EPPO data sheet on Invasive Plants

Myriophyllum aquaticum

IDENTITY

Preferred scientific name: *Myriophyllum aquaticum* (Vell.) Verde.
Other scientific names: *Enydria aquatica* Vell., *Myriophyllum brasiliense* Cambess., *Myriophyllum proserpinacoides* Gillies ex Hook. & Arn.
Taxonomic position: Haloragidaceae.
Common names: Parrot-feather, parrot feather watermilfoil water feather, Brazilian water milfoil (English), millefeuille aquatique, millefeuille du Brésil, myriophylle aquatique, myriophyllum variété verte (French), pinheirinha (Portuguese).
EPPO computer code: MYPBR
Notes on taxonomy and nomenclature
There are some 60 species of *Myriophyllum*, submerged, emergent or seasonally terrestrial, but only two are major aquatic weed species, *M. aquaticum* and the Eurasian milfoil *M. spicatum*.

MORPHOLOGY

M. aquaticum is a stout, aquatic or marsh-dwelling herb, with glabrous stems up to 2 m long and 4-5 mm diameter near the base, glaucous, and rooting freely from lower nodes. Submerged leaves in whorls of (4-)5-6, oblanceolate in outline, rounded at apex (1.7-) 3.5-4.0 cm long, (0.4-) 0.8-1.2 cm wide, pectinate, with 25-30 linear pinnae up to 0.7 cm long, the lower leaves usually decaying rapidly. Emergent leaves glaucous, bright blue-green, in whorls of (4-) 5-6, erect near apex, spreading in lower parts, narrowly oblanceolate in outline, rounded at apex, (1.5-) 2.5-3.5 cm long, (0.4 -) 0.7-0.8 cm wide, pectinate, with (18-) 24-36 pinnae in the upper part, the lower 5-7 mm of rachis naked); pinnae linear to subulate, 4.5-5.5 mm long, 0.3 mm wide, tips very shortly apiculate, slightly incurved. Numerous hydathodes at base of leaves. Both submerged and emergent leaves may occur on the same stem in plants growing in deeper waters, when the emergent portion tends to lie on or just above the surface. *M. aquaticum* is dioecious, males much less common than females. Inflorescence an indeterminate spike with flowers singly borne in axils of upper emergent leaves, subtended by 2 bracteoles. Bracteoles subulate, 1.2-1.5 mm long with (1-) 2 short teeth in the lower-third, sometimes almost trifid. Flowers strictly unisexual. Male flowers tetramerous, sessile at first, with pedicels to 4 mm long usually developing at anthesis. Sepals 4, ovate-deltoid, 0.7-0.8 mm long, 0.3 mm wide, very weakly denticulate, smooth. Petals 4, yellow, weakly hooded and keeled, (2.3-) 2.7-3.1 mm long, 0.8-1.1 mm wide. Stamens 8; filaments 0.1 mm long at anthesis; lengthening later to up to 1.2 mm; anthers yellow, linear-oblong (1.8-) 2.0-2.7 mm long, 0.2 mm wide, non-apiculate. Styles 0. Female flowers tetramerous, on pedicels 0.2-0.4 mm long. Sepals 4, white, deltoid, 0.4-0.5 mm long, 0.3 mm wide, denticulate with one to several small teeth on each margin, smooth. Petals 0. Stamens 0. Styles 4, clavate, 0.1-0.2 mm long, stigmas white, densely fimbriate. Ovary pyriform, 0.6-0.7 mm long, 0.6 mm wide, 4-ribbed longitudinally between sepals. Fruit (immature) on pedicel 0.7-0.8 mm long, cylindrical to ovoid, 1.7 mm long, 1.3-1.4 (-1.7) mm diameter. Sepals are first persistent, erect, deltoid, 0.6 mm long, 0.3 mm wide, toothed towards tip, withering at maturity. Mericarps cylindrical, 1.7 mm long, 0.6-0.7 mm diameter, slightly wider towards base, apex oblique, with an indistinct thickened rim, otherwise smooth, rounded on dorsal surface. Description after Orchard (1981).

SIMILARITIES TO OTHER SPECIES

The presence of emergent stems distinguishes *M. aquaticum* from related species, resembling miniature Christmas trees, generally having few branches, standing up to 30 cm or more high in shallow waters or muddy areas. *M. aquaticum* also differs from *M. spicatum* in having pinnatisect bracts, whereas those of *M. spicatum* are entire or only serrate.

PLANT TYPE

M. aquaticum is an aquatic (or semi-terrestrial) perennial plant, overwintering as rhizomes.

BIOLOGY AND ECOLOGY

M. aquaticum is a perennial tolerating disturbance caused by mechanical cutting, with shoots growing rapidly from overwintering rhizomes as water temperatures increase, with rhizomes also acting as a support for adventitious roots and providing buoyancy for emergent growth. Its stems may float out over the surface to form dense tangled rafts from which the emergent shoots arise. Small fragments root easily in mud to establish new colonies, and vegetative propagation appears to be much more important than seed production as a means of dispersal, and indeed in most of its introduced range male plants appear to be absent. *M. aquaticum* exhibits a high uptake of nitrogen and phosphorus (Barko and Smart, 1981; Sytsma and Anderson, 1993), a characteristic feature of highly competitive plants adapted to life in productive environments (Rejmankova, 1992; Murphy, 1995), but does not store phosphorus or carbon in its rhizomes which may explain the failure of to invade areas with cold winters.

Environmental requirements

In its native South America, *M. aquaticum* prefers warm areas, such as in Argentina, Chile, Peru and southern Brazil, over hotter tropical regions (Fernández et al., 1993). Warm, shallow water and eutrophic conditions favour the growth of *M. aquaticum* (Sutton, 1985), and it is moderately resistant to salinity (Haller et al., 1974), growing well at 3.3 parts per thousand salinity but killed by 10 parts per thousand.

Climatic and vegetational categorization

M. aquaticum is associated with areas with a warm to hot wet summer and a cool to hot winter. It is hardy only to zone 10 (-1 to 4°C). It is associated with the vegetation zones: temperate to tropical deciduous forests (extending to temperate steppes).

HABITAT

M. aquaticum is mainly found growing in low-lying areas, in shallow waters and on muddy substrates, but is also recorded at up to 1900 m altitude in Brazil and 3250 m in Peru. It is typically found in floodplain lagoon and backwater habitats of major rivers such as the Paraná in Brazil, and is listed as a weed in lakes, ponds, marshes, fens and irrigation channel systems in Argentina and Brazil, and in lakes and ponds only in Chile (Fernandez et al., 1993). Where introduced and invasive it is common in irrigation lines, ponds, streams and other water bodies.

CROPS / OTHER PLANTS AFFECTED

M. aquaticum is a rice weed in Indonesia and Cambodia, whereas the closely related *M. spicatum* is a weed of transplanted and deep-water rice in Bangladesh, India and Vietnam. In other areas, it principally affects natural vegetation on river and canal systems, ponds and lakes.

PATHWAYS FOR MOVEMENT AND DISPERSAL

Myriophyllum species have been largely spread by human dispersal, mainly via the trade in aquatic plants for aquaria. Once established in a new locality their spread is via a range of mechanisms. *M. spicatum* is easily spread downstream in the form of vegetative fragments and seeds, and in the Okanagan/Columbia river system of Canada and the north-western USA it advanced some 500 km during the period 1977-84, passing through four major dams and their impoundments. Plant fragments are also easily transported attached to ships or boats. In Egypt, f fragments on ships and other river traffic is the most likely mechanism for the upstream spread of *M. spicatum* as far as the Aswan dam. The spread of *M. spicatum* via natural vectors, such as in or on waterfowl is considered possible but unconfirmed.

USES AND BENEFITS

The main use of *M. aquaticum* is as an attractive ornamental species in ponds and aquaria, and it continues to be used and traded even though the risks posed by its spread are increasingly well known.

GEOGRAPHICAL DISTRIBUTION

EPPO region: Austria, France, Germany, Portugal, United Kingdom.
Asia: Cambodia, Indonesia (Java), Japan, Malaysia, Philippines, Thailand, Vietnam.
Africa: Madagascar, South Africa, Zimbabwe.
North America: Mexico, USA (Alabama, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New Jersey, New York, North Carolina, Massachusetts, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, Washington).
Central America and Caribbean: Costa Rica, Nicaragua.
South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay.
Oceania: Australia (New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia), New Zealand.

HISTORY OF INTRODUCTION / SPREAD

M. aquaticum is indigenous to South America (Orchard, 1981; Sutton, 1985), preferring subtropical areas (Fernandez et al., 1993). It was first found in Europe in around 1880 near Bordeaux, France where its invasive nature was noticed in 1913, and was recorded in the UK in 1960. The first record in North America was in 1890 in New Jersey and it had reached Washington by 1944. *M. aquaticum* was recorded in South Africa by 1919, Japan in 1920, New Zealand in 1929 and Australia in the 1960s. It is a problem weed in its native South America (Fernandez et al., 1993) and is aggressively spreading in Southern Africa, South East Asia, USA (Anderson, 1993) and Portugal (Teles and Pinto da Silva, 1975). *M. aquaticum* occurs but appears to not cause serious problems in cooler regions of central Europe.

IMPACT

Economic impact

Anderson (1993) outlines the ways in which aquatic weeds such as *M. aquaticum* can have detrimental impacts, including interference with the flow of irrigation water, transport, hydro-electric power production, fisheries, recreation, and increased risk of health hazards. Some specific problems reported for *M. aquaticum* include interference with fisheries in South Africa (Jacot-Guillarmod, 1977), major problems for hydroelectric power production and forestry development in Argentina (Fernandez et al., 1993) and increased incidence of mosquitoes in California (Anderson, 1993). *M. aquaticum* is a particular problem in irrigation channel and river systems, being one of the two most important aquatic weeds at 39% of sites surveyed in the Sorraia river system in Portugal. In California it had infested 24% of irrigation channel systems with 914 km of waterway affected by 1985, with direct control costs approximately Euro 200,000 over a 2-year period, with total annual expenditure on aquatic weed control in the western USA estimated to be up to Euro 50 million (Anderson, 1993).

Impacts on biodiversity

While *M. aquaticum* may provide cover for some aquatic organisms, it can seriously change physical and chemical characteristics of water bodies, and infestations alter aquatic ecosystems by shading out algae that serve as the basis of the aquatic food chain. In eutrophic coastal or brackish waters conditions it has been observed to displace native species.

RISK AND IMPACT FACTORS

M. aquaticum has negative impacts on the environment, biodiversity, native flora and fauna, tourism and transport.

SUMMARY OF INVASIVENESS

M. aquaticum has been introduced to most continents, and has proved to be highly invasive, especially in the USA, Australia and Europe. Original introductions all appeared to be deliberate, for use as an ornamental aquarium or pond plant, from where it escaped and spread rapidly by vegetative means. Its continuing use, promotion and availability as an ornamental species means further introduction to other areas is likely, of *M. aquaticum* or other closely related and probably equally invasive species of *Myriophyllum*.

	CHARACTERISTIC	**(Y)es, (N)o**
	Invasiveness	
1	Is the species invasive in its native range?	Y
2	Has it proved invasive outside its native range? (i.e. is it an invasive alien species)?	Y
3	Is it highly adaptable to different environments?	N
4	Does it have high reproductive potential? (e.g. for weeds; prolific seed production, high germination rate, reproduction by rhizomes, tubers, stolons or root/stem fragments).	Y
5	Is it highly mobile locally? (i.e. for weeds, propagules capable of moving long distances by wind, water, attachment to machinery, animals or humans).	Y
6	Can its propagules remain viable for more than one year?	N
7	Does it tolerate, or benefit from, cultivation, browsing pressure, mutilation, fire etc?	Y
	Impacts	
8	Is it competitive to agricultural and plantation crops or pasture plants?	Y
9	Does it cause impacts on ecosystem processes? (e.g. hydrology, sedimentation, fire risk, nutrient cycling etc.).	Y
10	Does it adversely affect natural communities? (biodiversity, native populations, endangered or threatened species) by competition or hybridization (underline one or both).	Y
11	Does it adversely affect community structure? (e.g. effects on the food chain, elimination or creation of a canopy).	Y
12	Does it adversely affect human health? (e.g. allergies, effects on water or air quality).	N
13	Does it have sociological impacts on recreational patterns, aesthetics, property values?	Y
14	Is it harmful to animals? (e.g. poisonous plant parts or vector of animal diseases).	N
15	Does it produce spines, thorns or burrs (or other discomfort)?	N
16	Is it a host or vector to recognised pests and pathogens of agriculture or forestry etc?	N
	Likelihood of entry/control	
17	Is it highly likely to be transported internationally (a) accidentally? (e.g. as a contaminant).	N
18	Is it highly likely to be transported internationally (b) deliberately? (e.g. as an ornamental)	Y
19	Is it difficult to identify / detect as a commodity contaminant? (e.g. due to small seed size)	N
20	Is it difficult to identify / detect in the field? (e.g. similarities to other species, inconspicuousness)	N
21	Is it difficult / costly to control? (e.g. resistance to pesticides)	Y

CONTROL

Mechanical control

M. aquaticum regrows rapidly from shoot fragments and as such mechanical cutting is rarely effective (Jacot-Guillarmod, 1977), however, more effective harvesting systems that remove the biomass and accumulated nutrient reserves may offer control possibilities (Sytsma and Anderson, 1993). The ecology and succession of *M. aquaticum* resulting from mechanical clearance in two highly mineralized, nutrient-rich canals in central Portugal is described by Ferreira and Moreira (1990).

Chemical control

M. aquaticum is highly susceptible to 2,4-D, in spray or granular formulations (Blackburn and Weldon, 1963; Braddock, 1966) and most effective when applied to young, actively-growing plants (Sutton and Bingham, 1970). Also effective are simazine, copper (Sutton et al., 1969; Sutton and Blackburn, 1971), endothal and dichlobenil (Mixon, 1974; Sikka et al., 1974). Glufosinate ammonium and 2,4-D amine were more effective than diquat and glyphosate in Portugal (Monteiro and Moreira, 1990).

Biological control

Cattle and waterfowl graze the shoots, but standard biocontrol fish such as grass carp (*Ctenopharyngodon idella*) were found to dislike *M. aquaticum* in Portugal and in the USA (Pine and Anderson, 1991), possibly due to high levels of tannin. There are no biocontrol agents. The insects *Lysathia flavipes* and *Listronotus marginicollis* attack *M. aquaticum* in its native range in Argentina (Habeck and Wilkerson, 1980), *Parapoynx allionealis* larvae mine the leaves and *Lysathia ludoviciana* and *Pythium carolinianaum* attack stems in the USA (Bernhardt and Duniway, 1984). However, it is rare to observe *M. aquaticum* in other than vigorous health, suggesting a high degree of natural resistance to pests and disease. Verma and Charudattan (1993) reported that *Mycoleptodiscus terrestris* formulated as a mycoherbicide in alginate beads showed some toxicity to *M. aquaticum*.

REGULATORY STATUS

M. aquaticum is a declared noxious aquatic weed in parts of the USA including Vermont (class A), Washington (class B) and Alabama (class C) and is on invasive species lists in a number of other states (USDA-NRCS, 2004).

In Canada and elsewhere, quarantine measures have been introduced involving public information campaigns and boat inspections (for example at ferry landing points on Vancouver Island, British Columbia) to try to minimize transfer of plant material to uninfested river and lake systems.

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