom. Alism. Juncag. 2, 9 (1868)**

≡ *Stratiotes nymphoides* Humb. & Bonpl. ex Willd., *Sp. Pl.*, ed. 4 (2), 821 (1806)
Holotype, Humboldt s.n., Venezuela; (B-Willd.).

Etymology: A reference to the similarity to the genus *Nymphaea*, from *numphe* (Greek), a female deity from Greek mythology, a nymph who haunts rivers, springs and forests.

Vernacular name: water poppy

Perennial aquatic herb with rosettes of floating or emergent leaves proliferating from stolons. Leaves long petiolate with sheathing bases; lamina 20–92 mm long, 15–95 mm wide, broad-ovate to orbicular, midvein swollen on the underside, coriaceous, shiny, glabrous, base cordate, sinus shallow; apex round to slightly mucronate, margin entire; petiole 60–490 mm long, 1.0–4.0 mm wide, terete, septate, glabrous. Flowers solitary to many, bracteate, 5.0–6.5 mm diameter, proliferating with leaves and stolons; pedicel terete 230–300 mm long, 3.0–3.5 mm wide, obviously septate, glabrous. Sepals green, 16–20 mm long, ovate to narrow-ovate. Petals yellow with dark yellow towards the base, 30–35 mm long, 32–40 mm wide, broad-obovate, apex round. Stamens up to approximately 30, filaments purple, 4–6 mm long, flattened, tapering, anthers yellow, 3–5 mm long, linear. Carpels 6–8, free, style attenuate from the ovary, persistent; stigma clavate, papillose, deep purple. Follicles 10–14.5 mm long, flask-shaped, brown. Many seeds per follicle, 1–1.5 × 0.6–0.8 mm, uncinata with a horseshoe-shaped embryo, covered with glandular trichomes, red-brown. Seeds not seen in New Zealand.

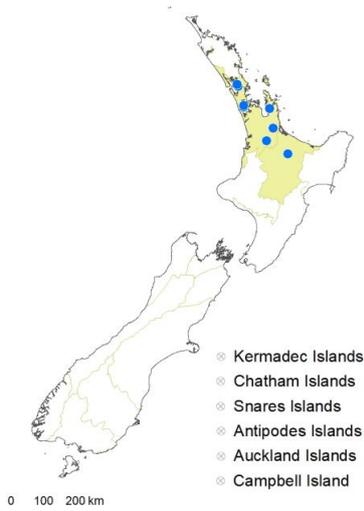


Fig. 23: *Hydrocleys nymphoides* distribution map based on databased records at AK, CHR, NZFRI, OTA, WAIK & WELT.

montana (marshwort) and *N. peltata* (fringed water lily). *Nuphar lutea* has larger, deeply cordate leaves and flowers with numerous tepals, not three petals. The two species of *Nymphoides*, *N. montana* and *N. peltata*, also have deeply cordate leaves, five petals, and distinctive fringed petal margins.

Ottelia ovalifolia (swamp lily), in the related monocot family Hydrocharitaceae, has many similarities to *Hydrocleys nymphoides*: three petals, a septate peduncle, similarly shaped leaf laminae (but more oblong) with primary parallel venation, but it can be distinguished from it by having white flowers, an absence of staminodes, an absence of an inflated midvein on the underside of the leaf-blade, and the presence of a distinctive, linear, submerged leaf-form.

Hydrocleys nymphoides is a designated unwanted organism in New Zealand under the Biosecurity Act, is banned from sale and distribution, and is targeted for eradication wherever it occurs.

Phenology: Flowering: Feb.–Mar.

Notes: Apparently sterile in New Zealand, seeds never recorded (Healy & Edgar 1980 p. 24–25).

Cytology: $2n = 16$ (Rao 1953, Darlington & Wylie 1955).

Distribution: North Island: Northland – Maungatapere; Auckland – Wellsford, Wharehine, Tauhoa, Laingholm, Glen Eden, Bombay, Pukekohe, Coromandel (Tapu River Valley), Cambridge, Te Aroha, Matamata, Tokanui; Volcanic Plateau – Rotorua, Lake Rotoehu, Te Puke.

Region of origin: Central America, Colombia, Bolivia, Ecuador, Venezuela, Brazil and southwards to Argentina.

Biostatus: Exotic; fully naturalised.

Habitat: Stagnant waters, farm and garden ponds, slow-flowing streams.

Notes: It spreads vegetatively by stolon fragments and can quickly establish dense mats of elastic stems.

First record: CHR 3447, F. Neve, Te Aroha [c. 1914], cited in Cheeseman (1914).

Recognition: This species is distinguished by its showy, poppy-like yellow and purple-centred flowers with three petals on septate peduncles. Also, the midvein of the leaf-blade underside is obviously inflated and the leaves are shallow-cordate. Similar yellow-flowered aquatics are *Nuphar lutea* (yellow water lily, brandy-bottle), *Nymphoides*



Fig. 24: *Hydrocleys nymphoides*. A whole plant showing a stolon, two leaves on septate petioles, and a flower on a septate pedicel.



Fig. 25: *Hydrocleys nymphoides*. Leaves, showing abaxial and adaxial sides (note the swollen midvein on the abaxial side of the leaf-blade).



Fig. 26: *Hydrocleys nymphoides*. Flower showing six free carpels with attenuate styles; also showing the inner stamens releasing pollen and the spreading outer sterile stamens.



Fig. 27: *Hydrocleys nymphoides*. A flower with three yellow obovate petals and three ovate green sepals attached to a distinctive septate pedicel.



Fig. 28: *Hydrocleys nymphoides*. Mature fruit – each fruit a follicle with many seeds, only four shown here.



Fig. 29: *Hydrocleys nymphoides*. Seeds with glandular trichomes and a furrow each side due to the folded embryo (uncinate or horseshoe-shaped).



Fig. 30: *Hydrocleys nymphoides*. A dense infestation in a stagnant pond.



Fig. 31: *Hydrocleys nymphoides*. Rosettes of floating leaves and emergent flowers proliferating from stolons.

***Sagittaria* L., Sp. Pl. 993 (1753)**

Type taxon: *Sagittaria sagittifolia* L.

Etymology: From *sagitta*, Latin for arrow, referring to the common leaf shape in this genus.

Perennial (in New Zealand), mostly emergent, glabrous, aquatic herbs. Rhizomes, stolons and corms often present. Roots fibrous, septate. Monoecious, polygamomonoecious, dioecious (rarely). Leaves from a basal rosette, petiolate (emergent leaves) or non-petiolate (submergent leaves); leaf-bases lobed or non-lobed on emergent leaves. Inflorescence a whorled raceme or panicle, bracteate, staminate flowers above, carpellate below on the same scape. Flowers imperfect, usually functionally unisexual, staminate flowers only or with non-functional carpels, carpellate flowers only or with staminodes; pedicellate. Androecium 6—many stamens in whorls; filaments linear, subulate or dilated, glabrous to densely pubescent; anthers nearly basifixed, extrorse dehiscence. Gynoecium with many free carpels spirally attached to a conical receptacle, style terminal; ovule placentation basal. Fruit a flattened obovate achene, beaked, winged. Seeds uncinata, glandular, without hairs.

Taxonomy: *Sagittaria* was monographed by Bogin (1955), and a regional revision was written by Haynes & Holm-Nielsen (1994) for the tropical Americas. Keener (2005) revised *Sagittaria* providing dichotomous keys, descriptions, and distribution maps for 40 species and eight infraspecific taxa.

1	Leaf bases cuneate or leaves linear.....	2
1'	Leaf bases lobed, either sagittate or hastate.....	3
2	Plants to 150 cm tall; inflorescence emergent, stout; filaments pubescent.....	<i>platyphylla</i>
2'	Plants to 90 cm; inflorescence floating, lax; filaments glabrous.....	<i>subulata</i>
3	Petiole semi-terete; rhizome thick and upright, corms and stolons absent	<i>montevidensis</i>
3'	Petiole trigonous; corms and stolons present....	<i>Sagittaria</i> sp. [Sagittifolia Group]

Sagittaria sp. in the key refers to the presence of an unidentified species in the *Sagittifolia* Group (Keener 2005), which has never been seen flowering – it is likely one of following species: *S. latifolia*, *S. sagittifolia* or *S. trifolia*. One field population has been found occurring in a small tributary of the Huruhurutakimo Stream, Whenuakite, Coromandel Peninsula, and it is likely the same species found in cultivation in several locations in New Zealand, presumably grown for the edible tubers. One of the species in the *Sagittifolia* Group, *Sagittaria sagittifolia*, is a designated unwanted organism in New Zealand under the Biosecurity Act. It is banned from sale and distribution and is targeted for eradication wherever it occurs.

Distribution: About 30 to 35 species of both tropical and temperate regions, with many species occurring in the Americas; also in Eurasia, West Africa, China, Japan, South East Asia.

Biostatus: Exotic; fully naturalised.

Table 4: Number of species in New Zealand within *Sagittaria* L.

Category	Number
Exotic: Fully Naturalised	3
Total	3

Recognition: Separate male and female flowers on the same plant (monoecious), septate roots, and showy, white, petaloid flowers will distinguish *Sagittaria* from *Alisma* and *Hydrocleys*.

Cytology: $2n = 11$.

Notes: All four naturalised species of *Sagittaria* have been recorded for the first-time post Healy & Edgar (1980).

***Sagittaria montevidensis* Cham. & Schldl., *Linnaea* 2: 156 (1827)**

Neotype: Lorentz 103 (W; *fide* Rataj, 1972)

Etymology: *montevidensis*, from Montevideo, Uruguay.

Vernacular name: giant arrowhead

Biostatus: Exotic; fully naturalised.

Sagittaria montevidensis* Cham. & Schldl., *Linnaea* 2: 156 (1827) subsp. *montevidensis

Etymology: *montevidensis*, from Montevideo, Uruguay.

Vernacular name: giant arrowhead

Erect, perennial herb, from a short, thick rhizome to 2 m tall, corms and stolons absent. Emergent leaves sheathing, petiolate; lamina 200–340 mm long, 195–260 mm wide, sagittate to hastate, glabrous, large lobes with caudate to acuminate tips, apex caudate or acuminate, margin entire; petioles 200–550 mm long, 5.0–20 mm wide, semi-terete (D-shaped), septate, glabrous. Inflorescence a whorled raceme or panicle, bracteate, 280–620 mm long, 50–150 mm wide; 3–15 whorls of 3–5 pedicellate flowers; scape 730–1800 mm long, 6–15 mm wide, erect, terete, emergent. Staminate flowers about 30 mm diameter, sterile carpels absent, pedicels spreading to ascending 0.2–1.3 mm wide, terete; sepals 7.0–12 mm long, 4–6 mm wide, ovate, concavo-convex, with conspicuous membranous margins; petals white with a dark red spot at base, 10–25 mm long, 20–25 mm wide, broad-ovate with a narrow claw, delicate, apex rounded, irregularly crenate; stamens 12–many; filaments 3–4 mm long, dilated, glabrous; carpellate flowers about 20 mm diameter, carpels many, staminodes absent, pedicels spreading, becoming recurved in fruit, distinctly thicker than staminate pedicels, terete; sepals 12–19 mm long, 7–10 mm wide, appressed and enclosing fruiting head, petals white with a dark red spot at base, delicate, deciduous 17–18 mm long, 18–20 mm wide, broad-ovate with a narrow claw, apex rounded. Fruiting head 12–20 mm diameter. Achenes 1.5–3.0 mm long, 1.5–2.0 mm wide, obovate with a lateral beak, winged, brown. Seeds uncinatae, brown.

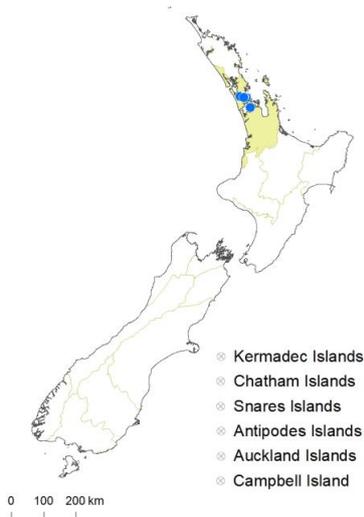


Fig. 32: *Sagittaria montevidensis* distribution map based on databased records at AK, CHR, NZFRI, OTA, WAIK & WELT.

Distribution: North Island: Auckland – Dairy Flat, Auckland City, Manukau, Wairoa River, Clevedon, Waikato (Ohinemuri River, Paeroa).

Region of origin: Ecuador, Peru to south-eastern Brazil, Uruguay, northern Chile.

Biostatus: Exotic; fully naturalised.

Habitat: Shallow ponds, river margins, riparian edges and mudflats.

First record: AK 227092, *G.D. Gregg*, Manukau, north of Redoubt Road, motorway exit, 1996, cited in Ford & Gregg (1997).

Recognition: *Sagittaria montevidensis* subsp. *montevidensis* has large, broad, arrow-shaped leaves and D-shaped petioles in T.S.; this and the white flowers with a conspicuous, dark-red petal spot distinguish it from other species of *Sagittaria* in New Zealand.

Sagittaria montevidensis subsp. *calycina* (not recorded in New Zealand) is distinguished by the absence of a coloured petal spot and shorter basal leaf-lobes (Haynes & Holm-Nielsen 1994).

Sagittaria montevidensis subsp. *montevidensis* is a designated unwanted organism in New Zealand under the Biosecurity Act, is banned from sale and distribution, and is targeted for eradication wherever it occurs.

Phenology: Flowering: Nov.–Feb. Fruiting: Dec.–Mar.

Cytology: $2n = 20, 22$ (Goldblatt & Johnson 2003).



Fig. 33: *Sagittaria montevidensis* subsp. *montevidensis*. Population in an Auckland City swale.



Fig. 34: *Sagittaria montevidensis* subsp. *montevidensis*. Broad arrow-shaped leaf-blade.



Fig. 35: *Sagittaria montevidensis* subsp. *montevidensis*. Male flowers showing the dark red spot at the base of the petals.

***Sagittaria platyphylla* (Engelm.) J.G.Sm., *N. Amer. Sagittaria* 29 (1894)**

≡ *Sagittaria graminea* var. *platyphylla* Engelm. in Gray, *Manual [Gray]*, ed. 5, 494 (1867)
U.S.A. Texas, *Lindheimer 713* (Lectotype, MO; isolectotypes, MO, GH, NY, US; *fide* Bogin 1955)

Etymology: From Greek *platus* (flat) and *phullon* (leaf), a reference to the flat leaves.

Vernacular names: broad-leaf arrowhead; delta arrowhead

Erect, perennial herb to 150 cm, with corms and stolons. Emergent leaves sheathing, petiolate; lamina 40–210 long, 20–100 mm wide, narrow or broad-elliptic, ovate or linear-ovate, glabrous, base cuneate and gradually tapering or occasionally sub-cordate, apex acuminate or acute, margin entire; petiole 240–657 mm long, 5.0–10 mm wide, trigonous, septate, conspicuously winged, glabrous. Submersed phyllodial leaves ribbon-like, 100–410 mm long, 6.0–23 mm wide, apex acuminate to obtuse, margin entire. Inflorescence a whorled raceme, pyramidal, bracteate, 50–150 mm long, 30–120 mm wide, 3–9 whorls of three pedicellate flowers; scape 150–650 mm long, 3–6 mm wide, erect, trigonous, emergent. Staminate flowers about 20 mm diameter, sterile carpels absent, pedicels spreading to ascending 0.5–0.8 mm wide, terete; sepals 4–9 mm long, 3–6 mm wide, ovate, concavo-convex, with conspicuous membranous margins; petals white, 8–10 mm long, 10–12.5 mm wide, broad-ovate with a narrow claw, delicate, apex rounded, irregularly crenate; stamens 17–41; filaments 1.5–2.5 mm long, dilated, densely pubescent; anthers yellow, 1.0–1.5 mm long, elliptic. Carpellate flowers, carpels many, staminodes absent, pedicels spreading, becoming recurved in fruit 1.0–2.0 mm wide, distinctly thicker than staminate pedicels, terete; sepals 5–8 mm long, 3–5 mm wide, ovate, concavo-convex, with membranous margins, spreading to reflexed, not enclosing fruiting head; petals white, delicate, deciduous 4.5–5.0 mm long, 5.5–6.0 mm wide, broad-ovate with a narrow claw, apex rounded. Fruiting head 5–15 mm diameter. Achenes 2.0–2.5 mm length, 0.5–1.5 mm wide, obovate with a lateral beak, without keel, winged, tuberculate, brown. Seeds about 1.0 mm long, 0.5 mm wide, uncinata, brown.

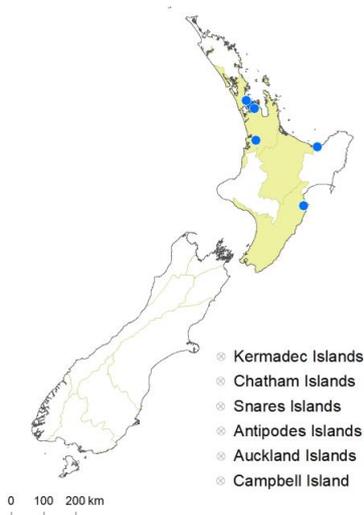


Fig. 36: *Sagittaria platyphylla* distribution map based on databased records at AK, CHR, NZFRI, OTA, WAIK & WELT.

There is no coloured spot on the petals of *S. platyphylla*, in contrast to *S. montevidensis*, and the petiole of *Sagittaria platyphylla* is trigonous rather than D-shaped (semi-terete). *Sagittaria platyphylla* emergent leaves are like those of *Alisma* spp., especially *A. lanceolatum*. The petiole of *S. platyphylla* is trigonous in contrast to the D-shaped (semi-terete) petioles of *Alisma* spp. When flowering, *Alisma* spp. have broader, taller inflorescences with smaller, but many more, pink or lilac flowers rather than white.

Sagittaria platyphylla is a designated unwanted organism in New Zealand under the Biosecurity Act, is banned from sale and distribution, and is targeted for eradication wherever it occurs.

Phenology: Flowering: Dec.–Apr. Fruiting: Mar.–May.

Cytology: $2n = 22$ (Fedorov 1969)



Fig. 37: *Sagittaria platyphylla*. Dense population.



Fig. 38: *Sagittaria platyphylla*. Leaf-blade.

Distribution: North Island: Auckland – Stanmore Bay, Whangaparāoa Peninsula, Auckland City, North Shore (Wairau Catchment), Glenfield, Pakuranga Stream, Waikato (near Kaniwhaniwha); Volcanic Plateau – Opotiki; southern North Island – Marton, Hawke's Bay (Te Mata Park).

iNaturalist record: <https://inaturalist.nz/observations/9764176>

Region of origin: Southern Missouri to Mississippi and Texas, U.S.A.

Biostatus: Exotic; fully naturalised.

Habitat: Wetlands, in streams and along edges of waterways, ponds, drains.

Notes: spreading by seed in waterways, and by rhizomes and corm fragmentation.

First record: AK 185308, *P.D. Champion*, Tamaki, Glenfield, Becroft Park, 1989.

Recognition: *Sagittaria platyphylla* has non-lobed elliptic or ovate leaves (which can be narrow or broad), distinguishing it from other large species of *Sagittaria* present in New Zealand: *S. montevidensis* and an unidentified species (in the *Sagittifolia* group), both of which have obviously lobed, arrow-shaped leaves.

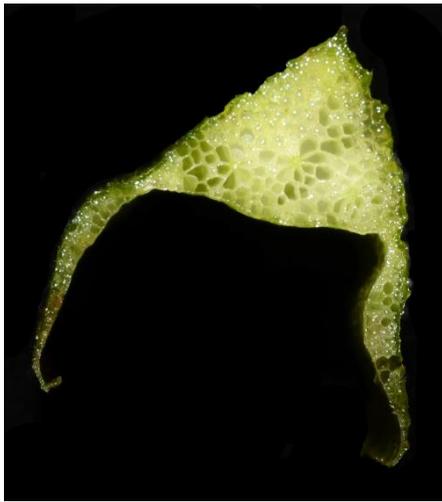


Fig. 39: *Sagittaria platyphylla*. T.S. of a leaf petiole showing triangular shape.



Fig. 40: *Sagittaria platyphylla*. Inflorescence: female flowers below with immature fruits developing (the petals are gone) and male flowers above, with petals and dehiscing pollen.



Fig. 41: *Sagittaria platyphylla*. Female fruit maturing, and male flowers decayed above.



Fig. 42: *Sagittaria platyphylla*. Male flower.



Fig. 43: *Sagittaria platyphylla*. Fruit, a flattened and beaked achene.



Fig. 44: *Sagittaria platyphylla*. Plants flowering in a farm pond.

Sagittaria subulata (L.) Buchenau, *Abh. Naturwiss. Vereins Bremen* 2: 490 (1871)

≡ *Alisma subulatum* L., *Sp. Pl.* 343 (1753) – as *subulata*

Type: U.S.A. Virginia, *Grosvontus s.n.* (BM, photo GH)

Etymology: From *subula* (Latin), meaning awl, a reference to the leaves, which can be pointed.

Vernacular names: dwarf arrowhead; floating arrowhead; needle arrowhead

Lax, perennial herb, with rosettes of floating or submersed leaves proliferating from stolons; corms present. Floating leaves shortly sheathing, petiolate; lamina 18–50 mm long, 3.5–12 mm wide, obovate or oblong, glabrous, base cuneate, apex obtuse or acute, margin entire; petioles 75–295 mm long, 1.5–4.0 mm wide, flattened, septate, glabrous. Submersed phyllodial leaves ribbon-like, with or without gradually expanding apices, ex-petiolate, 60–340 mm long, 3.0–10 mm wide, glabrous, obtuse or acute, margin entire. Inflorescence a whorled raceme, bracteate 50–80 mm long, 20–40 mm wide; 3–6 whorls of (2)–3 pedicellate flowers; scape 170–220 mm long, 1.0–3.0 mm wide, flattened, floating. Staminate flowers about 5–6 mm diameter, sterile carpels absent, pedicels spreading to ascending, 0.2–0.3 mm wide, terete; sepals 3–4 mm long, 1.5–2.0 mm wide, ovate, concavo-convex, with membranous margins; petals white, 3.0–6.0 mm long, 2.0–5.0 mm wide, broad-elliptic or broad-ovate, with a short claw, apex obtuse, irregularly crenate; stamens 6; filaments 0.6–2.0 mm long, dilated, glabrous; anthers yellow, 0.6–0.8 mm long, elliptic. Carpellate flowers, carpels many, occasionally a ring of staminodes present, pedicels spreading, becoming recurved in fruit, 0.3–1.5 mm wide, distinctly thicker than staminate pedicels, terete; sepals 2.0–3.7 mm long, 1.0–2.8 mm wide, ovate, concavo-convex, with membranous margins, spreading to reflexed, not enclosing fruiting head, petals white, delicate, deciduous, 5.0–5.5 mm long, 3.6–4.2 mm wide, broad-ovate with a short claw, apex rounded. Fruiting head 5.5–8.0 mm diameter. Achenes 2.0–2.5 mm length, 1.0–1.5 mm wide, obovate with a lateral beak, winged, brown. Seeds 1.4–1.5 mm long, 0.6–0.8 mm wide, uncinata, yellow-brown.

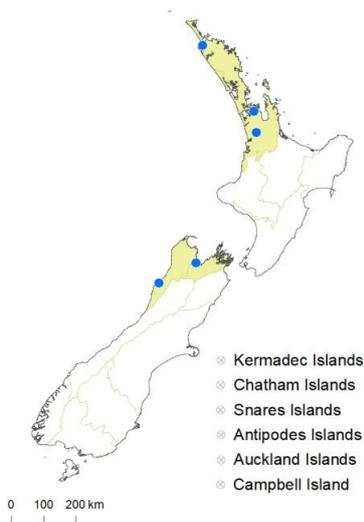


Fig. 45: *Sagittaria subulata* distribution map based on databased records at AK, CHR, NZFRI, OTA, WAIK & WELT.

The submerged, ribbon-like leaves can be confused with *Vallisneria australis* and the submerged foliage of *Ottelia ovalifolia* (both Hydrocharitaceae). *Ottelia ovalifolia* plants are not stoloniferous and *V. australis* flowers are apetalous.

The submerged, ribbon-like leaves can be confused with *Vallisneria australis* and the submerged foliage of *Ottelia ovalifolia* (both Hydrocharitaceae). *Ottelia ovalifolia* plants are not stoloniferous and *V. australis* flowers are apetalous.

Phenology: Flowering: Dec.–Feb. Fruiting: Feb.–Apr.

Cytology: $2n = 22$ (Uchiyama 1989).

Distribution: North Island: Auckland – Papakura Stream, Te Atatū, Waikato (Lake Waahi), Coromandel Peninsula (at Whenuakite, not seen since 1993, Paul Champion, pers. obs.). South Island: Sounds-Nelson – Upper Moutere; Western Nelson – Buller, Westport.

Region of origin: The coastal eastern states of North America from New York to Florida and Alabama.

Biostatus: Exotic; fully naturalised.

Habitat: Ponds, lakes, drains, stagnant or slow water-bodies.

First record: CHR 455652, *B. Menzies*, Buller, Westport, 19 Feb. 1988.

Recognition: A small, lax plant, which is mostly submersed, with ribbon-like leaves and small, unlobed obovate or oblong floating or emergent leaf-blades. Unlike *Sagittaria montevidensis* and *S. platyphylla*, the inflorescence is lax and floating rather than erect and emergent above the surface of the water. The flowers are much smaller than the other two species in New Zealand, only 5–6 mm in diameter for male flowers, compared with about 30 mm for *S. montevidensis* and 20 mm for *S. platyphylla*. The white flowers unfold just above the water surface and there is no coloured spot on the petals.



Fig. 46: *Sagittaria subulata*. A whole plant with floating leaves and flowers.



Fig. 47: *Sagittaria subulata*. Long, petiolate, floating leaves.



Fig. 48: *Sagittaria subulata*. Male flowers.

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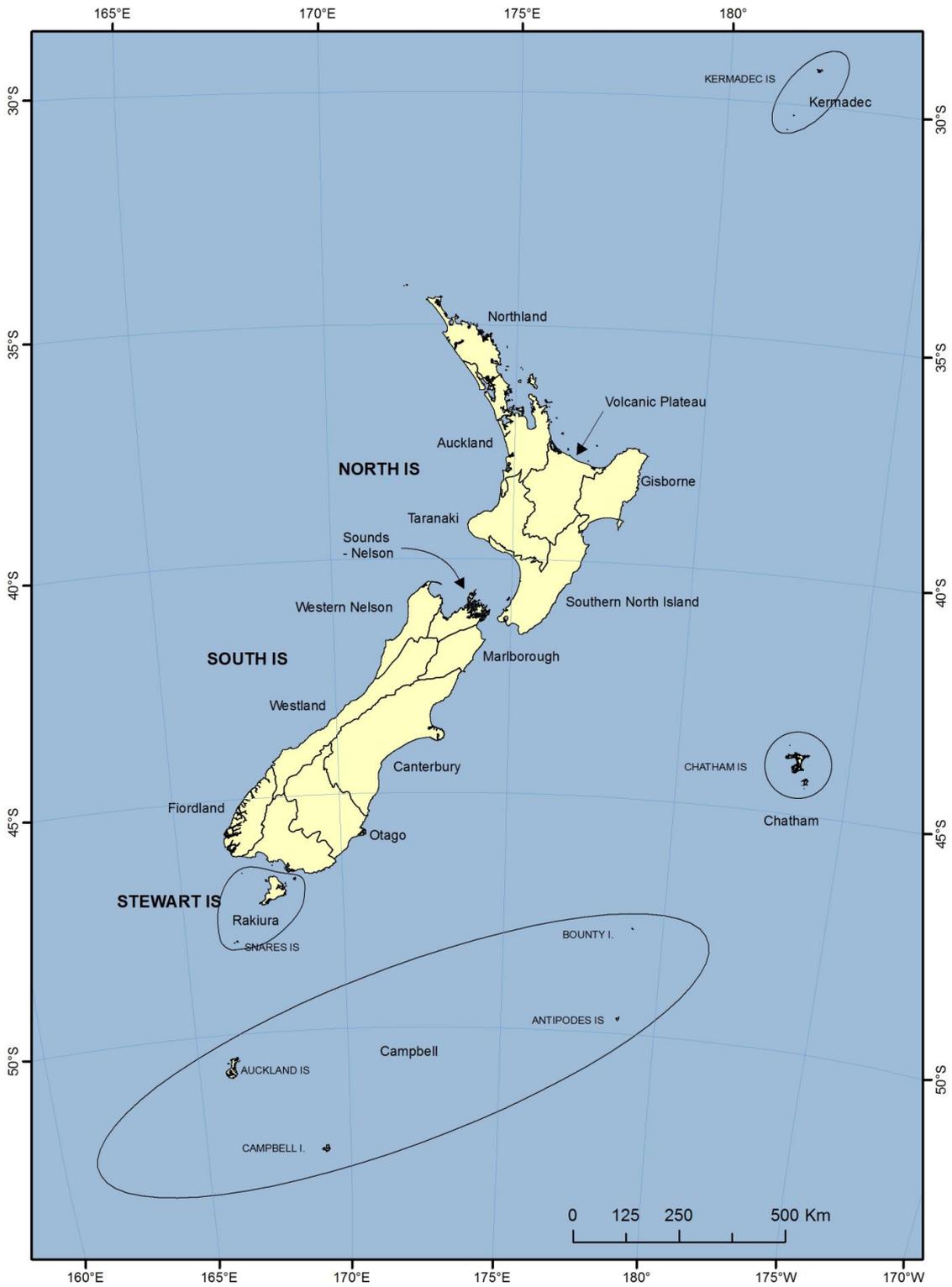
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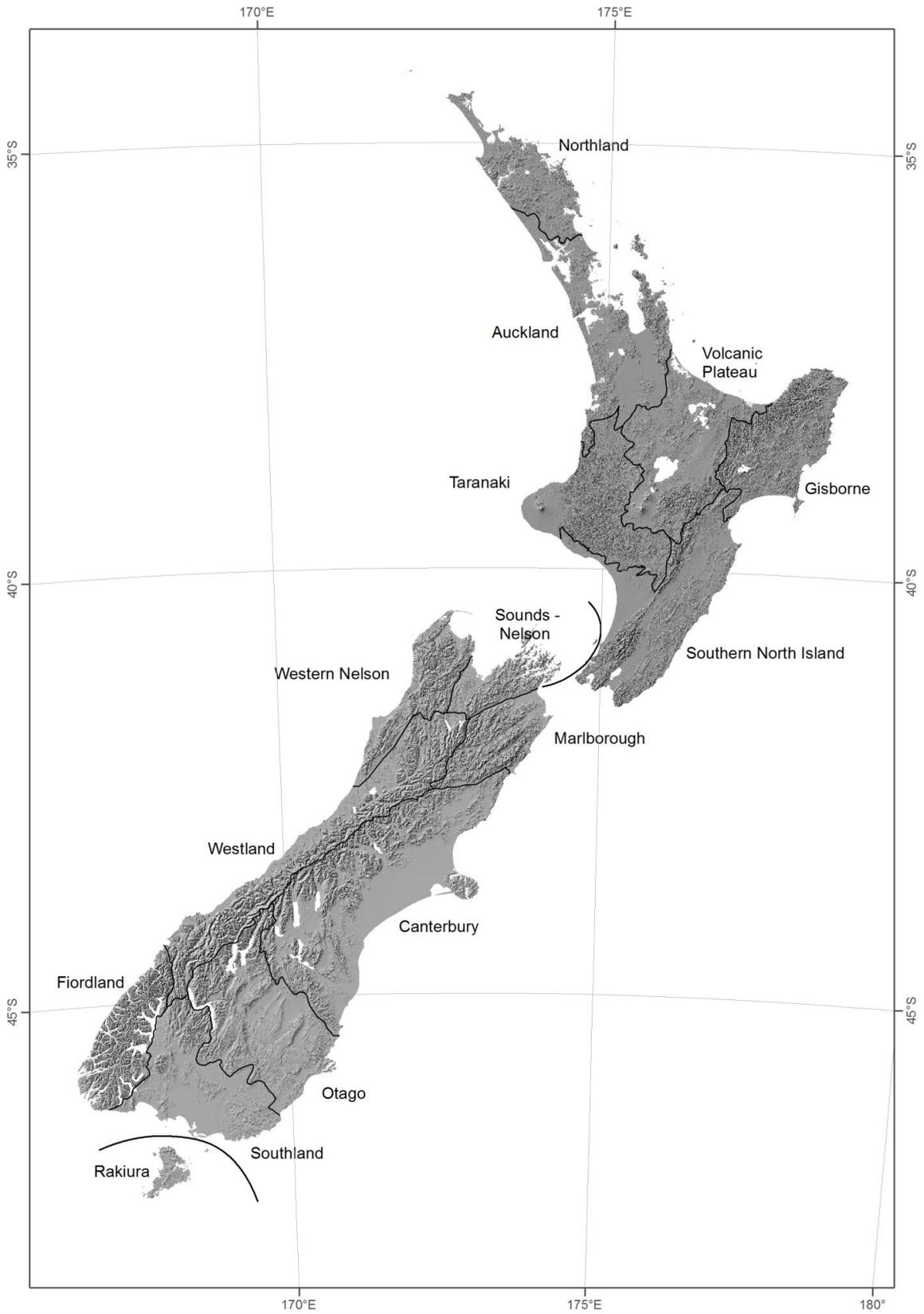
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Map 1: Map of New Zealand and offshore islands showing Ecological Provinces



Map 2: Map of New Zealand showing Ecological Provinces

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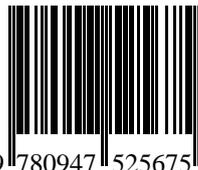
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