European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

EPPO Data sheets on invasive alien plants
Fiches informatives sur les plantes exotiques envahissantes

Ludwigia grandiflora and *L. peploides*
Onagraceae – Water primroses

Identity

Scientific name: *Ludwigia grandiflora* (Michx.) Greuter & Burdet
Synonym: *Ludwigia uruguayensis.*
Taxonomic position: Magnoliopsida (Dicotyledons), Onagraceae.
Common names: Perennial water primrose, Uruguayan primrose willow [EN].
EPPO code: LUDUR.
Phytosanitary categorization: EPPO A2 list no 364.

Scientific name: *Ludwigia peploides* (Kunth) P.H. Raven
Taxonomic position: Magnoliopsida (Dicotyledons), Onagraceae.
Common names: Creeping water primrose [EN].
EPPO code: LUDPE.
Phytosanitary categorization: EPPO A2 list no 364.

Geographical distribution for *Ludwigia grandiflora*

Native range

South America: Peru, Argentina, Chile, Costa Rica, Bolivia, Brazil (South), Colombia, Ecuador, Guatemala, Paraguay, Uruguay (CABI, 2010).

Introduced range

North America: United States (Alabama, Arkansas, California, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Missouri, Mississippi, North Carolina, New Jersey, New York, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, West Virginia). (USDA, 2010; Boersma *et al.*, 2006 in DEFRA, 2008).
Note: in North America, the species is spread across various States, but there are few occurrences reported.

Africa: Kenya (Thendi, 1996 in DEFRA, 2008).
EPPO Region: Belgium (Denys *et al.*, 2004), France (Dutartre *et al.*, 2007), Ireland (Caffrey, 2009), Italy (Celesti-Grapow *et al.*, 2009), the Netherlands (Kleuver & Hoverda, 1995), Spain (Castroviejo *et al.*, 1997), United Kingdom (Newman *et al.*, 2000), Germany (Nehring & Kolthoff, 2011).
Note: The species was found in a lake near Geneva in 2002 and was eradicated (GREN Biologie Appliquée Sarl, 2003), and has not been found since (GREN Biologie appliquée, pers. comm. 2009).

Geographical distribution for *Ludwigia peploides*

Native range

Central America: Costa Rica, Cuba, El Salvador, Dominican Republic, Guatemala, Haiti; Honduras, Jamaica, Nicaragua; Panama, Puerto Rico.
South America: Argentina, Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela.
Note: *Ludwigia peploides* in Argentina is known to occur in Buenos Aires, Corrientes, Entre Rios, Formosa, Mendoza, Salta, Santa Fe and Tucuman.
North America: United States (Alabama, Arkansas, California, Florida, Georgia, Indiana, Illinois, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, Tennessee, Texas), Mexico.
Note: The EPPO Expert Working Group (EWG) considered the proliferation of subspecies and varietal names in North America associated with supposed native status to be unhelpful. However, it is clear that *L. peploides* is probably native to most States where it is found in North America.

Introduced range

EPPO Region: Belgium (Branquart *et al.*, 2010), France (Dutartre *et al.*, 2007) including Corsica (Jeanmonod & Schlüssel, 2010), Greece (Zotos *et al.*, 2006), Italy (Celesti-Grapow *et al.*,

2009), the Netherlands (Holverda *et al.*, 2009), Spain (Verloove & Sánchez Gullón, 2008), Turkey (near Antalya) (Güner *et al.*, 2000), the UK (BSB, 2011).
Note: In the Netherlands there is one persistent population which is under management. At three other sites, plants have been successfully removed, or just disappeared (Proosdij & van Valkenburg, in press).
In the UK, the species was reported to be present in 3 locations in Southern Great Britain in 2006 (DEFRA, 2006).
Australasia: Australia (New South Wales, Northern Territory, Queensland, South Australia, Victoria) (Richardson *et al.*, 2007; Australia's Virtual Herbarium, 2011), New Zealand (North Island) (Webb *et al.*, 1988; Roy *et al.*, 2004).
Africa: Madagascar (GBIF Portal, 2011)
Asia: Thailand, Taiwan (GBIF Portal, 2011).

History of introduction and spread

The first observation of *Ludwigia* spp. in the EPPO region was on the river Lez near Montpellier, France, in 1830. The plant was introduced and had been cultivated at the botanical garden of Montpellier since 1823. According to Martins (1866), one of the gardeners had voluntarily introduced the plant into the river Lez. Another hypothesis is that the plant had been introduced unintentionally into the port of Montpellier Juvenal via the wool industry (Berner, 1971).

In France, *Ludwigia grandiflora* and *L. peploides* are no longer imported because sale and introduction in natural areas has been forbidden by law since 2007 (Ministère de l'écologie et du développement durable, 2007). In Belgium, there is a Royal Decree at the federal level under construction to prohibit the import and export of *L. grandiflora* and *L. peploides* and regional decrees to prohibit the sale, distribution and release into the wild of both species (Branquart, pers. comm. 2011). In Switzerland, there is a federal decree prohibiting the trade of *L. grandiflora* and *L. peploides* (Swiss Confederation, 2008). As of 2011-01-01, the signatories of the Dutch Code of conduct should stop selling *Ludwigia grandiflora* and *L. peploides* (Anon, 2010).

Morphology of *Ludwigia grandiflora* and *L. peploides*

Plant type

Perennial aquatic plants

Description

Perennial aquatic plants which form very dense (almost impenetrable) mats. *L. grandiflora* and *L. peploides* are morphologically very similar and are difficult to differentiate in the absence of flowers. Stems are glabrous to sparsely pubescent. They grow horizontally on water (or mud) and can emerge over the water surface. Leaves are alternate and polymorphic. Early growth consists of rosette-like clusters of rounded leaves on the water surface. At flowering, leaves lengthen to a lanceolate or elliptical shape. Two types of roots are observed: roots which adsorb nutrients and attach the plant to the soil, and adventitious roots located along the stems which ensure oxygen uptake and favour rooting of plant fragments (cuttings). Both species have bright yellow flowers (2–5 cm diameter) with 5 petals, growing from the leaf axils (in France, flowering occurs from June to September). The fruit is a cylindrical capsule of 13–25 mm long and 3–4 mm wide with 5 loculi containing numerous seeds of 1.5 mm. *Ludwigia* spp. can grow up to 3 m deep in water, and up to 80 cm above water level.

Biology and ecology of *Ludwigia grandiflora* and *L. peploides*

General

The species has a high growth rate, and several overwintering strategies (e.g. seeds, persistent vegetative material) (Dutartre *et al.*, 2007). The adventitious roots are capable of absorbing atmospheric oxygen, allowing the plant to tolerate anaerobic conditions (Rejamánková, 1992).

The species reproduces essentially through intense vegetative reproduction, and can easily regrow from fragments (Dandelot, 2004). Those fragments are buoyant and can easily float away from parent plants. In the Bagnas natural reserve (Hérault, France), the use of a filter allowed the production cuttings per day to be counted. These ranged from 41 to 881; the variability of these figures may be explained by the different seasons and currents (Legrand, 2002). Biomass production can be very rapid, with standing crop values normally reaching 2 kg of dry matter per m^2 (Dutartre, 2004b), but in ponds in South-West France, the maximum recorded dry matter reached 3.5 kg per m^2 (Pellote, 2003), although an absolute maximum of 7 kg of dry matter per m^2 has been recorded in South-East France by including both produced biomass and litter (Dandelot, 2004). These quantities of biomass were reached in 4–5 months. This large amount of biomass then produces a large propagule pressure.

Ludwigia grandiflora and *L. peploides* are outcrossing plants, pollinated by insects, with germination requiring cold stratification. In populations that produced many fruits, Dandelot (2004) estimated that *L. grandiflora* has a high potential seed output with around 10 000 seeds per m^2. Forty-eight to 58% of the produced seeds are viable (Ruaux *et al.*, 2009).

Habitats

Both *L. grandiflora* and *L. peploides* are mainly aquatic but are also able to colonize damp terrestrial habitats such as riverbanks or wet meadows. They can also grow on nutrient-poor to nutrient-rich soils and sediments including gravel banks, sand bars, mud and peat (Matrat *et al.*, 2006).

Ludwigia peploides is also found on sediment bars on river banks and in wet meadows (Laugareil, 2002; Zotos *et al.*, 2006), and colonizing brackish waters (Mesleard & Perennou, 1996).

Environmental requirements

The two species are tolerant of a wide range of conditions in terms of nutrient level, type of substrates (gravel banks or sediments) and water quality (Matrat *et al.*, 2004). They prefer light areas (biomass production is reduced under shade); they are limited by high flow velocity, by salinity (*L. grandiflora* tolerates up to 6 g L^{-1}) and by competition with high helophyte species (*Glyceria* spp., *Phalaris* spp.).

Climatic and vegetational categorization

If emergent parts of the plant are killed by frost, submerged or buried parts of the plants, as well as the rhizomes, are reported to survive the winter months explaining the increase of the two *Ludwigia* species further north (Dutartre *et al.*, 2007). *Ludwigia* spp. were also observed in the winter of 2009/2010 in outdoor ponds at the Plant Protection Service at Wageningen, NL (J. van Valkenburg, pers. comm. 2011).

Natural enemies

In France, observations showed that Louisiana crayfish (*Procambarus clarkii*) and coypu (*Myocastor coypus*) can eat large quantities of *Ludwigia* spp. (Lambert *et al.*, 2009). A beetle *Altica lythri* Aubé (Chrysomelidae) has also been observed to eat leaves of *Ludwigia* in South-West France (Petelczyc *et al.*, 2006). Two coleoptera of the genus *Galerucella* have also been observed on leaves of *Ludwigia* spp. (Dauphin, 1996).

Uses and benefits

Both species are traded for ornamental purposes.

Pathways for movement

Plants for planting of *L. grandiflora* and *L. peploides*.

Impact

Effects on plants

By outcompeting wetland grasses, *L. grandiflora* can reduce grazing space for livestock in wet meadows when it displaces grasses (Dutartre, 2004a). This effect is increased by the low palatability of *L. grandiflora* for livestock, as cattle and horses only eat the plant when no other species are available. This leads to loss of pasture space and may prevent farmers from receiving agri-environmental financial incentives developed in the framework of the Common Agricultural Policy.

Environmental and social impact

The rapid and extensive development of plant populations can block waterways, irrigation ditches and canals (and thus disturbs many human activities such as navigation, hunting, fishing, irrigation and drainage), reduce biodiversity and degrade water quality.

Studies in France have shown that *Ludwigia* species were able to rapidly produce high biomass (2–3.5 kg of dry matter per m^2 in 4–5 months). Biomass could double in 15–20 days in slow-flowing waters, and in 70 days in rivers. As an example, populations of *Ludwigia* spp. in Marais d'Orx occupied a few m^2 in 1993 and reached 130 ha in 1998. In France, these species are considered as dangerous invaders in aquatic or humid environments.

The dominance of *Ludwigia* spp. leads to local loss of both floral and faunal (macro-invertebrates and fishes) biodiversity (Dandelot, 2004). In several ponds in the Landes region (South-West France), decreases in *Potamogeton natans*, *Myriophyllum spicatum*, *Iris pseudacorus* and *Ludwigia palustris* have been observed as a consequence of competition with *Ludwigia grandiflora* and *Lagarosiphon major* (Dutartre, 2002). In Belgian ponds the cover of *L. grandiflora* has caused a reduction in native species richness. A decrease of 70% has been measured from uninvaded plots to heavily invaded plots. The submerged vegetation was the most vulnerable to the invasion. Significant differences in native species abundance following invasion were found for the submerged *Ceratophyllum demersum* and for the emergent *Alisma plantago-aquatica* and *Lycopus europaeus* (Stiers *et al.*, 2011). Uninvaded ponds supported a more distinct invertebrate community, including species (e.g. Ephemeroptera) that are rare or missing from invaded *L. grandiflora* ponds (Stiers *et al.*, 2011). Reductions of macroinvertebrates and fish populations have also been recorded in France (Grillas *et al.*, 1992; Dutartre *et al.*, 1997), the dense populations of *Ludwigia* spp. constituting a barrier for the movement of fish (Legrand, 2002).

Preliminary observations also show that *L. grandiflora* is not only integrated in the native plant-pollinator network, but also shows a dominance in terms of frequency of pollinator visits (I. Stiers, personal observation, 2001).

An analysis of the distribution of *Ludwigia* spp. in France shows that habitats under threat by this species include at least 12 habitats of interest for the European Commission, and 3 types of wet habitats (aquatic vegetations of the *Nymphaeion albae,* swamp vegetations with tall helophytes, prairial vegetations and flooded forests: Dutartre *et al.*, 2007).

Ludwigia spp. cause many significant changes of ecological processes and structures:

Reduced water flow: The high biomass production leads to the slowing down of water flow and causes increased sedimentation, which may lead to increased flood risk by reduction of channel carrying capacity. In static open waters, the slow rate of litter decomposition can lead to shallowing of the water body and succession to swamp and marsh type vegetation.

Reduction in oxygen concentrations: in static waters, dense stands prevent the transfer of oxygen between water and the atmosphere, reduction in light availability for submerged plants reduces photosynthetic oxygen production and consumption of oxygen by *Ludwigia* spp., root respiration results in severe deoxygenation which is harmful to aquatic fauna. Concentrations of

oxygen <1 mg L^{-1} have been recorded in waters where *Ludwigia* spp. are present (Dandelot *et al.*, 2005a).

Lower pH: Decreases in pH are common due to the suppression of submerged aquatic photosynthetic processes (Dandelot *et al.*, 2005b).

Changed circulation: A slowing down of water circulation (Dutartre, 1988) in channels, ditches and shallow rivers with increasing sedimentation, risks of flooding in autumn, modifications of flora and fauna communities, fish disappearing in dense beds, etc.

Altered hydrological regimes: *Ludwigia* spp. can also cause change in hydrological regimes of water bodies (Dandelot *et al.*, 2005b).

Control

Mechanical control is possible but care should be taken not to produce more fragments which may disseminate the plants further. The following methods can be used: reprofiling of banks, mechanical removal and manual removal. Herbicides are available for chemical management but their use in the natural environment is difficult.

Regulatory status

In France, there has been a ban of trade of *L. grandiflora* and *L. peploides* since 2007 (Ministère de l'écologie et du développement durable, 2007). There is also a ban on the 2 species in Portugal (Decreto Lei 565/99, 1999). The species are currently proposed to be banned in Belgium and in the UK. In the Netherlands, a code of conduct is implemented to tackle the trade of these species.

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