Department of **Agriculture and Fisheries**
Biosecurity Queensland

Water mimosa

Neptunia oleracea

Dead and awake

Neptunia plena

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Contents

Identity and taxonomy

Neptunia oleracea Lour.

Synonyms: *Acacia lacustris* Desf., *Desmanthus lacustris* Willd., *D. natans* Willd., *D. stolonifer* DC, *Mimosa aquatica* Pers., *M. lacustris* H. and B., *M. natans* L.f., *M. prostrata* Lam., *Neptunia natans* (L.f.) Druce, *N. prostrata* (Lam.) Baillon, *N. stolonifera* Guillemin.

Common names: Water mimosa, water sensitive plant, garden puff (United States), neptunie potegère (France), juqueri manso, malicia de agua (Portugal), kemon (Indonesia), kemon air, keman gajah, tangki, (Malaysia), kânhchhnaèt (Cambodia), ('phak) kas'ééd (Laos), phakkrachet, pakchit, gra ched (Thailand), rau nh[us]t, rau r[us]t (Vietnam).

Neptunia plena (L.) Benth.

Synonyms: *Acacia lycopodioides* Desv., *A. punctata* Desf., *Desmanthus comosus* A. Rich., *D. plenus* (L.) Willd., *D. polyphyllus* DC, *D. punctatus* Willd., *Mimosa adenanthera* Roxb., *M. lycopodioides* Desf., *M. plena* L., *M. punctata* L., *Neptunia polyphylla* (DC.) Benth., *N. surinamensis* Steud.

Common names: Dead and awake, water dead and awake, sensitiva de agua (Spanish–Columbia), aquatic sensitive plant (Singapore), water Neptunia (United States–Puerto Rico).

Taxonomy and genetics

Neptunia is a pantropical genus of 11 or 12 species. The genus is split into two sections: section *Neptunia* and section *Pentanthera*. *Neptunia oleracea* and *N. plena* belong to section *Neptunia*. These two species are the only aquatic or semi-aquatic species in the genus.

There are five native species of *Neptunia* in Queensland: *N. amplexicaulis* Domin, *N. dimorphantha* Domin, *N. gracilis* Benth., *N. major* (Benth.) Windler, and *N. monosperma* F. Muell. ex Benth. (Henderson 2002). All these species belong to section *Pentanthera* and are endemic to north-eastern Australia.

The base chromosome number in *Neptunia* appears to be 2n=28. *Neptunia oleracea* 2n=56 is a tetraploid (Windler 1966) while *Neptunia plena* is an aneuploid 2n=78.

Descriptions (from Windler 1966)

N. plena—Stems branched and usually erect or ascending; leaves with a suppressed gland between or just below the lowest pair of pinnae; seeds 8–20; leaflets frequently more than 20 pairs per pinna.

N. oleracea—Stems rarely branched, usually free floating; leaves lacking glands; seeds 4–8; leaflets 20 or less per pinna.

Neptunia oleracea

'Herb, perennial, aquatic, floating or prostrate near water's edge. Tap root thick, becoming woody. Stems to 1.5 m long, rarely branched, becoming detached from the primary root system, forming a spongy-fibrous indument between the nodes and producing fibrous adventitious roots at the nodes when growing in water. Stipules usually not evident on floating stems, persistent, 5.5–15.0 mm long, 3.0–5.0 mm broad, membranous, faintly nerved, lanceolate, with the base obliquely cordate, glabrous, with the margins entire. Leaves bipinnate, with 2–3 9–4) pairs of pinnae; petioles 2.0–6.8 cm long, angled, glabrous, glandless; stipels none; rachis angled, glabrous, glandless, prolonged into a linear leaf-like projection 2.0–5.0 mm long, the projection glabrous; pinna rachis distinctly winged, extended beyond the attachment of the terminal pair of leaflets, glabrous or sparsely ciliate; leaflets 8–20 pairs per pinna, 5.0–18.0 mm long, 1.5–3.5 mm broad, oblong, obtuse to broadly acute, occasionally mucronulate, asymmetrical, glabrous or sparsely ciliate on the margins, the surface appearing minutely punctate, the venation consisting of one main vein with the lateral veins obscure' (Windler 1966).

'Inflorescence a spike, erect or slightly nodding, pedunculate, borne solitary in the axils of the leaves. Spikes obovoid in bud. Peduncles 5.0–20.0 (–30.0) cm long, glabrous, usually with two bracts subtending the spike, 3.0–11.0 mm long. Flowers 30–50 per spike, sessile, each subtended by a single bract 2.0–3.1 mm long. Upper flowers perfect, sessile; calyx campanulate, green, 2.0–3.0 mm long, 5-lobed, with lobes 0.4–0.7 mm long, broadly acute, the margins entire; petals 5, regular, free or slightly coalescent at the margins, green, 3.0–4.3 mm long; stamens 10, free, 6.0–8.9 mm long, with the filaments slender, flattened, white, 5.1–8.2 mm long, anthers exserted, biocular, yellow, 0.7–0.9 mm long, lacking a terminal stalked gland; pistil 7.0–8.9 mm long, usually exserted beyond the stamens; ovary 1.2–2.0 mm long, glabrous, stipitate; style slender, elongate; stigma truncate, concave. Lower flowers sterile, sessile; calyx campanulate, 5 lobed, 0.9–1.5 mm long, with the lobes 0.3–0.5 mm long, broadly acute; petals 5, regular, free, green, 2.2–3.5 mm long; stamens 10, sterile, petal-like, yellow, 7.0–16.0 mm long, 0.5–1.0mm broad; gynoecium absent' (Windler 1966).

'Legume broadly oblong, flat, membranous-coriaceous, glabrous, marginally dehiscent, 1.9–2.8 cm long, 0.8–1.0 cm broad, with the body usually at right angles to the stripe, the stripe 0.4–0.8 cm long, longer than the persistent calyx. Seeds 4–8 per legume, brown, ovoid, compressed, 4.0–5.1 mm long, 2.7–3.5 mm broad' (Windler 1966). The leaves of *N. oleracea* are very sensitive to a touch (Darwin 1880).

Neptunia plena

'Herb, perennial, terrestrial or semi-aquatic, erect to ascending (rarely prostrate). Tap root thick, becoming woody. Stems to 2 m tall, terete, glabrous or forming a spongy-fibrous indument when in water. Stipules persistent, 4.0–12.0 mm long, 3.0–6.5 mm broad, membranous, lanceolate, with the base obliquely cordate, glabrous, with the margins entire. Leaves bipinnate, with 2–4 (–5) pairs of pinnae; petioles 1.0–4.0 cm long, angled, glabrous, with gland just below the lowest pair of pinnae; stipels none; rachis angled, glabrous, glandless, prolonged into a linear leaf-like projection 1.5–5.5 mm long, the projection glabrous; pinnae rachis distinctly winged, extended beyond the attachment of the terminal pair of leaflets, sparsely ciliate on the margins; the cilia occasionally absent; leaflets 9–38 pairs per pinna, 4.0–14.0 (–18.0) mm long, 1.0–3.0 (–3.5) mm broad, oblong, obtuse to broadly acute, occasionally mucronulate, asymmetrical, glabrous or sparsely ciliate on the margins, the surface appearing minutely punctate, the venation consisting of one main vein with the lateral veins obscure' (Windler 1966).

'Inflorescence a spike, nodding, 1.0–1.8 cm long, pedunculate, borne solitary in the axils of the leaves. Spikes obovoid in bud. Peduncles 2.8–13.0 (–17.0) cm long, glabrous, usually with 2 (–3) bracts in the lower half, the bracts 5.0–12.0 (–15.0) mm long. Flowers 30–60 per spike, sessile, each subtended by a single bract 1.0–2.7 mm long. Upper flowers perfect, sessile; calyx campanulate, yellow, 2.0–3.0 mm long, 5-lobed, with lobes 0.3–0.6 mm long, broadly acute, with the margins entire; petals 5, regular, free, yellow, 3.4–5.0 mm long; stamens 10, free, 6.5–9.0 mm long, with the filaments slender, flattened, white, 6.0–8.5 mm long, anthers exserted, biocular, yellow, 1.0–1.2 mm long, bearing a terminal gland; pistil 6.5–9.0 mm long, with the stigma usually exserted beyond the stamens; ovary 1.8–2.3 mm long, glabrous, stipitate; style slender, elongate; stigma truncate, concave. Lower flowers sterile, sessile; calyx campanulate, 5 lobed, 0.9–1.5 mm long, with the lobes 0.3–0.5 mm long, broadly acute; petals 5, regular, free, green, 2.1–3.0 mm long; stamens 10, sterile, petal-like, yellow, 9.0–16.0 mm long, 1.0–1.6mm broad; yellow; gynoecium absent' (Windler 1966).

'Legume oblong, flat, membranous-coriaceous, glabrous, marginally dehiscent, 1.5–5.5 cm long, 0.7–1.1 cm broad, rounded to the lateral stripe, the stripe 3.0–9.1 mm long, longer than the persistent calyx. Seeds 8–20 per legume, brown, ovoid, compressed, 4.0–4.1 mm long, 2.2–2.3 mm wide' (Windler 1966).

Reproduction and dispersal

N. oleracea can be propagated from seeds, but the conventional horticultural method is by stem cuttings (Paisooksantivatana 1993).

'The presence of a hard seed-coat and the requirement for temperature fluctuations are of great ecological significance in the survival of *N. oleracea* in aquatic environments. At Bharatpur (India), the plant produces large numbers of seeds in October and November. These seeds settle on the substratum after dehiscence of the pods. During summer, the ponds dry up and the seeds are exposed to diurnal temperature fluctuations. Soil surface temperatures rise to 50 ±5 °C during the day and are 22 ±3 °C at night, but the seeds do not germinate due to lack of moisture. The onset of rains during June results in gradual accumulation of water in the ponds, favouring germination' (Sharma et al. 1984).

Seed longevity

This study was unable to find information on seed longevity. However, seeds of a related species, *N. lutea* germinated after 90 years of storage.

Origin

The exact origin of *N. oleracea* is unclear; however, it is generally accepted as being native to tropical Asia, Africa and South America (Windler 1966). It grows wild and is cultivated as a vegetable throughout South-East Asia, particularly Thailand and Indo-China (Paisooksantivatana 1993).

N. plena occurs in the coastal regions of southern North America, Central America, northern South America, and tropical Asia (Windler 1966).

History of introduction

It is not known when *N. oleracea* first arrived in Queensland, but the first record is possibly from a glasshouse in the Brisbane Botanic Gardens in 1979.

The Queensland Herbarium has a record of a cultivated specimen of *N. plena* collected in 1964 from the Moreton district of Queensland.

N. oleraceae is currently being used by some South-East Asian communities as a vegetable and is being sold in local farmers' markets in the Brisbane area.

Worldwide distribution

Neptunia oleracea

Africa

North-east tropical Africa:	Sudan, Ethiopia, Somalia
East tropical Africa:	Kenya, Tanzania, Uganda
West central tropical Africa:	Burkino Faso, Cameroon, Zaire
West tropical Africa:	Benin, Gambia, Ghana, Mali, Niger, Nigeria, Senegal, Togo
South tropical Africa:	Angola, Burundi, Malawi, Mozambique, Zambia, Zimbabwe
Southern Africa:	Botswana, Madagascar, Namibia, South Africa—Natal, Transvaal

Asia—tropical

Indian subcontinent:	India, Sri Lanka
Indo-China:	Cambodia, Laos, Myanmar, Thailand (Koo et al. 2000), Vietnam
Malesia:	Indonesia —Java, Borneo, Sumatra, Sulawesi, Malaysia, Philippines

Northern America

Mexico:	Sinaloa, Jalisco, Guerrero, Chiapas

Southern America

Mesoamerica:	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama
Caribbean:	Cuba, Dominican Republic, Jamaica, Puerto Rico
Northern South America:	Bolivia, Ecuador, Guyana, Suriname, Venezuela
Brazil:	Bahia, Ceara, Para, Parana
Western South America:	Colombia, Ecuador, Peru

Neptunia plena

Asia—tropical

China:	Fujian, Guangdong
Indian subcontinent:	India—Andhra Pradesh, Goa, Gujarat, Madhaya Pradesh, Maharashtra, Orissa, Pondicherry, Punjab, Rajasthan, Tamil Nadu, west Bengal, Sri Lanka
Malesia:	Indonesia—Java, Malaysia, Singapore

Northern America

United States:	Texas
Mexico:	Baja California, Guerrero, Michoacan, Oaxaca, Sinaloa, Chiapas

Southern America

Mesoamerica:	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama
Caribbean:	Antigua-Barbuda, Aruba, Bahamas, Cuba, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Puerto Rico, Trinidad and Tobago
Northern South America:	Bolivia, Ecuador Galapagos, French Guiana, Guyana, Suriname, Venezuela
Brazil:	Bahia, Ceara, Maranhao, Para, Pernambuco
Western South America:	Colombia, Ecuador, Peru

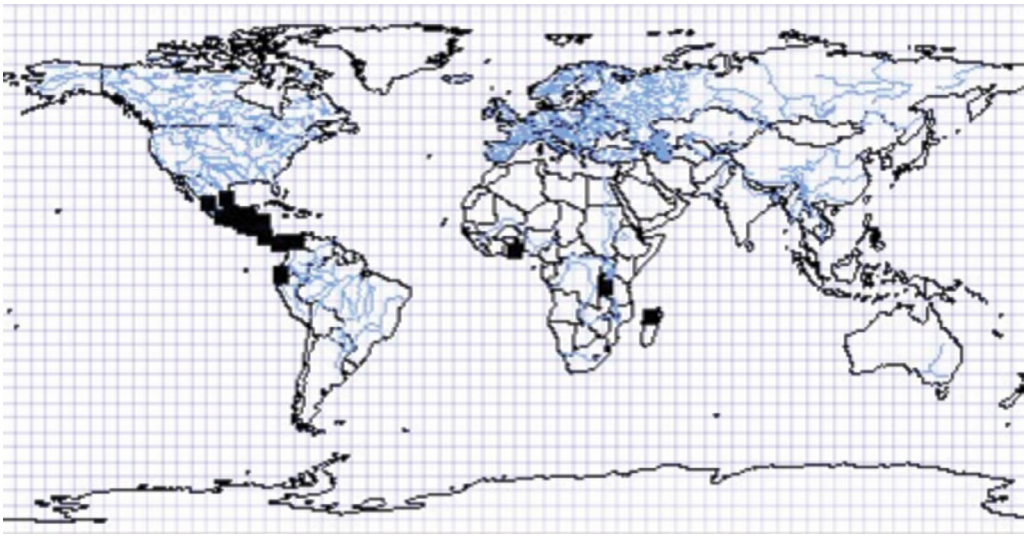

Figure 1. *N. oleracea* distribution (Missouri Botanic Gardens Tropicos W³ database).

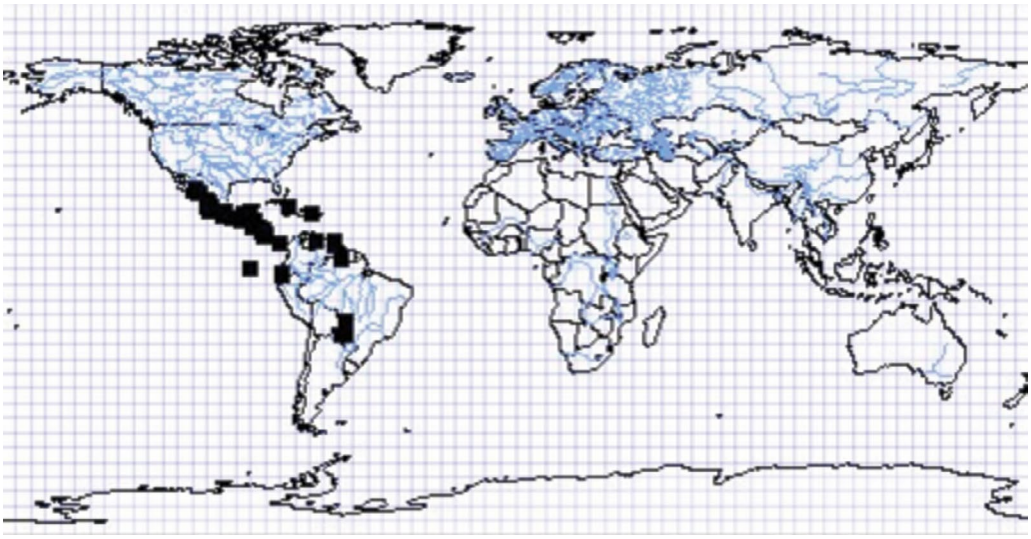

Figure 2. *N. plena* collections (Missouri Botanic Gardens Tropicos W[3] database).

Distribution in Australia

Three collections of *Neptunia* spp. have been made in South East Queensland in 2006. A further collection was made in North Queensland in May 2006. These were recorded by the Queensland Herbarium as follows:

First specimen: *Neptunia oleracea*

AQ number: 741904
ID number: 141/06

Collection details:

Date: 1 February 2006
Location: Property near the corner of School Road and Logan Reserve Road, backing onto the Logan River. Refidex map 262 B19. Growing in dam as a single clump. Used by Cambodian owner for eating growing tips.

Second specimen: *Neptunia oleracea*

AQ Number: 751351
ID Number: Brought to counter

Collection details:

Date: 15 February 2006
Location: Proposed monastery site, 27°47'25"S, 152°35'24"E.
Growing in 0.25 ha dam totally dominant from wet soil to 30 cm depth and rising over 60 cm above surface. Yellow flowers were observed. Population exhibited no insect damage.

Third specimen: *Neptunia plena*

AQ number: 751366
ID number: 465/06

Collection details:

Date: 29 March 2006
Location: Ritchie Road, Pallara. [South of Willawong–Acacia Ridge] 27°36'47"S, 153°00'03"E

Fourth specimen: *Neptunia plena*

AQ number: 767924
ID number: 669/06

Collection details:

Date: 3 May 2006
Location: Lake Placid approx. 20 km from Cairns
N. plena has been recorded at Virginia, south east of Darwin (12°33'S 131°1'E).

Preferred habitat and climate

N. oleracea and *N. plena* take root on the banks of watercourses but can grow out over the water surface, forming floating rafts. They tend to prefer canals, ponds and swamps. Within their native range, both species are common floating plants in and around fresh water pools, swamps and canals at low altitudes up to 300 m. When the water level falls during the dry season, the plants often perish. The rooted land form has smaller leaves and flowers, and has no spongy floating tissue. The plants prefers 30–80 cm depth of slow-moving water, full sun and hot and humid conditions. Shade, brackish water and saline soil adversely affect plant growth (Paisooksantivatana 1993).

History as a weed overseas and interstate

N. natans (= *N. oleracea*) has been assessed as a weed by Australian Quarantin and Inspection Servivce (AQIS) and entry into Australia of plant and seed is prohibited (AQIS ICON database 2006).

An infestation of *N. plena* was found in a waterhole on a property at Virginia, Northern Territory south-east of Darwin. It was controlled in October 2004, with follow-up into 2005. By mid-June 2005, there had been no regrowth, but monitoring of the area will continue for 5–10 years to check for regrowth and to carry out follow-up control as necessary (Northern Territory Department of Primary Industry, Fisheries and Mines, 2005).

Holm et al. (1991) listed *N. oleracea* as a weed in Cambodia, India and Thailand; however, its significance was not known. *N. oleracea* is also a problem plant in Madagascar in its putative native range.

Impact

N_2 fixation

N. oleracea and *N. plena* fix their own nitrogen via a symbiotic relationship with soil bacteria stored in specialised root nodules. *N. oleraceae* is nodulated by *Allorhizobium undicola* (De Lajudie et al. 1998) and *Devosia Neptuniae* (Rivas et al. 2002; Rivas et al. 2003). When cultivated as a vegetable, highest yields of these plants are achieved when an effective rhizobium is used for inoculation (Yanasugondha & Buranakarl 1981). In two studies in Brazil, there were differences in the $\delta^{15}N$ values for *N. oleracea* which are an indication of the amount of nitrogen derived from the atmosphere. In both studies, nodulation was present and abundant on *N. oleracea* but in one case the $\delta^{15}N$ value was surprisingly high and not dissimilar to non-legumes (Kern et al. 2000; Kreibich et al. 2006). This variation may be attributed to differences in nitrogen fixing ability of the nodulating bacteria or the amount of mineral nitrogen available in the water in which *N. oleracea* was growing. It is not known which rhizobium nodulates *N. oleracea* or *N. plena* in Queensland.

Effect on water resources

Neptunia spp. may increase water loss from dams through increased evaporation via water transpiration through its leaves.

Economic benefits

Ponded pasture

N. oleracea was recommended by Wildin et al. (1996) for evaluation and introduction trials as a potential pasture species to be used in conjunction with introduced grasses *Brachiaria mutica*, *Echinochloa polystachya* cv. Amity, and *Hymenachne amplexicaulis* cv. Olive in ponded pasture systems in Queensland. It has been suggested that *Neptunia* might be a valuable source of nitrogen for ponded pastures, as well as offering quality grazing to livestock.

Horticultural crop

N. oleracea is grown as a vegetable in South-East Asia, especially Thailand.

The energy value of *N. oleracea* is 184 kj/100 g. The edible portion of shoots contain (per 100 g):

Moisture	89.4 g
Protein	6.4 g
Fat	0.4 g
Carbohydrates	0.8 g
Fibre	1.8 g
Ash	1.2 g
Ca	887 mg
P	7 mg
Fe	5.3 mg
Vitamin A	5155 IU
Vitamin B1	0.12 mg
Vitamin B2	0.14 mg
Niacin	8.2 mg
Vitamin C	1.8 mg

N. oleracea is a popular Thai vegetable that is most often used in *yam phak ka ched*, a spicy and sour salad with seafoods or *kaeng som* soup.

Herbal medicine

The people of Kelantan (Malaysia) use the roots of *N. oleracea* as an external remedy for necrosis of the nose and hard palate. The juice of the stem is squeezed into the ear to cure earache and the root is used in the advanced stage of syphilis in Malaysia (Paisooksantivatana 1993).

In Nigeria, *N. oleracea* is used in the treatment of yellow fever and Guinea worm infection (Ita 1994).

An inhibitor of the tumour promoter induced Epstein-Barr virus activation, a chlorophyll related compound, Pheophorbide *a*, has been isolated from *N. oleracea* (Nakamura et al. 1996).

Pest potential in Queensland

N. oleracea and *N. plena* appear well adapted to tropical and subtropical freshwater wetlands in Queensland. In fact, climate modelling suggests that these species are well suited to much of northern Australia (Figure 3).

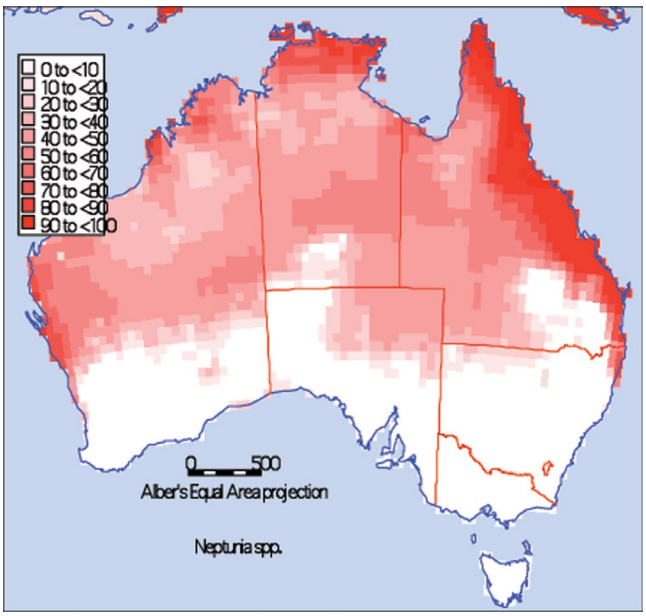

Figure 3. Potential distribution of *N. oleracea* and *N. plena*, as predicted by the CLIMEX computer software (deep red indicates areas where climate is most suitable, light red is marginally suitable and white is unsuitable).

Since *Neptunia* spp. are nitrogen-fixing legumes, their growth might increase levels of nitrogen in freshwater bodies, perhaps leading to increased algal blooms and increased vigour of associated weed species such as water hyacinth, water lettuce, salvinia and perhaps ponded pasture species such as aleman grass (*Echinochloa polystachya*), para grass (*Urochloa mutica*) and hymenachne (*Hymenachne amplexicaulis*). In the Amazon basin, *N. oleracea* is often found growing in association with aleman grass (Colares & Colares 2002).

Dense growth of *Neptunia* spp. might increase water loss from dams through increased evapo-transpiration.

Biological control

In South-East Asia, no diseases have been recorded and very few pests attack water mimosa. The larvae of the leaf roller *Synclita* sp. may attack the spongy tissue and stem. Plant-eating fish, turtles, ducks and geese feed on water mimosa (Paisooksantivatana 1993).

Neurostrota gunniella was introduced to Australia for the biological control *Mimosa pigra*. It was not released in South-East Asia because it 'showed substantial attack on the important vegetable *N. oleracea*' (Forno et al., 2000). *Neurostrota gunniella* could have a greater impact on *N. oleracea*, being a softer fleshy plant, than on *Mimosa pigra*. There is some optimism about the potential performance of *Neurostrota gunniella* in South East Queensland (Wendy Forno, pers. comm.)

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