EPPO Datasheet: *Pistia stratiotes*

Last updated: 2020-04-23

IDENTITY

Preferred name: *Pistia stratiotes*
Authority: Linnaeus
Taxonomic position: Plantae: Magnoliophyta: Angiospermae: Basal monocotyledons: Alismatales: Araceae: Aroideae
Other scientific names: *Pistia occidentalis* Blume
Common names: Nile cabbage, tropical duckweed, water lettuce (US)
view more common names online...
EPPO Categorization: A2 list
view more categorizations online...
EU Categorization: IAS of Union concern
EPPO Code: PIIST

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GEOGRAPHICAL DISTRIBUTION

History of introduction and spread

The native range of the species is not clear, but it is suggested, that the species is either native to South America (Neuenschwander *et al.* 2009), or that *P. stratiotes* is a pan-tropical species occupying a native range across the tropical and subtropical regions of Asia, Africa, Australia and South America (Gillett *et al*., 1988; Evans 2013). See EPPO (2020 and 2017) for further details.

Pistia stratiotes has a pan-tropical and subtropical distribution. *P. stratiotes* is widespread throughout Africa, where the plant was first recorded in South Africa in 1865 from KwaZulu-Natal (Hill, 2003). In North Africa, *P. stratiotes* was first recorded on a small multipurpose impoundment near the town of Fez in Morocco in 2012 (Hill, 2013).

In Asia, *P. stratiotes* has a wide distribution and is recorded as invasive (CABI, 2016). The plant was recorded in the Philippines as early as 1925, floating in abundance in shallow waters (Merrill, 1925; Waterhouse, 1997).

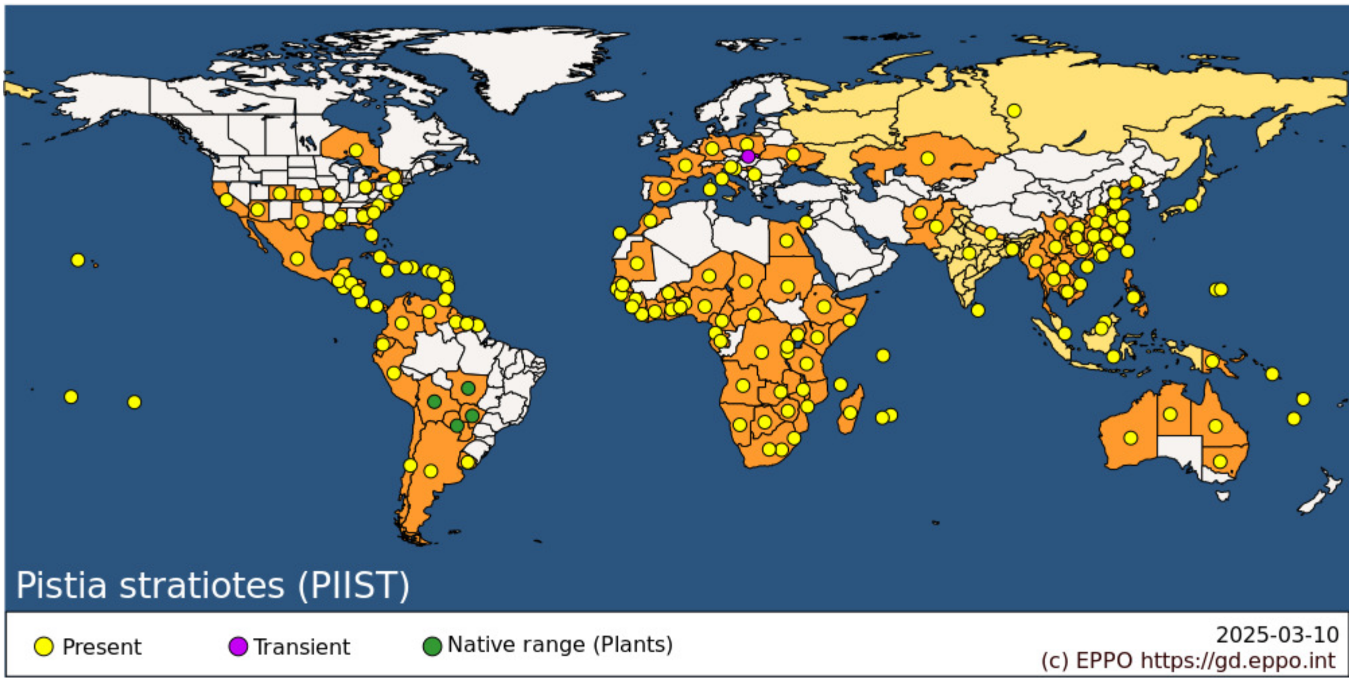
Pistia stratiotes is widespread in the Northern Territory in Australia. The species has been eradicated from the North Island of New Zealand. *Pistia stratiotes* is invasive in Papua New Guinea where it was first recorded in 1971.

Pistia stratiotes occurs in several states in the USA. It is generally considered as an introduced plant species and is classified as a pest species and under regulation in some states. There are casual records from the Great Lakes (Adebayo *et al.*, 2011).

In the EPPO region, *P. stratiotes* was first recorded in the Netherlands in 1973, but plants did not become established (Mennema, 1977). The first reports from Austria and Germany were made in 1980. Repeated introductions failed to establish in Germany up until 2005; however, since 2008, an established population has been permanently present in thermal sections of the River Erft (Hussner, 2014). In Italy, *P. stratiotes* was found first in 1998 (Brundu et al., 2012). In France, *P. stratiotes* was found once in the Landes department in 2003, but is now no longer present (EPPO, 2012). Several casual populations have been recorded in the Mediterranean parts of France since 1998 (SILENE, 2016). *Pistia stratiotes* is now considered as established in at least one location, in a canal along the Rhône, where first observations date back to 2005 (G. Fried, 2016, pers. comm.). In 2012, management action was undertaken due to the high density reached by *P. stratiotes* colonies at the end of the summer. In September 2016, *P. stratiotes* was recorded along 17 km of the canal, including several portions with 100% cover.

In Slovenia, an established population has been documented from thermal rivers (Sajna *et al.*, 2007). In Belgium, the species was first observed in 2000, and was still present in 2015, mainly in East Flanders (Verloove, 2006; update 2015). In Russia, *P. stratiotes* is known from some ponds and rivers around Moscow (Schanzer *et al.*, 2003). *Pistia stratiotes* was found in Spain (Garc?a Murillo *et al.*, 2005), although the species is no longer present on the mainland. On the Canary Islands, the species is considered invasive. In the United Kingdom, the species is occasionally recorded: four occurrences are detailed as persisting for more than 5 years in the database of the Botanical Society of Britain and Ireland. *Pistia stratiotes* was first discovered in Somerset in 2004, when a few plants were discovered on the Burnham Levels. The plant was recorded as well established in the Bridgwater and Taunton Canal in 2010 (Somerset Rare Plant Group Newsletter, 2010).

Distribution



EPPO Region: Croatia, France (mainland), Germany, Israel, Italy (mainland, Sardegna), Kazakhstan, Morocco, Poland, Russia, Serbia, Slovakia, Slovenia, Spain (mainland, Islas Canárias), Ukraine
Africa: Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Democratic republic of the, Cote d'Ivoire, Egypt, Equatorial Guinea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe
Asia: Afghanistan, Bangladesh, Brunei Darussalam, Cambodia, China (Anhui, Aomen (Macau), Chongqing, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Liaoning, Shandong, Sichuan, Tianjin, Xianggang (Hong Kong), Yunnan, Zhejiang), India, Indonesia, Israel, Japan, Kazakhstan, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam
North America: Canada (Ontario), Mexico, United States of America (Arizona, California, Colorado, Delaware, Florida, Georgia, Hawaii, Kansas, Louisiana, Maryland, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, South Carolina, Texas)
Central America and Caribbean: Antigua and Barbuda, Belize, Costa Rica, Cuba, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Montserrat, Nicaragua, Panama, Puerto Rico, Saint Lucia, Trinidad and Tobago, Virgin Islands (US)
South America: Argentina, Bolivia, Brazil (Mato Grosso, Mato Grosso do Sul), Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela
Oceania: Australia (New South Wales, Northern Territory, Queensland, Western Australia), Cook Islands, French Polynesia, Guam, New Caledonia, Northern Mariana Islands, Papua New Guinea, Solomon Islands, Vanuatu

MORPHOLOGY

Plant type

Perennial floating aquatic macrophyte.

Description

Pistia stratiotes is a free-floating plant with a rosette of obovate to spatulate, short haired leaves. *Pistia stratiotes* is a clonal plant that forms small colonies with daughter plants attached to the mother plant through stolons. Dispersal is enhanced through detachment of daughter plants which form new colonies. The upper sides of the leaves are light green, while the undersides are almost white. The floating plants have large feathery root systems which hang freely in the water. The solitary inflorescence is axillary and inconspicuous, with short peduncles in the centre of the rosette. The spadix, with a single pistillate flower and several staminate flowers enclosed in a whitish spathe, is pale green, hairy outside and glabrous inside (Neuenschwander *et al.*, 2009). The peduncle bends after fertilization and pushes the fruits under water where up to 30 seeds per fruit can be released (Neuenschwander *et al.*, 2009; Kurugundla, 2014). Flowering plants are widely observed within the EPPO region and the plants produce numerous viable seeds (Hussner, 2014).

BIOLOGY AND ECOLOGY

General

Mats of *P. stratiotes* can cause similar problems to those caused by excessive growth of other floating plants; for example, they can reduce access to the water for recreation; interfere with various engineering structures such as weirs, floodgates or locks; block drains and cause flooding; stop livestock reaching water; prevent photosynthesis in the water below the mat; degrade potable water; impact native animals and plants more generally by significantly altering aquatic ecosystems; reduce the aesthetic appeal of water bodies; and favour the spread of certain diseases spread by mosquitoes and snails.

Habitats

Pistia stratiotes grows in slow-moving rivers and reservoirs, irrigation channels, ponds, lakes, canals and ditches (Cilliers, 1991; Venema, 2001; Adebayo *et al.*, 2011; Hussner *et al.* 2014). The species often invades rice paddies in Asia as well as other wetland habitats. *Pistia stratiotes* can survive drying and can re-infest ephemeral waters which are subject to seasonal drying because of seed survival and germination.

Environmental requirements

Pistia stratiotes can grow under varying physical and chemical conditions. Its growth is optimal at temperatures between 22 and 30°C and high-nutrient conditions (Pieterse *et al*., 1981; Henry-Silva *et al*., 2008). However, plants still develop at temperatures as low as 10°C (Pieterse *et al.*, 1981; Hussner *et al.*, 2014). The plants are susceptible to low temperatures and frost, and die back when enclosed in ice and at temperatures slightly above 0°C (MacIsaac *et al.*, 2016) (Fig. 1). *Pistia stratiotes* can withstand freezing air temperatures as the small floating form, as long as the leaves are in direct contact with the water surface in water temperatures >10°C (Hussner *et al.*, 2014). Seeds of *P. stratiotes* germinate at a lower temperature limit of 20°C, are resistant to frost and can withstand temperatures of -5°C; however, germination rates decrease with a prolonged period of frost (Pieterse *et al.*, 1981; Kan & Song, 2008; Hussner *et al*., 2014; Kurugundla, 2014). *Pistia stratiotes* was found to be tolerant to salt and can withstand 200 mM NaCl in the water (6 PSU) (Upadhyay & Panda, 2005).

Natural enemies

There are no known natural enemies of *P. stratiotes* within the EPPO region. Biological control using *Neohydronomus affinis* is considered to be the most effective control method (Hill, 2003). However, this biological control agent requires a certain temperature regime, and thus the use of *N. affinis* seems not to be an option within most parts of the EPPO region.

Uses and benefits

Pistia stratiotes is widely sold as an ornamental species within the EPPO region. The species is also sold/exchanged between aquarists. The species regularly features on aquatic plant websites and online retailers.

Outside the EPPO region, *P. stratiotes* is widely used for phytoremediation of metals, chemical products, oil, removal of pharmaceuticals and personal care products or for urban sewage treatment. *Pistia stratiotes* biomass can be used for bioethanol production, with ethanol yields per unit biomass comparable to that of other agricultural biomasses (Mishima *et al.*, 2008), and biogas production (Abbasi *et al.*, 1991). However, implementation of this is unlikely to be economically viable based on experiences in Uganda and elsewhere (M Hill, 2016, pers. comm.).

The fibre content, carbohydrate and crude protein content of P. stratiotes is comparable to that of quality forages (Parsons & Cuthbertson, 2001). While cows find *P. stratiotes* unpalatable, the plants can be fed to pigs (Nonindigenous Aquatic Species Database, 2015). *Pistia stratiotes* is also used in Ayurvedic medicine and for its diuretic, antidiabetic, antidermatophytic, antifungal and antimicrobial properties (Nonindigenous Aquatic Species Database, 2015).

PATHWAYS FOR MOVEMENT

Plants for planting is considered the main pathway for entry into the EPPO region. Brunel (2009) reports that more than 3600 individual plants were imported into the EPPO region (mainly into France), though the period of these imports is not specified. From this pathway, the individual plants can be transferred to suitable habitats through either intentional introductions into the environment or unintentionally through the disposal of aquarium material.

Consideration can be given to river systems within the EPPO region which are connected to countries outside the EPPO region. It is possible that the use of recreational equipment (e.g. fishing or canoeing gear) could spread the species, particularly as seeds or seedlings, although this is not likely to be a significant pathway at present given the rarity of the plant within the EPPO region. However, there are campaigns within the EU to raise awareness of the movement of invasive alien plants by this pathway. For example, the ‘Check, Clean and Dry’ campaign in Great Britain highlights the need to inspect and treat recreational material following use.

IMPACTS

Effects on plants

In general, dense monospecific growth of any aquatic plant species can incur impacts on native plant communities and other aquatic organisms such as macro- and micro-invertebrates, fish and waterfowl (Carpenter & Lodge, 1986). This species can completely transform and alter trophic dynamics, resulting in long-term changes.

Dense mats of *P. stratiotes* block sunlight, reducing primary production, and decrease water turbidity (Cai, 2006 in Neuenschwander *et al.*, 2009). Furthermore, the water shaded by *Pistia* shows decreased levels of oxygen and increased levels of nitrate, ammonium and phosphorus (Neuenschwander *et al.*, 2009). As a result of this altered habitat, submerged vegetation decreased under dense mats along the River Erft in western Germany (Hussner, 2014). Cilliers *et al.* (1996) reported that *P. stratiotes* threatens indigenous flora and fauna in South Africa.

Environmental and social impact

Pistia stratiotes may have serious negative effects on the multifunctional human use of water bodies. These harmful effects include impediment of the transport of irrigation and drainage water, interference with hydroelectric schemes from artificial lakes, hindrance of navigation and fishing and the creation of habitats favourable for the transmission of water-borne diseases (Mbati & Neuenschwander, 2005).

The dense mats of *P. stratiotes* can provide a suitable habitat for disease-carrying mosquitoes such as *Culex*, *Anopheles* and *Mansonia* species (Lounibos & Dewald, 1989). This has serious implications for human health. Gangstad & Cardarelli (1990) note that larvae of *Mansonia* mosquitoes may obtain oxygen directly from the roots of *P. stratiotes*.

There are references on the impact of the species in rice paddies, where it is documented as a serious weed (SuasaArd, 1979 in Dray & Center, 2002); however, it is also documented as having a positive effect on rice yields when used as a soil conditioner (Roger *et al.*, 1984). Although no accurate measurements are available of the loss of water needed for agriculture through transpiration from beds of *P. stratiotes*, losses are believed to be considerable (Holm *et al*., 1977). *Pistia stratiotes* can reduce water flow in drainage and irrigation systems and flood control canals (Dray & Center, 2002), and increase water loss by evapotranspiration (Sharma, 1984; but see Allen *et al.*, 1997 in Neuenschwander et al., 2009 for contrasting results). *Pistia stratiotes* mats also block water flow and reduce hydropower production (Dray & Center, 2002).

Increased mortality rates of fish and macro-invertebrates has been reported from the USA as a result of the presence of *P. stratiotes* (Dray & Center, 2002). In addition, the presence of *P. stratiotes* can increase the rates of siltation which can act to smother and degrade fish spawning sites (Dray & Center, 2002). Besides the blocking of sunlight, *Pistia* mats limit the wind-induced mixing of the water column, and thus the water beneath *Pistia* mats can become thermally stratified (Sculthorpe, 1967; Attionu, 1976), with reduced dissolved oxygen levels and increased alkalinity.

Impacts in the EPPO area are of course likely be attenuated by climatic suitability, but in areas where *P. stratiotes* will overwinter and spread, impacts are likely to be similar. For example, many of the impacts on biodiversity relate to ecosystem processes such as decomposition and the alteration of nutrient cycling, which, assuming that *P. stratiotes* is able to reach the levels of abundance required for these impacts to be displayed, can be assumed to occur in these areas just as much as in the current area of distribution.

Aquatic free-floating plants are highly opportunistic and have the ability to exploit novel habitats. Other non-native mat-forming species have been shown to have high impacts in the pest risk analysis (PRA) area. Ecological impacts occur within the PRA area on flora and fauna, specifically documented for the former in the River Erft in Germany, where floating mats shade out native submerged vegetation.

The potential economic impact of *P. stratiotes* in the EPPO region could be significant if the species spreads and establishes in further areas. There is potential for the species to impede transport and affect recreation, irrigation and drainage. Based on experience elsewhere in the world, management is likely to be both expensive and difficult. There are no indigenous host-specific natural enemies in the EPPO region to regulate the pest species, and in many EPPO countries herbicide application in or around water bodies is highly regulated or not permitted.

CONTROL

P. stratiotes can be controlled using chemical, physical/ mechanical and biological means (reviewed in Global Invasive Species Database, 2005 and CABI, 2016).

As for all aquatic plants, removal by hand is recommended for early infestations and small areas in particular. Weed harvesters can be used for biomass reduction of large infestations, but eradication is only achievable in combination with other control options (e.g. hand removal, chemical control). All hand or physical removal should be carried out before the plant starts to produce viable seeds to limit the risk of plant re-growth Queensland Government (2017).

The biological characteristic that allows for its persistence after mechanical control is that it can reproduce vegetatively from plant fragments that remain in situ after treatment. Seeds, if present and able to germinate, may persist in an area subject to control by either approach, requiring continued control over a number of years to increase the probability of achieving eradication (Millane & Caffrey, 2014).

Chemical control of *P. stratiotes* is carried out using various herbicides with different levels of efficacy. Glyphosate, diquat, bispyribac-sodium, flumioxazin and imazamox caused biomass reduction of up to >99% (Martins *et al.*, 2002; Emerine, 2010; Mudge & Haller, 2012; Glomski & Mudge, 2013). Chemical control has also been used in combination with biological control (Cilliers *et al.*, 1996). Repeated applications would be needed to effectively eradicate large populations, but eradications of small populations would be feasible. Re-infestation is possible from untreated plants and regeneration from seeds.

Based on annual costs in Florida associated with controlling *P. stratiotes* on at least 4000 ha of public waterways, total expenditures exceed 2 million USD (Center, 1994). Other states in the eastern USA spend a combined total of more than 100 000 USD per year on *P. stratiotes* control (Center, 1994). In Florida, the combined total cost for controlling *P. stratiotes* and *Eichhornia crassipes* equates to 4– 5 million USD per year, over the last 40 years.

To date, 46 species of phytophagous insects have been recorded on *P. stratiotes* (South America 25 species, Asia 13 species, Africa 8 species) (Cordo & Sosa, 2000). Most of these species are generalist that are not suitable for biological control, but 11 weevil species, belonging to the genera *Neohydronomus*, *Pistiacola* and *Argentinorhynchus* , are assumed to be monophagous.

REGULATORY STATUS

Europe (overall): *P. stratiotes* has been on the EPPO List of Alien Invasive Plants since 2012; prior to that it was on the EPPO Alert List from 2007. In 2016, *P. stratiotes* was identified as a priority for risk assessment within the requirements of Regulation 1143/2014 (Branquart *et al.*, 2016; Tanner *et al.*, 2017). A subsequent PRA concluded that *P. stratiotes* had a high phytosanitary risk to the endangered area (EPPO, 2017) and was added to the EPPO A2 List of pests recommended for regulation. In 2022, *P. stratiotes* was added as a species of (EU) Union concern (EU Regulation 1143/2014).

Netherlands: a code of conduct recommended that the sale of *P. stratiotes* is only allowed when additional information is provided on the label. The warning label must inform customers about the potential invasion risk of the species to reduce the risk of release into the wild (Verbrugge *et al.*, 2014).

Germany: *P. stratiotes* has been listed as a potentially invasive plant (Nehring & Hussner, 2013) and the Federal Agency for Nature Conservation, Germany recommends that the species is not traded.

Portugal: in Portugal the species is included in the list of prohibited plants Decreto-Lei no. 565/99 (http://www.silva plus.com/fotos/editor2/LegislacaoPT/Floresta/dec_lei_565_ 99.pdf).

Spain: in Spain, the species is included in the list of the prohibited species of the Real Decreto 630/2013 (http://www. boe.es/boe/dias/2013/08/03/pdfs/BOE-A-2013-8565.pdf).

North America: *P. stratiotes* is listed as an alien species in Alabama (class C, noxious weed), California (B list, noxious weed), Connecticut (potentially invasive, banned), Florida (prohibited aquatic plant, Class 2), South Carolina (invasive aquatic plant) and Texas (noxious plant) (USDA, 2015).

New Zealand: *P. stratiotes* is legally prohibited from sale (Champion *et al.*, 2014).

Japan: *P. stratiotes* is subject to legal control (https://www.nies.go.jp/biodiversity/invasive/DB/etoc8_plants.html).

South Africa: in South Africa control of the species is enabled by the Conservation of Agricultural Resources (CARA) Act 43 of 1983, as amended, in conjunction with the National Environmental Management: Biodiversity (NEMBA) Act 10 of 2004. *P. stratiotes* was specifically defined as a Category 1b ‘invader species’ on the NEMBA mandated list of 2014 [Invasive Species South Africa (2017)]. Category 1b means that the invasive species ‘must be controlled and wherever possible, removed and destroyed. Any form of trade or planting is strictly prohibited’ (http://www.en vironment.gov.za).

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