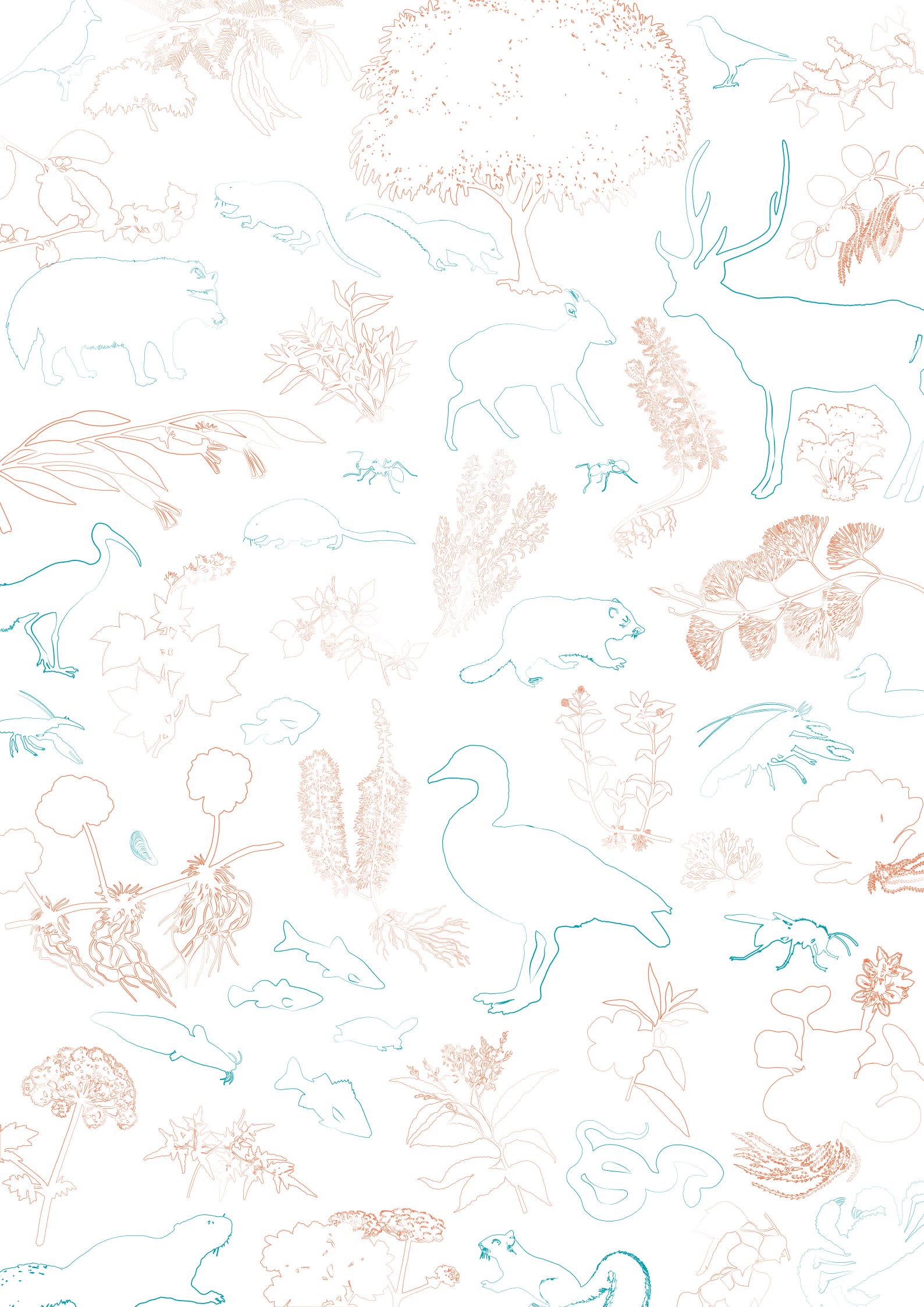
European Commission

An introduction to the invasive alien species of Union concern

Version 2022

Environment



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Feedback: Comments which could support improvement of this document are welcome. Please send your comments by e-mail to ENV-IAS@ec.europa.eu

Contents
ANIMALS

Contents

PLANTS

Introduction

Alien species are animals and plants that have been introduced through human action to a new natural environment from other parts of the world. Some alien species have been brought to the European Union (EU) deliberately, including the American skunk cabbage as an ornamental plant, the pond slider for the pet trade, the signal crayfish for the food industry, and the coypu for fur farming. Others, such as the Asian hornet or the Indian house crow, have found their way into the EU as passengers on board of ships, or they have been accidentally imported as a contaminant with commercial goods.

Not all alien species cause trouble in their new environment. They often have difficulties growing and reproducing, and some become beneficial and part of everyday life, without necessarily causing harm to the environment or people. For others, however, including those mentioned above, the new natural environment turns out to be surprisingly favourable, in particular in the absence of their natural enemies. This allows them to spread and reproduce excessively, feeding on native species or out-competing them for habitat and resources; sometimes also carrying parasites and diseases that are lethal to native wildlife (not to mention the impact on livestock or crops) or dangerous to human health. In these cases, these species are called invasive alien species (IAS).

Ecological barriers like oceans and mountain ranges have allowed ecosystems to evolve independently, so that the species within them are adapted to each other and interact in a delicate balance. Moving species across those barriers can severely disrupt this balance and may even change these ecosystems entirely. Indeed, invasive alien species are recognised as one of the main drivers of species extinction and global biodiversity loss[1] and as one of the five direct drivers of change in nature with the largest relative global impacts[2]. Invasive alien species also cause damage amounting to many billions of euros to the European Union economy every year.

Invasive alien species can easily spread across borders. This is why the EU has adopted a law - the EU IAS Regulation[3] - to tackle the problem in a coordinated, joint effort across all Member States. The EU IAS Regulation is fairly young: it entered into force in January 2015. It contributed to the implementation of the EU Biodiversity Strategy 2020 and is currently contributing to the implementation of the EU Biodiversity Strategy 2030. This strategy sets a specific target to combat the threat of invasive alien species in order to halt the loss of biodiversity and ecosystem services.

At the core of the EU IAS Regulation is a list of invasive alien species of Union concern (the Union list), including a selection of species that cause the most damage to native biodiversity, and for which concerted measures are required across the EU. The EU IAS Regulation imposes restrictions on the keeping, importing, selling, breeding and growing of the listed species. Member States are also required to take measures for their surveillance, early detection and rapid eradication, and to manage populations that are already widely spread in their territory. However, prevention is the priority, as established populations can be expensive to manage and difficult or impossible to eradicate.

As new information and evidence become available, the Union list is updated at regular intervals. The process of adding new species to the list starts with a proposal by an EU Member State or by the European Commission, underpinned by a risk assessment. This is then followed by an expert evaluation of the robustness of the available evidence and consultations with a range of stakeholders and the Member States, followed by approval from a Committee of Member State representatives and adoption by the Commission. The initial Union list entered into force in 2016, and was updated in 2017, 2019 and 2022. It currently includes 88 invasive alien species.

This brochure presents, at a glance, the currently listed invasive alien species of Union concern, offering brief, non-technical and informal summaries of each of the 88 species. This includes dedicated descriptions of their main biological and ecological features, along with information on their origin, present distribution in the EU, pathways of introduction into the EU, how they threaten European native biodiversity, and which management measures are currently available to mitigate their impacts. You can read more on the scientific evidence and risk assessments of the invasive alien species of Union concern on the Commission's official webpage dedicated to invasive alien species[4].

(1) https://www.cbd.int/invasive/
(2) https://ipbes.net/global-assessment
(3) Regulation (EU) 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014R1143
(4) https://ec.europa.eu/environment/nature/invasivealien/list/index_en.htm

Acridotheres tristis
Common myna

Description

The common myna, about the size of a starling, has brown body plumage, with a glossy black head, neck and upper breast and white patches on the wings and tail. Legs, feet and bill are bright yellow, like the bare skin around the eye, which is the most distinctive feature of this bird. Males and females are very similar. Common mynas are social birds; a single communal roost can gather together thousands of individuals. The species is very noisy and able to emit a wide variety of calls. The common myna can adapt to a wide range of climates, with severe winters being the most limiting factor. It is commonly found in open areas, scrubland, cultivated land, as well as urban and suburban areas. It feeds on bird eggs and chicks, reptiles, insects, earthworms, seeds, fruit, nectar and animal remains.

Distribution

The common myna is native to Central, South and South East Asia and now, following a number of introductions, occurs in all continents, except South America and Antarctica. It also occurs on several islands in all oceans. It has established populations in two EU Member States (Portugal and Italy) with records also from Austria, Croatia, Belgium, Finland, France, Germany, the Netherlands, Poland, Slovenia, Spain and Sweden; although not all are currently confirmed. In Spain, a breeding population was present in the Balearics, Mallorca, but was eradicated in 2007 and similarly, the species was eradicated from the Canary Islands.

Illustration: *Acridotheres tristis* (Common myna)

Pathways

The main pathways of introduction into the EU are intentional releases into the wild from the pet trade and unintentional escapes from captive stocks (for instance, zoos). Other possible pathways include via human-assisted transportation, for example, as hitchhikers on ships and ferries. The species is also capable of spreading unaided through natural dispersal, particularly along corridors e.g. roads and railways. Outside of Europe, a major pathway of introduction has been the release as a biological control agent against pest invertebrate species.

Impact

In Europe, the adverse effects of the common myna on native biodiversity are not well documented, but the species has a considerable impact within its introduced range. The species is known to contribute to the decline of native birds through predation of eggs and nestlings, e.g. the Tahiti flycatcher (*Pomarea nigra*), and competition for food, roosting sites and nesting sites, e.g. Seychelles Magpie Robin (*Copsychus sechellarum*). It can also spread parasites and pathogens and disperse the seeds of alien plants, which may indirectly facilitate major habitat changes. The diet of the common myna is varied and flexible, allowing the species to take advantage of seasonal/temporary food sources and also become an agricultural pest due to their varied, omnivorous diet.

Management

While it is time and resource consuming, established populations of this invasive alien species can be successfully eradicated, as was recently achieved in the Canary and the Balearic Islands through shooting. However, the success of eradication campaigns relies heavily on their rapid implementation to avoid newly introduced birds from spreading and establishing. Where eradication campaigns are unfeasible or fail, control methods are available (trapping and shooting) but they are costly and require high levels of effort and coordination to implement. EU-level action can raise awareness and increase knowledge on the species and pathways of introduction. These actions can then facilitate the prevention of new introductions, rapid detection and eradication of any newly establishing population and the management of existing ones.

Photo: *Acridotheres tristis* (Common myna) © Guérin Nicolas, Creative Commons Attribution-Share Alike 3.0 via Wikimedia

Alopochen aegyptiaca (Alopochen aegyptiacus)*
Egyptian goose

Description

The Egyptian goose is a pale brown goose with long pink legs and a pink-red bill. It has brown, black and orange patches on its back and red around its eyes, with a black rump and tail feathers. When in flight, there are extensive white panels on the under and upper forewing. Body length is 67-73 cm, wingspan is 110-135 cm and weight is 1.5-2.3 kg. Males and females have the same plumage but males are slightly larger. The species lives in a range of wetland habitats, including lakes, ponds, reservoirs, estuaries, sewage works, swampy woodland and meadows, and is often found in parks. It grazes on grasses, growing crops, aquatic plants and possibly some animal material. The species nests on the ground and occasionally in trees, and usually pairs for life, with both the male and female caring for the offspring.

Distribution

The Egyptian goose is native to central and southern Africa and has been introduced to the USA, Israel, United Arab Emirates and Mauritius. In Europe the species was first introduced in the 17th century to the UK. The species has had incidental breeding or has established populations in ten EU Member States (Spain, France, the Netherlands, Belgium, Germany, Denmark, Poland, the Czech Republic, Slovakia and Bulgaria) and records in all EU Member States.

Illustration: *Alopochen aegyptiaca* (Egyptian goose)

*Scientific name as indicated in the Commission Implementing Regulation

Pathways

The Egyptian goose is kept in captivity, in private collections, for ornamental purposes. The main pathways of introduction are through deliberate releases and escapes from confinement. Captive birds are released into the wild for the "improvement" of local fauna, or escape unintentionally. Once released or after escaping, the species is capable of naturally dispersing across borders, due to its high reproductive potential and spreading capacity.

Impact

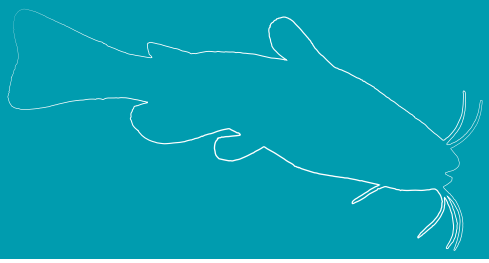
The Egyptian goose is aggressive towards native birds, including taking over nests of waterfowl, birds of prey and owls, and killing other ducks and songbirds. It may hybridise with other duck species. It is a vector of the avian influenza virus, paramyxovirus and salmonella, with possible transmission to wild birds, poultry and humans. Flocks of Egyptian geese damage crops through foraging, trampling and faecal pollution. The latter causes also eutrophication of water bodies, with negative effects on both aquatic ecosystem functioning and recreational values. Trampling, faecal pollution and aggressive behaviour can also be a nuisance in other recreational areas, such as golf courses and parks.

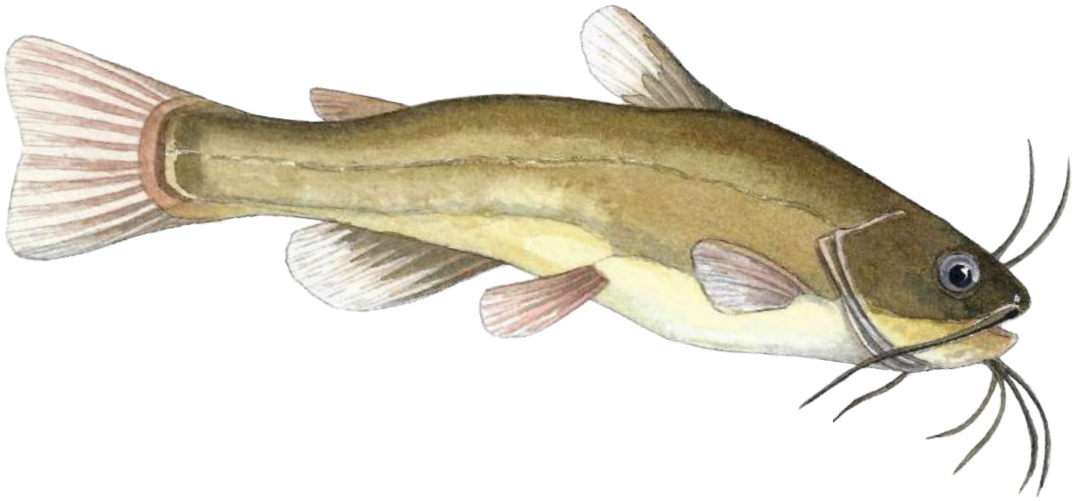
Management

Awareness raising on the negative impacts of the Egyptian goose is crucial for gaining public support for its management, because control programmes may face opposition resulting from the species' aesthetic appeal. Those animals remaining in captivity should be housed securely to avoid unintentional introduction through escapes. Spread limitation may be achieved through control of established populations, targeting both big concentrations and smaller populations. Hunting and targeted culling are recommended, as well as destroying eggs by piercing or oiling. Traps with live decoy birds are also effective. Impacts in man-made habitats may be reduced through landscape design that reduces grazing areas and waterbodies, and by using falconry to deter the species.

Photo: *Alopochen aegyptiaca* (Egyptian goose) © Alexis Lours, CC BY 4.0 via Wikimedia

Ameiurus melas
Black bullhead





Description

The black bullhead generally reaches 25-30 cm in length and has distinctive, almost black chin barbels. Body colour varies but the back is solidly dark, usually in shades of green or grey, with lighter sides and yellow or white on the underside. There is little difference in male and female appearance. The species is primarily found in lakes, reservoirs and ponds and is a nocturnal feeder, consuming clams, snails, plant material and fishes. There is a high degree of similarity between the black bullhead and the brown bullhead (*Ameiurus nebulosus*), but the primary distinguishing feature is the colour of the anal and caudal fins, which have black and white radiation on the black bullhead.

Distribution

The black bullhead is native to eastern and central USA, in the Great Lakes, Hudson Bay and Mississippi River basins, coupled with adjacent regions in Canada and northern Mexico. The species has established populations in 15 EU Member States (Austria, Bulgaria, Croatia, the Czech Republic, France, Germany, Hungary, Italy, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and the Netherlands), with records also from Belgium and Sweden.

Illustration: *Ameiurus melas* (Black bullhead)

Pathways

Introductions of the black bullhead by anglers have been occurring in the EU since the late 18th century, and the species is now widespread. Although there are currently no active introduction pathways into the EU, unauthorised introduction by anglers is considered the main vector for new, within and between Member States introductions, coupled with possible escapes from aquaria or aquaculture. Natural spread is slow due to the limited dispersal distance of young fish.

Impact

The black bullhead is associated with degraded or impacted ecosystems, with the ability to survive in low oxygen conditions for extended periods and thrive in harsh conditions. Potential impacts arise due to the species' ability to form dense populations, leading to changes in fish communities, competition for food or space and predation on native species. They are generalist omnivores, which could suggest potential impacts on a wide range of prey species, however more evidence is needed to better understand these impacts. A further indirect impact is through the generation of turbidity, which can impact the feeding efficiency of native species reliant on visual cues to feed. Along with other catfish species, black bullhead are also potential vectors of non-native parasites.

Management

The black bullhead is virtually impossible to eradicate once established in large riverine systems, therefore the most effective method of control is to prevent its introduction. Raising awareness of the impacts among anglers could prevent intentional introductions and encourage reporting. Additional detection methods include the use of environmental DNA tools, public reporting or fish surveys, but the latter are very expensive and not guaranteed to detect the species. Rapid eradication is dependent on location, the stage of invasion and population size. In still water bodies it may be possible by draining down the water body, alternatively, mechanical removal techniques include electrofishing, fyke/seine nets and targeted angling. Repeated removal attempts will lead to higher efficiency. Rotenone (or other piscicide use) may be effective but there are legal constraints on its use within the EU.

Photo: *Ameiurus melas* (Black bullhead) © Christian Schwarz, CC BY-NC via iNaturalist

Arthurdendyus triangulatus
New Zealand flatworm

Description

This terrestrial flatworm (also known as a planarian) is commonly associated with disturbed habitats and southern beech (*Nothofagus*) forests within the native range. In the native range, it also has nocturnal habits and is most commonly found in gardens, parks or pastures on the soil surface under rocks, wood, plastic or other debris. In invaded areas, the species feeds on lumbricid earthworms. The body shape is flattened dorso-ventrally, smooth and non-segmented, brown in colour and covered in mucus, with a marginal edge coloured beige which extends to the ventral surface. The size of this species (50-200 mm in length) can vary depending on food availability, with starved flatworms reabsorbing tissues and shrinking, but the species is usually larger than the native *Microplana* flatworms (10-20 mm in length) in Europe.

Distribution

This flatworm is native to New Zealand and has been introduced to Iceland, the Faroe Islands and the UK. The species has been established in one EU Member State (Ireland) and there are no records from any other Member States. It was first recorded in Ireland in 1984 and is now well established within the country. The species appears well suited to the mild, Atlantic climate of Ireland and could successfully establish in Atlantic coastal regions of the EU.

Illustrations: *Arthurdendyus triangulatus* (New Zealand flatworm)

Pathways

The unintentional introduction and spread of this cryptic soil-dwelling species, whose records are mostly associated with botanic gardens, garden centres and nurseries, is primarily facilitated by the movement of moist soil or plant materials and growing medium accompanying plants or root balls. The species can be transported as adults, juveniles or egg capsules. The main pathways are therefore the ornamental plant trade (especially containerised plants, e.g. *Dicksonia* tree ferns, or rhododendron), as well as the horticultural trade, and more generally as a contaminant of nursery material and habitat material.

Impact

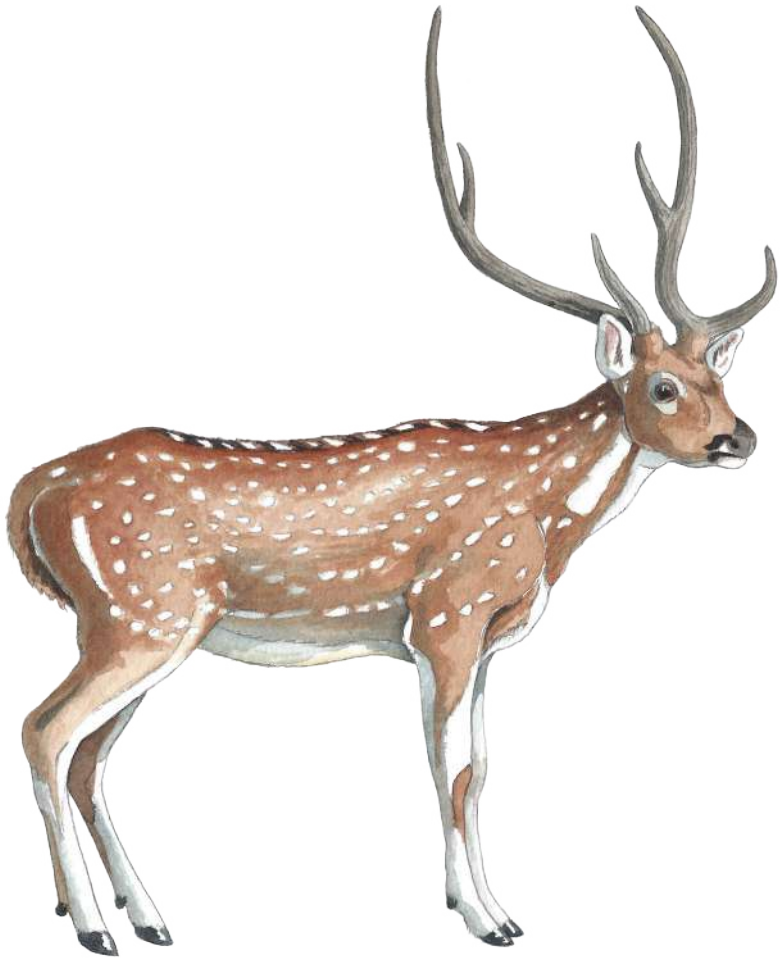
The New Zealand flatworm is a predator of earthworms. This may negatively impact grassland productivity by lowering the numbers of nutrient-cycling earthworms, which may turn into a reduction in grass yield and consequently major economic costs. Earthworms are also an important food source for many native birds and mammals, hence a significant decline in earthworms would have severe knock-on effects for species that rely on earthworms for food.

Management

Once established, New Zealand flatworms are very difficult and expensive to control and measures could negatively affect native soil-dwelling organisms and soil biodiversity. Therefore, preventing their introduction is the most effective management measure. Since the species can be translocated with soil in potted plants, tighter controls over plant trade are needed. Ornamental plant traders and farmers can also help in prevention efforts by inspecting pots or trays carefully. Farmers should also consider inspecting all silage and hay bales they bring onto their farm. Where the species has become widespread, additional management measures have to be taken e.g. crop rotation to disrupt flatworms without affecting earthworms or manure input to enhance earthworm populations.

Photo: *Arthurdendyus triangulatus* (New Zealand flatworm) © Stephen James McWilliam, Creative Commons Attribution 4.0 via Wiki media

Axis axis
Chital



Description

The axis deer, or chital, is a moderately large deer, with a reddish-brown coat, and typical white spots arranged in longitudinal rows on the lower flanks. Underparts and throat are white, and a dorsal dark stripe runs from the nape to the tip of the tail. In its native range, it mostly occurs in the tropical and subtropical climate and is typical of the grassland-forest ecotone. The preferred habitat is moist and dry deciduous forest near water, interspersed with dry thorn scrublands or grasslands. However, this predominantly generalist grazer adapts very well to habitats and climates in many other regions where it is introduced, and easily habituates to human presence. However, its distribution is limited by severe winter conditions, particularly strong frosts and thick snow cover.

Distribution

The chital is a deer native to the Indian subcontinent (India, Nepal, Bhutan, Bangladesh and Sri Lanka), introduced in many regions worldwide e.g. Russia, western Asia, North America, South America, South Africa and Australia (also in New Zealand before being eradicated). At present, in the EU, the chital has only one established population in Croatia, but there are historic records from the Czech Republic, France, Ireland and Slovenia.

Illustration: *Axis Axis* (Chital)

Pathways

Introductions into the EU have occurred on numerous occasions since the late-18th and early-19th centuries, mostly for hunting, but most populations did not establish. Recent pathways of introduction include releases and escapes from deer farms or private collections. Natural spread from neighbouring non-EU countries is possible (the chital is also a capable swimmer), but the chances of this are very low.

Impact

The chital has been recorded as causing significant damage in gardens, orchards and vineyards, when at a high population density, but there is very little information on the impact on biodiversity. Presumably, it may have an impact on native vegetation, e.g. through browsing and bark stripping, and may have a number of indirect effects on fauna and ecosystem processes. When alongside other herbivores and where natural predators are absent, the chital can affect lower layers of forests by preventing trees' natural recruitment. It may also compete for resources with other ungulates, potentially displacing native deer and may have an impact on crops and livestock. Eventually, it may transmit infectious diseases (including to other deer and to humans), and be involved in deer-vehicle collisions.

Management

The keeping of chital in zoos and private collections and any other ownership is now being phased out, preventing introduction. Early detection methods include public awareness-raising and the reporting of new incursions through citizen science initiatives or existing hunting networks. Eradication or control is possible mainly through shooting, but the actual success of eradication programmes may depend on several factors, including the population size, invasion stage and overall availability of resources. Other potential control methods include fertility control, which is still in development. The use of traps and nets, or toxins are sometimes used as a supporting method (e.g. in New Zealand) but there are legal constraints on the use of toxins within the EU. Other techniques, such as deer-proof fencing may reduce local impacts.

Photo: *Axis Axis* (Chital) © Yathin S Krishnappa, Creative Commons Attribution-Share Alike 3.0 via Wikimedia

Callosciurus erythraeus
Pallas's squirrel

Description

Pallas's squirrel, also known as the red-bellied tree squirrel, is generally brown on the upper body with a reddish hue on the underside. Colouration in the tail often has some black mixed in amongst the brown. In its native range, it inhabits tropical and subtropical broadleaf forests. However, this tree squirrel is adaptable to new habitats, being found in deciduous, coniferous and mixed wooded areas, but also in more open urban parks. They consume a wide range of foods including seeds, fruit, buds, mushrooms, berries, insects and bird eggs. In urban areas, the squirrel may also benefit from supplementary feeding. They frequently engage in bark stripping, particularly when food availability is limited. Females can produce up to three litters per year, provided food supply is high.

Distribution

Pallas's squirrel is native to South East Asia, from Central China south to Malaysia, with a wide distribution throughout. It has been introduced to multiple locations in both Japan and Argentina, and in these regions the range expansion rate ranges from 6-22 km² per year. The squirrel is established in four EU Member States (France, the Netherlands, Belgium and Italy) and there are no records from any other Member States.

Pathways

The primary pathways of introduction are the intentional release or unintentional escape from captivity e.g. wildlife parks, zoos, private collections and pet shops. Of these, the pet trade is considered the most likely pathway, due to escapes and deliberate introductions into woods and parks. Natural dispersal will also facilitate movement and although juvenile dispersal is considered low, they are adaptable and capable of crossing habitat gaps.

Illustration: *Callosciurus erythraeus* (Pallas's squirrel)

Impact

The most significant impact associated with Pallas's squirrel is damage to trees, caused by bark stripping. This practice increases the potential for fungal infections and the risk of invertebrate damage, both of which can reduce tree health and yield. Predation of bird eggs has been observed in Argentina and Japan, suggesting potentially problematic impacts on native avifauna. Competition with the native European red squirrel (*Sciurus vulgaris*), for food and shelter, is considered a strong potential impact. Pathogen transmission to native squirrels is also considered a risk but is currently not well documented. Fruit consumption in citrus and olive orchards, coupled with damage to cables/sprinkler systems, etc., contributes towards the impacts on agriculture, infrastructure and businesses.

Management

A key aspect of management is to phase out the keeping of Pallas's squirrel from zoos, collections and any other ownership. Raising awareness with pet owners of the problems posed by this species should further reduce the risk of accidental or deliberate release. Eradication programs are ongoing within EU Member States, primarily by means of live trapping and shooting or keeping animals in captivity. In general, cage traps provide a cost-effective method to facilitate population control and eradication programmes. Fertility control may be useful in the future, but is still under development.

Photo: *Callosciurus erythraeus* (Pallas's squirrel) © iStockphoto/kojihirano

Callosciurus finlaysonii
Finlayson's squirrel

Description

Coat colour in Finlayson's squirrel varies significantly between individuals, ranging from all white, to red or to black. As a result, the species is sometimes known as the variable squirrel. Normally there is a sharp distinction between the dark back and the pale underside. Typical colour morphs in Europe have an olive-brown back and cinnamon tail, but this can vary substantially (grey or brown back and/or tail, or completely white tail/underside). This canopy-dwelling squirrel is found in a range of wooded habitats and feeds opportunistically and seasonally, primarily on vegetative matter including fruit, seeds, flowers, sap and buds, but also on insects. In its native range, the squirrel is a known predator of bird eggs. Populations may establish from limited founders, as females can produce up to three litters per year with 1-4 young.

Distribution

The Finlayson's squirrel is native to South East Asia, from central Myanmar, Thailand, Laos and Cambodia to Vietnam. The species has an established population in one EU Member State, Italy, with no records in any other EU Member States. It has adapted to Mediterranean urban and suburban areas, in addition to deciduous and pine forests, and supplementary feeding in urban areas can likely facilitate its establishment.

Pathways

The primary pathway of introduction into the EU is the release of captive animals into parks and woodlands. The species has been held within the pet trade, meaning accidental or deliberate releases are still active pathways, as are escapes from zoos and other collections. These releases/escapes make entry and translocation within or between Member States a high probability and natural dispersal can subsequently occur.

Illustration: *Callosciurus finlaysonii* (Finlayson's squirrel)

Impact

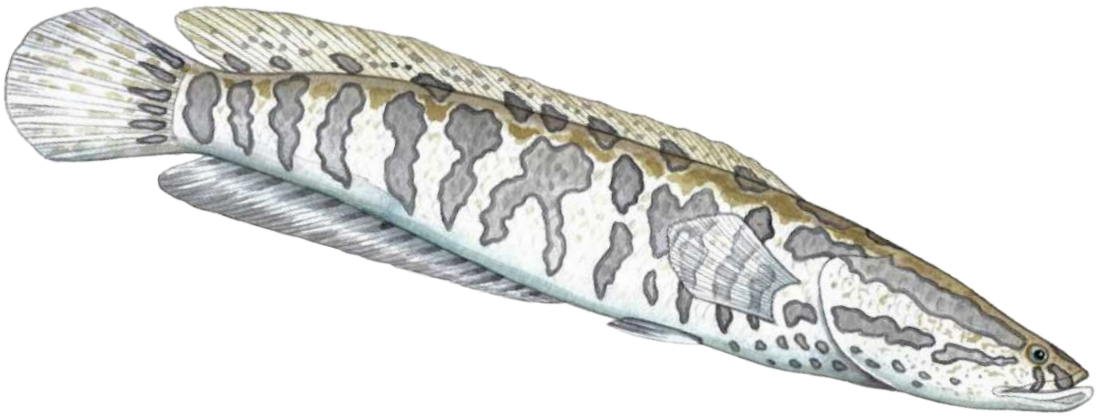
The biggest impact of Finlayson's squirrel is bark stripping, which increases the risk of fungal infection and invertebrate damage to trees and can ultimately reduce tree health and yield. Damage to electric cables and other infrastructure by the species has also been reported. Although evidence of their impacts on native species and biodiversity is limited, these can be inferred from other alien squirrel introductions. This can include interspecific competition with native species, particularly native European red squirrel (*Sciurus vulgaris*) and Calabrian black squirrel (*Sciurus meridionalis*), in addition to woodland birds and dormice, predation of birds' nests and the transmission of pathogens to native squirrel species.

Management

The keeping of Finlayson's squirrels is now being phased out from zoos, collections and any other ownership. Raising awareness with pet owners on the problems posed by the release of this species should further reduce the risks. Detection methods for new/resurgent populations use visual searches, hair tubes, camera traps or baited feeding sites. The main eradication methods include live-trapping and shooting. Fertility control is another potential control measure, although this is still in development. Long-term control is best achieved through the combination of trapping and shooting, to limit commercial damage to trees and reduce impacts on native species.

Photo: *Callosciurus finlaysonii* (Finlayson's squirrel) © Khemthong Tonsakulrungruang, CC BY-NC via iNaturalist

Channa argus
Northern snakehead



Description

This freshwater fish has an elongated, torpedo-shaped body, with long dorsal and anal fins. A primary characteristic of the genus is the distinctive colour patterning, which can vary depending on habitat. The species is piscivorous, with up to 33% of their diet composed of other fish species, but they also predate on frogs, beetles, dragonfly larvae and crayfish. The northern snakehead demonstrates high fecundity, reaching sexual maturity at 2-3 years. Females are capable of producing over 100 000 eggs annually, and spawning up to five times per year in dense aquatic vegetation. Adults will guard their young until their fins develop. They are very resilient, able to tolerate water temperatures of 0-30 °C and, as obligate air breathers, can survive out of water for up to four days.

Distribution

The northern snakehead is native to Asia (China, South Korea and Russia), inhabiting rivers, lakes and reservoirs. The species has been introduced to the USA, with the first records dating from the 1990s. It was introduced into the EU in the 1950/60s as an experimental stocking programme for angling in the Czech Republic, but its establishment failed. It is not established in any EU Member State but has been recorded in the Czech Republic.

Illustration: *Channa argus* (Northern snakehead)

Pathways

The only potential pathways of introduction into the EU are the aquarium trade, angling or live food, but all are considered low risk. Although anglers were considered responsible for the spread of northern snakehead in both their native and introduced ranges, there does not appear to be significant interest in a snakehead fishery within the EU. Additionally, the species does not appear to be a popular aquarium fish.

Impact

There is no information available on the impact of the northern snakehead in the EU, but in countries outside the EU (Australia, Japan and Florida, USA) it has been assessed to be of medium risk of becoming invasive. In its introduced range, it exerts major biodiversity and ecosystem impacts through competition but also predation, as it is known to be 'highly predatory' of fish; other prey include crayfish, dragonfly larvae, beetles and frogs. It is also likely to spread if introduced to the EU due to its high fertility, tolerance of a wide range of conditions, few natural enemies and ability to move short distances overland. Based on its predatory behaviour, it could present a potential economic threat to wild fish stocks and aquaculture.

Management

The northern snakehead would be virtually impossible to eradicate once established, so the most effective way to mitigate any impact is to prevent its introduction. Raising awareness of the threats posed is a cost-effective measure to prevent deliberate releases. Early detection methods include reporting from recreational/commercial fishers, environmental DNA, or continuous fish surveys, but the latter is expensive and not guaranteed to detect the species. Rapid eradication is dependent on location, dispersal ability, the stage of invasion and population size. In enclosed water bodies, mechanical removal (traps, nets and electrofishing) and drain-down may be effective. Containment may be difficult due to natural dispersal, but controls include mechanical removal or targeted angling.

Photo: *Channa argus* (Northern snakehead) © Brian Gratwicke, CC BY 2.0 via Flickr.com

Corvus splendens
Indian house crow

Description

The Indian house crow is a typical crow, a generalist, opportunistic and intelligent. It is a slim bird, with relatively long legs, wings and tail, weighing between 250 and 350 g. Its plumage is glossy black on the head, back, bib, wings and tail, with the rest of the body, including bill and legs, medium to dark grey. There is no difference in plumage between males and females but males are slightly larger. Immature birds are duller, with no or little sheen to their plumage. This species is omnivorous, feeding on human refuse, small vertebrates, invertebrates, crops and fruit. The species is often seen in flocks and lives in the vicinity of humans, including city centres, and will move into farmland but is not common in intact forest or uninhabited uplands.

Distribution

The Indian house crow is native to the Indian subcontinent, including all of India, Pakistan, the Maldives and Sri Lanka, and also in Myanmar (Burma) and western Yunnan. It has been introduced to Israel, eastern and southern Africa and Singapore. In the EU the species established in the Netherlands but was successfully removed, and has been recorded in Belgium, Denmark, France, Hungary, Ireland, Italy, Poland, Lithuania, Latvia and Spain.

Illustration: *Corvus splendens* (Indian house crow)

Pathways

The main pathway of introduction for the Indian house crow is as a hitchhiker on ships. New sightings of the species, including European records, are usually from ports and surrounding areas, as well as other coastal locations. Although, as in any bird, dispersal potential of the Indian house crow is considerable, natural dispersal across borders following the introduction via ship-assisted transfer is not considered an important pathway of spread.

Impact

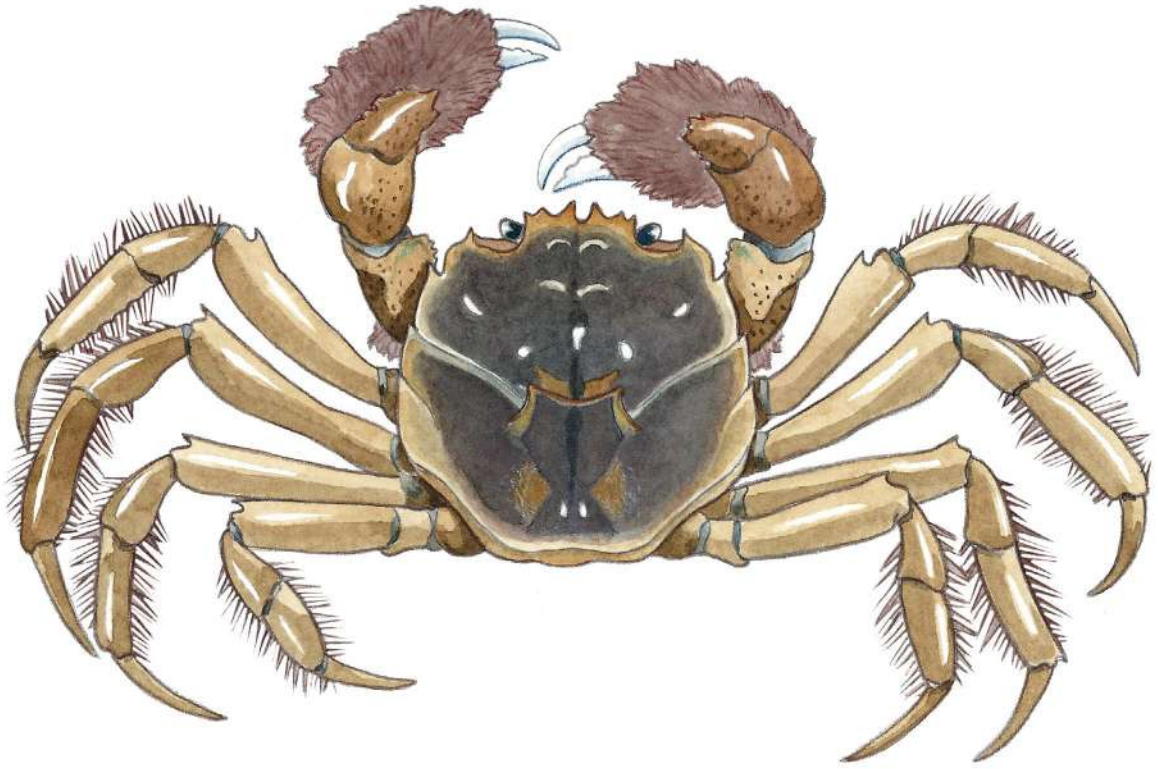
The Indian house crow can predate on eggs, chicks and adult wild birds, other small vertebrates and invertebrates, which may lead to significant declines in species abundance. The species can also displace native birds through competition for nesting sites, food, and through aggressive behaviour. It is known to carry pathogens and parasites that can potentially be transmitted to other wildlife, livestock and humans. It also damages crops, food supplies and infrastructure (e.g. electrical cables), contaminates urban areas with faeces and increases the risk of collision with planes at airports. Nuisance behaviour towards humans also includes noise, food theft and direct attacks.

Management

Awareness raising on the negative impacts of the Indian house crow is crucial for gaining public support for its management, because control programmes may face opposition. New introductions may be prevented by eliminating individuals hitchhiking on ships. All arriving birds should be eliminated as soon as possible. Shooting is the recommended method for prevention of population establishment. It can also be successfully used to eradicate populations that have already established, before they spread to other areas. Shooting can be supplemented with other methods of control, including brood destruction and trapping of adult birds. As population recovery may be fast, complete eradication is essential. However, the Indian house crows are intelligent and when persecuted, become very vigilant.

Photo: *Corvus splendens* (Indian house crow) © Walwyn, CC BY-NC 2.0 via Flickr

Eriocheir sinensis
Chinese mitten crab



Description

The Chinese mitten crab can reach a carapace width of 8 cm and is characterised by a dark brown to grey-green colour. The carapace is smooth, with four spines per side. Claws have dense hair mats (hence the common name) and white tips. This crab is catadromous, spending most of its life in freshwater, but returning to the sea to breed. It can tolerate a broad range of water temperatures and salinities, and intensively digs burrows into estuarine banks. The species is omnivorous, feeding on invertebrates, aquatic plants, and plankton. It has a very high reproductive rate, producing from 250 000 to 1 million eggs per female, and a very good dispersal capacity with reported distances of 1 500 km. Its life span is up to five years, but on average two years.

Distribution

The Chinese mitten crab is native to Asia (from south China to Vladivostok in Russia) and has been introduced to other Asian countries, North America and Europe, where it was first reported in Germany in 1912. Within the EU it is established in 18 Member States (Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Spain and Sweden), with records from Hungary, Italy, Luxembourg and Slovakia. Populations are particularly abundant and widespread in northern Europe.

Illustration: *Eriocheir sinensis* (Chinese mitten crab)

Pathways

In Europe, the main pathway of introduction for the Chinese mitten crab is via ship ballast water, transporting the species at the planktonic stages. Other potential pathways reported include biofouling, aquaculture (the species is particularly popular within Asian communities), and the ornamental trade. Secondary spread, through natural dispersal, has also occurred within the EU through interconnected waterways, particularly in central Europe.

Impact

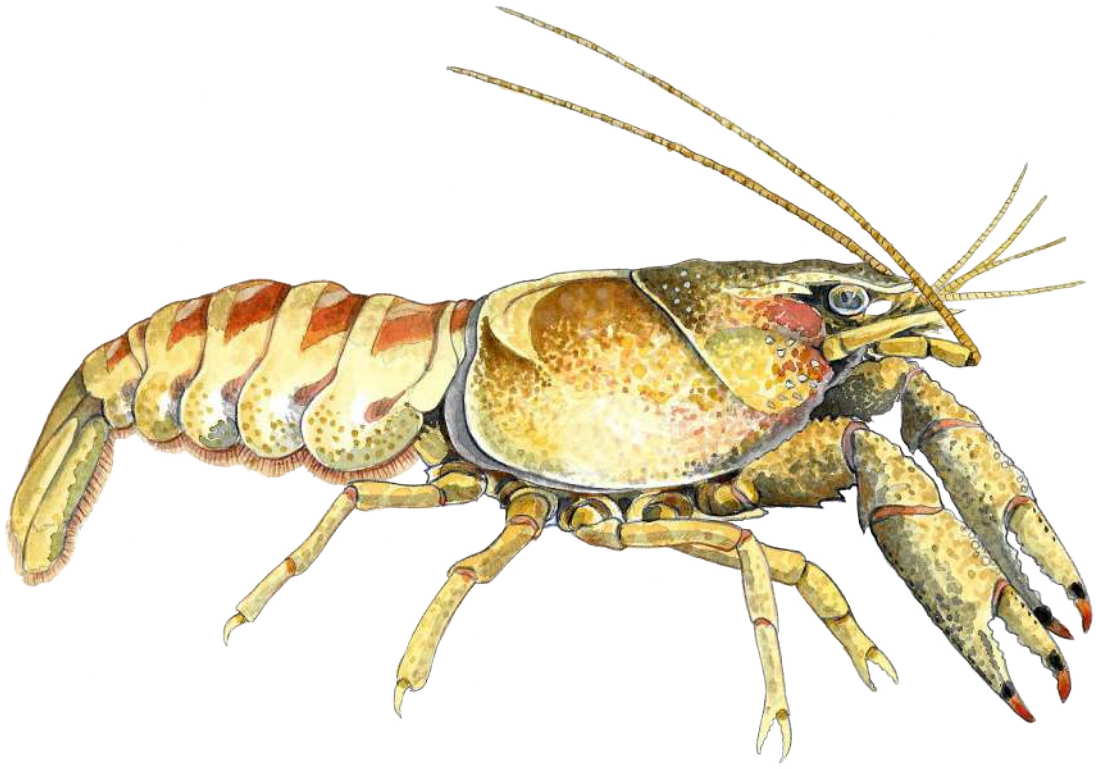
The Chinese mitten crab has many negative ecological and socio-economic impacts. Due to its omnivorous feeding habits, it can reduce the populations of macroinvertebrates and plants, impacting the aquatic food chain and competing with other species. The species also impacts habitats through its burrowing behaviour, which accelerates the erosion of dikes, banks and levees and increases the water turbidity. It can also transmit the crayfish plague, lethal for the native European crayfish. Socio-economically, it damages fisheries and aquaculture, and clogs water intakes when juveniles migrate towards estuaries. It is also the second intermediate host for the human lung fluke parasite; however, this is not yet reported in Europe.

Management

Management of the Chinese mitten crab is very difficult, and eradication of the species has never been reported. Preventative measures include the management of biofouling and ballast waters; the ballast water management convention will minimise the risk of introduction. Raising public awareness of the species and its impacts can help prevent its illegal introduction and further spread. Citizen science projects and using environmental DNA can assist its detection at the early stage of invasion and monitor distribution. Mechanical and physical control measures (trapping, barriers, and diversions) have been developed to control or contain the species. An integrated approach is recommended to tackle the species at different life stages.

Photo: *Eriocheir sinensis* (Chinese mitten crab) © iStockphoto/MikeLane45

Faxonius limosus (Orconectes limosus)
Spiny-cheek crayfish



Description

The spiny-cheek crayfish can reach a length of 12 cm and is characterised by a pale-dark brown or olive-green colour and transverse brown-red bands on the abdomen. The carapace is relatively smooth with a prominent areola (the space between grooves on the carapace) and sharp spines on its sides, hence the common name. The tips of the claws are orange with black bands. The species can disperse overland and occupy a wide range of environments, from streams to lakes and even brackish and polluted waters. In Europe, it digs burrows into banks. This crayfish is omnivorous and opportunistic. It has a very high reproductive rate, starting in the second summer of life with up to 600 eggs per female and the potential for parthenogenesis (development of an embryo from an unfertilized egg cell). It has a good dispersal capacity and a life span of up to four years.

Distribution

The spiny-cheek crayfish is native to North America, in the Atlantic watershed from Maine to Jams River in Virginia. It was introduced elsewhere in North America, in Morocco and Europe, where it was first introduced to Poland in 1890. It is now established in 20 Member States (Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Romania, Slovakia, Slovenia and Spain). Populations are particularly abundant and widespread in Belgium, the Czech Republic, France, Germany, the Netherlands and Poland.

Illustration: *Faxonius limosus (Orconectes limosus)* (Spiny-cheek crayfish)

Pathways

In Europe, the first main pathway of introduction was for aquaculture to replace declining native stocks. The species could also have been introduced for ornamental purposes, as potentially happened in the UK, or as a contaminant of fish batches, which likely happened in Italy. It can also be spread by accidental means, for example as a contaminant of angling equipment. The crayfish was present in the German internet pet trade in the 2000s, although not among the most popular species traded. If introduced, it is likely to spread rapidly upon entering a connected waterways system.

Impact

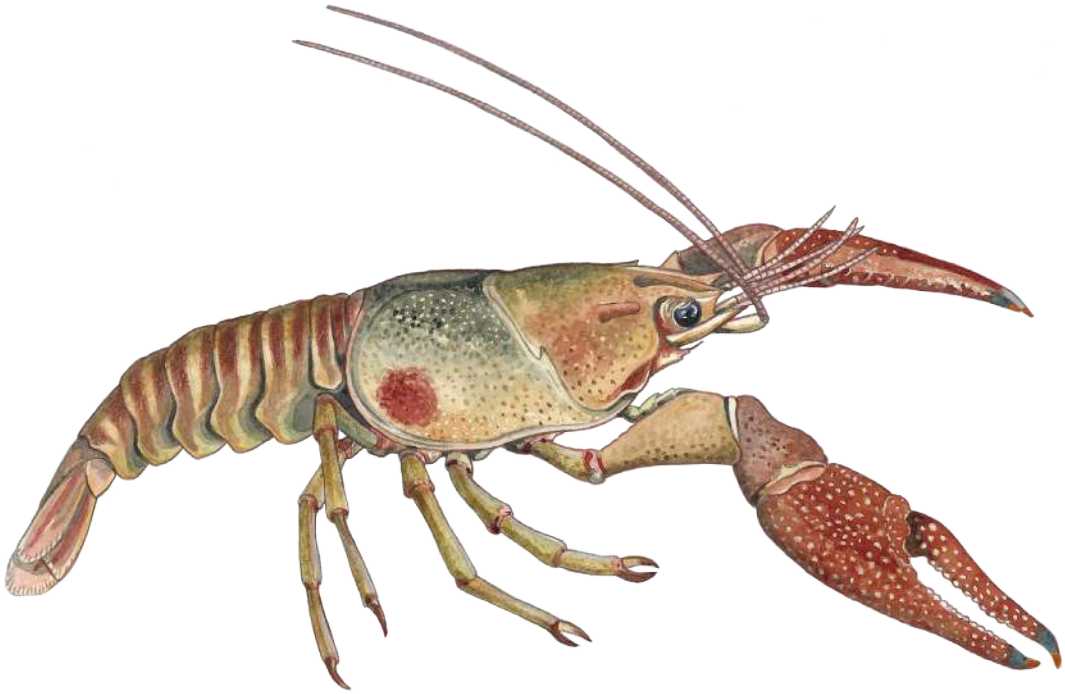
The spiny-cheek crayfish has many documented negative ecological and socio-economic impacts. Due to its omnivorous feeding habits, it reduces the population of macroinvertebrates and aquatic plants. Furthermore, it can transmit the crayfish plague, lethal to native European crayfish. By digging burrows, it increases the water turbidity and destabilises the banks, and it is also a bioturbator, altering the substrate and riverbed. Potential impacts for fisheries have also been hypothesised.

Management

As with other aquatic species, managing the spiny-cheek crayfish is very difficult once in the wild. Raising public awareness of the species and its impacts can help prevent its illegal introduction and further spread. Citizen science projects and using environmental DNA can facilitate its detection at the early stage of invasion and monitor its distribution. Eradication is possible in closed systems at the beginning of the invasion. Methods including trapping, pond drawdown (i.e. emptying the pond and using lime), construction of barriers or diversions, biocides, and the use of native predators have been developed to control or contain the species and other similar invasive crayfish. An integrated approach (using two or more methods) is recommended to tackle the species and its different life stages.

Photo: *Faxonius limosus (Orconectes limosus)* (Spiny-cheek crayfish) © iStockphoto/Dragisa

Faxonius rusticus
Rusty crayfish



Description

The rusty crayfish has a brownish-green body with dark, rusty-red spots on either side of the carapace and the total length is usually 10 cm (without claws), with males larger than females. The species is not capable of hybridising with, or being misidentified as, a native EU crayfish species. Other alien crayfish species are already present in the EU but can be easily distinguished based on morphological and colour characters. The rusty crayfish inhabits streams, ponds and lakes with slower, deeper pools as well as the shallow fast water, with varying substrates and temperatures ranging from 0 °C to 39 °C. It requires plenty of debris for cover, permanent water, and will build burrows for reproduction or to escape extreme conditions.

Distribution

The rusty crayfish is native to the Ohio river basin in the USA, spanning tributaries in western Ohio, Indiana, Kentucky, and northern Tennessee. It has been introduced to 22 States beyond its native range, spanning the entire USA. Within the EU, it has been recorded in France but has no established populations in any other Member States. However, under future climate predictions the species is capable of establishing in the Atlantic, Mediterranean and Continental sub-regions.

Illustrations: *Faxonius rusticus* (Rusty crayfish)

Pathways

The main introduction pathway into the EU is through escape from confinement, either as live food for aquaculture, live bait for angling or through the pet/aquarium trade via accidental escapes or intentional release. The species is already in ornamental trade within the EU so this pathway is considered likely. If released, the species has few constraints and is able to establish, rapidly colonising watersheds. Natural dispersal is also likely within accessible water systems but also across land between nearby water bodies. Human-assisted spread is also possible through the use as live bait for angling or released to establish populations for the aquarium trade.

Impact

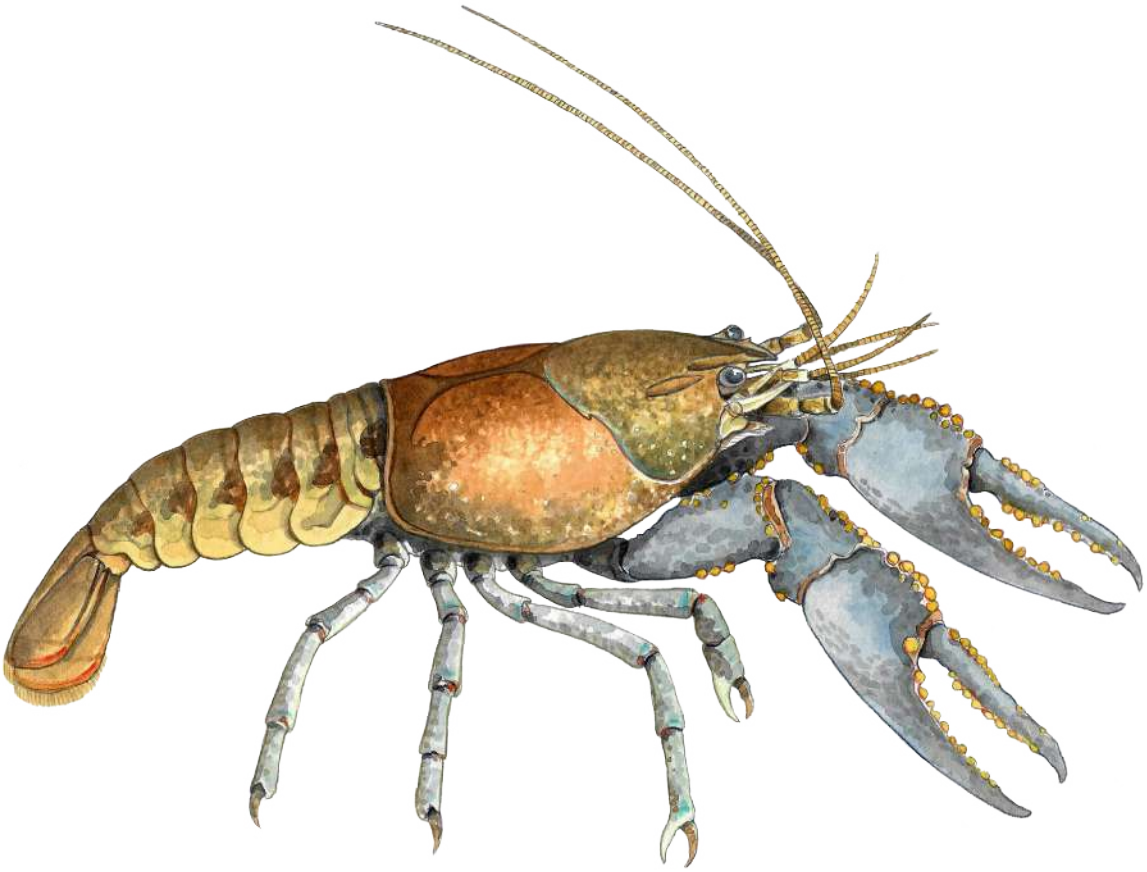
The rusty crayfish can establish in a variety of habitats and is considered one of the most invasive crayfish due its aggressive behaviour. Based on its impacts seen in the USA it could affect local biodiversity and ecosystems through its omnivorous diet of aquatic plants, macroinvertebrates and fish eggs, compounded by high population densities. It could also compete with native crayfish for resources, diet and shelter or transmit the crayfish plague. Additional impacts seen in the USA include damage to sport fishing and fisheries and the destabilising of banks, causing access problems, and impacting flood defences through burrowing behaviour.

Management

Once introduced eradication is very challenging, therefore, the most effective way of mitigating impacts is to prevent its introduction. Increasing public awareness through campaigns and education could curb illegal introductions. In closed systems (e.g. ponds) management practices include trapping, electrofishing or water drainage. For control of established populations, additional practices include physical diversions or barriers within rivers (but they can also impede the dispersal of native species), or biological control through fish predation of juveniles and small crayfish, which was used effectively in the USA alongside trapping to remove a population.

Photo: *Faxonius rusticus* (Rusty crayfish) © Peterwchen, CC BY-SA 4.0 via Wikimedia commons

Faxonius virilis (Orconectes virilis)
Virile crayfish



Description

The virile crayfish can reach a length of 13 cm (on average less than 10 cm) and is characterised by an olive-brown colour and sometimes by dark brown medial spots on the abdomen. The carapace is smooth with a small areola (the space between grooves on the carapace) and a row of tubercles on shoulders, one with a prominent spine. Claws have distinct yellow wart-like tubercles and can be blue. The species can occupy a wide range of environments, from streams to lakes (even in deep water), and extensively digs burrows into banks. The crayfish is omnivorous and opportunistic. It has a very high reproductive rate, starting in the second summer of life with up to ~ 500 eggs per female and the life span is up to four years.

Distribution

The virile crayfish is native to North America, from the Great Lakes area in the north to Texas in the south. It was introduced elsewhere in the USA, in Mexico, Canada, and Europe, where it was first reported in the Netherlands in 2004. The Netherlands had remained the sole EU Member State where the species was established until late 2021 when a new population was discovered in France. The species has also been recorded in Belgium. Considering the species' adaptability to different environments and to severe winter conditions, most European countries could be suitable for its establishment.

Illustration: *Faxonius virilis (Orconectes virilis)* (Virile crayfish)

Pathways

The initial pathway of introduction into the EU was thought to be related to ornamental trade: the virile crayfish was known to be sold by aquarium and garden pond wholesalers but rarely in the internet trade. In the USA, the species has been widely introduced within the angling sector as live bait for fish. Once in a system of connected water bodies, natural dispersal is likely, and the species can spread rapidly, at a rate of more than 2 km per year. In the Netherlands, the species colonised several hundred kilometres of waterways in just two years.

Impact

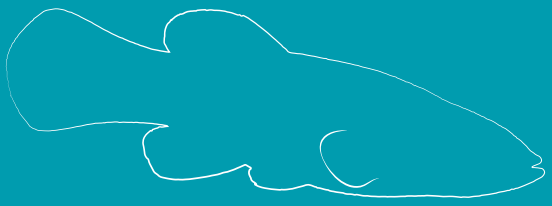
The virile crayfish has already been reported to cause the decline of macrophytes in the Netherlands. The species can also transmit crayfish plague, lethal for the European native crayfish. Based on its invasion history in the USA, it could also exert other negative ecological and socio-economic impacts in Europe, including the reduction of populations of macroinvertebrates due to its feeding habits. By digging burrows, it can increase water turbidity and contribute to the destabilisation of banks. The burrowing activity can increase maintenance costs and the risk of flooding.

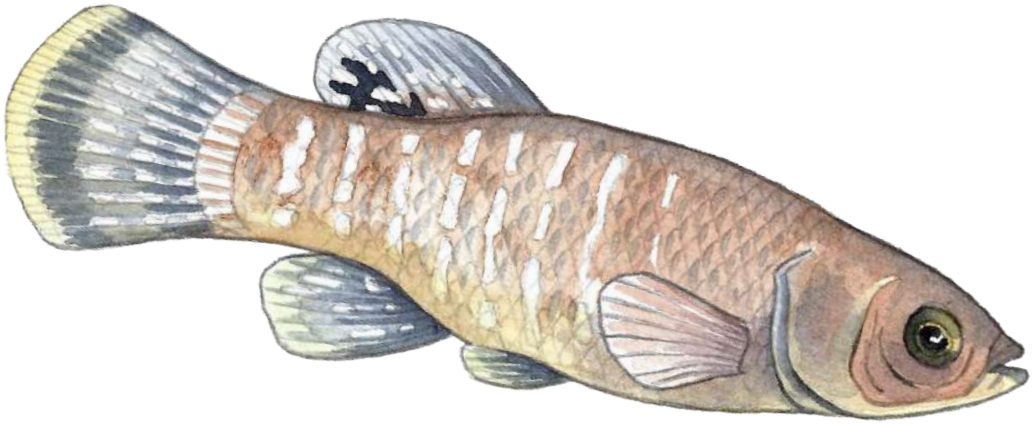
Management

As with other aquatic species, managing the virile crayfish is very difficult once in the wild. Raising public awareness of the species and its impacts can help prevent its illegal introduction and further spread. Citizen science projects and using environmental DNA can facilitate its detection at the early invasion stage and monitor its distribution. Eradication is possible in closed systems at the beginning of the invasion. Methods including trapping, pond drawdown, construction of barriers or diversions, biocides, and the use of native predators have been developed to control or contain other similar invasive crayfish and could be applied to this species. An integrated approach (using two or more methods) is recommended to tackle the species and its different life stages.

Photo: *Faxonius virilis (Orconectes virilis)* (Virile crayfish) © Alan Schmierer, Creative Commons Zero, Public Domain Dedication via Wikimedia

Fundulus heteroclitus
Mummichog





Description

The mummichog is a small killifish, reaching sexual maturity at approximately 35 mm in length (within the first year), with a lifespan of up to four years. They are tolerant of wide ranges in temperature (-1.5-36.3 °C) and salinity (0-120.3 ppm) and capable of withstanding rapid changes in either parameter. They inhabit brackish, salt water or neighbouring freshwater areas, mainly in sheltered coastal saltmarshes, tidal creeks, estuaries or bays. Mummichog feed primarily on small crustaceans, polychaetes and plant matter, usually at high tide during daylight hours but also opportunistically. They display a primary spawning peak in spring, followed by a smaller one in summer. Eggs resist desiccation for several days, and they are generally spawned in areas covered by high spring tides.

Distribution

The mummichog is native to the western Atlantic coast, from the Gulf of St. Lawrence (Canada) to northeast Florida (USA). Although not widely introduced worldwide, it has established two populations within the EU (Portugal and Spain) with no records in any other Member States. It was first recorded in Spain in the 1970s and in Portugal in 2002, however the lack of monitoring in Portugal means it could have been present for much longer.

Illustrations: *Fundulus heteroclitus* (Mummichog)

Pathways

Potential pathways of introduction into the EU include intentional introductions via the aquarium trade or escapes from research laboratories, as mummichog are a model species used extensively in experimental research. Unintentional introductions may also arise from contaminants of bait or animals (aquaculture), or ballast water. Natural dispersal of the mummichog is likely to be slow and infrequent due to their sedentary behaviour and small home ranges.

Impact

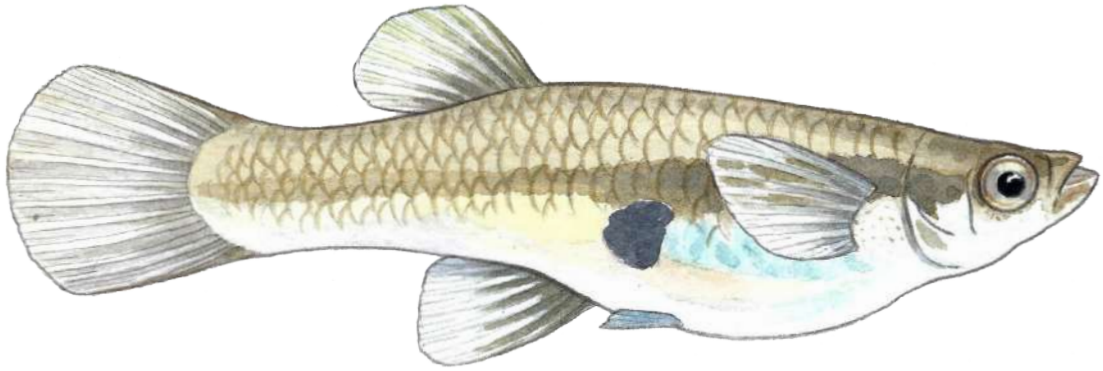
There is observational evidence that the mummichog is causing population declines of two endangered killifish species, the Baetican killifish (*Aphanius baeticus)* and the Spanish killifish (*Aphanius iberus*), endemic to Spain. Other impacts are unknown but competition with other fish species for space, caused by its high reproductive rate and abundance, could have subsequent ecological effects on native species, food webs and ecosystem functioning. Within the EU, saltmarshes are often protected due to their unique ecological characteristics and so the mummichog could affect a multitude of native, threatened species if it established.

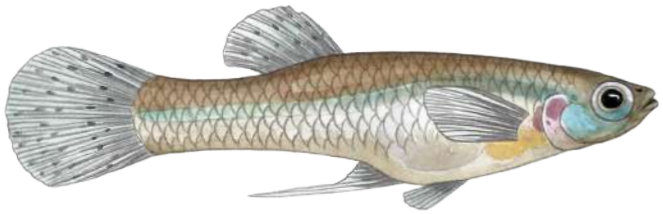
Management

Raising awareness among existing owners and research laboratories may prevent escapes or deliberate releases. Early detection, by monitoring suitable habitats near existing populations using environmental DNA or citizen science, is essential to avoid establishment. The mummichog can tolerate extreme chemical (contamination) and physical conditions (temperature, salinity, oxygen, etc.), making it difficult to control. Eradication will only be feasible for recently established populations in a small or enclosed habitat. When established in its typical open habitat of coastal lagoons and estuaries, eradication will not be feasible. Control methods, such as fishing nets, have not been effective in preventing establishment.

Photo: *Fundulus heteroclitus* (Mummichog) © Fishes of Georgia Photo Gallery, CC BY-NC-ND 2.0 via Fickr.com

Gambusia affinis
Western mosquitofish





Description

The western mosquitofish is dull grey or brown in colour, with rounded fins and an upturned mouth adapted for feeding at the surface of the water. There is a high degree of similarity, in appearance and behaviour, between the western mosquitofish and eastern mosquitofish (*Gambusia holbrooki*), both of which are present in Europe. The western mosquitofish is a live-bearing species, with the average brood size ranging from 30-50 young (although maximum brood size can vary greatly). It lives in lowland ponds, lakes and streams, generally preferring standing water with dark-coloured, silty substrate and dense sub-surface vegetation, to provide cover from potential predators. Despite the name, there is limited evidence that mosquitofish reduce mosquito population densities.

Distribution

The western mosquitofish is native to the Mississippi River basin in North America (USA and Mexico) and has been introduced to every continent, except Antarctica, as the result of human-assisted movement. Within the EU, the species is only established in one Member State, Italy, within one isolated pond. There are no records within any other EU Member State but the species could establish in most of the western and southern Member States.

Illustrations: *Gambusia affinis* (Western mosquitofish) female (above) male (below)

Pathways

Western mosquitofish could be introduced through a variety of pathways, including the pet/aquarium trade, transport contamination or deliberate introductions for biological control; but there is little evidence of the species' effectiveness for the latter. If mosquitofish from the pet/aquarium trade are housed in garden ponds, the risk of wider dispersal is enhanced particularly when the pond is located on a flood plain. The pathway into the EU that is considered most likely is through contamination of imports, specifically shipments of other biological control species, pet fish for aquaria or garden ponds, live angling bait and fish for restocking.

Impact

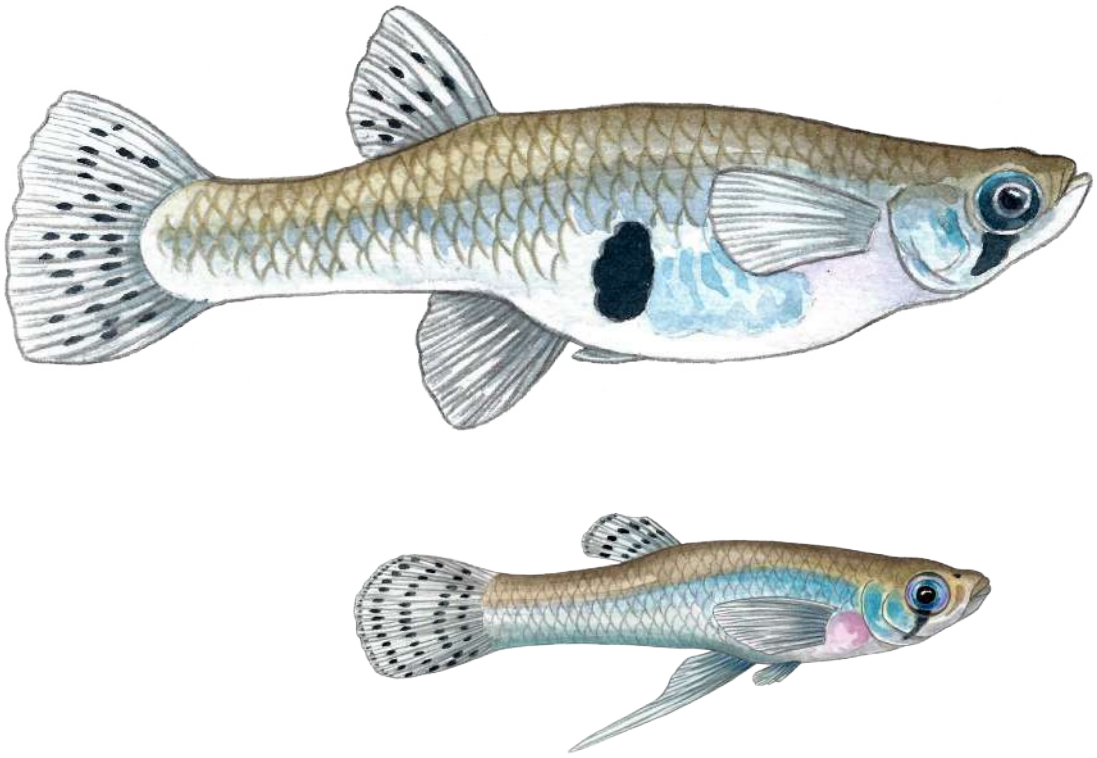
The impact of the western mosquitofish is currently unknown, due to its localised and limited population within Europe. Potential impacts on biodiversity, based on the eastern mosquitofish, which is more widespread in Europe, include displacing native or endemic fish species, through predation and competition, and potentially contributing to eutrophication processes. They also reduce rotifer, crustacean and insect populations, thus enabling phytoplankton blooms.

Management

If introduced, the species is very likely to establish but they are poor dispersers. Raising public awareness on the risks posed by invasive species should reduce further introductions via the pet trade. Detection methods include electrofishing, fyke-netting and environmental DNA, but seine/dip nets and traps are more efficient. Eradication is dependent on location, dispersal ability and the level of establishment. In small enclosed water bodies effective management measures include drain-down, biomanipulation (e.g. native predators), lime treatment or piscicides (e.g. rotenone). However, the species is less sensitive to piscicides and there are legal constraints on their use within the EU. These practices could also be used to control established populations, alongside methods such as electrofishing, seine/fyke nets and minnow traps.

Photo: *Gambusia affinis* (Western mosquitofish) © sbeep, CC BY-NC via iNaturalist

Gambusia holbrooki
Eastern mosquitofish



Description

There is a high degree of similarity between the eastern mosquitofish and western mosquitofish (*Gambusia affinis*), both of which are present within Europe. However, eastern mosquitofish possess eight dorsal fin rays while western mosquitofish have seven. Although the eastern mosquitofish prefers warmer water temperatures, it can adapt to cold conditions, including winter ice cover. It is an adaptive species, responsive to salinity, food resources and population size, making them successful fish invaders. Mosquitofish mature at four to six weeks, meaning up to three generations may be produced in one year. The species inhabits lowland ponds, lakes and streams with still water, silt substrate and dense vegetation cover and they feed on algae and detritus.

Distribution

The eastern mosquitofish is native to the Mississippi River basin in North America (USA and Mexico) and has been introduced to non-native ranges within North America and all other continents, except Antarctica. The species has established populations in ten EU Member States (Croatia, Cyprus, France, Greece, Hungary, Italy, Portugal, Romania, Slovenia and Spain), with records also from Bulgaria.

Illustrations: *Gambusia holbrooki* (Eastern mosquitofish) female (above) male (below)

Pathways

The eastern mosquitofish has been introduced globally, primarily as a biocontrol agent for mosquito control to prevent the spread of malaria. It has been intentionally introduced into the EU for this purpose since at least the 1920s and this is still considered an active introduction pathway. However, research shows limited evidence that it can reduce either mosquito populations or mosquito-borne diseases. Additional pathways include escapes through the pet trade or as a transport contaminant with other intentional fish transfers. Transport contaminant is the most likely pathway, as fish transfers may occur for multiple reasons including bait and re-stocking. If mosquitofish are present in the transfer, their survival during passage is high due to their tolerance to low oxygen conditions.

Impact

The aggressive and predatory behaviour of mosquitofish impacts native fish populations through predation and competition for food and habitat. In the EU, they impact endangered toothcarp species in Spain and Corfu killifish (*Valencia letourneuxi*) in Greece.

Outside the EU, mosquitofish have been responsible for a reduction in threatened fish and amphibian species (Australia) as well as reducing rotifer, crustacean and insect populations and enabling phytoplankton blooms.

Management

Raising public awareness should reduce further unauthorised introductions for the pet trade or as a biocontrol for mosquitos, as there is limited evidence, if any, for the latter. Detection methods include electrofishing, citizen-science monitoring, fyke-netting or environmental DNA, but seine/dip nets and traps are more efficient for mosquitofish. In small enclosed water bodies, the use of drain-down, biomanipulation (e.g. use of native predators), lime treatment and piscicides (e.g. rotenone) may be effective in eradicating populations. However, the species is resistant to piscicides and there are legal constraints on their use within the EU. These methods could also be used to control populations, alongside depletion methods via removal through electrofishing, seine nets, minnow traps, or fyke nets.

Photo: *Gambusia holbrooki* (Eastern mosquitofish) © MarshBunny, Creative Commons Attribution-Share Alike 4.0 via Wikimedia Commons

Herpestes auropunctatus (Herpestes javanicus)*
Small Asian mongoose

Description

This slender-bodied mongoose is brown in colour, with fur flecked with golden spots. The average litter size is 2-3 young and, depending on food availability, females can produce up to three litters annually. Their diet is varied, and can include small mammals, birds, reptiles, invertebrates and plant matter. The major dietary components differ by population, with some populations feeding primarily on insects and some on fruit. The mongoose prefers dry habitats and will inhabit grassland, secondary growth and dense forests, but also around areas of human habitation. The species is capable of swimming, but will generally avoid water and reduce its activity during rainy periods. The maximum lifespan in the wild is 3-4 years.

Distribution

The small Asian mongoose is native to a wide range of countries, from northern Saudi Arabia stretching eastwards throughout Southeast Asia. It has been introduced to a wide range of countries, particularly offshore islands, since the 1800s, with particularly severe impacts in the Caribbean and on Hawaii, Mauritius and Fiji among others. In the EU the species has been recorded in Croatia, both on offshore islands and the mainland coast.

Illustration: *Herpestes auropunctatus* (Small Asian mongoose)

*Scientific name as indicated in the Commission Implementing Regulation

Pathways

The primary pathways available to this species are via the pet trade and as a biological control. Historically, the small Asian mongoose was introduced to control rats and snakes in agricultural areas, however this proved highly unsuccessful as the mongoose itself predated native species and, at best, only partially reduced rat populations. The pet trade is a major pathway, due to the ease with which the small Asian mongoose can be captured in its places of origin.

Impact

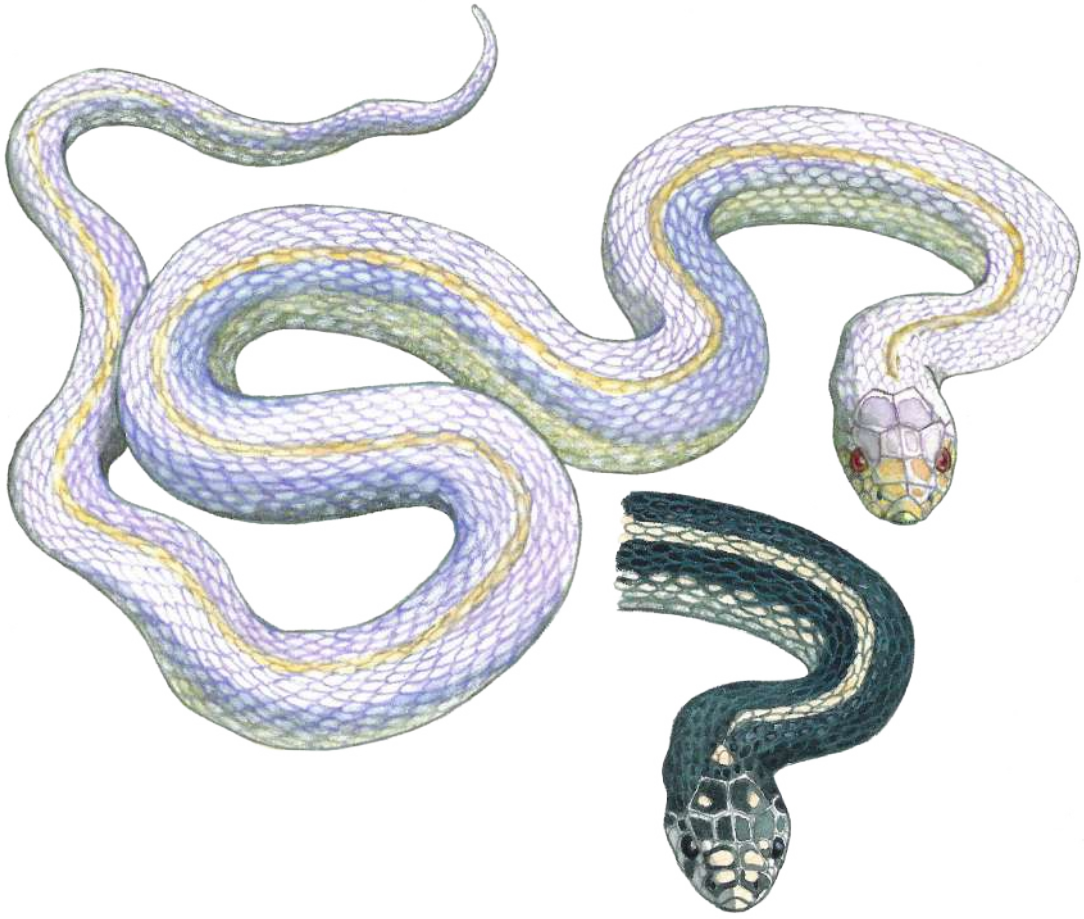
The impacts of the small Asian mongoose on native species are extreme and the species is known to have spread rapidly from the areas in which it was first introduced. The mongoose is responsible for the decline, and in some cases localised removal, of ground nesting island birds, along with mammals, amphibians and reptiles. In addition to predation on native and endemic species, the mongoose also damages crop production and poultry. With regards to parasites and pathogens, the species can act as a reservoir for diseases including rabies, leptospirosis and salmonella, among others. It is therefore possible that the mongoose may facilitate pathogen transmission to humans, livestock and other animals.

Management

Controlling the pet trade and raising awareness about the species' impacts should reduce the possibility of escapes/deliberate release from captivity. Furthermore, highlighting the impacts when used as for biocontrol may also lessen the likelihood of deliberate introductions. Trapping is the primary mechanism used to control small Asian mongoose populations. Cage traps are widely used for eradication, control and containment, often in conjunction with shooting. Spring trapping is an option, and although it has not yet been used to eradicate the species, it has been used to reduce populations to a few individuals. The effectiveness of spring traps depends on the area trapped, trap spacing, bait type and the skill of the trapper in trap placement and setting.

Photo: *Herpestes auropunctatus* (Small Asian mongoose) © iStockphoto/kajornyot

Lampropeltis getula
Common kingsnake



Description

The common kingsnake is a slender snake characterised by a dark ground colour covered by a series of white rings, although the species may exhibit substantial colour pattern variation (which has resulted in a large number of described subspecies). The species can also exhibit albino coloration. In its native range, the common kingsnake lives in a wide range of habitats from open coniferous forest and woodland, swamps, coastal marshes and river bottoms, to farmland, prairie, and desert habitats, from sea level to around 2 130 m above sea level. It has a generalist diet, feeding on a variety of animals, including reptiles, birds, rodents, small mammals, amphibians and eggs. Its main predators are birds of prey, other snakes, small carnivores and other generalist species like the wild boar.

Distribution

The common kingsnake is native to the USA and northwestern Mexico, from the Pacific to the Atlantic coast of North America. The species has been recorded in four EU Member States (Belgium, Germany, Italy and the Netherlands) but it has not yet established populations in any, except in the Canary islands (in Gran Canaria, Spain), which is an outermost region.

Illustrations: *Lampropeltis getula* (Common kingsnake) main drawing illustrating albino coloration and the head drawing illustrating the black and white variation

Pathways

The common kingsnake is found within the pet trade, and so the main pathways of introduction include escape from confinement, via private pet owners or zoological gardens, and release in nature through deliberate introductions of unwanted pets. Other potential pathways include as transport stowaways or contaminants on plants. Casual records in the EU illustrate that the species is widely kept as a pet and that escapes may occur sporadically.

Impact

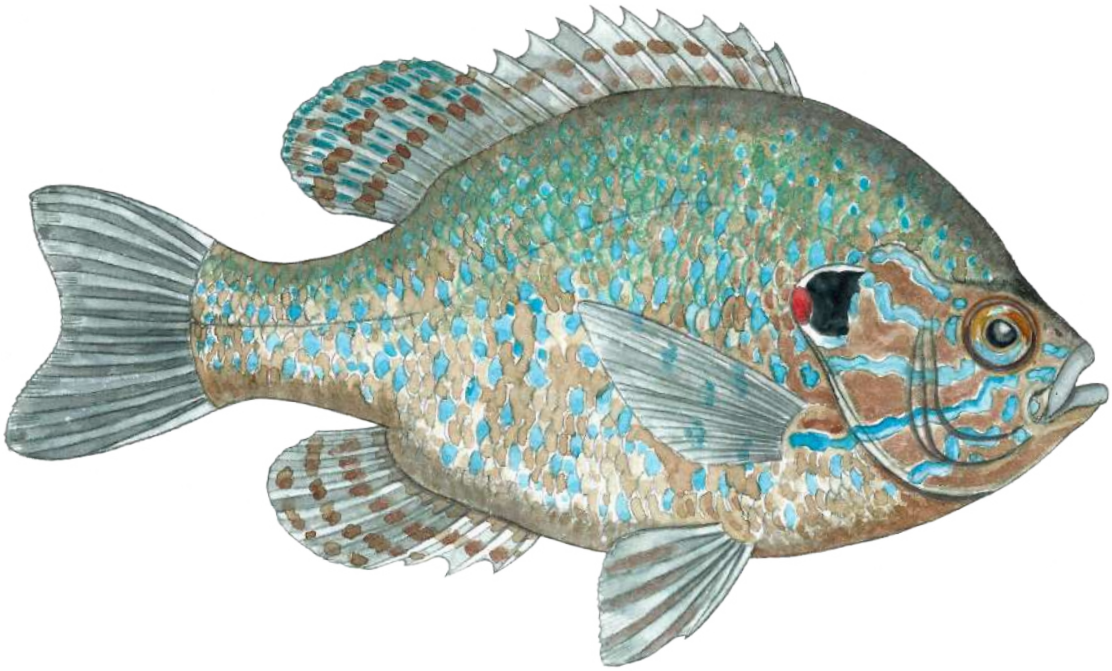
The common kingsnake may have a major impact on biodiversity, particularly through predation, and to a lesser extent through competition and the spread of diseases. It has a generalist diet, and as such could pose a threat to many native European species. Within Gran Canaria it is reported to predate on small rodents, birds and endemic lizards, the latter can be important seed dispersers and so their decline could also impact native plant species or vegetation structure. There are concerns that the endemic Gran Canaria giant lizard (*Gallotia stehlini*) might become threatened in the future, as it made up the largest proportion of prey for the common kingsnake. It could also be a possible carrier of snake fungal disease, potentially damaging native reptile species, but this remains largely undocumented.

Management

Raising public awareness of the risks posed by the common kingsnake in the natural environment could reduce the risk of deliberate introductions and assist reporting and detection. Monitoring and early detection is difficult due to the species' secretive nature. Some monitoring techniques, include terrestrial drift fences with funnel and pitfall traps, artificial coverboard arrays or aquatic funnel traps. If established, it would be difficult to contain the species and eradication of established populations could be impossible, as experienced in Gran Canaria. In Gran Canaria, control methods included trapping (funnel, pitfall and pheromone traps), artificial barriers, artificial covers/refugia and hunting with raptors. Hand capture was the most effective control measure.

Photo: *Lampropeltis getula* (Common kingsnake) © J. Maughn, CC BY-NC 2.0 via Flickr.com

Lepomis gibbosus
Pumpkinseed



Description

The pumpkinseed is a freshwater fish, which usually reaches around 10 cm in length (but can grow up to 40 cm). It has a laterally compressed oval shape, with sharp spines in the dorsal and anal fins. Its body has a colourful pigmentation (dark olive background with orange, yellow, green and blue patterns), with speckles and vertical bars, and a typical black and red-orange spot on its gill cover. In both its native and alien range, the pumpkinseed occurs and reproduces in lakes, ponds, reservoirs and small rivers, particularly those with high vegetation cover, and can tolerate a wide range of climatic conditions. The species feeds on several species of small vertebrates, particularly fish and fish eggs, as well as a wide range of invertebrates.

Distribution

The pumpkinseed is native to the eastern States and Provinces of North America and has been introduced in several parts of the world, including western North America, South America, Asia and Africa. In the EU, the species is considered established in all Member States, apart from Estonia, Ireland, Malta and Sweden. The pumpkinseed has been recently recorded in Sweden, and is established in other European countries, including Norway, Switzerland and the UK.

Illustration: *Lepomis gibbosus* (Pumpkinseed)

Pathways

It was first introduced to Europe in the 1880s as an ornamental fish for outdoor ponds and indoor aquaria. It has since been released in multiple water basins across the EU, also for sport fishing and fish cultures, e.g. for use as forage food for largemouth bass, or as a biocontrol agent for the control of the fish louse. The pumpkinseed could also be introduced accidentally as a contaminant of aquaculture, for example with imports of carp fry used in stocking.

Impact

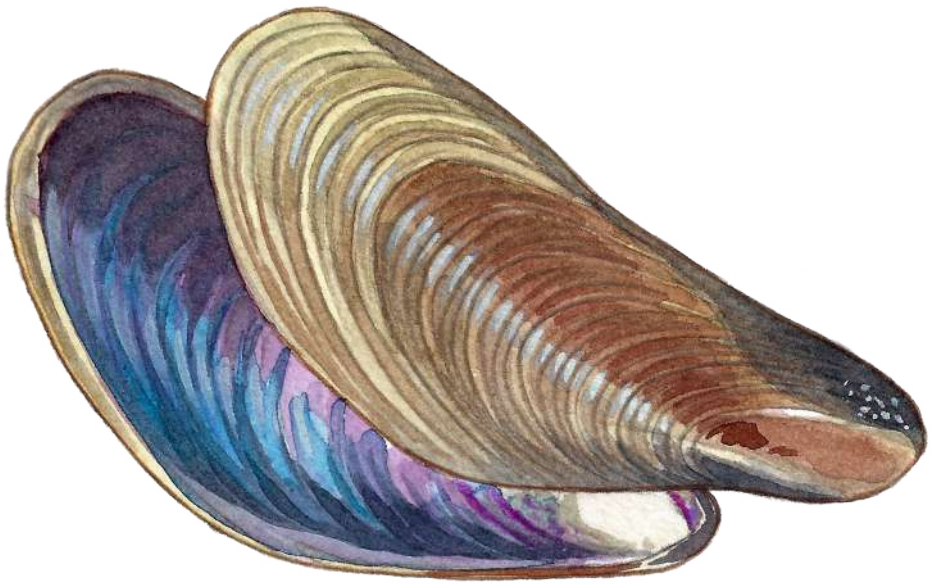
The impact of pumpkinseed on native species and abiotic conditions of water bodies is so high that it is considered an 'ecosystem-altering' invasive alien species. The species outcompetes native fish as it has an aggressive behaviour, and predates upon their eggs and juveniles. There is evidence it is also responsible for considerable declines in local invertebrates and endangered amphibians, including several species listed in the Habitats Directive, and as such protected by EU legislation. For this reason, the pumpkinseed can have a remarkable impact on natural and semi-natural habitats as well as recreational fishing waters.

Management

The control of the species in habitats outside its native range is very difficult, mostly due to the high reproductive success. The main management tools and techniques include the use and combination of barriers and nets, drainage of water bodies, electrofishing, hand removal and piscicides, but the latter has legal constraints on its use within the EU. However, eradication of established populations from large water basins is virtually impossible due to a number of technical constraints. Therefore, preventing further introductions and spread through public awareness-raising campaigns is critical. Although unlikely to be effective in the long-term, the removal of this species through over-fishing may be useful in decreasing its impact on native biodiversity, particularly in smaller water bodies.

Photo: *Lepomis gibbosus* (Pumpkinseed) © Bernard Dupont, CC BY-SA 2.0 via Flickr

Limnoperna fortunei
Golden mussel



Description

The golden mussel is a freshwater bivalve mollusc, which inhabits river basins between the temperatures of 5-35 °C but can survive in waters of low salinity, such as estuarine habitats. It can also tolerate polluted waters with low levels of calcium, oxygen and pH. It grows in aggregated dense clumps on hard surfaces, due to the production of byssal threads. The shells of adults are yellow-brown and in clear water, they look golden, hence their common name the 'golden mussel'. The shape and characteristics of the golden mussel can lead to misidentification with other species including the native European marine blue mussel (*Mytilus edulis*) and the invasive alien freshwater *Dreissena* species, i.e. the zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*Dreissena bugensis).*

Distribution

The golden mussel is native to southeast China, and has been introduced to countries within South East Asia (Hong Kong, Taiwan, Vietnam, Lagos, Thailand, Japan and South Korea) and South America (Argentina, Bolivia, Brazil, Paraguay and Uruguay). The species is currently absent from all EU Member States, but can establish under the current climate conditions in Europe, particularly southern Europe.

Illustration: *Limnoperna fortunei* (Golden mussel)

Pathways

There are few pathways of introduction and all are unintentional. The first is as a transport stowaway during the larval stage via ship/ballast water, in ships originating from either South America or South East Asia. The second is as a contaminant, on animals, such as the Asian clam (*Corbicula fluminea*) imported for food, or ornamental plants for aquaria, although these pathways are unlikely. If introduced, natural dispersal through waterways is likely as well as unintentional human-assisted spread by several vectors (nets, buoys, boats, and fishing gear), as seen with the golden mussel in South America and the similar zebra mussel in the EU.

Impact

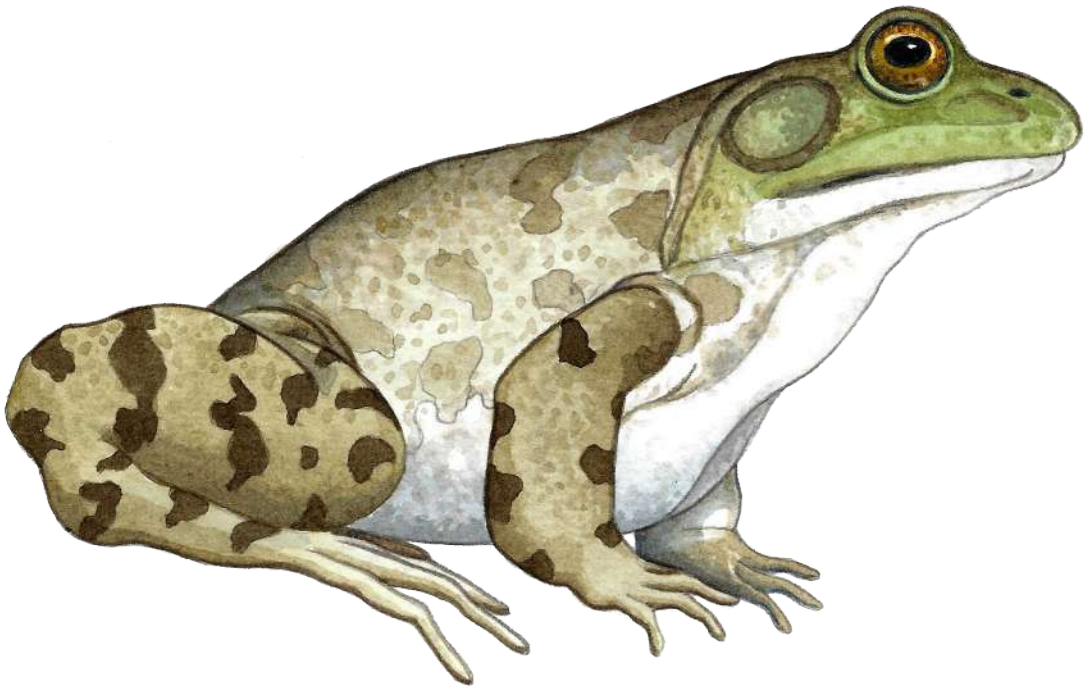
Available evidence, based on the golden mussel introduced range and its similarity to the zebra mussel, which is present in the EU, suggests that this species can pose a serious risk to biodiversity. It can cause disruption of nutrient cycles through filtering activity, biofouling of native species, enhanced toxic cyanobacterial blooms, deterioration of water quality, can outcompete threatened molluscs and other invertebrates, and can transmit parasites to fish. In its native and introduced range, it can also impact industrial facilities. Being a fouler organism, it can clog/foul water intake sieves and filters, pipes, heat exchangers, and condensers, can cause contamination of food for markets and also block irrigation systems.

Management

The eradication of the golden mussel is considered unlikely, based on its ecological similarity to the zebra mussel, and so preventing its introduction is the most effective control measure. The ballast water management convention will minimise the risk of introduction. Public awareness raising can increase biosecurity through check, clean and dry campaigns, as seen in Ireland. Early detection is difficult at the larval stage but adults occurring in densely packed clusters can be monitored through surveys or citizen-science. Potential control measures used on the zebra mussel include biological control using cyprinid fish stocks, mechanical control and hand removal. Biological control was used for the zebra mussel within Ireland, in an enclosed lake, but eradication was not possible.

Photo: *Limnoperna fortunei* (Golden mussel) © Boltovskoy, CC BY-SA 4.0 via Wikimedia commons

Lithobates catesbeianus
American bullfrog



Description

The American bullfrog is the largest of the North American frogs, reaching a length of almost 20 cm and weighing up to half a kilo. The tadpoles reach up to 15 cm in length and are much larger than any other species. The species common name comes from its distinctive call, which sounds like the mooing of a cow. The American bullfrog lives in a wide range of aquatic habitats including lakes, ponds, swamps, bogs, marshes and backwaters, as well as artificial and modified habitats. The American bullfrog has the ability to colonise a whole range of habitats and to feed on many species. The diet of this voracious opportunistic predator seems to reflect habitat rather than food preference, a feature that increases its fitness in a wide range of ecological situations.

Distribution

The American bullfrog is native to the eastern part of North America, and has been introduced in the last century to the western part, as well as into more than 40 countries worldwide. In the EU, there are established populations in seven Member States (Belgium, France, Germany, Greece, Italy, the Netherlands and Spain) and has been recorded in Slovenia, with historic records in Austria and Denmark.

Illustration: *Lithobates catesbeianus* (American Bullfrog)

Pathways

The American bullfrog is an edible species mainly introduced as a consequence of escapes from breeding facilities (where it was farmed for human consumption and trade in aquaculture) but also from garden ponds. In some cases the species was also released intentionally to establish wild populations to be regularly harvested, or as seen outside of the EU, to act as a biological control agent (as a predator of unwanted species, like insect pests in Hawaii). Deluge floods can facilitate the dispersal of tadpoles and eggs between water bodies and juveniles will migrate en masse overland at the end of each breeding season.

Impact

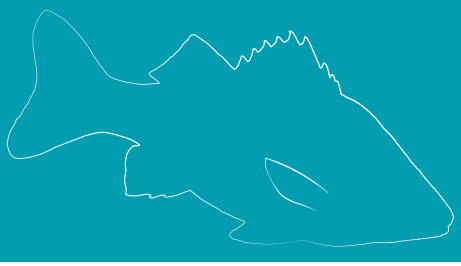
The American bullfrog is known to feed on many species, from insects and other invertebrates to several vertebrates, such as amphibians and reptiles, small mammals and birds. Due to this diet, the species can be an important predator of native and endangered amphibians and fish. Like other introduced species with a wide trophic niche, the American bullfrog may outcompete and displace other indigenous amphibians, at both adult and larval stages. The American bullfrog represents a major conservation concern for native ecosystems also for the inherent risk of transmission of diseases and parasites to the native amphibian fauna. For example as a vector of the chytrid fungus, a pathogen implicated in massive die-offs of amphibians worldwide.

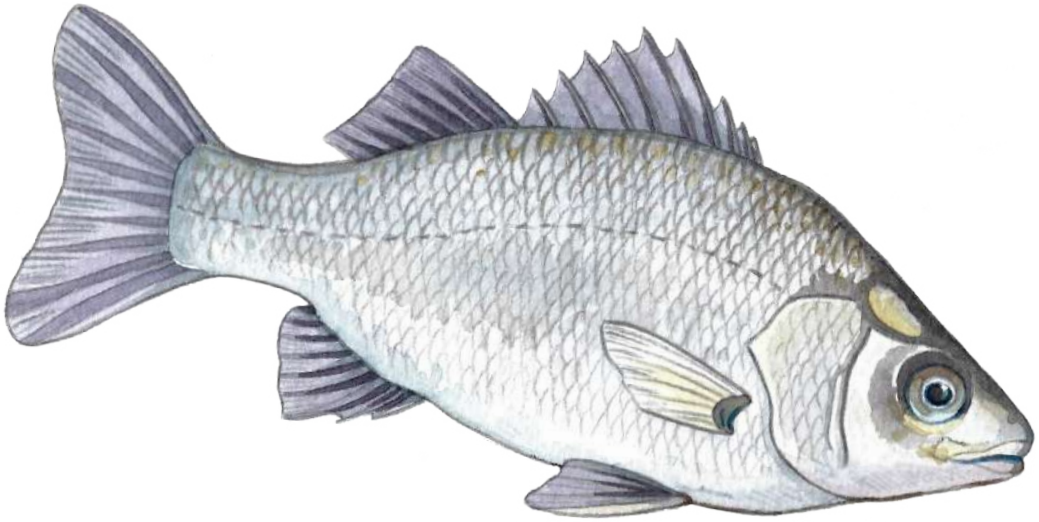
Management

Careful monitoring is necessary for the early detection and management of newly established populations. The main management strategies include a number of (integrated) techniques, such as isolation of breeding ponds with frog-proof fencing combined with pitfall trapping, netting, draining, electrofishing and shooting. Within the EU, eradication or control programmes have been carried out, for example in France, Belgium, Germany and the Netherlands. The species has been successfully managed in countries outside the EU e.g. United Kingdom and Canada. Innovative genetic techniques, like the release of sterile triploid males, are currently being tested combined with other traditional methods (e.g. fish traps) in Belgium, through a LIFE project co-funded by the European Commission. The import of this species is also banned through the EU Wildlife Trade Regulations.

Photo: *Lithobates catesbeianus* (American Bullfrog) © Cephas, CC BY-SA 3.0 via Wikimedia

Morone americana
White perch





Description

The white perch reaches an average length of 12-18 cm and their colour varies from dark greyish-green, dark silvery-green, or dark brown to almost black on the back, pale-olive or silvery-green on the sides and silvery-white on the belly. They inhabit fresh, brackish and coastal waters in quiet water such as large rivers, lakes or ponds with muddy substrate, living and feeding at the bottom of the waterbody. The only other organism that is likely to look very similar to the white perch is the *Morone* hybrid (*M. chrysops x M. saxatilis)*, which has been imported to some EU and neighbouring countries for aquaculture, and there are a few reports of specimens of this hybrid being captured from EU rivers.

Distribution

The white perch is native to the west coast of North America, from Quebec to South Carolina along the Atlantic coast, with the peak abundance in the Hudson River and the Chesapeake Bay. The species has spread through the Erie and Welland canals into the Great Lakes and has been established in all of them and their surrounding States, as well as in Kentucky, Massachusetts, Missouri, Nebraska, New Hampshire, and Vermont. To date, none of the EU Member States have established populations or records of white perch, but it is capable of establishing in most Member States under both current and future climate predictions.

Illustration: *Morone americana* (White perch)

Pathways

Within North America, white perch have been introduced intentionally in non-native waters by voluntary and incidental stocking, and possible angler introductions for sport fishing. Potential pathways into the EU include as a transport stowaway in ship/boat ballast water, transport as a contaminant of animals through the importation of other *Morone* species for aquaculture or release in nature by anglers, but the latter two are considered unlikely.

Impact

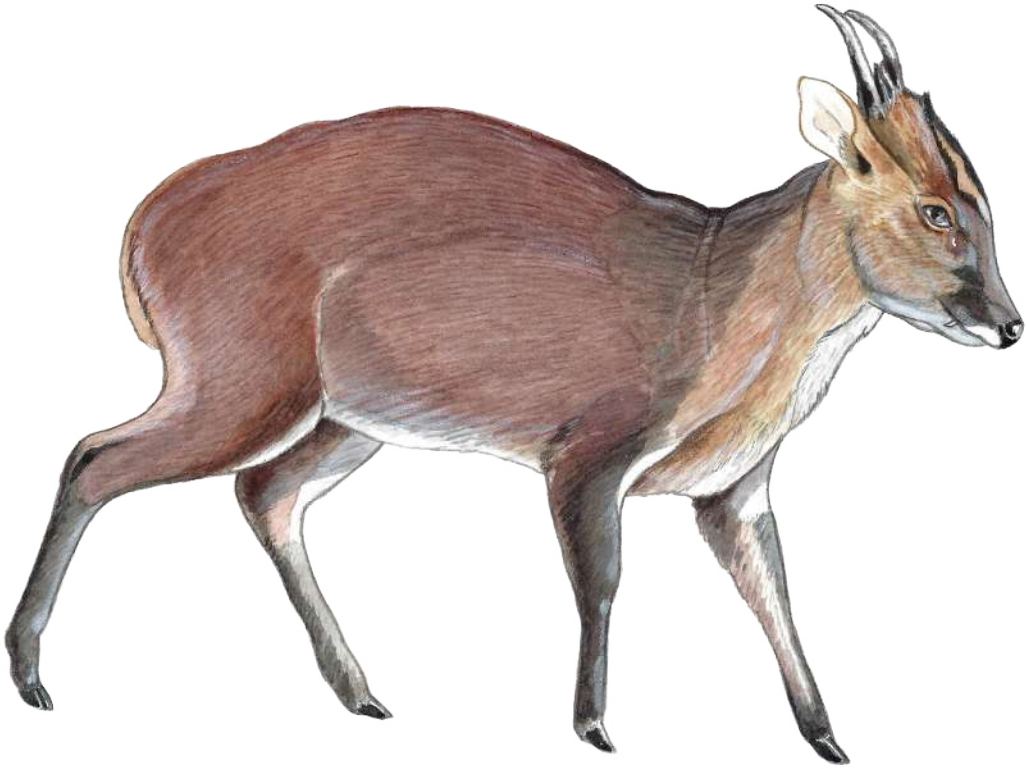
Due to the absence of white perch populations in the EU, the impact of the species in the region is unknown. However, in North American non-native ranges, there is evidence that the white perch can have adverse effects on biodiversity and ecosystems. It can dominate environments due to its opportunistic feeding, broadcast spawning and high fecundity. As a result, it has been found to compete with native fish for food, potentially predate on fish eggs affecting the recruitment of populations of prey species, and hybridise with native species. In the USA they can also impact commercial fisheries and recreationally important fish.

Management

If introduced it would be difficult to contain or prevent natural dispersal, and eradication is virtually impossible once the species has been established, so preventing its introduction is the most effective control method. The ballast water management convention will minimise the risk of accidental introduction. If introduced into a river system, recreational or commercial fishers could euthanise the fish when captured, as a rapid response. If established, targeted fishing efforts through angling, fyke or seine netting, or the use of strobe-light deterrents, could keep them restricted to certain areas. The only situation when eradication could be successful is in enclosed waters of limited surface area using intensive netting and/or electrofishing.

Photo: *Morone americana* (White perch) © Neil DeMaster, CC BY-NC via iNaturalist

Muntiacus reevesi
Muntjac



Description

The Reeve's muntjac, known commonly in the EU as the muntjac, is a small species of deer. They are secretive animals, living in dense woodland and along forest edges. They are reddish-brown in colour with a creamy white belly and dark striped markings on the face under the eyes. Males have short and simple antlers, together with enlarged incisor teeth forming small tusks. Females lack antlers and tusks but have bony lumps on their heads. They are a small species, standing half a meter in height at the shoulder and adults typically weigh between 10-18 kg. This small size makes them distinct from other deer species in the EU. During the mating season or when disturbed, they produce a distinctive, barking call.

Distribution

Muntjac are native to subtropical forests in South Asia and have been introduced to Japan and Europe. Within the EU the species has established populations in six Member States (Belgium, Denmark, France, Germany, Ireland and the Netherlands), with no records from any other Member State.

Illustration: *Muntiacus reevesi* (Muntjac)

Pathways

Muntjac were initially released as a free-living ornamental species onto a number of country estates and deer parks across northern Europe in the early 20th century. Escapes from these points of initial release and subsequent spread into the wild have been the primary source for the current European populations. However, further releases continue to occur, either accidentally or purposely, to promote local hunting opportunities. These activities have led to new population centres becoming established and the spread of this species into new regions of Europe which they would have been unlikely to reach through natural dispersion from areas of earlier introductions.

Impact

Muntjac preferentially live in woodland and selectively browse woodland plants, new shoots and grasses. Their grazing can therefore change the structure and species composition of woodland. While grazing impacts are common to many deer species, these impacts are particularly notable for muntjac as they can reach very high local densities. Impacts include changes to the structure of native woodland and the loss of the ground layer, with subsequent effects on a wide range of other species such as butterflies and other invertebrates that depend on native vegetation. Muntjac can also damage forestry, with newly planted trees requiring protection, while natural woodland and coppice regeneration can be limited by muntjac grazing.

Management

Muntjac have the potential to spread more widely within Europe. Limits to the keeping of this species in public and private collections together with the prevention of their transport and trade, should limit the risk of further spread. Effective surveillance to identify whether new populations have established in an area, followed by rapid eradication, will limit the formation of new populations. However, the secretive nature of this species can make the surveillance of newly established populations challenging. In areas where they are already well established, their numbers and impacts are primarily managed by shooting, as is the case with other deer species.

Photo: *Muntiacus reevesi* (Muntjac) © Cloudtail the Snow leopard, CC BY-NC-ND 2.0 via Flickr

Myocastor coypus
Coypu

Description

The coypu or nutria is a large, semi-aquatic rodent that lives in burrows alongside wetland areas and feeds on aquatic and bankside vegetation. They have a bare, round tail and course dark brown outer fur with soft grey underfur. They also have large, brown front teeth. Their eyes and ears are set high on their heads, reflecting their swimming habits, and they have webbed hind-feet. Adults typically weigh between 4 and 9 kg. They are broadly similar in appearance to beavers and muskrats, but they lack the broad flat tail of the beaver, while muskrats are considerably smaller and lack the webbing on their hind feet. Coypu can breed throughout the year and, under favourable circumstances, females may have multiple litters with an average of 15 young per year.

Distribution

Coypu are native to South America but have been widely introduced to other continents, primarily through escapes from fur farms, with populations established in North America, Asia and Africa. They were introduced to Europe in the 19th century for fur farming. Since their introduction, coypu have become established in 17 Member States (Austria, Belgium, Bulgaria, Croatia, the Czech Republic, France, Germany, Greece, Hungary, Italy, Latvia, Luxembourg, Poland, Romania, Slovakia, Slovenia and Spain). They are localised in The Netherlands and Ireland, and have previously been recorded in Denmark, Finland and Sweden.

Pathways

Coypu were widely hunted for their fur in their native range, but as wild populations dwindled other approaches were developed. Commercial fur-farming began in Argentina in the late 19th century and the practice soon spread to many other parts of the world. Commercial fur farming in Europe became widespread in the 20th century, although it has now ceased. The current European population is descended from animals that escaped or were deliberately released from these farms and their subsequent spread throughout the wild. As a semi-aquatic species, coypu can disperse along water courses and also cross land to colonise new areas.

Illustration: *Myocastor coypus* (Coypu)

Impact

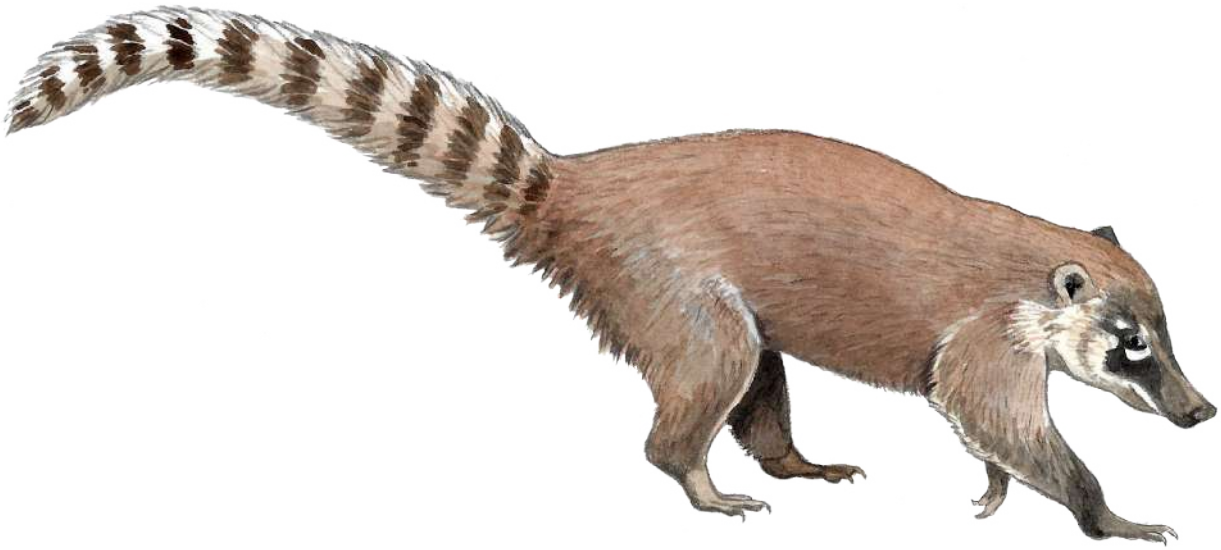
Coypu dig burrows in riverbanks, which can damage drainage schemes, particularly in low-lying areas. This burrowing activity may also make dikes and levees susceptible to collapse when combined with other pressures such as flooding. Their feeding habits can impact on natural habitats, with marked effects on reedbeds and other aquatic vegetation. Coypu may affect waterbird breeding success by using nests as resting platforms, thus breaking or sinking the eggs. They are considered an agricultural pest in many areas, grazing on crops in neighbouring fields such as cereals, root crops and the saplings of fruit and nut trees.

Management

Given the widespread nature of this species, in most areas of the EU management is focused on reducing local impacts. A number of countries subsidise the local control of coypu to protect drainage schemes and agricultural crops. These primarily use traps and shooting, traps set on floating rafts are considered to be particularly effective. More intensive management has been used in the USA to protect native wetlands, while the species was eradicated from the eastern region of the UK following a long-term trapping programme. Surveillance followed by rapid eradication should prevent the establishment of new populations.

Photo: *Myocastor coypus* (Coypu) © Valentin F.R., CC0 1.0 via Flickr

Nasua nasua
Coati



Description

The coati is a medium-sized animal, with a head-to-tail length of 80-130 cm, black facial markings and a distinctive banded tail. Their colouring ranges from golden/reddish brown to dark brown or grey. Coati are arboreal (but feed on the ground also) and inhabit a range of forest types including evergreen, deciduous, rainforest and dry scrub forest. Although elusive, they are comfortable living in close proximity to humans and are known to feed on human food waste. Their natural diet primarily consists of invertebrates, fruit, eggs, chicks and limited consumption of other small vertebrates. They often travel around 2 km a day, moving through patches of vegetation quickly. Females and juvenile males travel in large groups, while adult males are solitary. Litters consist of 3-4 pups, and the pups are kept in nests for 5-6 weeks.

Distribution

The coati is native to South America and is broadly distributed, from Uruguay and northern Argentina up to Colombia and Venezuela. It has been introduced to Robinson Crusoe Island off Chile, Anchieta Island off Brazil, Florida and the UK. Within the EU, the species has established in one Member State, Spain, on the Island of Majorca where at least one breeding population is confirmed, with records also from Germany.

Pathways

The primary pathway of introduction into the EU is the escape or deliberate release from captivity, as the coati is widely kept in zoos, wildlife parks and in the pet trade. It is a semi-common pet in Europe, with accidental releases potentially more frequent from private owners than zoos. These activities have contributed to the breeding population in Spain, specifically on the island of Majorca. Dispersal from the established population is considered possible.

Illustration: *Nasua nasua* (Coati)

Impact

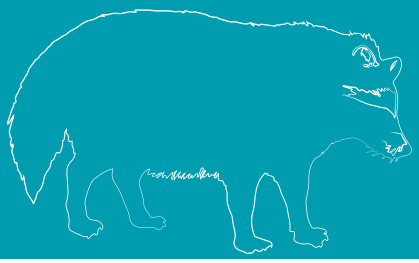
In its introduced range outside of the EU, the coati has had a devastating impact on native bird species due to its strong predation pressure on eggs and chicks. Given the prevalence of island introductions, these impacts are often particularly severe on seabird populations. Furthermore, their burrowing activities can result in soil erosion, which can have a significant impact on vegetation. Within the EU, no specific studies on diet are available, but the species' presence in Natura 2 000 sites in Majorca means a decrease in the region's conservation status is expected if it is not contained. The coati is also susceptible to numerous parasites and pathogens to which humans and other animals can be subject to, including parvovirus, leptospirosis, rabies and tuberculosis.

Management

For any coati remaining in captivity, containment facilities need to be secure and well-maintained. Furthermore, surgical sterilisation is recommended to prevent reproduction. Raising awareness among the public should reduce the risk of deliberate release, and producing identification materials will support citizen science measures for early detection. Targeted survey and monitoring methods include hair-traps, faecal collection and camera traps. An eradication programme undertaken in Majorca from 2002-2013 utilised live-trapping, shooting by professionals and support from local hunters. It should be noted that removal of groups is easier than the removal of solitary males. The deployment of Judas animals is not yet in use, but may be a potential tool.

Photo: *Nasua nasua* (Coati) © iStockphoto/Andrea Izzotti

Nyctereutes procyonoides
Raccoon dog



Description

The raccoon dog is a medium-sized carnivore with distinctive black facial markings and dense heavy fur that mixes brown, grey and black colourings. They are mainly nocturnal and live in woods and wetlands, although they have increasingly spread into urban areas. Raccoon dogs are known to hibernate in cold conditions. This species is omnivorous, feeding on invertebrates, plant materials and animals. Adults typically weigh between 3 and 10 kg, reaching sexual maturity at the age of ten months with litter size generally consisting of 6-9 pups. Although they are not closely related, raccoon dogs have some similarities to the raccoon as both have distinctive black facial markings, however raccoons can be distinguished by their striped tails and short front limbs.

Distribution

The raccoon dog is native to eastern Asia and Japan and has been introduced to the non-native ranges of Russia and Europe. The species is widely established in 16 EU Member States and has the potential for further spread. The wild populations are established in Austria, Bulgaria, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Poland, Romania, Slovakia and Sweden. Small numbers have also been recorded in Ireland.

Illustration: *Nyctereutes procyonoides* (Raccoon dog)

Pathways

Raccoon dogs were widely introduced to the former Soviet Union/USSR in the early 20th century to support fur farming and released into the wild to provide a free-living resource. This Russian population provides a major pathway for spread into Europe. They were also farmed in a number of European countries. Raccoon dogs are also kept as a specialist pet species and in small animal collections. Escapes or releases from these provide a further ongoing pathway for introduction. The current European population is descended from animals that escaped or were deliberately released from these sources and subsequently spread.

Impact

As a medium-sized omnivorous predator, raccoon dogs may impact on a wide range of native species. There are concerns regarding their impacts on native biodiversity, in particular on amphibians, birds and their nests and invertebrates, although there is uncertainty regarding the seriousness of some of these impacts. There is also some evidence of competitive interactions with other medium-sized predators such as foxes and badgers. Raccoon dogs may also have minor impacts on agricultural activities such as fruit-growing and vineyards. Significantly, raccoon dogs can also carry a range of diseases and parasites of concern to human, livestock and domestic dog health, including rabies, roundworms and sarcoptic mange.

Management

The ban on the keeping, transport and sale of raccoon dogs will reduce the risk of further spread to areas currently free of this species, while surveillance followed by rapid eradication should prevent the establishment of new populations. Given their spread from the east, in some regions management to limit further spread uses neutered, radiomarked individuals to act as sentinels/Judas animals to detect and aid the removal of new arrivals into an area. For those areas where the species is now well-established, most management is focused on reducing impacts. Control involves a range of methods including trapping and shooting. In some areas the risk from rabies is controlled by spreading vaccine baits.

Photo: *Nyctereutes procyonoides* (Raccoon dog) © Cloudtail the Snow Leopard, CC BY-NC-ND 2.0 via Flickr

Ondatra zibethicus
Muskrat

Description

The muskrat is a medium-sized, semi-aquatic rodent. They are generally similar in appearance to the coypu and beaver, but considerably smaller and lack webbing on their feet, while their tails are scaly and flattened from side to side to aid their swimming. Muskrats are covered in a dense, thick brown fur and adults weigh between 0.6 and 2 kg. They live in slow-flowing aquatic habitats and spend most of their time in the water. This species builds nests that are typically dug into the bank with an underwater entrance. They are primarily herbivorous, feeding on aquatic vegetation and neighbouring crops, but will also eat animals such as freshwater mussels. Sexual maturity is reached the spring following birth with an average of 2-3 litters per year.

Distribution

Muskrats are native to North America but have been widely introduced into other regions of the world, including Asia and South America. The muskrat is now established throughout much of the EU, with free-living populations in 19 Member States (Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Romania, Spain and Sweden). Denmark and Greece have also recorded the occurrence of this species. Muskrats were also introduced into Ireland, however they were successfully eradicated in the 1930s.

Pathways

Muskrats were originally hunted in their native range for their fur. As native populations dwindled and the demand for fur increased, commercial fur farming was developed. Muskrats were imported for this purpose and were widely farmed in Europe in the 20th century, although this practice has now ceased. Escapes from these farms, either accidental or deliberate, have provided the main pathway for the introduction of this species into the wild. The current European population is descended from animals that escaped or were deliberately released from these farms and subsequently spread. As a semi-aquatic species, muskrats can disperse along water courses and also across land to colonise new areas.

Illustration: *Ondatra zibethicus* (Muskrat)

Impact

Muskrats are primarily herbivorous, therefore grazing by this species can alter the composition and structure of native wetland vegetation. This in turn can have consequences for aquatic invertebrates and fish nurseries. Muskrats can also exert a strong predation pressure on endangered species such as the freshwater pearl mussel (*Margaritifera margaritifera*). The burrowing activities of the species can have significant impacts on drainage and land reclamation activities, threatening the integrity of dikes and drainage systems. The economic impact of the muskrat is considerable, including damage to crops, irrigation systems, roads and railways, dams and flood protection systems.

Management

Surveillance followed by rapid eradication should prevent the establishment of new populations. However, given the already widespread nature of this species in the EU, most current management is focused on reducing their impacts. Control involves a range of methods including trapping, poisoning and the use of hunters. Muskrats are extensively managed in many low-lying areas where their burrowing activities threaten agricultural drainage and land reclamation schemes, in particular in the Netherlands, Belgium and France.

Photo: *Ondatra zibethicus* (Muskrat) © iStockphoto/Grigorii_Pisotckii

Oxyura jamaicensis
Ruddy duck

Description

The ruddy duck has a body length of 35-43 cm (including tail), wingspan of 53-62 cm, weight of 350-800 g and the tail is long and stiff, often held erect. The head is large, with a strong bill. Males are significantly larger than females; in spring males have a deep chestnut body, black cap with contrasting white cheeks and blue bill. Undertail coverts are white and tops of wings in flying birds are dark. In winter the colours are dull grey-brown, paler below, with grey bill. Females and immature birds resemble winter males but with off-white cheeks and a diffuse stripe across. This species occurs in different waterbodies and usually breeds in marshes adjacent to shallow lakes and ponds. It will dive and swim under water and is omnivorous, but predominantly feeds on plant matter.

Distribution

The ruddy duck is native to North America and the Caribbean, with introduced populations in North Africa, the Middle East and Europe. In the EU there are established populations in five Member States (Belgium, France, the Netherlands, Portugal and Spain) and incidental records in many other Member States. As a result of a pan-European control programme implemented during recent years, the total numbers and the range of the species have decreased.

Illustration: *Oxyura jamaicensis* (Ruddy duck)

Pathways

The ruddy duck is kept in captivity for ornamental purposes and the main pathway of introduction are escapes from private wildfowl collections due to the negligence of their owners, as well as deliberate releases in the wild for the "improvement" of local fauna. These pathways have been the reason for the establishment of the species within Europe. After escape or release, the ruddy duck may naturally spread across borders, thanks to its high dispersal capacity.

Impact

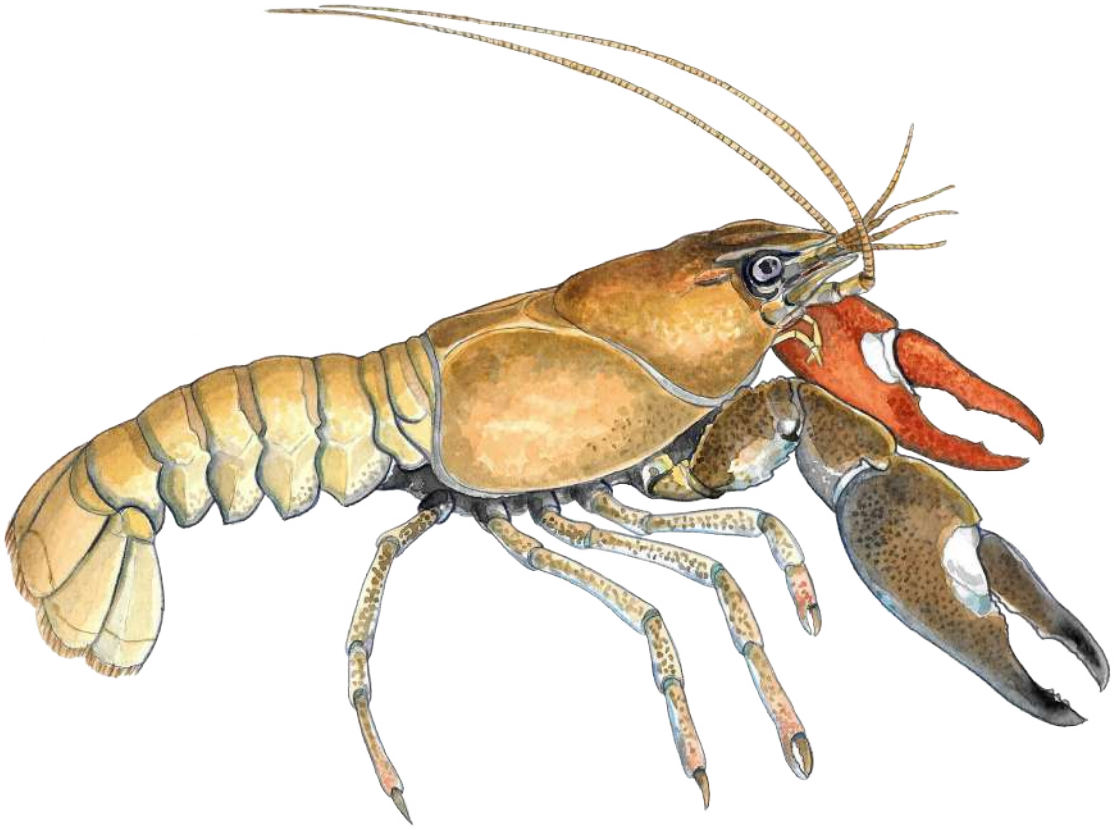
The main impact caused by the ruddy duck is the hybridisation with the globally threatened white-headed duck (*Oxyura leucocephala*), a native to Europe. Hybridisation between these two species is considered to be the major factor for the decline and possible extinction of the white-headed duck due to the incorporation of alien genes into the species genetic makeup. The ruddy duck also competes with its European counterpart for food and nesting places. The ruddy duck is also aggressive towards other waterbirds, such as grebes. This species is known to be a vector of the H5N1 strain of bird influenza virus, lethal to birds, and which may potentially be transmitted to wild species, poultry and humans.

Management

New introductions may be prevented by enforcement of legal provisions that restrict pet trade and keeping of the ruddy duck in private collections. Awareness raising on the negative impacts of the ruddy duck is crucial for gaining public support for its management, because control programmes may face opposition resulting from the species' aesthetic appeal. Spread limitation may be achieved through control of established populations through various methods, including shooting, trapping and egg-control. Successful management programmes in the UK and France apply targeted culling by dedicated task forces. Hybrids between the ruddy duck and the white-headed duck are also eliminated. It is essential that all recorded individuals are removed as birds can disperse and establish elsewhere.

Photo: *Oxyura jamaicensis* (Ruddy duck) © Janet and Phil, CC BY-NC-ND 2.0 via Flickr

Pacifastacus leniusculus
Signal crayfish



Description

Adult signal crayfish can reach a length of 16 cm (occasionally 20 cm) and are characterised by either a bluish or reddish brown colour. The species has two big claws with a typical white-turquoise patch between the fingers and red underside parts. The carapace is smooth, with a large areola (the space between grooves on the carapace). The species inhabits various environments, from small rivers to lakes and even brackish waters, and it constructs burrows under rocks or into banks. It is omnivorous and opportunistic: adults feed mainly on plant material, while young individuals feed on animal proteins. It has a high reproductive potential, starting in the second or third year with 200-400 eggs per female, and a good dispersal capacity, in water and overland. This crayfish species can live up to 20 years.

Distribution

The signal crayfish is native to North America, from British Columbia to central California and Utah. It has been introduced elsewhere in the USA, and also to Japan, and Europe, where it was first introduced to Sweden in 1959. It is now established in 22 EU Member States (Austria, Belgium, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain and Sweden), being the most widespread alien crayfish in Europe. Populations are particularly abundant in north and central Europe.

Illustration: *Pacifastacus leniusculus* (Signal crayfish)

Pathways

In Europe, the main pathway of introduction was release in the wild for commercial stocking purposes. Later, the signal crayfish was moved legally and illegally for aquaculture activities to boost stocks of native crayfish (in heavy decline due to crayfish plague), particularly in northern Europe. The signal crayfish is an important cultured species in Scandinavia due to the traditional consumption of crayfish in this region. Other deliberate introductions arose from sources such as the live food trade, live bait or for use in aquaria. Accidental introductions occurred from canals and escapes from holding facilities.

Impact

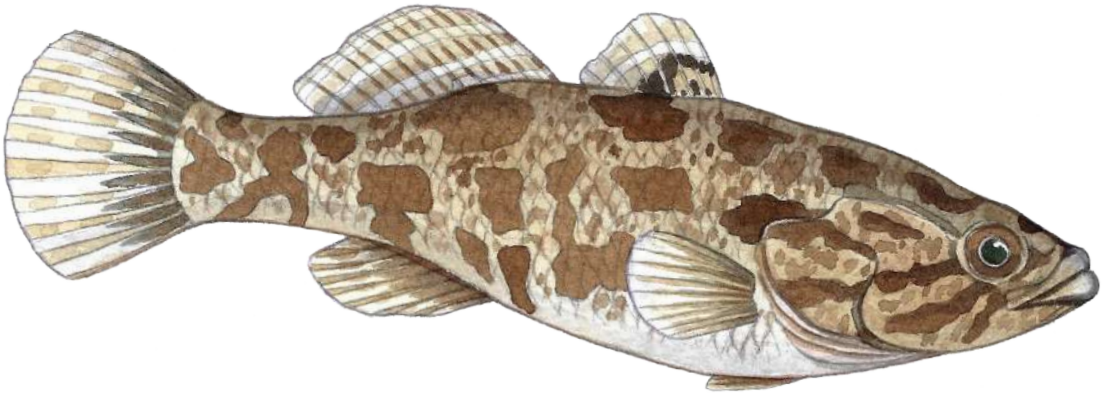
The signal crayfish has many documented negative ecological and socio-economic impacts. As a more aggressive competitor, it has already outcompeted the native crayfish in some areas and can monopolise resources. It can also transmit the crayfish plague, lethal for the European native crayfish. Due to its omnivorous feeding habits, this crayfish species reduces the populations of amphibians, fishes, macroinvertebrates and aquatic plants. Furthermore, its burrowing activity alters the surrounding habitat and communities, increases water turbidity, and possibly induces bank collapse.

Management

As with other aquatic species, managing the signal crayfish is very difficult once in the wild. Raising public awareness of the species and its impacts can help prevent its illegal introduction and further spread. Citizen science projects and using environmental DNA can facilitate its detection at the early stage of invasion and monitor its distribution. Eradication is possible in closed systems at the beginning of the invasion. Methods including trapping, pond drawdown, the use of native predators, and biocides have been developed to control or contain the species. An integrated approach (using two or more methods) is recommended to tackle the species and its different life stages.

Photo: *Pacifastacus leniusculus* (Signal crayfish) © Astacoides, Creative Commons Attribution-Share Alike 3.0 via Wikimedia

Perccottus glenii
Amur sleeper



Description

This small, streamlined fish is about 10-20 cm long, and can reach a maximum length of 25 cm. Its body, characterised by a large head with eyes placed almost on its top, and rounded fins, has a brownish colour, with a varied pattern of dark patches. It mainly occurs in lentic waters, like stagnant rivers and bogs, ponds, lakes, and marshes, especially with dense underwater vegetation (it tends to avoid river stretches with fast and slow current). Females can lay over 20 000 eggs, which are protected by the males during incubation. The species can survive in dried out or completely frozen waters by hibernating (after digging itself into mud) and can withstand poorly oxygenated waters or other harsh environmental conditions (i.e. high alkalinity).

Distribution

The Amur sleeper is native to North Korea and far eastern Russia. It is one of the most widespread and successful invasive fish species in European inland waters, especially in eastern Europe and in large parts of the Danube and the Vistula rivers. The species is currently present in ten EU Member States (Bulgaria, Croatia, Estonia, Germany, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia) and past records in Italy are not confirmed.

Illustration: *Perccottus glenii* (Amur sleeper)

Pathways

The introduction of the species into the EU has been mostly a consequence of aquarium trade, use as a live bait and aquaculture. Stowaway individuals in consignments of other fish species (mainly commercial stocks of Asian carp species from fish farms in infested areas) is probably the most important pathway of introduction and spread. Natural spread is likely the main vector for downstream dispersal.

Impact

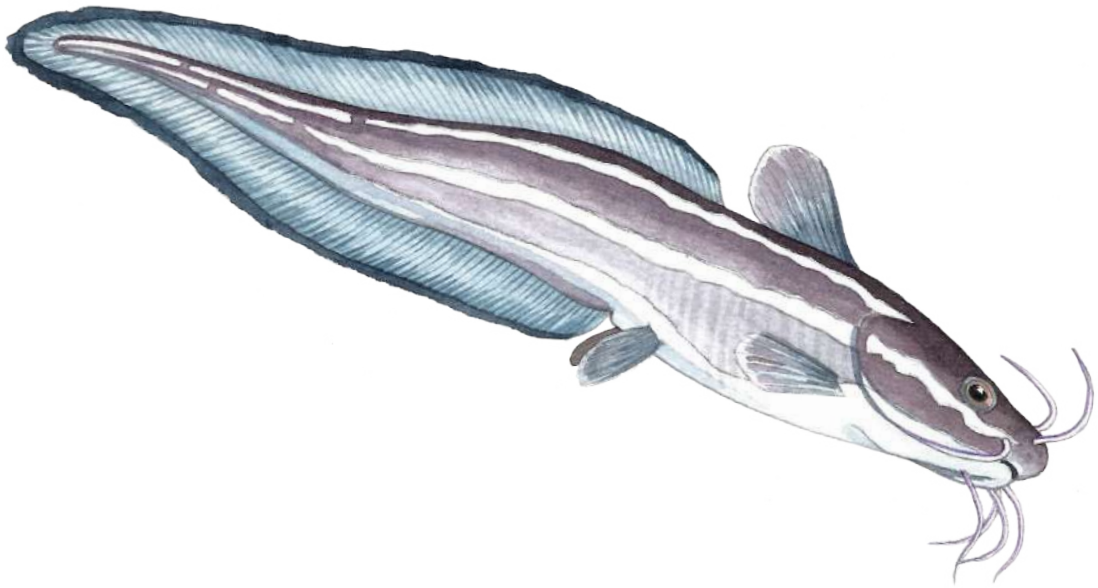
The Amur sleeper is a voracious predator. It can have a significant negative impact through competition for food and predation on a wide variety of native freshwater species, especially amphibians and their larvae and tadpoles, as well as other freshwater fish and their eggs, and invertebrates (including larvae of large species). Other ecological impacts are the transmission of diseases and the disruption of food webs. The main ecosystems at risk are those where high densities of Amur sleepers can be expected, such as oxbow ponds, lakes, and other standing or slow running waters. The Amur sleeper may also reduce production of economically important fish species.

Management

Given the difficulties and the costs and restrictions associated with eradicating or controlling this species (e.g. through piscicides and ammonia), management of potential pathways and the rapid eradication of any newly emerging populations should prevent the species from spreading into yet unaffected water bodies. However, rapid eradication may be difficult, due to the difficulties to detect the species at an early stage of invasion. Surveillance of fish transport and stocking activities is key to prevent this stowaway species to be introduced undetected in fish consignments. Eventually, large predatory fish may help reducing the population density of Amur sleepers, hence maintaining healthy populations of species like pike and perch may be part of an effective management strategy.

Photo: *Perccottus glenii* (Amur sleeper) © Petrtyl, Creative Commons Attribution-Share Alike 3.0 via Wikimedia

Plotosus lineatus
Striped eel catfish



Description

The striped eel catfish is a marine catfish species, with a tail similar to an eel, which can reach a maximum length of 32 cm. The body colour is brown to cream, with two longitudinal bands along the sides (less evident in adults). Similarly to other catfish, the mouth has four pairs of barbels, but the shape and colour distinguish it from any other Mediterranean fish. The dorsal and anal fins are continuous with the caudal fin, with venomous serrate spines in the first dorsal and each of the pectoral fins. In its native range, this marine catfish species inhabits a variety of coastal benthic habitats, coral reefs, seagrass beds, estuaries and tidal pools. Usually, it avoids deep waters, especially at the juvenile stage, but in general it can tolerate a wide range of salinities and occupies many different marine habitats.

Distribution

The striped eel catfish is native to the Indian and Pacific oceans, from the Red Sea and East Africa to Samoa, Japan, Korea, Australia and Micronesia. It has not yet been recorded in the EU, but is currently established in the Levantine Sea (Israel, Lebanon, Syria, Turkey, Egypt) and in Tunisia, where it is expanding. Therefore, its future establishment in the EU, i.e. Cyprus, Greece, Italy (Sicily), France (Corsica) and Spain, is considered very likely, as its thermal requirements are met throughout the Mediterranean.

Illustration: *Plotosus lineatus* (Striped eel catfish)

Pathways

The species entered the Mediterranean through the Suez Canal, and as such is considered a “Lessepsian migrant”. Because of its presence in the Mediterranean, it is considered likely to enter the EU in the near future through natural dispersal. It is likely that the dispersal of juveniles and adults has driven the spread of this species in the Mediterranean Sea so far, travelling 100-200 km per year. However, it is probably only the adults that can travel long distances.

Impact

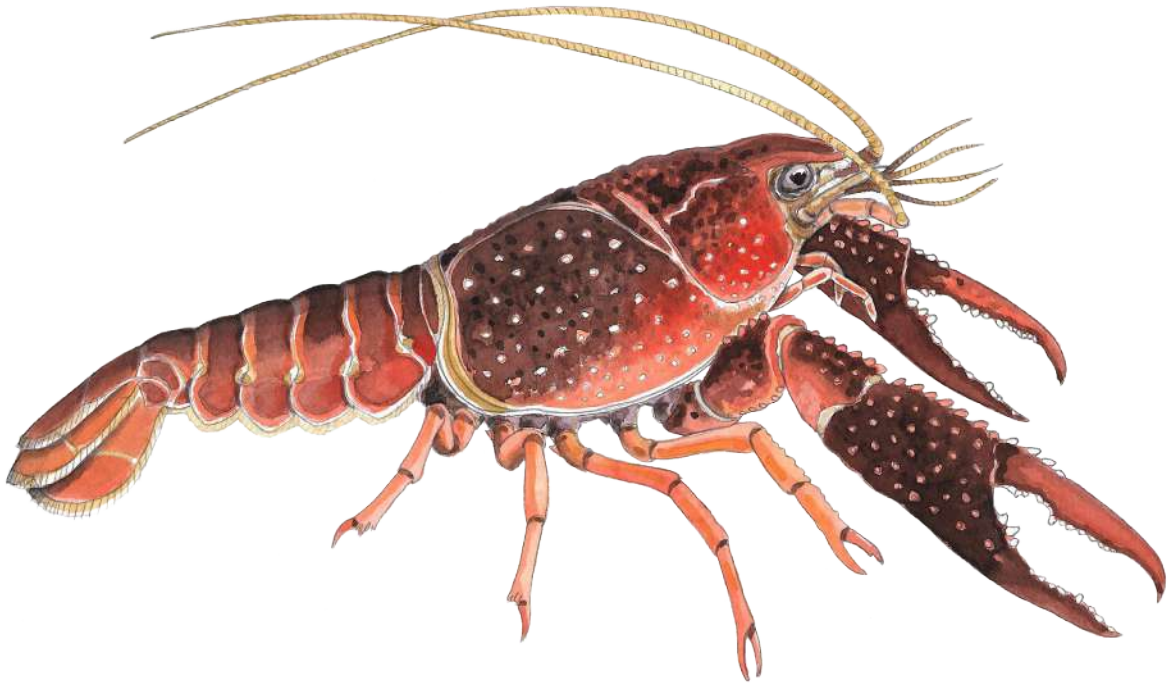
The striped eel catfish has the potential to exert significant predation pressure on native prey species (e.g. crustaceans, molluscs, polychaetes and small fish), compete for resources with other fish and cause changes in native community structure. Furthermore, juvenile feeding swarms can increase turbidity and alter properties of the sediment with consequences for nutrient cycling. The species may also negatively impact the fishing industry and fishers’ income, because of its presence as a bycatch species that is difficult to remove from fishing gear. One of the most distinctive features of this species is the presence of concealed spines in the first dorsal fin and in each of the pectoral fins, that can deliver a highly toxic venom when touched, fatal even to humans, and therefore, represents a threat to human health.

Management

There are currently no management measures that could affect the species’ capability to establish in the EU via natural dispersal. Awareness-raising campaigns run in association with aquarium suppliers, and improved biosecurity measures in private, public and research aquaria may prevent further introductions. Theoretically, eradication may be possible for localised, newly established populations at low densities with limited dispersal capabilities. This would require an early warning system, monitoring efforts and a removal program. Moreover, targeted intensive fishing could help to provide local control of its impact on native biodiversity, especially during the reproductive period. However, due to the species ecology, eradication measures may be destructive for native species and habitats.

Photo: *Plotosus lineatus* (Striped eel catfish) © François Libert, CC BY-SA 2.0 via Flickr.com

Procambarus clarkii
Red swamp crayfish



Description

The red swamp crayfish can reach an average length of 15 cm and is characterised by a dark red colour, although other colour morphs exist. Young and smaller individuals are greenish-brown. The carapace is rough and lacks the areola (the space between grooves on the carapace). The claws are bigger in adults (particularly males), red and spiny. The species is aquatic but can disperse overland, intensively dig burrows into banks and occupy various environments, from swamps to lakes and even brackish waters. This crayfish is omnivorous and opportunistic: adults feed mainly on plants/plant detritus, while young consume higher proportions of animal proteins. It has a high reproductive potential, starting in the first year with up to 600 eggs per female, and a good dispersal capacity. Its average life span is two years.

Distribution

The red swamp crayfish is native to North America (south-east USA and north-east of Mexico) and was introduced to several countries in South America, Asia and Africa. In Europe, it was first introduced to Spain in 1973, and is now established in 12 Member States (Austria, Belgium, the Czech Republic, Cyprus, France, Germany, Hungary, Italy, the Netherlands, Poland, Portugal and Spain). Populations are particularly abundant and widespread in Mediterranean countries. The species is also present on several islands (i.e., São Miguel-Azores, Majorca, Sardinia, Sicily and Tenerife).

Illustration: *Procambarus clarkii* (Red swamp crayfish)

Pathways

In Europe, the first main pathway of introduction was for aquaculture, as the species is very adaptable and prolific. Later, in the mid-1980s, ornamental trade became more important, and the introductions in central Europe were probably due to releases from aquaria by citizens. The species was also very popular in the internet trade, as hobbyists appreciated blue, yellow, black, and white varieties.

Impact

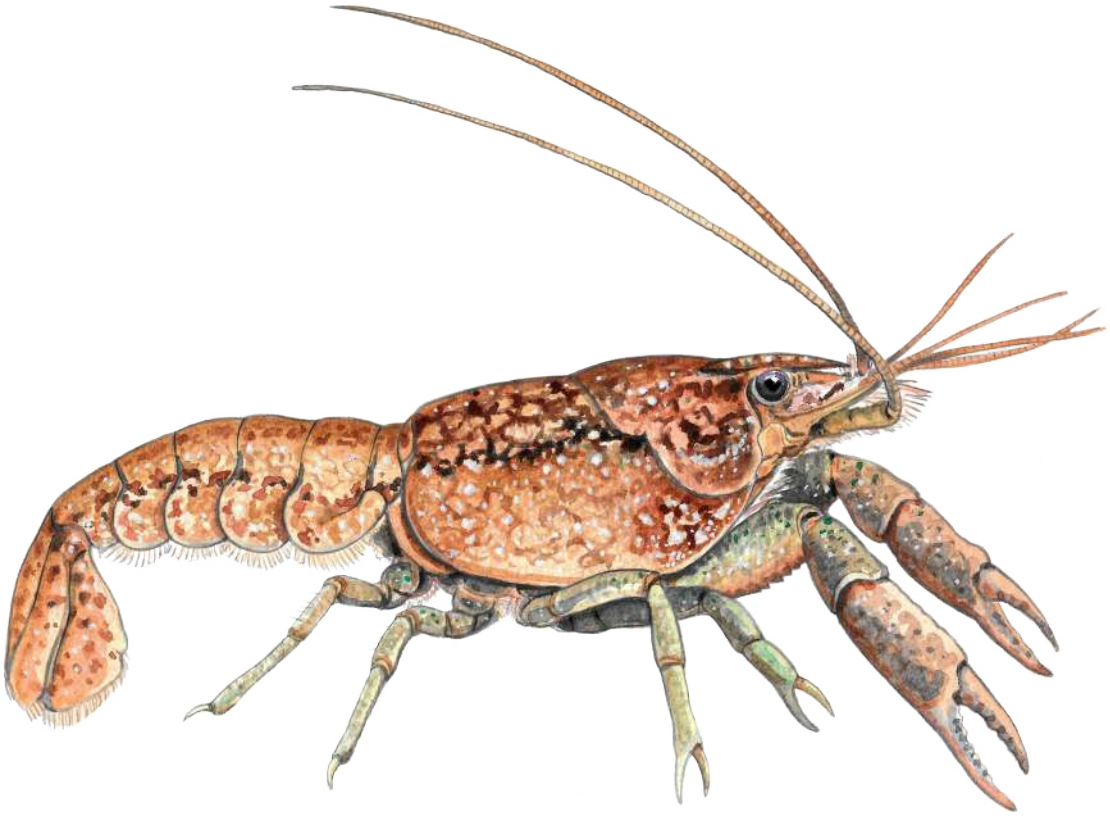
The red swamp crayfish has many documented negative ecological and socio-economic impacts. In particular, it can transmit crayfish plague and chytridiomycosis, which are lethal for the European native crayfish and amphibians, respectively. Due to its omnivorous feeding habits, it reduces the populations of amphibians, macroinvertebrates and aquatic plants. By digging burrows, it increases the water turbidity and facilitates the collapse of banks. The species also accumulates toxins and heavy metals in its tissues, harming predators at higher trophic levels and humans consuming it.

Management

As with other aquatic species, managing the red swamp crayfish is very difficult once in the wild. Raising public awareness of the species and its impacts can help prevent its illegal introduction and further spread. Citizen science projects and using environmental DNA can facilitate its detection at the early stage of invasion and monitor its distribution. Eradication is possible in closed systems at the beginning of the invasion. Methods including trapping, pond drawdown, the use of native predators, male sterilisation, and biocides have been developed to control or contain the species. An integrated approach (using two or more methods) is recommended to tackle the species and its different life stages.

Photo: *Procambarus clarkii* (Red swamp crayfish) © iStockphoto/giocalde

Procambarus virginalis (Procambarus fallax f. *virginalis)*
Marbled crayfish



Description

The marbled crayfish can reach a length of 10-13 cm and are characterised by a marbled pattern, particularly in the carapace. This pattern is variable, usually dark brown to olive. The carapace is smooth, with a small areola (the space between grooves on the carapace). Claws are small and marbled. The species digs burrows and prefers slow-moving waters (wetlands, lakes, swamps, ditches, and ponds) but also inhabits fast-moving waters (rivers and streams). It is omnivorous, with a preference for plant detritus and molluscs. It is an obligate parthenogenetic species, meaning individuals are all clones and females. It has a very high reproductive potential; reproduction starts within the first year, 2-3 times per year, with up to 700 eggs per female. The average life span for this species is 2-3 years.

Distribution

The exact native range of the marble crayfish is unknown, although it should be in North America, being a *Procambarus* species. It has been introduced to Japan, Madagascar, and Europe, where it was first reported in Germany in 2003. It is now established in 11 EU Member States (Belgium, the Czech Republic, Croatia, Estonia, Germany, Hungary, Italy, the Netherlands, Poland, Romania and Slovakia), with records also from Sweden. New findings of the species are continuously reported.

Illustration: *Procambarus virginalis* (Marbled crayfish)

Pathways

In Europe, the primary pathway of introduction was the ornamental trade, and the species likely originated from the aquarium trade in Germany. The marbled crayfish is highly appreciated for its marble pattern and was very popular in the internet trade. However, its frequent reproduction and prolificacy could be a problem for people. As a result, introductions in Europe are probably due to releases from aquaria by citizens.

Impact

There are no well-documented impacts of the marbled crayfish in the EU, its spread being very recent. However, the species has been found to outcompete other invasive alien crayfishes present in Europe, for example the red swamp crayfish, and thus it could exert many potential negative ecological impacts. Similarly to other invasive crayfish species, it could transmit the crayfish plague, lethal for the European native crayfish. Due to its omnivorous feeding habits, it can affect the local populations of macroinvertebrates and aquatic plants, and by digging burrows it can increase the water turbidity and bank destabilisation.

Management

As with other aquatic species, managing the marbled crayfish is very difficult once in the wild, also considering its parthenogenesis. Raising public awareness of the species and its potential impacts can help prevent its illegal introduction and further spread. Citizen science projects and using environmental DNA can facilitate its detection at the early stage of invasion and monitor its distribution. No attempts at management have been conducted to date. Eradication could be possible in closed systems at the beginning of the invasion. Methods including trapping, pond drawdown, and the use of native predators could be used for control/containment. An integrated approach is recommended to tackle the species and its different life stages.

Photo: *Procambarus virginalis* (Marbled crayfish) © André Karwath, Creative Commons Attribution-Share Alike 2.5 via Wikimedia

Procyon lotor
Raccoon

Description

The raccoon is a medium-sized carnivore with a distinctive black eye-stripe and a ringed bushy tail. They are mainly nocturnal and live in woods and wetlands, although they have increasingly spread into urban areas. Their coat is generally grey with dense underfur, while adults typically weigh between 5 and 26 kg. They have heavy hind-quarters with short front limbs and dexterous front paws. Raccoons are omnivorous, feeding on invertebrates, plant materials and animals. They have some similarities to the raccoon dog as both have distinctive black facial markings, however raccoons can be distinguished by their striped tails and short front limbs. Raccoons have high reproductive potential, with litter sizes ranging from 1-8 young.

Distribution

The racoon is native to Central and North America and has also been introduced to Japan, some Caribbean Islands and Russia. Within the EU, the raccoon is widely established in 15 EU Member States and has the potential for further spread. Populations are established in Austria, Belgium, Croatia, the Czech Republic, Denmark, France, Germany, Hungary, Italy, Luxemburg, Poland, Romania, Slovakia, Slovenia and Spain, while small numbers have been recorded in Ireland.

Illustration: *Procyon lotor* (Raccoon)

Pathways

Fur farming has provided the main pathway for the introduction of raccoons to new regions. During the 20th century they were farmed in a number of European countries, although this practice has now ceased. Raccoons are also kept as a specialist pet species, as well as part of small animal collections. Historically, escapes or releases from fur farms probably provided the main pathway for introduction, however with the decline in fur farming, escapes of pets or display animals now provide the main risks. The current European population is descended from animals that escaped or were deliberately released from these sources and subsequently spread.

Impact

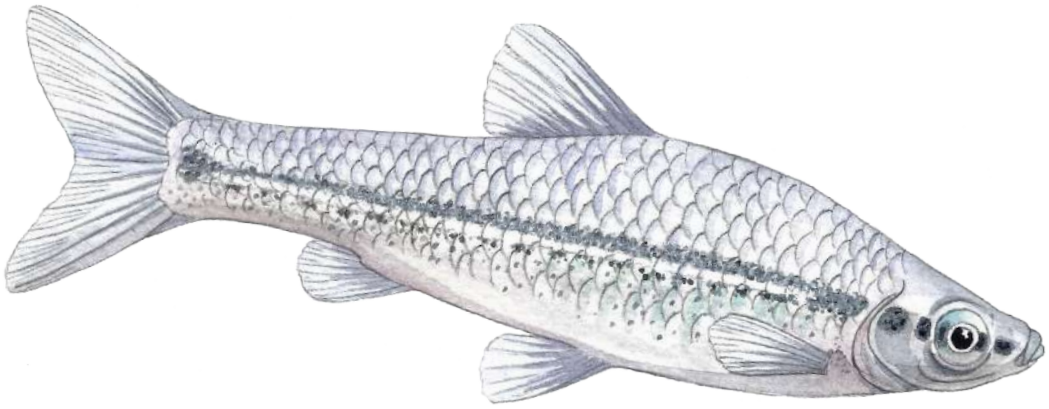
As a medium-sized generalist predator, raccoons can impact a wide range of native species. There are particular concerns regarding their impacts on native biodiversity, in particular in wetland habitats and on amphibians, birds and their nests. Raccoons also impact on agricultural activities such as fruit-growing, vineyards and chicken farms. Nuisance activities include raiding human refuse and damaging buildings by using roof spaces and basements as dens. Raccoons can also carry a range of diseases and parasites of concern to human, livestock and domestic dog health, including rabies, roundworms and toxoplasmosis.

Management

The ban on the species keep, transport and sale, associated with the pet trade and small animal collections, will reduce the risk of further spread to areas currently free of this species. Raccoons are distinctive and new populations are likely to be identified relatively quickly. This provides a particular opportunity for surveillance to be followed by rapid eradication, to prevent the establishment of new populations in areas currently clear of this species. Control involves a range of methods including trapping and shooting. For those areas where the species is now well-established, most management is focused on reducing impacts.

Photo: *Procyon lotor* (Raccoon) © iStockphoto/Jason Ondreicka

Pseudorasbora parva
Stone moroko



Description

The stone moroko is a small freshwater fish which can reach a total length of 11 cm, but is usually below 5 cm, with males having a larger body size than females. The body colour is grey-green above and silvery below, with a dark lateral line across the full body, with the exception of the tail which is brown in colour. It typically inhabits small ponds and ditches, with good vegetation cover, but sometimes larger lakes and streams, as well as disturbed habitats. It feeds on zooplankton, small insects, fish and fish eggs, as well as on vegetation. The stone moroko is very robust and adaptable, has a high reproduction rate and can tolerate high concentrations of toxic chemicals (including piscicides, like rotenone), which makes this species one of the most invasive fish in Europe.

Distribution

The stone moroko is native to eastern Asia, including Siberia, Japan, Taiwan, Korea, and China. It has been introduced to various areas in Europe and Asia. In the EU it was initially introduced in Romania, in 1961, and now there are established populations in almost all Member States, with the notable exception of Cyprus, Estonia, Finland, Ireland, Latvia, Malta, Portugal and Sweden.

Illustration: *Pseudorasbora parva* (Stone moroko)

Pathways

The main introduction pathway is aquaculture, mainly associated to the species being unintentionally moved as a contaminant in consignments of other traded fish, especially Chinese carp species. However, other pathways also contribute to the species introduction, including recreational fishing and ornamental fish trade. Natural dispersal and angling (including as contaminant of live bait moved from one water body to another) represent the secondary pathways.

Impact

Due to the stone moroko's high tolerance of a wide range of environmental conditions and because it occasionally predates on the eggs of other fish species, such as the indigenous gudgeon, it can quickly dominate new water bodies, causing the loss of native species. It can also compete for food with other cyprinid fish and exert high grazing pressure, which in turn may alter ecosystem function and result in habitat changes. As a carrier for a number of pathogens, the stone moroko has an important role in the spread of diseases and parasites, posing a potential threat to other fish species. This may also have a negative impact on aquaculture and fishing activities.

Management

Accidental introductions of stone moroko through contaminated stocks of fish, moved for aquaculture, can be prevented through raising awareness among regulatory authorities and ensuring the implementation of sufficient screening for invasive alien species. The species spread can be prevented through containment methods, including the use of filters on pond outflows and ad hoc regulatory measures to prevent fish movements. Eradication is considered feasible only from small isolated waters, e.g. through the use of water drainage or piscicides, although there are legal constraints on piscicide use within the EU. Population control to limit ecological and economic impacts in invaded water bodies can be implemented through the use of a range of mechanical removal techniques, especially baited fish traps.

Photo: *Pseudorasbora parva* (Stone moroko) © iStockphoto/wrangle

Pycnonotus cafer
Red-vented bulbul

Description

The red-vented bulbul is about 21 cm in length and in general is dark in colour with a crest, a brown abdomen and a distinctive crimson vent under the tail coverts. The species can often have two to three broods each year consisting of 2-4 eggs. When not breeding, the bulbuls tend to form large flocks and gather in communal roosts. They are noisy, gregarious birds and their flight is quick and “bouncy” rather than even. They can live in diverse habitats including dry scrub, plains, cropland, natural forests, forest edges and plantations, but prefer anthropogenic environments (urban areas, gardens, parks, farms, etc.). The species' primary food is berries and fruits, they will also feed on buds, seeds and flower nectar and are known to also eat insects and small lizards.

Distribution

The red-vented bulbul is native to the Indian subcontinent, South East Asia, and Malay Peninsula. It has been introduced to seven continental locations and is present on at least 37 islands within Asia, North America and Oceania. It was first introduced outside its native range in 1903 in Fiji as a fighting bird, since then it has also been introduced to control unwanted insects, but most introductions have been unintentional. Within the EU, the red-vented bulbul has an established population in Spain with records also from Belgium and the Netherlands. However, the Mediterranean is the only suitable region for establishment under current and future climate conditions.

Illustration: *Pycnonotus cafer* (Red-vented bulbul)

Pathways

The main pathways of introduction are as escapes from zoos or private collections, as the bulbuls are already present in collections in a number of EU Member States. In the Pacific, introduction, either intentional or accidental, of caged birds is blamed for most releases. Introduction as a transport stowaway on a ship/boat is possible, having potentially occurred in the Pacific Ocean, and could be a potential risk between islands within the Mediterranean, if introduced.

Impact

Impacts within the EU are, as yet, unknown as the only established population is still small. Potential ecological impacts are the spread of invasive alien plant species through seed dispersal, competition for food or space and harassment of native birds (recorded in French Polynesia, Hawaii, Tahiti) and the predation of geckos, lizards and invertebrates (recorded in Hawaii). Damage to cultivated plants by feeding on fruits and buds could cause a major economic impact, as seen in countries globally. The species could also impact UNESCO Biosphere reserves or the Natura 2000 network, if a large population were to be established.

Management

The introduction of red-vented bulbul through escapes from confinement was reduced following a ban on the importation of wild birds into the EU since 2005, with zoos having to obtain special licences. Public awareness raising could prevent establishment and assist in monitoring and early detection. Loud characteristics make the species more susceptible to eradication campaigns, which are most effective if started rapidly after detection. Eradications have been successful using a combination of shooting, trapping or mist netting. Control methods of established populations mirror those for eradication; for agriculture, damage can be mitigated using netting or deterrents.

Photo: *Pycnonotus cafer* (Red-vented bulbul) © Larry Hubble, CC BY-NC-ND 2.0 via Flickr.com

Sciurus carolinensis
Grey squirrel

Description

The grey squirrel is a medium-sized tree squirrel, 38-53 cm in total length, which is grey on the body, with white underparts and washed with light brown around the hips, feet and head. The tail is grey with a distinctive white fur halo around the edge. This species weighs 300-710 g. The species lives in deciduous, mixed and coniferous woodland habitats, feeding on nuts and a variety of other foods (tree flowers, buds, mushrooms, berries, occasionally insects and bird eggs/young). The species is also regularly found in parks and towns, where it benefits from supplemental feeding. Females can have two litters per year with 2-5 weaned young. It is a highly adaptive and opportunistic species and dispersal capacity is high, with juveniles dispersing 1-3 km from the natal site.

Distribution

The grey squirrel is native to eastern North America, from the Gulf of Mexico to the southern parts of Canada. The species has been introduced to many localities of North America, Australia, and South Africa. In the EU the species has established populations in two EU Member States (Ireland and Italy), with no records from other Member States. Climate conditions in most of Europe are considered suitable for grey squirrel establishment.

Pathways

The primary pathways of introduction for the grey squirrel are escape or deliberate release from captivity. The origin of the pathway is considered to be the keeping of the animals in captivity but also deliberate introductions in parks and woods in the 19th century. Humans can further promote the spread by transporting them between areas, either intentionally or unintentionally e.g. as a transport stowaway. Once introduced, the species has a high natural dispersal capacity, and populations can establish quickly from few founders.

Illustration: *Sciurus carolinensis* (Grey squirrel)

Impact

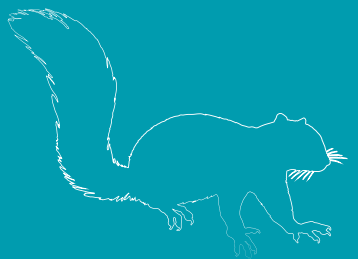
A major impact of the grey squirrel is the replacement of the native European red squirrel (*Sciurus vulgaris*) through resource competition and disease, acting as a reservoir host to a squirrel poxvirus that is fatal to red squirrels. In addition, spill-over of gastro-intestinal nematode, *Strongyloides robustus*, to red squirrels occurs in Italy, which may lead to parasite-mediated competition. Grey squirrels also predate bird eggs and fledglings, but are not known to cause population declines. Within the UK the species impacts commercial forestry through bark stripping, which can reduce timber yield and influences woodland management practices. This can cause a shift away from trees susceptible to squirrel damage, which could then influence the flora and fauna associated with specific woodland types.

Management

Once widely established, the grey squirrel is difficult if not impossible to eradicate. Control actions in the UK, Ireland and Italy, through live trapping and shooting, show that high removal rates are necessary for success but that numbers return quickly once control stops. Therefore, some success can be achieved at a local level with a high control effort, or on islands. However, practical difficulties can arise due to diverse land ownership or public opposition to control/eradication. The use of an oral immunocontraceptive is currently under investigation. Some natural predators exist in Europe e.g. raptors, fox, feral and domestic cats, but only the pine marten (*Martes martes*) has been proven to negatively impact grey squirrel populations and enable red squirrel recovery in some areas.

Photo: *Sciurus carolinensis* (Grey squirrel) © Dennis Church, CC BY-NC-ND 2.0 via Flickr

Sciurus niger
Fox squirrel



Description

The fox squirrel is a medium-sized tree squirrel weighing between 501 - 1 361 g. Males and females do not differ in appearance. Coat colour can vary in its native range, but generally, the species is grey to orange in the body and tail with an orange to white underside. The species has a high reproductive rate, with 1-2 litters per year producing 2-5 young. They have effective dispersal abilities and are highly adaptable to different habitats. Preferred habitats include open woodland with sparse undergrowth and mature forest patches, but they can also establish in urban areas e.g. town parks. The species has a varied diet of plants and animals e.g. seeds, fruits, flowers, buds, fungi, crops, insects and occasionally bird eggs and fledglings.

Distribution

The fox squirrel is native to eastern and central USA, where populations are declining, and has been successfully introduced and has established in western USA and Canada, but has not been introduced anywhere outside of North America. Within the EU, the species has been recorded in the Netherlands on a number of occasions but there are no established populations in any Member State. Based on its native range the species is capable of establishing across most of the EU except for the Boreal and Alpine regions in northern Europe.

Illustration: *Sciurus niger* (Fox squirrel)

Pathways

The primary pathways of introduction for the fox squirrel are escape or deliberate release from captivity. Natural dispersal is not expected as there are no established populations, however once introduced the species has a high natural dispersal capacity, and can establish quickly from few founders.

Impact

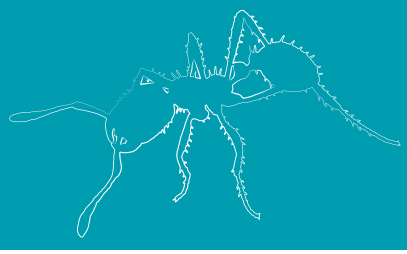
The fox squirrel is absent from Europe, so the potential impacts of this species are unknown. Based on the impacts of the introduced American grey squirrel (*Sciurus carolinensis*), the fox squirrel could impact the native European red squirrel (*Sciurus vulgaris*) through competitive exclusion and squirrel poxvirus transmission. The species could also have negative impacts on breeding birds through predation, but there is no evidence for this. Bark-stripping could occur when food availability is low, seed crops could be harmed from the consumption of flowers and buds and the dispersal of seeds could have impacts on ecosystem structures. Socio-economic impacts include damage to local agriculture and forestry through bark-stripping.

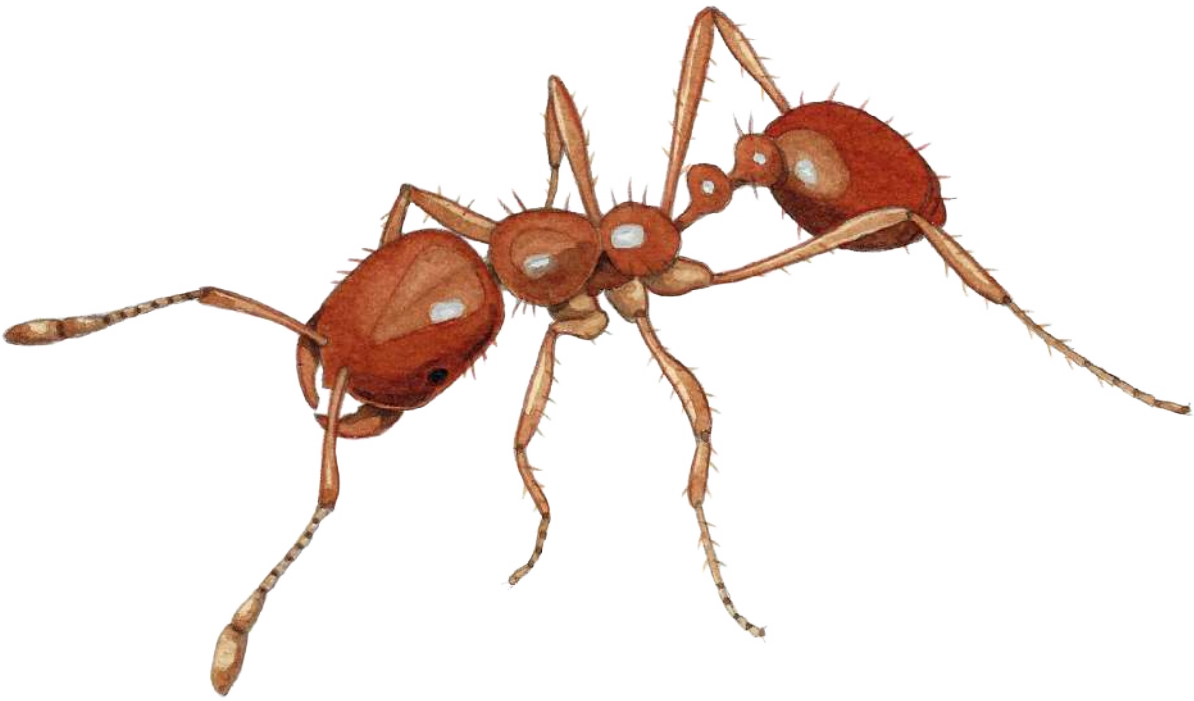
Management

Established fox squirrel populations are difficult and costly to control, and management actions are rarely successful when populations are already widespread. It may be possible to eradicate fox squirrel populations at an early stage of invasion, as immigration from other populations is not possible. Management techniques include trapping and shooting but a high control effort is required as populations are able to survive a loss of less than 40%, but not with a loss of 80%. In the UK some natural predators occasionally prey on grey squirrels e.g. foxes and raptors, but only the pine marten (*Martes martes)* have been proven to negatively impact grey squirrel populations, and these predators could potentially also prey on the fox squirrel.

Photo: *Sciurus niger* (Fox squirrel) © iStockphoto/chas53

Solenopsis geminata
Tropical fire ant





Description

The total body length of the tropical fire ant is 3-5 mm long, the body is often orange to brown in colour and the head is brown. The species feeds on seeds, tends honeydew-producing insects and feeds on arthropods (including a number of insect pests). Colonies can be monogynous (having one queen) or polygynous (having several queens) and can be unicolonial (i.e. exhibiting high aggression towards other colonies) or multicolonial (i.e. exhibiting lack of aggression towards other colonies and forming large supercolonies). The latter enables colonies to reach high local densities and dominate entire habitats. They inhabit open disturbed soils in sunny areas, specifically in urban and semi-urban habitats and agricultural areas. They can also survive in climate-controlled buildings, greenhouses or other human dwellings and infrastructure.

Distribution

The tropical fire ant is almost certainly native to South America, Central America and Mexico, and most probably south-eastern USA, although its exact range within the New World is unclear. It has been extraordinarily successful in spreading into five other continents. In the EU, the species has been recorded in four EU Member States (Cyprus, Greece, Italy and the Netherlands) but has no established populations. Based on the climatic conditions, the tropical fire ant is capable of establishing across the Mediterranean region.

Illustrations: *Solenopsis geminata* (Tropical fire ant)

Pathways

The tropical fire ant is termed a “tramp” ant, it can hitchhike through many pathways but only the entry of queen ants and nests present a risk of establishment. The most likely pathway of introduction is as a contaminant within the horticultural trade, but transport stowaways in airplanes and in container/bulk transport are also possible. Although natural dispersal is possible, human-assisted transport will aid the rate of spread through the movement of materials, plants, vegetation material or soils.

Impact

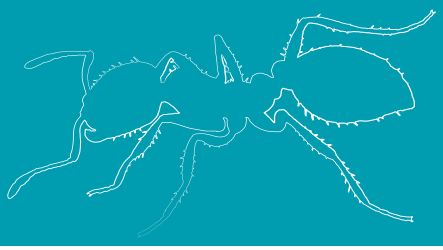
The tropical fire ant is one of the most widespread invasive ant species but it is not considered as one of the worst. In its native and introduced range it is often at the top end of dominance hierarchies. Additionally, they have been reported attacking young birds, young tortoises and land iguanas in the Galapagos. They have also been known to interfere with seed dispersal by reducing numbers of plant mutualists. Economic impacts include significant losses in agricultural crops, mounds damaging roads and chewing of domestic and commercial electrical equipment. They also pose a human health risk as they can sting people and may cause an allergic reaction that requires medical care and can sometimes cause anaphylaxis.

Management

Management practices are in place to prevent the introduction of the tropical fire ant into the EU via the horticultural trade, with plants and soils chemically treated before shipment, however, this is not systematically done between Member States. There are no practices in place for the management of hitchhikers within transport e.g. air freight, sea freight, train. The eradication of single nests is straightforward and was successful in a building in the Netherlands using chlordecone. Eradication is more difficult in the wild but has been successful at a local scale in Australia. If the tropical fire ant is established, several applications of chemical insecticides must be applied over consecutive years, followed by intensive surveillance to ensure removal.

Photo: *Solenopsis geminata* (Tropical fire ant) © Judy Gallagher, CC BY 2.0 via Flickr.com

Solenopsis invicta
Red imported fire ant



Description

The red imported fire ant is quite small, varying from 2-6 mm in length, and is predominantly reddish-brown in colour. The species is among the 18 to 20 "true fire ants", looking very similar to all of them, especially to the black imported fire ant *Solenopsis richteri*. The nests vary in shape and size, but all have a honeycomb-like internal structure and it inhabits rainforests, secondary forests and plantations. However, in the introduced range it has a strong preference for urban and agricultural environments. The species will create unicolonial colonies, establishing new colonies by budding. The diet consists of invertebrates, vertebrates, plants and oily or sugary foods. However, it is known to prefer protein-rich food sources and may be a great consumer of insects.

Distribution

The red imported fire ant is native to tropical and subtropical South America. It has been unintentionally introduced (and subsequently spread) in southern states of the USA (from California to Florida), Mexico, Panama, many Caribbean islands, Australia, New Zealand (eradicated), China (southeast), Malaysia, Singapore and Taiwan. Within the EU, the species has been recorded in the Netherlands but has no established populations in any Member State.

Illustration: *Solenopsis invicta* (Red imported fire ant)

Pathways

It is termed a “tramp” ant, as it can hitchhike via many pathways but only the entry of queen ants and nests present a risk of establishment. The most likely pathway of introduction is in contaminated soil through the horticultural trade, but transport stowaways on container/bulk imports are also likely. It has already been recorded/intercepted in Europe, but its establishment is limited by climate. It can disperse naturally but spreads mainly through human-assisted transport e.g. in soil.

Impact

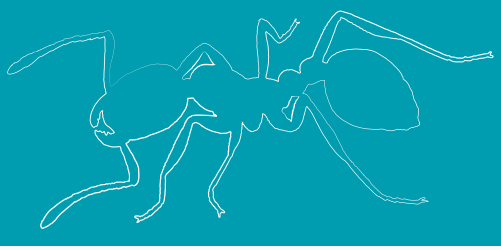
The red imported fire ant is considered one of the 100 most invasive alien species on earth. In southern North America, it threatens several arthropods, molluscs, reptiles, birds, amphibians and mammals by direct predation, competition or stinging. It can also impact plant species by changing soil properties, tending of plant pests, direct seed predation and competition with native ant seed dispersers, although there are few studies on these impacts. Economic impacts have huge financial costs amounting to millions of dollars in mainland USA, Hawaii and Australia. These include agricultural impacts by feeding on crops and harming cattle, human health impacts due to the sting and finally impacts on infrastructure and equipment.

Management

There are currently no management practices against transport stowaways and although horticulture plants and soils/substrates are usually chemically treated before shipment, it can be easily infested after treatment. In order to prevent introduction, monitoring and inspections of imported goods and containers should be conducted at ports of entry. If introduced, it is of utmost importance to start eradication programmes as soon as possible. The eradication of single nests is straightforward through mechanical control or chemical control. The eradication of established colonies outdoors is more problematic, here the use of broadcast granular bait-formulated products is recommended. Successful eradications have been conducted in New Zealand and parts of Australia and Taiwan.

Photo: *Solenopsis invicta* (Red imported fire ant) © Judy Gallagher, CC BY 2.0 via Flickr.com

Solenopsis richteri
Black imported fire ant



Description

The black imported fire ant is dark reddish brown to predominantly black in colour, ranging in size from 1.5-5 mm. The species is among the 18 to 20 “true fire ants”, which all look very similar and have the potential of becoming invasive. The species is observed hybridising regularly with the red imported fire ant (*Solenopsis invicta*). The black imported fire ant is a social insect that lives in colonies, usually associated with a mound, and favours a range of low vegetation cover habitats, including urban areas, agricultural land and grasslands. Fire ants are omnivorous, consuming primarily other arthropods and honeydew produced by aphids, but also seeds, plant parts, fruits, dead plant and animal tissues and living prey subdued by stinging.

Distribution

The black imported fire ant is native to South America, following the Atlantic coast from south-eastern Brazil through Uruguay to eastern Argentina. The species has established populations outside its native range within southern USA, in Alabama, Mississippi and Tennessee. Its current distribution is restricted by the presence of red imported fire ants. No EU Member States have established populations or records of the black imported fire ant.

Illustration: *Solenopsis richteri* (Black imported fire ant)

Pathways

The black imported fire ant is termed a “tramp” ant, hitchhiking through many pathways, but only the entry of queen ants and nests present a risk of establishment. The most likely pathway of introduction is as a contaminant through the horticulture trade. Other pathways include as a stowaway on airplanes, in containers or other commodities (e.g. machinery). It has never been intercepted but if it enters the EU there is a major risk of spread between Member States via human assisted pathways, e.g. soil.

Impact

There is no research on impacts of black imported fire ants, principally due to its limited distribution and displacement by the red imported fire ant. It is one of the less successful invasive ant species but, based on the impacts of the red imported fire ant, it is likely to have moderate to major environmental, economic and social impacts. It may impact plant/insect interactions by reducing the abundance and richness of local ants and more broadly ground active insects and may also predate on lizards. It may impact agriculture (e.g. stinging domestic stock) and horticulture (e.g. stinging pickers, mounds interfering with equipment) and have significant medical consequences, even at low ant densities, due to the sting.

Management

There are currently no management practices against hitchhiking ants but the quarantine inspections at ports of exit and entry, as in the USA and China, could reduce the risk of entry. Horticulture plants and soils/substrates are usually chemically treated before shipment, but can be infested after treatment either before departure or during transport. Eradication of single nests is straightforward in buildings but much less so outdoors. However, successful eradications of red imported fire ants have been conducted in New Zealand and parts of Australia and Taiwan. The most effective control method is the use of chemical insecticides. If the population is established, several applications are required per year over consecutive years, followed by intensive surveillance.

Photo: *Solenopsis richteri* (Black imported fire ant) © Luciano Peralta, CC BY-NC via iNaturalist

Tamias sibiricus
Siberian chipmunk

Description

The Siberian chipmunk is a small striped squirrel, weighing about 100g. Both males and females look the same, with a light ash grey body, red-brown colouration on the head, rump and tail and distinctive dark brown to black stripes down the back. Females are capable of having more than one litter a year with 3-7 young but this depends on resources. The species feeds on nuts, seeds, tree buds, mushrooms, berries and cereals. It is primarily a forest species, living in woodland habitats with a bushy understory, but is also regularly found in parks and towns. Shelters are often burrows that consist of a single entry 5 cm in diameter emerging on the ground, but other types of refuge include cavities in trees, old stumps, or holes in old walls or buildings.

Distribution

The Siberian chipmunk has a vast native range from the northern parts of European Russia, eastwards to the shores of China. The species has been introduced to two Japanese islands, Honshu and Hokkaido, and the Moscow region of Russia. Within the EU it has established populations in six Member States (Belgium, Denmark, France, Germany, Italy and the Netherlands), with records from Austria, Greece, Spain and Sweden.

Illustration: *Tamias sibiricus* (Siberian chipmunk)

Pathways

The Siberian chipmunk has been introduced to Europe since the 1960s and 70s, for the pet trade. These animals were either abandoned by owners, deliberately introduced, or escaped from captivity. Today, the primary pathway of introduction remains escape or deliberate release from captivity. The species is capable of establishing from few founders, but natural dispersal is slow and human assisted spread is unlikely.

Impact

The environmental and economic impacts of the Siberian chipmunk are not widely studied. In its native range the species is reported to have a significant impact on forest nut production, on cereal crops and may affect the breeding success of the dusky warbler (*Phylloscopus fuscatus*). Within Europe, they may threaten other native rodents e.g. European red squirrel (*Sciurus vulgaris*) and bank vole (*Clethrionomys glareolus*), and maybe some birds through competition for food, although there is no published evidence for this. However, it has been recorded as a significant predator of bird eggs/young. Research conducted in France showed the species is a major reservoir for Lyme disease and can host large numbers of ticks, potentially having human health implications.

Management

The containment, control and eradication of the Siberian chipmunk is possible within Europe. Due to the relatively slow rate of spread, and the easy recognition of the species in a new environment, populations can be contained. In the UK, after a large escape of chipmunks all individuals were successfully captured, however escapee populations in Europe have still managed to become established. Transferable control methods, used for other invasive species e.g. American grey squirrel (*Sciurus carolinensis*), include trapping and shooting. However, practical difficulties are likely to arise due to diverse landownership and potential public opposition to control. Potential natural predators also exist, such as raptors, red fox (*Vulpes vulpes*), feral and domestic cats, and owls.

Photo: *Tamias sibiricus* (Siberian chipmunk) © iStockphoto/maxtrox

Threskiornis aethiopicus
Sacred ibis

Description

The sacred ibis has a body length of 65-89 cm, its wingspan is 112-124 cm, it weighs about 1.5 kg and males are larger than females. In adults the head and the neck are bare and black. The plumage is white except for black tips of flight feathers. On the ground these birds give the impression of a black "tail" and in flight they are visible as a black stripe along the hind verge. The bill is long, curved and thick. In immature birds the head and neck are feathered and they have blackish-brown inner wing feathers. The sacred ibis occurs, usually in flocks, in various habitats, including marshes, reed beds, meadows, fields, farmyards, rubbish dumps, parks and other suburban and urban areas. It feeds on a wide range of food, including invertebrates, vertebrates and organic rubbish.

Distribution

The sacred ibis is native to Africa, where it occurs in areas south of the Sahara, and to south-western Iraq, where an isolated population exists in the area bordering Iran and Kuwait. The species has been introduced to Taiwan and there are records from many European countries. Within the EU, the species is established in two Member States (France and Italy), and occasional breeding has been recorded in Germany and the Netherlands.

Illustration: *Threskiornis aethiopicus* (Sacred ibis)

Pathways

The main pathways of introduction for the sacred ibis are escapes of captive birds kept in zoological gardens and in private collections. Zoo escapes were the primary reason for the establishment of this species in Europe. Thanks to its high reproductive potential and remarkable dispersal abilities, the sacred ibis naturally spreads across borders from areas in which it has been introduced.

Impact

The sacred ibis is an opportunistic species, predating on amphibians and on the eggs and juveniles of various birds associated with aquatic environments, including terns, herons and waders. Broods of ground-nesting species are also destroyed through trampling by flocks of foraging ibises. In addition, the sacred ibis competes for nesting sites with egrets and spoonbills. It is known to host a number of viruses and bacteria, such as avian influenza, cholera, chlamydia and salmonella, which can potentially be transmitted to wild birds, poultry and humans. In large densities the sacred ibis may cause damage around the breeding colonies, roosts and foraging sites, by trampling vegetation and the production of large amounts of droppings, causing the death of trees, shrubs and grassy vegetation.

Management

To prevent further escapes from captivity it is recommended to house the species in secure aviaries and not enable free flight. Spread limitation may be achieved through control of established populations. Raising awareness of the negative impacts of the sacred ibis is crucial for gaining public support for its management, because control programmes may face opposition resulting from the species' aesthetic appeal. Volunteer hunting as well as targeted culling, through shooting, and net-trapping of adult birds are recommended control methods. Destroying eggs by removing, piercing or oiling has also been applied. Individuals from controlled populations become less approachable over time and disperse over large areas, which makes management more difficult.

Photo: *Threskiornis aethiopicus* (Sacred ibis) © iStockphoto/EcoPic

Trachemys scripta

Red-eared, yellow-bellied and Cumberland sliders

Description

The common slider is a large freshwater turtle that can reach 60 cm in length, with the carapace and skin olive to brown in colour, with yellow stripes or spots. A typical feature is the presence of prominent yellow to red patches on each side of the head. Based on these patterns, three sub-species can be distinguished: red-eared, yellow-bellied and Cumberland sliders. The species is highly adaptable and occurs in a wide range of freshwater habitats, especially with suitable basking sites, soft bottoms and rich vegetation, e.g. swamps, ditches, lakes, ponds and rivers. It is an opportunistic predator whose diet - carnivorous in juveniles and omnivorous in adults - includes both plants and every kind of animal they can capture.

Distribution

The common slider is native to the eastern USA and adjacent areas of north-eastern Mexico, but is present in several countries across the globe, including in North and South America, Asia, Africa, Australia and Europe. In the EU it has established populations in nine Member States (France, Germany, Greece, Italy, Latvia, Poland, Portugal, Slovenia and Spain) and has been recorded in Austria and the Netherlands (its status is unknown in Lithuania and Romania).

Illustration: *Trachemys scripta* (Red-eared, yellow-bellied and Cumberland sliders)

Pathways

Common sliders are among the world's most commonly traded pet reptiles and in the past, over 50 million individuals were imported into Europe. Many have since escaped or been deliberately released into the wild. The import of the red-eared slider into the EU has been regulated since 1997 through the EU Wildlife Trade Regulations, but this legislation did not cover the other subspecies, which led the market industry to shift toward the yellow-bellied and Cumberland sliders (and other species too).

Impact

With its voracious appetite and a very flexible diet, the common slider may represent a serious threat for several species occurring in aquatic habitats, from insects and other invertebrates to amphibians and reptiles, small mammals and birds. In addition, by eating various species of aquatic plants, the species can heavily damage wetland vegetation in some cases. All this can result in an impact on whole freshwater communities. Common sliders may also compete with indigenous freshwater turtles, mostly for food, basking sites and nesting sites, and contribute to the spread of diseases and parasites that could affect other aquatic wildlife and even humans e.g. by being a possible reservoir for salmonella. In addition, they can inflict painful bites.

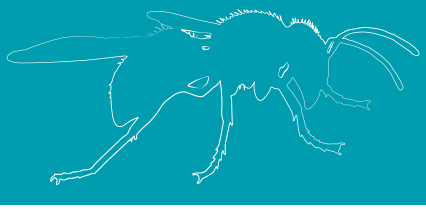
Management

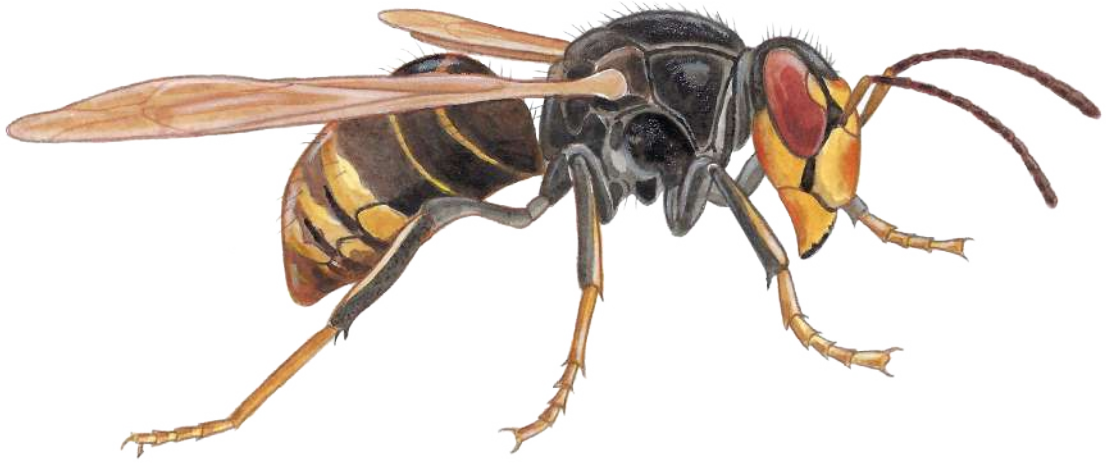
Public awareness is key to prevent the common slider from being released into the wild. Early detection of new populations can be achieved by implementing a number of surveillance measures, e.g. through environmental DNA, citizen science or trapping methods. However, following the species introduction, they can be captured through a variety of methods, including various devices (like nets, fences and pitfalls), angling or by hand. Floating boards used by common sliders as basking sites seem very effective when equipped with baited cages on top. Sniffer dogs are also used to detect and remove both freshwater turtles and their eggs. Eggs can also be found and removed by following females to nesting areas. Other methods to remove the species are through the drainage of ponds (coupled with fencing and traps) and shooting.

Photo: *Trachemys scripta* (Red-eared, yellow-bellied and Cumberland sliders) © iStockphoto/master1305

Vespa velutina nigrithorax

Asian hornet or yellow-legged hornet





Description

The Asian hornet has a complex life-cycle. Overwintered queens produce a primary nest in early spring but when the first generation of workers become adults the colony moves and builds a secondary nest usually in a higher location than the primary nest, e.g. in a tree. The secondary nest usually has the entrance to the side and this can be useful in distinguishing Asian hornet nests from other wasp nests. Asian hornets are slightly smaller than European hornets (*Vespa crabro*). The queens are up to 30 mm in length while the workers are up to 25 mm. Asian hornets have a velvety black or dark brown thorax and brown abdominal segments with a yellow band. The legs are brown but with distinctive yellow ends. The head is black but with an orange yellow face.

Distribution

The Asian hornet originates from Asia with the native range including Bhutan, China (including Hong Kong), east Nepal, north-east India and north Vietnam and has been recorded in South Korea and Japan. Within the EU it has established in eight Member States (Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain (including Mallorca)). Within Europe, it has also established in the Channel Islands and Switzerland.

Illustration: *Vespa velutina nigrithorax* (Asian hornet or yellow-legged hornet)

Pathways

The main pathway of introduction into the EU is the unintentional human-assisted transport of founding queens as a stowaway. The Asian hornet arrived in France with traded goods transported from China and in 2019 an individual was found in northern Germany, constituting the most northern record of this species in Europe. Natural dispersal is also a possibility, with the rate of spread of the Asian hornet varying between countries from 10-78 km/year.

Impact

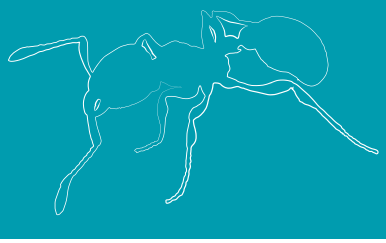
Up to 13 000 individuals can be present annually in a single colony (with an average of approximately 6 000 individuals) and several hundred queens can be produced in the autumn. Notably and in contrast, a colony of 40 000-60 000 honeybees will only have one queen. Asian hornet workers prey on many insects including honeybees (*Apis mellifera*) and wild pollinators. Honeybees are considered an easy source of prey for Asian hornets with each individual hornet capable of taking 25-30 honeybees a day to their nest. There are also concerns for human health because, while the Asian hornet sting is no worse than the European hornet sting, the proximity of the Asian hornets to humans when in low positions at the primary nest stage, increases the probability of contact.

Management

Early-detection and rapid eradication is critical for the successful management of Asian hornets which is most effective early in the season, when vegetation cover in trees in sparse, and before queens and males are produced and go on to reproduce. Individuals return to the nest at night and so removal of the entire nest is possible. Citizen science approaches can be used for early-warning with people engaged in reporting sightings of concern to relevant schemes. However, nests can be difficult to detect when hidden in dense vegetation and at height. There are a number of emerging technologies that could be deployed to improve detection including radio tracking, harmonic radar tracking and forward looking infrared cameras by ground inspections or attached to drones. The Asian hornet has been successfully eradicated from the UK.

Photo: *Vespa velutina nigrithorax* (Asian hornet or yellow-legged hornet) © iStockphoto/AlbertoNovo

Wasmannia auropunctata
Little fire ant



Description

The little fire ant is typically small to medium-sized, with the workers ranging from 1-2 mm, and is light to golden brown in colour. It is a true generalist in its choice of nest sites and habitats, allowing it to thrive in a wide range of conditions from wet to dry and from early successional to mature forests. The diet is omnivorous and very flexible, preying on invertebrates and consuming plant parts and when honeydew-producing insects are present, this makes up a large part of its diet. The species has a venomous sting that gives it a greater ability to subdue vertebrate and large invertebrate prey. Cold climates appear to be unsuitable for the successful invasion and establishment of the little fire ant, but it may survive in human habitations or infrastructures.

Distribution

The little fire ant is native to Central and South America and has been extraordinarily successful in spreading into several continents (parts of Africa, North America, non-native range within South America, Europe and Australia) and has colonised many tropical islands. Within the EU, the little fire ant has established populations in one Member State (Spain), with records also from Germany, Italy and the Netherlands.

Illustration: *Wasmannia auropunctata* (Little fire ant)

Pathways

It is considered a “tramp ant” species, due to its close association with humans, but only the entry of queen ants and nests present a risk of establishment. Pathways of introduction include both natural (e.g. floating on debris), and human-mediated routes (e.g. horticultural trade, food contaminant, in soil, moved by road, sea or air). An additional emerging pathway is the ant market on the internet. Natural spread is a minor risk but spread via human assistance is considered major.

Impact

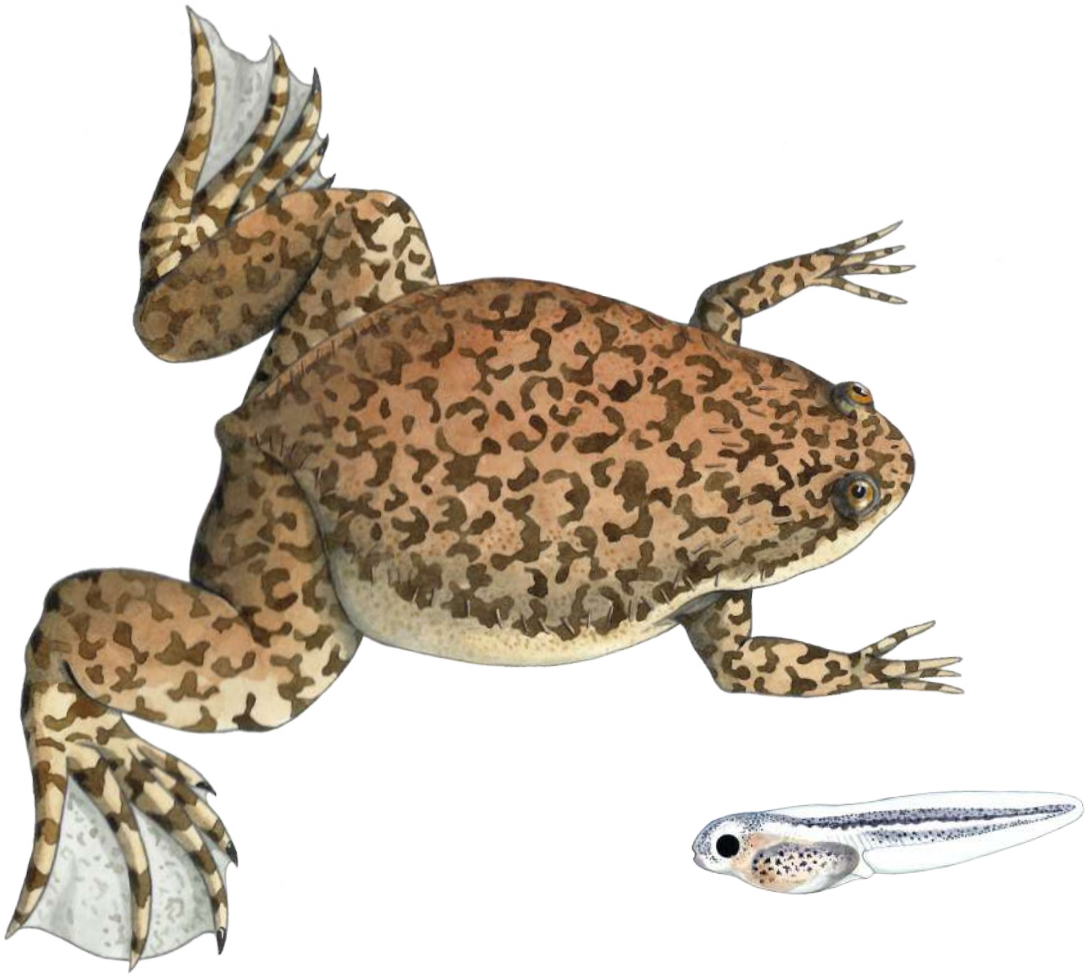
The little fire ant is considered as one of the worst and most widespread invasive ant species on earth. In their non-native range they alter invertebrate communities causing a major decrease in native ant and other invertebrate species (Israel), this can interfere with seed dispersal by native ant species. It can also significantly impact reptiles (New Caledonia) and bird hatchlings (northern Melanesia region). They can inflict considerable crop loss by tending honeydew-producing insects, especially mealybugs, which impact rural subsistence gardens (Solomon Islands). It is a social nuisance and is a health risk, having a painful sting to humans and domestic animals.

Management

There are currently no management practices in place within the EU against hitchhiking ants via airplanes, shipping, habitat material, etc. In the horticultural trade, plants and soils/substrates are often chemically treated and fruits and vegetables washed before shipment, to prevent introduction. Eradication is only possible for small populations in accessible areas, whereas larger populations should be the target of containment. Currently the most effective method for eradicating, containing or controlling is through chemical control and populations have been successfully eradicated in the Galapagos and Hawaii. In addition, fire and vegetation clearing or improved land management and planting, have also been used in invaded countries.

Photo: *Wasmannia auropunctata* (Little fire ant) © Philipp Hoenle, CC BY-NC via iNaturalist

Xenopus laevis
African clawed frog



Description

The African clawed frog is characterised by a flattened shape, with very developed and webbed hind legs, and eyes positioned at the top of a small head, which lacks a tongue and eardrums. Adults can reach 12 cm in length. This species is principally aquatic throughout its life but is able to migrate overland. It inhabits a variety of water bodies, including heavily modified, artificial habitats, but tends to avoid large rivers and water bodies with predatory fish. The species is a highly opportunistic generalist predator and has a very adaptable diet, which can be modified according to available resources. It also has a very high reproductive potential and good dispersal capacity, via waterways and short distances overland, which all contribute to its strong invasive potential.

Distribution

The African clawed frog is native throughout much of sub-Saharan Africa and has been introduced to the USA, Chile, China, Japan and Europe. In the EU, the species has established populations in three Member States (France, Italy and Portugal), with records also from Belgium, Germany, the Netherlands, Spain and Sweden. In wider Europe, it was also introduced in the UK, where it has now been eradicated.

Illustrations: *Xenopus laevis* (African clawed frog) adult (on the left) and tadpole (on the right, not to scale)

Pathways

Pathways of introduction include escapes and deliberate releases from captive populations within the pet trade and research laboratories, where the species is commonly used in biomedical research. This dates as far back as the 1930s, when it was used for pregnancy testing. Other pathways, though not active in the EU, include its use in training within laboratories and as live bait for freshwater angling, with possible subsequent escapes/releases.

Impact

The African clawed frog may negatively affect local populations of amphibians, fish and invertebrates. In particular, potential impacts include predation on and competition with native amphibians, including eggs and larvae, as well as fish. For this reason, in some countries the species is also considered a threat to fresh-water aquaculture farms, especially of carp. Moreover, adult African clawed frogs are thought to be a cause of trophic cascades through the consumption of benthic macroinvertebrates, while tadpoles are primarily phytoplankton feeders. As such, the species is thought to negatively affect the invaded ecosystems. It could also act as a potential reservoir/vector for chytrid fungus and Ranavirus, although to date there is no evidence of this.

Management

Raising awareness of the problems posed by the release or presence of this species, among the general public and key stakeholders e.g. pet owners and laboratories, could reduce the risk of further introductions. Small successful eradication campaigns have been carried out in the UK, Spain and the USA, using a combination of methods, including aquatic (baited) traps, fyke-nets, hand-dipping or electro-fishing. Other management techniques, which are only effective in specific circumstances, include fencing, pond draining, pond destruction, and the addition of salt to the waterbody. One additional option that still requires further research and development, is the release of sterile males to reduce breeding success.

Photo: *Xenopus laevis* (African clawed frog) © Brian Gratwicke, CC BY 2.0 via Flickr

Acacia saligna
Golden wreath wattle

Description

Golden wreath wattle is an evergreen bushy shrub or small tree, with dark green to blue-green long and narrow leaves (phyllodes) and bright and dense yellow, globular flower heads. The seed pods are brown, long and narrow (8-12 cm), which contract around several dark-brown seeds inside. In its native range, the species is associated with watercourses, sand dunes and coastal plains, is well adapted to semi-arid environments and is fire-resilient. The species can flower within 2-3 years and can produce large seed crops, so natural spread can occur very effectively. Following cutting, fire and soil disturbance, it will also grow vigorously from stumps, produce root suckers or germinate after heat has ruptured the seed casing, and can establish large and dense clonal stands. Golden wreath wattle is also known as the Port Jackson wattle, or *Acacia cyanophylla.*

Distribution

Golden wreath wattle is endemic to western Australia and has been introduced to many countries within Africa, Asia, Europe, North and South America and Oceania. The species has established populations in four EU Member States (Spain, Cyprus, Italy and Portugal) with records also known from Croatia, France, Greece and Malta. The increase in fire frequency and intensity in the Mediterranean region is likely to reinforce its populations.

Illustrations: *Acacia saligna* (Golden wreath wrattle)

Pathways

Golden wreath wattle was first intentionally introduced into coastal areas of several EU Member States within the Mediterranean region to stabilise sand dunes, for afforestation, and as an ornamental and landscaping plant. The primary pathway of introduction into the EU is as plants for planting in the horticulture trade, including for sale online. Natural dispersal is likely near watercourses or through human-mediated spread related to contaminated soils.

Impact

Golden wreath wattle often forms dense stands in its introduced range through rapid growth, massive seed production and clonal propagation, thereby affecting community composition and outcompeting native flora. In addition, this highly invasive alien tree species reduces surface runoff and soil water reserves and disturbs nutrient cycling. It may also increase fire intensity and frequency under extreme climatic conditions.

Management

Golden wreath wattle is very difficult to control once established because of its high regrowth rates and long-lived soil seed bank, and so early detection for rapid eradication is essential. Preventive measures include awareness-raising campaigns aimed at the public, foresters, and horticulturalists and the application of best management practices for habitats and land uses that are at risk of invasion and for the construction and management of roads e.g. managing soil movement and green waste. Control measures include hand pulling of seedlings and for established plants an integrated approach with chemical and mechanical control, biological control, along with various forms of cultural control e.g. grazing management, dedicated guidelines on prescribed burning, and restoration programmes.

Photo: *Acacia saligna* (Golden wreath wattle) © SAplants, Creative Commons Attribution-Share Alike 4.0 via Wikimedia

Ailanthus altissima
Tree of heaven

Description

Tree of heaven is a deciduous tree 20-25 m tall with a straight trunk and smooth, greyish bark. It has a sparse crown with thick branches. The leaves are made up of smaller leaflets (pinnately compound) and are up to 1 m long. It is a fast-growing plant with both male and female trees, with a very early onset of fruiting. It reproduces prolifically by winged and elongated fruits with a single seed, it can also rapidly regrow from roots in both high and low disturbance sites, when space is available. The species is able to set seeds as early as four years. The species thrives in areas with a long and warm growing season with regular cold winters. Although the species prefers open, largely human-influenced habitats, it can also grow and reproduce under canopies and invade open semi-natural areas (forest clearings, scrub vegetation, riparian areas and coastal vegetation).

Distribution

Tree of heaven is native to eastern China and northern Vietnam and has been introduced to all continents except Antarctica. The species is present in 18 EU Member States (Austria, Belgium, Croatia, Cyprus, the Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia and Spain) and has been recorded in Luxembourg, Malta and Sweden. In addition, there are a few cultivars of the species used and the current distribution of tree of heaven, in its introduced range, corresponds to the locations where it was cultivated and has since spread.

Illustration: *Ailanthus altissima* (Tree of heaven)

Pathways

Historically, tree of heaven has been used in forestry, as a windbreak, for anti-erosion and on landfill sites, due to its tolerance of polluted environments. The main pathway of introduction is through the ornamental plant trade and natural dispersal, as the seeds are easily transported by wind or in contaminated soil. Thus, it is widely found along linear structures e.g. roads, railways or rivers, in the landscape and at a considerable distance from its cultivation sites.

Impact

Tree of heaven has a negative impact on both nature and human activities. Its negative impact on biodiversity is particularly evident in species-rich protected areas, where it is considered one of the most problematic species. The species is an allelopathic tree, where toxins in the bark and leaves accumulate in the soil and inhibit the growth of other plants. Young trees can therefore grow rapidly and out-compete other species, forming dense thickets that displace native vegetation. The species can also damage buildings and transport infrastructure due to root encroachment and has negative economic impacts through increased costs for maintenance. In addition, the leaves and flowers can cause dermatitis and the pollen is allergenic, causing human health impacts.

Management

Tree of heaven is already well established throughout the EU, it is therefore vital to prevent its spread within and between Member States. Due to the mode of spread and rapid dispersal ability of the species, it is essential to prevent seed production, especially around dispersal routes e.g. transport infrastructure or watercourses. Due to the species' early onset of seeds (as early as four years from seedlings), early eradication of isolated female plants is crucial. Mechanical methods of control cannot be used in isolation because they lead to abundant regeneration. Effective management is based on the combination of mechanical and chemical treatments. The most effective method for adult trees is the targeted application of herbicide directly to the trunk, which enables the chemical to be absorbed by the whole plant, including the root system.

Photo: *Ailanthus altissima* (Tree of heaven) © Maja Dumat, Creative Commons Licence BY 2.0 via Flickr

Alternanthera philoxeroides
Alligator weed

Description

Alligator weed is an amphibian herb, adapted to both land and water environments, which grows horizontally above-ground, with creeping stems and roots and shoots which form at the nodes and the tips. It has dark green, smooth leaves which are opposite and elliptic, reaching 3.5-7.1 cm in length. Mature plants have hollow stems up to 10 m long that form thick interwoven mats throughout the waterbody and emerge up to 20 cm out of the water when the plant flowers. Inflorescences are white, 1.4-1.7 cm in diameter and on a short stalk. The species can grow in a variety of aquatic habitats and although more suited to aquatic and riparian habitats, alligator weed is also a vigorous coloniser of terrestrial habitats where the extensive (up to 2 m) deep rhizome system can sustain the population throughout extended dry periods.

Distribution

Alligator weed is native to the Parana River basin in South America (Brazil, Argentina and Paraguay), and is found at present in over 35 countries on five continents. In the EU it is currently established in two Member States (France and Italy), and has been recently recorded in the northwest of Spain. Based on the behaviour of the species in Italy and France, it is likely to establish in other parts of the Mediterranean region.

Illustration: *Alternanthera philoxeroides* (Alligator weed)

Pathways

It is not clear the source of the established populations of alligator weed in the EU. It is not a regular ornamental aquatic plant, but it could potentially be introduced as a contaminant of other ornamental aquatic plants. It has been intercepted numerous times as a contaminant of potted plants originating from China. Another possible pathway could be misidentified plants of a similar looking leafy vegetable *Alternanthera sessilis*.

Impact

By its ability to form dense mats, alligator weed rapidly chokes up riverine habitats, reducing both the quality and flow of water and preventing light and oxygen from entering the water column with drastic consequences for the ecosystem and its biodiversity. Throughout the invasive range, studies have shown that alligator weed alters the native plant community composition. Likewise, the species has been shown to alter the invertebrate and insect community structure in areas that it invades. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits. In Asia, North America and Australia, considerable losses are reported in a range of crops.

Management

As management of this species is complicated once it is established, early detection by a well-coordinated citizen science programme in the Member States at most risk is very important. Rapid eradication of small infestations (<100 m²) is possible using manual removal of aquatic vegetation, but terrestrial vegetation requires significant excavation up to 1.8 m deep. Chemical control is possible using repeated high dose applications for a period between 3-5 years. However, the risk of spread in those 3-5 years is very high, leading to additional populations that will require control. Also, the use of chemicals around water bodies is restricted within the EU. Management is difficult, labour intensive and requires significant capital investment in equipment, high disposal costs of harvested vegetation and ongoing monitoring for 10 years.

Photo: *Alternanthera philoxeroides* (Alligator weed) © Melissa McMasters, CC BY 2.0 via Flickr.com

Andropogon virginicus
Broomsedge bluestem

Description

Broomsedge bluestem is a densely tufted, perennial grass which can reach more than 2 m of height. It has light-green to reddish brown stems and long-ciliated leaf sheaths; inflorescences are covered by silky hairs. The species colonises a wide variety of environments: ruderal and burnt areas, abandoned fields, quarries, wetlands, open, also degraded, pastures, grasslands, and open woodlands. Broomsedge bluestem can thrive in different soils, including scarcely fertile or polluted. Together with the ability to live in different conditions, key to its success is the prolific production of seeds, long-dispersed by wind, and its tolerance for fire. Fire is an important factor in its ecology and invasion dynamic, because it maintains habitat conditions suitable to the species.

Distribution

Broomsedge bluestem is native to North (eastern and south-eastern), Central and South America (Colombia). It has been introduced outside its native range in North America (California and Hawaii), Asia (Georgia, Japan and South Korea), Europe (Russia) and Oceania (Australia and New Zealand). Within the EU, the species is established in one Member State, France, where it is localised in the southwest region (Landes and Gironde Departments). There are no records from any other Member States.

Illustrations: *Andropogon virginicus* (Broomsedge bluestem)

Pathways

The primary pathway of introduction is as a stowaway of machinery and equipment. It was first found in a military camp in France in the mid-20th century, potentially being accidentally introduced from the USA via munitions. Its recent expansion in France seems to be related to accidental spread via forestry machinery. Additional pathways include human-assisted spread as an ornamental plant, through unintentional transportation via hay and livestock, as observed in Australia, or human clothing. Natural dispersal is also possible via birds or animal fur, wind or water.

Impact

Broomsedge bluestem can be detrimental to biodiversity: being highly competitive, it can form dense stands, outcompeting native plants (also thanks to the release of allelopathic compounds), degrading habitats and increasing the risk of fire. Broomsedge bluestem can interfere with dynamics of renewal of habitat after fire events and transform vegetation from native woodlands to fire-adapted non-native grassland. Locally its massive occurrence can alter primary production, nutrient cycling and water content in soils. Negative impacts can occur both in natural environments and in forest plantations and pastures, causing economic loss related to timber and forage production. Negative impacts have been recorded mainly in the USA and Australia, but they are also likely to occur in the EU.

Management

Prevention is the most effective measure of management, as once broomsedge bluestem is established, it is hard to manage. The implementation of biosecurity measures (e.g. clearing machinery and equipment) are key to avoid new introductions and spread. Then, early detection strategies (including citizen science projects) should be implemented in order to rapidly eradicate and manage new sites of the species. Physical (hand removal) and chemical (herbicides, when allowed) control can be implemented to rapidly eradicate the species in small stands, while once it is widespread the integration of the both is more effective. Experiences in the USA suggest mowing and grazing integrated with tall herb planting and soil fertilisation are effective options.

Photo: *Andropogon virginicus* (Broomsedge bluestem) © Paul Marcum, CC BY-NC via iNaturalist

Asclepias syriaca
Common milkweed

Description

Common milkweed is an herbaceous perennial plant reproducing easily both by seed and vegetatively. The adult plants are around 1.5 m tall with a straight, unbranched stem and the whole plant is covered in a dense and short fur. The root system is branched, consisting of long rhizomes around 10 cm below the soil surface, connecting the above-ground shoots. Individual flowers are small, pink to white in colour, and the fruit is an elongated ovoid with many fluffy seeds. The species tolerates various climatic and soil conditions and is well adapted to drought. It grows in anthropogenic and (semi-) natural habitats such as roadsides, railway lines, abandoned sites and meadows, arable land, vineyards and orchards. One characteristic is the release of white, poisonous, latex-like milk after any disturbance.

Distribution

Common milkweed is native to North America and has been introduced to Japan and Iraq. In the EU, it has established in 13 Member States (Austria, Bulgaria, Croatia, the Czech Republic, Denmark, France, Hungary, Italy, Lithuania, the Netherlands, Poland, Romania and Slovakia) and has been recorded in Germany, Slovenia, Spain and Sweden. The species is most abundant in the warm regions of southern and south-eastern Europe.

Illustration: *Asclepias syriaca* (Common milkweed)

Pathways

The main pathway of introduction for common milkweed was as an ornamental plant, introduced by beekeepers through online sales and cultivated from existing plants. In addition, it was sometimes used as a fibre, used in the past as a filler and insulation, and as a medicinal plant. It has rapid natural spread in habitats modified by humans, such as along road and railway networks. The abundant distribution of the species in the Hungarian Plain is a result of deliberate cultivation, abandonment and subsequent spread. A number of other closely related species of milkweed occur in Europe and are cultivated for ornamental purposes.

Impact

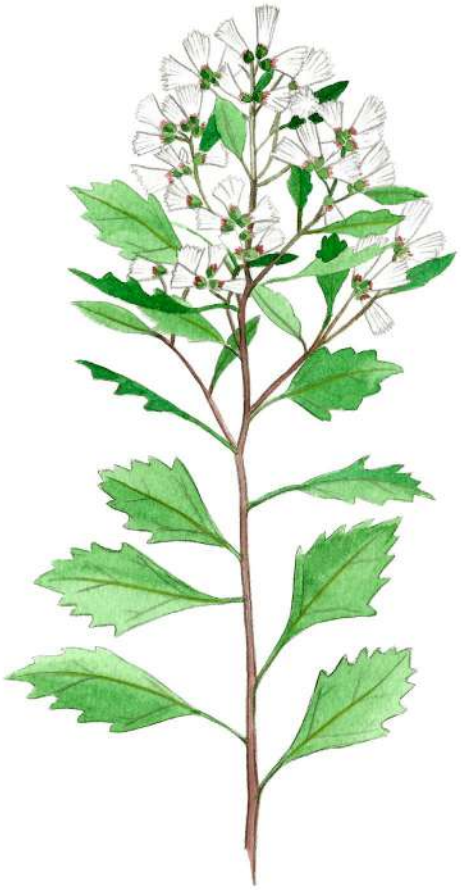
Common milkweed produces relatively dense populations, which can create shade, and releases harmful chemical compounds into the soil. These characteristics cause significant negative impacts on native plant communities through competition. Common milkweed also has a negative socio-economic impact as it is an invasive weed in agricultural areas and all parts of the plant are poisonous, which can harm livestock, and so the species is considered a noxious weed in some countries.

Management

For the eradication of common milkweed, mowing and grazing are not sufficiently effective, and so it is advisable to use chemical control (herbicides) to ensure management effectiveness. The use of herbicides is required for a minimum of three years, and optimally five years or more, depending on the age of the stand and the density of the underground rhizomes and root systems. Due to the high regeneration capacity of the species, follow-up treatments are required on sites throughout the season e.g. 2-3 times. Management should be conducted just before flowering, which reduces plant regeneration from adventitious root buds. When it is not possible to target the whole area effectively, it is necessary to limit seed production and the possibility of seed dispersal.

Photo: *Asclepias syriaca* (Common milkweed) © Judy Gallagher, CC BY 2.0 via Flickr

Baccharis halimifolia
Eastern baccharis



Description

Eastern baccharis is a broad-leaved shrub or little tree. Its pale green, alternate leaves are generally elongated even if variably shaped. When flowering, female and male plants can be distinguished by the colour of inflorescences, white and green-yellow (due to a large amount of pollen) respectively. It produces abundant seeds and has a good resprouting capacity. It is a sun-loving species, but shade-tolerant too, with a strong tolerance to salinity; it can colonise sites after disturbance, but it is competitive in undisturbed habitats too. Indeed, it can be found in coastal habitats from wetlands to forests, tidal rivers and sandy places; in Europe, it is often found in estuarine habitats and anthropogenic habitat, also far from the coast (roads, railways, wastelands, etc.).

Distribution

Eastern baccharis is native to North America (Canada, USA), Mexico and the Caribbean (Bahamas, Cuba). It has been introduced to Australia and New Zealand, western Asia (Georgia) and Europe. The species has established populations in four EU Member States (Belgium, France, Italy and Spain) and while reported in the Netherlands, it is no longer recorded there. It occurs in both the Atlantic and Mediterranean regions, with almost a continued distribution on the Atlantic side in the Bay of Biscay region and scattered but invasive distribution on the Mediterranean coastline.

Illustration: *Baccharis halimifolia* (Eastern baccharis)

Pathways

Eastern baccharis has been intentionally introduced to Europe since the 17th century, as an ornamental plant in botanical gardens and cultivated as an amenity plant for soil stabilisation or windbreak. The species successfully spread from cultivated sites, and once established in the wild, eastern baccharis can rapidly spread through the dispersal of numerous light-weight seeds easily dispersed by wind and water. Human-assisted dispersal is mainly related to unintentional transportation of seeds through soils, garden waste abandonment and as hitchhikers on vehicles and machinery.

Impact

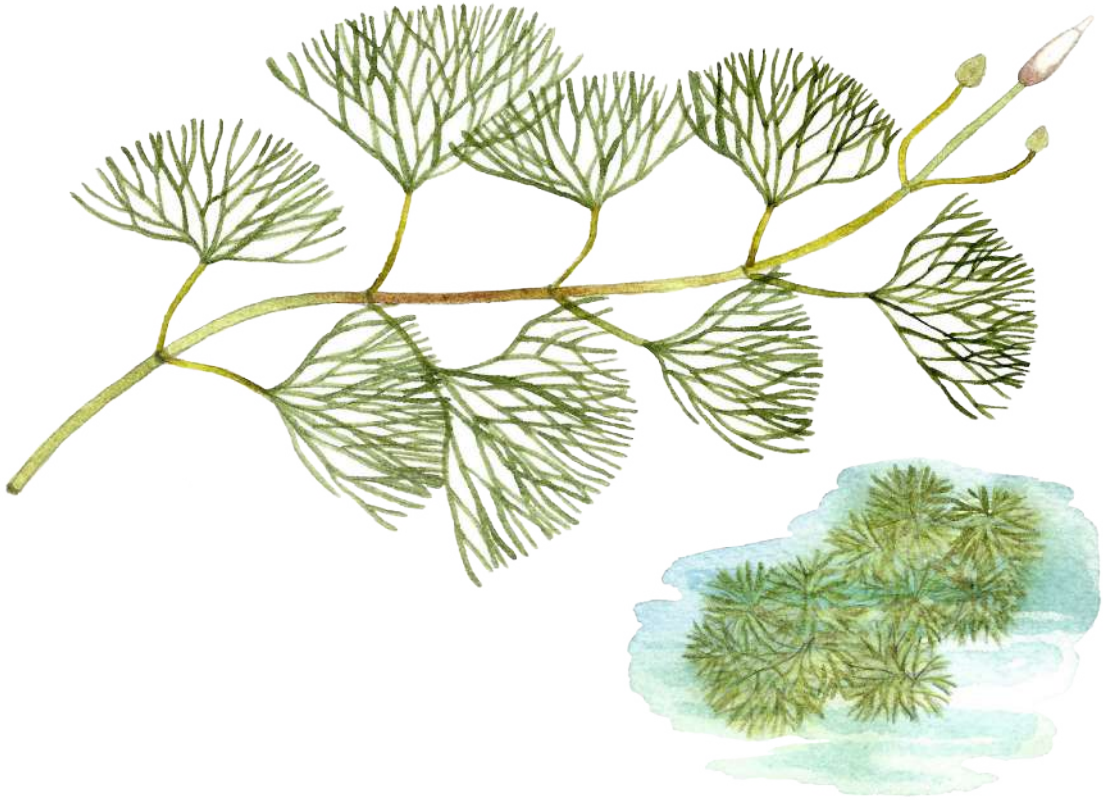
Eastern baccharis can outcompete native plants and alter the structure of habitats to the point of replacing native communities, with negative effects for species and habitats of conservation concern. Effects can be detrimental for insects and birds, whose richness and abundance seem to decrease in invaded sites. In invaded sites, alterations affect microclimatic conditions, sedimentation rate, light interception and fire regime, due to its inflammable resinous leaves and wood. Changes in ecosystem processes can be so severe that the plant is considered a “transformer species”. Its presence has been associated to economic losses in salt production in French saltworks and it can facilitate the presence of unpleasant insects (e.g. mosquitoes), shielding them against insecticides.

Management

It is very important to prevent secondary expansion of eastern baccharis, raising awareness among citizens and local authorities about effective management measures and biosecurity protocols (garden waste disposal, soil transportation or vehicle and machinery movement) to halt its unintentional human-assisted spread. Early detection and eradication strategies (including citizen science projects) should be implemented to rapidly find and manage new sites. Physical (manual removal, mechanical excavation) or chemical control can be effective in eradicating small populations, while integrated control is usually necessary for larger populations. Repeated mowing and grazing can be effective in controlling and containing eastern baccharis.

Photo: *Baccharis halimifolia* (Eastern baccharis) © iStockphoto/glasslanguage

Cabomba caroliniana
Fanwort



Description

Fanwort is a submerged rooted, perennial aquatic plant with short, fragile rhizomes. The erect shoots are upturned extensions of the horizontal rhizomes. The leaves are finely dissected, fan shaped and opposite, up to 1.5-5.5 cm wide. When flowering, small leaves are produced that accompany the white flowers that are up to 1 cm in diameter. Plants usually grow in stagnant or slow flowing waters up to 3 m depth. In autumn, the stem tips bend over and fall to the bottom, the stem breaks up easily and falls close to the 'parent' plant. In winter the stems settle onto the sediment and break up, leaving viable nodes and stem pieces to regrow in spring. Fragments are shed and disperse from the parent plant during flow events.

Distribution

Fanwort is native to South America (Brazil, Argentina, Paraguay and Uruguay), is considered native to south-eastern USA by some and has been introduced to five continents. In the EU it has established populations in two Member States (France and the Netherlands), and has been recorded in Austria, Belgium, Germany, Hungary, Poland and Sweden. Based on the climatic and habitat requirements of fanwort, it is likely to establish in eastern European countries and the Mediterranean region.

Illustrations: *Cabomba caroliniana* (Fanwort)

Pathways

Fanwort is a very popular aquarium species and has been introduced to the wild worldwide through unintentional disposal of surplus aquarium material and escape from cultivation for the aquarium trade. Although originating from South America, major production of the species for the European market is conducted in South East Asia. Once established, the fragile stems are easily fragmented and spread by boats, or management equipment that is not properly cleaned.

Impact

By its ability to form dense mats, fanwort rapidly chokes ponds, small watercourses, and even lakes, reducing both the quality and flow of water and preventing light and oxygen from entering the water column with drastic consequences for the ecosystem and its biodiversity. When dense mats of fanwort decay, the available oxygen in the water may be depleted and cause foul-smelling water. The resulting low oxygen conditions can lead to fish mortality and harm other aquatic organisms. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits.

Management

As management of this species once established is complicated, early detection by a well-coordinated citizen science programme is very important. Containment of existing populations and prevention of further spread is critical. The essential point of effective fanwort management is the removal of the rhizomes. Choice of control method mainly depends on the size of the infestation and the local situation. Rapid eradication of small infestations (<100 m²) is possible by shading the waterway for a full growing season or manual removal through divers or by mechanical means e.g. suction dredging. Once fully established in larger systems, maintenance and prevention of spread can be achieved by mechanical mowers, rake boats or hydro-jet equipment and the installation of physical barriers.

Photo: *Cabomba caroliniana* (Fanwort) © Leslie J. Mehrhoff, Creative Commons Attribution 3.0 via Wikimedia

Cardiospermum grandiflorum
Balloon vine

Description

Balloon vine is a perennial climbing semi-woody vine with compound leaves, reddish green bristly haired stem and white flowers in clusters. It has a very distinctive balloon-shaped fruit, which gives the plant its common name. Balloon vine thrives in open, sunny habitats, colonising different types of soils but preferring well-drained ground, although seeds and young plants can survive in both flooded and dry conditions. Subtropical climate is optimal for the species. Balloon vine can be found both in natural (forest edge, along watercourses, rocky slopes, coastal cliffs, Mediterranean scrubs) and disturbed sites (abandoned fields, margins of domestic gardens, urban environments, along roads). It mainly reproduces via abundant seeds, but it can also regenerate from root fragments.

Distribution

Balloon vine is native to Central and South America, from southern Mexico to the Caribbean and Brazil. Outside its native range, it has been introduced to North America, Africa, Asia (Sri Lanka), Australia, New Zealand and Europe. Within the EU the species has established in five Member States (Spain, Portugal, France, Italy and Malta), where the plant has a localised and quite scattered distribution, but locally can be invasive. On the Atlantic side, it occurs in the Macaronesian region, specifically in the Canary Islands (Spain) and Madeira (Portugal), and in the Mediterranean basin in mainland France, Italy (including Sicily) and Malta.

Illustration: *Cardiospermum grandiflorum* (Balloon vine)

Pathways

Balloon vine was originally introduced to Europe as an ornamental plant and unintentionally as a wool contaminant, however, these are no longer considered active pathways. Once introduced, it can escape from gardens or naturalised sites through both natural or human-assisted dispersal. Inside the fruit, the "balloon", seeds can be transported by water for months, covering very long distances both on watercourses and sea (also at intercontinental scale) and also via wind. Seeds and parts of the plant can also be dispersed following the abandonment of garden waste, movement of soils or as hitchhikers on vehicles and machinery.

Impact

Balloon vine has the ability to grow in dense, wide mats. It can smother plants, damaging them, alter environmental conditions (e.g. light regime) and native flora composition and vegetation dynamics. Both in Malta and the Macaronesia region, balloon vine is a threat to flora of conservation concern; in Malta it is considered devastating for native biodiversity. Outside Europe, negative impacts have occurred for wildlife and livestock (e.g. hindering of movement), and an increase in fire risk has been recorded. The massive presence of balloon vine can radically change ecosystem processes and services, with an impact on supporting (e.g. primary production), regulating (e.g. exposure of riverbanks to erosion) and cultural (landscape change) services.

Management

A ban on trade within the EU prevents new introductions, but there is a risk of misidentification with the similar species, *Cardiospermum halicacabum,* which is still in trade. Secondary expansion can be prevented through raising awareness, containment campaigns and sharing biosecurity protocols to halt involuntary human transportation. Early detection of any new sites and rapid eradication are fundamental and can be implemented through surveillance by local authorities, professionals and citizens. At the early stages of establishment balloon vine can be effectively eradicated through physical control, removing the whole plant by hand or with manual tools, but for established populations, this technique is often integrated with chemical control (herbicides).

Photo: *Cardiospermum grandiflorum* (Balloon vine) © Bernd Sauerwein, CC BY-SA 3.0 via Wikimedia commons

Celastrus orbiculatus
Oriental bittersweet

Description

Oriental bittersweet is a deciduous, twining, woody vine or shrub which grows in a very wide range of soil types and habitats (forests, sand dunes and open fields). The species is able to tolerate shade, and germinates well in low light conditions under canopy. However, it thrives in recently disturbed habitats, growing fastest in high light habitats caused by wind or other natural or human disturbance events. Leaves of oriental bittersweet are glossy, rounded, finely toothed and arranged alternately along the stem. Clusters of small greenish flowers emerge from leaf axils and the fruits are globose capsules, 6 to 8 mm in diameter, which change in colour from green to bright yellow as they mature. Upon ripening, the yellow outer covering of the fruit splits open to a vivid red colour.

Distribution

Oriental bittersweet is native to eastern Asia and it has been introduced to the USA, Canada and New Zealand. In the USA, it has been reported in 25 States, from four Provinces in Canada and has a localised distribution on New Zealand's North Island. In the EU the species has been recorded in eight EU Member States (Austria, Belgium, the Czech Republic, Germany, the Netherlands, Poland and Sweden) but has no established populations.

Illustration: *Celastrus orbiculatus* (Oriental bittersweet)

Pathways

The species was intentionally introduced into the EU for ornamental planting in the 19th century with its attractive bi-coloured fruits and bright yellow autumn leaf colour. The main pathway of introduction is escape from botanical gardens or through the horticulture trade. Human-assisted dispersal is a major threat and can occur through the improper disposal of seeds, pieces of root or contaminated soil. Natural dispersal by birds, small mammals and other wildlife, which are attracted to the multi-coloured fruit (e.g. starlings), is also a threat. Due to the species' high fruit and seed production, rapid growth rates, tolerance of soils and light and reproduction from both seeds and root material, the species can spread quickly.

Impact

Oriental bittersweet is a stem twiner and although it does not usually kill the tree it can cause damage and hinder growth, cause deformation, shade mature trees and increase the risk of windfall. It can dominate the understory and grow rapidly when forest gaps occur, affecting the survival and growth of other plant species, significantly altering habitat conditions for native species and potentially impacting ecosystems of conservation value. In the USA, these impacts can make trees for timber production worthless and young trees can be totally overgrown in forest plantations.

Management

The control of oriental bittersweet is challenging once established, so it is important to prevent additional introductions. Early detection and rapid eradication are critical for limiting the spread of bird-dispersed plants. Early detection methods include citizen science monitoring systems and general public awareness campaigns. Within the USA, measures for rapid eradication of small patches include physical removal through hand-pulling and uprooting, mechanical control through mowing or digging and chemical control via spray or directly to cut stems. For control and containment of large infestations, mechanical control is not recommended, but chemical control is effective.

Photo: *Celastrus orbiculatus* (Oriental bittersweet) © A. Purcel, CC BY 4.0 via Wikimedia commons

Cortaderia jubata
Purple pampas grass

Description

Purple pampas grass is a tall, perennial grass species. It can grow up to 4 m in height and has large, serrated leaves and a tall, fluffy inflorescence, sometimes referred to as a plume, that is usually pink to violet in colour, but turning brown with age. Only female plants of purple pampas are known to occur within the EU, and this species reproduces from seeds produced from unfertilised female ovules (a process called apomixis). The species can be found in riparian and wetland areas, heathlands, shrublands and coastal dunes. It is very similar to *Cortaderia selloana*, which is currently present within the EU and also highly invasive. Although studies using both morphological and genetic traits have identified distinct features unique to each species, distinguishing between the individuals of the two species might be difficult in the field.

Distribution

Purple pampas grass is native to Argentina, Chile, Bolivia, Ecuador, Peru and Colombia. It has been introduced and is having detrimental impacts in Hawaii, Australia, South Africa and, in particular, New Zealand and California (USA). There are no established populations in the EU, but it has the potential to invade and impact vast areas, and is capable of establishing in the Atlantic, Black Sea, Continental, and Mediterranean regions.

Illustrations: *Cortaderia jubata* (Purple pampas grass)

Pathways

Purple pampas grass was first reported in Europe in the 19th century, used as an ornamental species, but also as hedging or for windbreaks, but it has not established outside of cultivation. The main pathway of introduction is as an escape from confinement or garden escape. Human-assisted dispersal is a possibility through the disposal of green waste or transported on machinery. Natural dispersal of seeds can also occur via either wind or water courses. Although it is not very popular, *C. selloana* (commonly found in trade within the EU) and purple pampas grass can be easily confused and therefore one species may be misidentified for another, even by experts, and transported mistakenly.

Impact

In its introduced range, purple pampas grass invades a wide variety of habitats, primarily disturbed environments such as recently burnt or disturbed vegetation, roadsides, and forestry plantations. It produces an immense number of seeds (over 100 000 per plume) that are easily dispersed by wind, and forms dense, monotypic stands, outcompeting native flora and leading to a reduction in the abundance of native fauna such as arthropods and rodents. Furthermore, invasions can have particularly damaging impacts on forestry plantations as the species can compete with forestry species, can hinder access to plantations and increase fire risk.

Management

Manual control has been found to be effective, if labour intensive. For small infestations of small plants, hand-pulling is recommended as the management measure. Larger plants are more difficult to remove because of their serrated leaves, but can be dug out (with a pick, mattock or shovel) or mechanically removed. Once purple pampas grass is established, its effective management is extremely difficult and costly, particularly due to high seed production rates resulting in frequent reinvasion. Therefore, prevention and early detection are critical in the EU. This species is genetically and morphologically very similar to *C. selloana* and so surveying known introduction sites of the latter species may help identify undetected populations of purple pampas grass within the EU, enabling a rapid response.

Photo: *Cortaderia jubata* (Purple pampas grass) © Jon Sullivan, CC BY-NC 2.0 via Flickr.com

Ehrharta calycina
Perennial veldtgrass

Description

Perennial veldtgrass is a tussock grass, 30-70 cm high. Leaves are green to reddish-purple-tinged, often reddish purple also at the point where they meet the stem. Flowered inflorescences are red panicles. It has a broad environmental tolerance and it is resilient to frost, fire and drought. However, heavy grazed sites, waterlogged and highly saline soils are unsuitable. It thrives in sandy soils and disturbed areas.

In its invaded range, perennial veldtgrass can be found in different habitats from natural to disturbed conditions; specifically, in Spain it has been found in dunes, dry pastures and in Portugal along roadsides and open woodlands. It reproduces mainly by seeds, abundant and viable for several years (5), and secondarily from rhizome fragments.

Distribution

Perennial veldtgrass is native to South Africa and southern Namibia and has been introduced to the USA, Chile and Uruguay, north Africa (Tunisia and Egypt), Asia (India), Oceania (Australia and New Zealand) and Europe. Within the EU, it is established in two Member States (Portugal and Spain), with no records from any other Member States. It has a scattered and localised distribution on mainland Spain, the Balearic Islands (Menorca) and the Lisboa region of Portugal.

Illustrations: *Ehrharta calycina* (Perennial veldtgrass)

Pathways

The main pathway of introduction for perennial veldtgrass is as a cultivated plant to reduce soil erosion. Its seeds have been traded, and on occasion as plant cuttings. Introduction pathways into the EU are uncertain, as there is little evidence of cultivation. It may have been imported as a contaminant of hay; but there is no evidence for this. Additional pathways include as a hitchhiker on vehicles, machinery and equipment or natural dispersal via wind, water, rodents and grazing mammals (fur and dung).

Impact

When dominant, perennial veldtgrass can cause severe negative impacts, altering vegetation dynamics, transforming habitats and outcompeting native plants. Thanks to its rapid growth, it can shade out native plants and prevent their germination and establishment, leading to the displacement of local flora. Locally, impacts on fauna have also been recorded. It can cause major habitat modifications, shifting habitats from shrub or woodland communities to grasslands. In Australia this has created a grass-fire cycle, where the fire promotes the growth of the grass and the grass fuels fires, enabling the species to reach a high abundance. These impacts have been recorded outside the EU, but similar impacts are likely to occur.

Management

Awareness raising campaigns and citizen science projects could enable early detection and rapid eradication strategies, involving both citizens and local authorities. In Europe, perennial verdtgrass is localised and vectors of spread act on short distances, therefore, the appropriate management of known sites could prevent secondary spread from established populations. Containment areas, where the plant is managed and human actions are regulated, would be a useful measure. Management techniques of perennial veldtgrass are understudied but physical control is likely to be effective. However, on larger established areas an integrated approach using mechanical and chemical control should be required, but grazing and prescribed burning could also be considered.

Photo: *Ehrharta calycina* (Perennial veldtgrass) © Harry Rose, CC BY 2.0 via Flickr

Elodea nuttallii
Nuttall's waterweed

Description

Nuttall's waterweed is a perennial, submerged aquatic plant that typically grows in muddy substrates in meso- or eutrophic waters at depths of 3 m or less. However, the plant can grow more vigorously to depths of up to 6 m in eutrophic waters and form dense stands which can reach the water surface. Nuttall's waterweed stems are long and slender and often branched, with whorls of 3-5 leaves that are mostly recurved and usually twisted, and small white, waxy flowers less than 8 mm wide. The species can be found growing in a wide range of water bodies, in general in quiet water such as shorelines of lakes, reservoirs and ponds, along rivers and streams, and also in wetlands, canals and ditches. It is tolerant of disturbance and oil pollution, and is found in fresh to slightly brackish coastal water, and temperate regions.

Distribution

Nuttall's waterweed is native to temperate regions of North America and has been introduced to Japan. The species is established in 16 EU Member States (Austria, Belgium, Bulgaria, Denmark, France, Germany, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Romania, Slovakia, Slovenia and Sweden) and has been recorded in Croatia, the Czech Republic and Estonia, but it is likely to establish in all Member States.

Illustration: *Elodea nuttallii* (nuttall's waterweed)

Pathways

The main pathway of introduction is escape from captivity, mainly the ornamental plant trade. Nuttall's waterweed is popular as an oxygenating plant amongst ornamental pond and garden enthusiasts due to its easy growth and hardiness, but has now been largely replaced by other species. Local spread is largely the result of the fragile stems, which are easily fragmented and spread via boats or management equipment.

Impact

Due to its rapid growth and ability to form a thick entangled mass, Nuttall's waterweed rapidly chokes ponds, watercourses, and even lakes, reducing both the quality and flow of water and preventing light and oxygen from entering the water column. This can have drastic consequences for the ecosystem and its biodiversity. When dense stands of Nuttall's waterweed decay, the available oxygen in the water may be depleted and cause foul-smelling water. The resulting low oxygen conditions can lead to fish mortality and harm to other aquatic organisms. Cultural services can be affected by infestations of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits.

Management

The control and eradication of Nuttall's waterweed is very difficult, and thus it is important to act as soon as possible, when a new infestation is found. Early detection and rapid eradication is crucial. Early detection is best achieved through well-coordinated public awareness campaigns, to ensure the public are informed of the species and can identify new infestations. Eradication of small infestations is possible with hand weeding, benthic barriers, suction dredging, or by a combination of control measures. Eradication of large infestations is difficult to achieve. Once fully established in larger systems, maintenance and prevention of spread can be achieved by mechanical mowers, rake boats or hydro-jet equipment and the installation of physical barriers.

Photo: *Elodea nuttallii* (nuttall's waterweed) © Christian Fischer, Creative Commons Attribution-Share Alike 3.0 via Wikimedia

Gunnera tinctoria
Chilean rhubarb

Description

Chilean rhubarb is a high (up to 2 m), clump-forming, herbaceous perennial plant, with a stout horizontal stem (rhizome) and very large, deciduous umbrella-shaped leaves (diameter up to 2 m). It produces a large amount of seeds (up to 25 000/year), forming a consistent soil seed bank. It spreads clonally by its rhizome, and it can also regenerate from fragments of stem or rhizome. A symbiosis with nitrogen fixing cyanobacteria supports its rapid growth. Chilean rhubarb thrives in temperate climates with high precipitation and humidity. It prefers moist soils, tolerates seasonal waterlogged conditions and sea spray. In Europe, it is found on coastal cliffs, riparian areas, forests and wetlands, but also in human-shaped habitats such as former agricultural fields, quarries and road sides.

Distribution

Chilean rhubarb is native to South America, occurring in Chile, Argentina, Peru, Bolivia, Ecuador, Colombia and Venezuela. It has been introduced to the USA (California), New Zealand and the UK. The species is established in two EU Member States, Ireland and Portugal (São Miguel Island, Azores) and has been recorded in France (Brittany and Lower Normandy), where it is localised but considered a potentially invasive plant to monitor.

Illustrations: *Gunnera tinctoria* (Chilean rhubarb)

Pathways

The main pathway of introduction for Chilean rhubarb is through the horticultural trade, being a very popular ornamental plant. Planted, especially around ponds and watercourses, it easily escapes from confinement into the wild through the dispersal of seed and plant fragments. Natural dispersal via water is the main long-distance vector, but also via birds and potentially livestock. Human-assisted dispersal can also occur via vehicles, disposal of garden waste, contaminated soil or on clothing.

Impact

Chilean rhubarb can be a very strong competitor and it can cause severe impacts to ecosystems. It can shade out plant and animal communities beneath its impressive leaves, displace native plants, interfere with composition and recruitment of resident species and alter vegetation dynamics. Severe impacts to species and habitats of conservation concern have been registered both inside and outside Europe. Its massive presence can modify ecosystem processes causing imbalances in litter production and decomposition, affecting water and biogeochemical cycles and exacerbating soil erosion. Detrimental effects to human activities are related to the blocking of drains and streams, loss of land for agricultural use, obstacle to access to recreational areas or a change in landscape perception.

Management

Within trade, attention must be paid to mislabelled material (e.g. seeds) from similar *Gunnera* species. Awareness raising campaigns should prevent unintentional introductions or dispersal, informing citizens and authorities of the risks of the plant, as well as management and biosecurity measures to adopt. Local bodies and citizens should be involved in early detection strategies in order to rapidly intercept new sites and eradicate them before flowering occurs. Young plants can be effectively dug out, but for established, adult plants long-term integrated strategies are necessary. Management measures to reduce plants include chemical and mechanical control. To reduce recruitment, flowering should be prevented alongside soil seed bank control.

Photo: *Gunnera tinctoria* (Chilean rhubarb) © James Gaither, CC BY-NC-ND 2.0 via Flickr

Gymnocoronis spilanthoides
Senegal tea plant

Description

Senegal tea plant is a perennial aquatic herb. It grows in erect bushes, crawls on banks or floats in mats on water and occasionally it has a submerged form. It has opposite dark green elongated, glossy leaves and white spherical inflorescences. It reproduces both by seeds and fragments of stem, rhizome and leaves, which is likely to be its main propagation strategy in its invasive range. Senegal tea plant thrives in warm climates, but tolerates cold. In optimal conditions, its growth can be very rapid (15 cm in a week). It is favoured by shallow and slow-flowing waters and disturbed environments. It can be found in rivers, reservoirs, irrigation channels, ponds, lakes, canals, ditches and also in high-nutrient marshes and swamps; it has been occasionally found in rice fields.

Distribution

Native to South America, Senegal tea plant has been introduced outside its native range in Central America (Mexico), Asia (India, China, Taiwan and Japan), Oceania (Australia and New Zealand) and Europe. In the EU, it is established in two Member States (Hungary and Italy), with localised distributions. In 1988, Senegal tea plant was found in two localised sites, in thermal waters and ditches, in Hungary, but today it is established and more widespread. As of 2015, two populations are known in northern Italy, along an irrigation canal and in a rice field. It has also been recorded in the Netherlands. However, this small population along a watercourse was rapidly eradicated and monitoring is in progress to control any re-growth.

Illustration: *Gymnocoronis spilanthoides* (Senegal tea plant)

Pathways

The primary pathway of introduction for Senegal tea plant is as an aquarium plant or ornamental plant for ponds. Secondarily, it has been used as a water purifier, although there is no evidence of its effectiveness, and as a plant attractive to butterflies. Once introduced, it escaped from aquaria and ponds thanks to natural and human-assisted dispersal. The escape of plant fragments via water courses is the main natural dispersal route, allowing long distance transport, and seeds can also be dispersed by animals. Human-assisted spread is possible through the incorrect cleaning of aquaria and as a contaminant on equipment, machinery or boats.

Impact

Senegal tea plant can cause a series of negative impacts both to biodiversity and human activities. Most impacts observed are from outside Europe, but these impacts are likely to occur within Europe if the species becomes invasive. As a rapid-growth plant, it can outcompete, sometimes displace, slow-growing native species. Floating mats can alter underwater conditions (e.g. reduction of light and oxygen), with impacts for aquatic plants and animals and waterfowl relying on these aquatic organisms. It can increase evapotranspiration rates, with consequent water loss mostly critical for smaller water bodies. Dense plant beds of the species can hinder water flow, causing problems along irrigation channels and increasing flooding risk. Also, access to and navigation within water bodies can be hampered.

Management

To prevent possible new introductions through the trade of mislabelled plants, inspections by customs and vendors should be conducted. Biosecurity measures could also prevent unintentional introduction or spread via contaminated equipment, boats or machinery. Early detection and rapid eradication can be implemented involving local authorities, professionals and citizens. The containment of Senegal tea plant is key to prevent further spread. The dispersal of seeds or fragments of plant can be hindered by floating barriers and the control of access to sites where it is present. Physical control can be effective in removing the plant and chemical control with herbicides, but the use of herbicides around water bodies is restricted within the EU.

Photo: *Gymnocoronis spilanthoides* (Senegal tea plant) © John Tann, CC BY 2.0 via Flickr.com

Hakea sericea
Needle bush

Description

Needle bush is a single-stemmed, woody shrub or small tree, 0.6 to 4.5 m tall, with simple, needle-like leaves, cream-coloured flowers and woody follicles or fruits. The species has a canopy-stored seed bank, which is typically released following the death of the plant, frequently caused by fire. The needle bush grows in dry forests and heaths with a warm temperate climate, but is resistant to drought and frost to -7 °C, when established. Characteristics promoting invasion include its prolific seed bank in the absence of natural enemies, the high seed longevity in the canopy and efficient seed dispersal. In the invaded range of the species, densities of up to 7 500 seeds per m² have been reported and the winged seeds can facilitate dispersal over several kilometres.

Distribution

Needle bush is a shrub native to southeastern Australia, specifically in southeastern Queensland and southeastern New South Wales. The species has been introduced to New Zealand and South Africa, and is widespread in South Africa.

Within the EU, the needle bush has established populations in three Member States (France, Portugal and Spain), with no records in any other Member States.

Illustration: *Hakea sericea* (Needle bush)

Pathways

Early records exist for the introduction of needle bush into European botanical gardens in the 19th century. In the 1930s the needle bush was then cultivated as a hedge plant in Portugal and has since then become highly invasive. Currently, horticulture trade is the only pathway of introduction into the EU, but there is no evidence of it being commonly imported. Natural spread is possible through seed dispersal by wind or water or human-assisted dispersal, through the improper disposal of soil or plant waste. The likelihood of further establishment in similar habitats within suitable areas within the EU is considered to be high.

Impact

Within the EU, needle bush forms extensive, dense and impenetrable thickets, which can exclude native vegetation, affecting community composition and wildlife, reducing the amount of water available. This can increase the probability of fires and reduce the runoff in mountain catchments. This invasive alien plant impacts rare endemic species, such as *Succisa pinnatifida*, a rare endemic plant of the Iberian Peninsula, in biodiversity hotspots and Natura 2000 sites in Portugal and France. It can also cause a cultural impact by restricting access for the public through its prickly foliage. In South Africa, it can also invade and degrade agricultural, pasture and forestry land.

Management

To prevent the unintentional introduction and spread of needle bush, public awareness campaigns could be conducted. For rapid eradication, measures include hand-pulling of young plants and cutting and incineration of larger plants. For larger infestations, the fell and burn technique has been effective in South Africa. However, needle bush has a canopy-stored seed bank, which is released following the death of the plant, frequently caused by fire, and so secondary treatment is required to eliminate seedlings. Although this is a very effective control method, the increased fire intensities using this technique can have a negative effect on sensitive ecosystems. Fire prevention activities in general may also be beneficial to prevent seed dispersal and regeneration of this species.

Photo: *Hakea sericea* (Needle bush) © Shaun Swanepoel, Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) via iNaturalist

Heracleum mantegazzianum
Giant hogweed

Description

Giant hogweed is a perennial plant known by its distinctively large leaves, tall flowering stem (up to 5.5 m) and distinctive flower head. In Europe, apart from giant hogweed, there are two other closely related invasive hogweed species, namely Persian hogweed (*H. persicum*) and Sosnowsky's hogweed (*H. sosnowskyi*). Giant hogweed blooms and finishes its life cycle usually in the 3rd to 5th year of life, but can postpone flowering for up to 12 years. As for other hogweed species, it is pollinated by a wide range of insects and reproduces exclusively by wind-dispersed seeds, with one plant producing up to 30 000 seeds. In its native range, giant hogweed occurs naturally in high-elevation meadows below the upper forest boundary, but grows in a wide range of habitats from natural to highly human made.

Distribution

Giant hogweed is native to the Caucasus in southern Russia and Georgia. It has been introduced to northern USA, southern Canada, Australia, New Zealand and Europe. Within the EU it has established in 15 Member States (Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, the Netherlands, Poland, Slovakia and Sweden) with records also in Croatia, Estonia and Slovenia.

Illustrations: *Heracleum mantegazzianum* (Giant hogweed)

Pathways

Historically, giant hogweed was propagated as an ornamental plant and was, and sometimes still is, popular among beekeepers. Its current distribution corresponds to locations of historic sites where it was cultivated and from where it spread into the surrounding area e.g. gardens, parks, roads, railway embankments, etc. The current pathways of introduction include as a contaminant of soil, misidentified as other *Heracleum* species or occasionally transported intentionally as a horticultural plant. Secondary natural spread within the EU is likely to be much more important as the seeds can be dispersed easily by the wind and it is able to colonise new sites quickly, from neighbouring existing stands.

Impact

Giant hogweed has been shown to have a significant negative impact on biodiversity. Dense stands of giant hogweed reduce native plant diversity, can cause changes in the seedbank composition and alter ecosystem functions over time. Giant hogweed is also known to cause a phototoxic reaction for humans after contact with the plant, and so it poses a serious human health risk.

Management

Due to the species easy detectability, even before flowering, the absence of spread by vegetative fragments and the high effectiveness of appropriately implemented eradication interventions, small populations of giant hogweed can be eradicated relatively easily. The most effective management measure is the use of herbicides. Mowing and grazing are not effective methods of eradication because they do not cause plant mortality, they just reduce the size of the plants and the amount of seeds produced. However, they may be the only feasible management option in large infested areas where herbicide use is limited. Seeds can remain viable in the soil for seven years, which must be taken into account in management planning.

Photo: *Heracleum mantegazzianum* (Giant hogweed) iStockphoto/jenochei

Heracleum persicum
Persian hogweed

Description

Persian hogweed, also known as Tromsø palm, is an herbaceous plant growing to a height of 3 m. Leaves are large, deeply palmated and the flowering stem is purple. The plant is polycarpic, flowering several times over the plant's lifetime and flowers are pollinated by a wide range of insects. The species reproduces exclusively by wind-dispersed seeds. This species is smaller than the other invasive hogweed species in Europe and has a strong anise odour. There are two similar and closely related species of tall invasive hogweed in Europe, these include giant hogweed (*H. mantegazzianum)* and Sosnowsky's hogweed (*H. sosnowskyi*). For Persian hogweed, there is a limited knowledge base from the invaded range but it is known to spread in natural environments and occurs in coastal habitats (beaches), grasslands, meadows, pasturelands, edges of forests, wetlands, riverbanks/canal sides, rail/roadsides, and in urban areas along roads and other disturbed habitats.

Distribution

Persian hogweed is native to Turkey, Iran and Iraq. From these regions come frequent studies on the use of the species as a source of oil and extracts for medicine and antioxidant. Outside of the species' native range, it has only been introduced to Europe. Within the EU, the species has established populations within four Member States (Denmark, Norway, Finland and Sweden), with no records from any other Member States.

Illustrations: *Heracleum persicum* (Persian hogweed)

Pathways

The species was introduced to Scandinavia as an ornamental plant. There is no evidence that the species is currently traded or intentionally dispersed further within the EU. Secondary spread from already infested sites is highly possible. The main pathway of spread for Persian hogweed is via soil, either as a contaminant or a stowaway on machinery, vehicles and footwear. Although the seed production of Persian hogweed is thought to be inferior to other invasive hogweed species within the EU, the species can bloom several times in a lifetime. Natural dispersal of seeds can occur both locally near the mother plants and over long distances by watercourses or on snow by wind.

Impact

There are few studies on the impacts of Persian hogweed in its invaded range. However, the plant contains photosensitizing furanocoumarins which can cause a phototoxic reaction for humans after contact with the plant. Although the intensity of the reaction depends on the sensitivity of the individual, it poses a serious human health risk. Also, recent studies have confirmed that Persian hogweed can have negative impacts on vegetation, taxonomic diversity, native biomass, and species richness in the invaded areas. The impact of the species is comparable to other invasive hogweed species within the EU, like giant hogweed and Sosnowsky's hogweed.

Management

Persian hogweed has limited distribution within the EU, and so most efforts should be invested in preventative measures. The monitoring and adequate phytosanitary measures (e.g., cleaning etc.) of soil, machinery and vehicles could prevent introduction as a contaminant or stowaway. Fortunately, the species can be easily detected by public and stakeholders, due to its exotic appearance and large size, and raising public awareness of the species is important to stop its deliberate planting. If detected, small populations can be eradicated relatively easily through cutting at the roots or applying herbicides. For larger infestations mowing and grazing are not effective methods of eradication, because they do not cause plant mortality but just reduce the size of the plants and the number of seeds produced. Instead, established populations need to be managed with herbicides.

Photo: *Heracleum persicum* (Persian hogweed) © Asbjorn Floden, CC BY-NC 2.0 via Fickr.com

Heracleum sosnowskyi
Sosnowsky's hogweed

Description

Sosnowsky's hogweed belongs to the group of tall invasive hogweeds, this includes giant hogweed (*H. mantegazzianum*) and Persian hogweed (*H. persicum*), which are both also invasive within Europe. Sosnowsky's hogweed is sometimes misidentified as giant hogweed, so in some countries, the distributional data for the species may not be precise. However, the leaves are less sharply spiked than giant hogweed. Sosnowsky's hogweed is a monocarpic perennial herbaceous plant with large leaves and a tall, ridged, sparsely haired flowering stem (up to 5.5 m) with purple blotches. The species has a conspicuous flower head (ca 50 cm in diameter) consisting of many small white flowers, which are pollinated by a wide range of insects. Reproduction is exclusively by wind-dispersed seeds. Sosnowsky's hogweed is found in both artificial habitats (roadsides, disturbed areas or agricultural fields), and semi-natural habitats (parks, gardens or abandoned farms) and can rapidly invade open areas and areas along water basins, roads and forest edges.

Distribution

Sosnowsky's hogweed is native to the eastern Caucasian ridge, Transcaucasia and Turkey and has been introduced to Europe. Within the EU, the species has established in six Member States (Estonia, Latvia, Lithuania, Poland, Hungary and Germany) and has been recorded in Finland, Portugal, Belgium, Italy, Romania and the Czech Republic. It is also recorded in Serbia and Ukraine. However, as previously mentioned, the species is very similar to giant hogweed and so records may be not precise.

Illustrations: *Heracleum sosnowskyi* (Sosnowsky's hogweed)

Pathways

From the 1960s, Sosnowsky's hogweed was cultivated for forage over wide areas in Russia, Belarus, Ukraine and the Baltic States. It was also tested in Germany, Hungary and Poland but is no longer used as a fodder crop in Europe following its listing as a species of Union concern reaction. The main pathway of introduction is now as a contaminant of soil or a stowaway on machinery, vehicles or footwear. Once introduced natural dispersal can occur through the spread of seeds via wind or on the fur/hide of animals (cattle).

Impact

Sosnowsky's hogweed forms dense stands, can increase nitrogen levels within the soil and can cause eutrophication, which further stimulates the species' dominance. These dense stands shade out other plant species, which can lead to a strong decline in the species richness within the habitats. These effects are multiplied by the fact that it was planted in large numbers, in fields and meadows, in a number of Member States. It could also promote soil erosion, as seen with giant hogweed, exposing bare soil when vegetation dies back in the winter. Similarly, like other hogweeds, it can cause a strong phototoxic reaction for humans after contact with the plant, so can be a human health risk.

Management

Due to its exotic appearance and large size, Sosnowsky's hogweed can be easily detected. Raising public awareness can assist in developing understanding and increase reporting. If detected, rapid eradication is crucial as the species can spread easily by seed. Small populations can be eradicated relatively easily using manual or mechanical removal measures (root cutting, cutting the plant, mowing, flower removal and ploughing), grazing or the application of herbicides, or a combination of these. Large infestations need to be managed with herbicides. Mowing and grazing are not effective methods for eradication because they do not cause plant mortality, they just reduce the size of the plants and the number of seeds produced. However, mowing and grazing can be the only possible management options in large infested areas, where herbicide use is limited.

Photo: *Heracleum sosnowskyi* (Sosnowsky's hogweed) © By I, Hugo.arg, CC BY-SA 3.0 via Wikimedia

Humulus scandens
Japanese hop

Description

Japanese hop is a herbaceous, annual vine with prickly stems and separate male and female plants. It climbs or trails across landscapes forming dense vegetation cover, building up monodominant stands. It is found in meadows, wetlands forest margins and on the sand or gravel deposits of riversides, easily colonising disturbed areas. It can grow between 0.5-5 m, but can reach heights of 11 m. Its branched intertwining stem enables it to wrap around vegetation and other structures. It has palmately lobed, light green leaves of 5-12 cm length and greenish to yellow flowers, which are predominantly wind pollinated or by honeybees. It flowers late in the season (July-September) and one plant can produce 800-1 200 seeds, which can remain viable in the soil for up to three years.

Distribution

The native range of the Japanese hop includes large areas in temperate Asia, from south-western China to Vietnam, Korea, Japan and the Khabarovsk region in the Russian Far East. It has been introduced to North and South America and Europe. In North America it is established over a large area in eastern Canada, through all central and eastern federal states, to Alabama and Georgia in the south-east of the USA. In South America it is recorded from north-eastern Argentina and in Asia from Uzbekistan. In the EU it has established populations in four Member States (Croatia, France, Hungary and Italy) with records also from Austria, Belgium, the Czech Republic, Germany, Romania and Slovenia. Elsewhere in Europe is has established in Switzerland, Serbia and has been recorded in Ukraine.

Illustration: *Humulus scandens* (Japanese hop)

Pathways

The main pathway of introduction for the Japanese hop, throughout the 19th century, was as an ornamental plant within the horticulture trade. In recent years, seeds have also been available through online sales. Within the USA and the EU, plants escaped from gardens and spread via natural dispersal by animals and via water courses over long distances. Human-assisted spread can also occur through the movement of garden waste, in topsoil or via machinery and equipment.

Impact

In its native range, the Japanese hop is considered a weed. In its introduced range, it can outcompete native species, thus reducing species richness and altering community composition and possibly ecosystem function. Where it climbs over existing vegetation, it can block out light to other species and also ring-bark saplings, sometimes resulting in the death of the affected young tree, affecting successional processes. The dense vegetation cover this plant forms, dies off in winter and may lead to increased erosion of river banks as the native vegetation has been lost and is thus unable to provide bank stability over the winter.

Management

Stakeholder communication is important in preventing the spread of the species, for example, informing land managers of the risks around soil removal where seeds might be present or ensuring gardeners understand the invasive impacts of the species and removing it securely from gardens. Restoring ecosystems could reduce establishment and spread as this plant thrives in disturbed, open areas. For newly established populations, finding and managing the source of the infestation is important to prevent future spread. Established plants can be managed through manual pulling and cutting, which is best undertaken in late spring before seeds establish. Repeated cutting may be necessary. Chemical control is used in North America but there is no information on its use within Europe, where it is prohibited in riparian habitats.

Photo: *Humulus scandens* (Japanese hop) © Matthew Beziat, CC BY-NC 2.0 via Flickr

Hydrocotyle ranunculoides
Floating pennywort

Description

Floating pennywort is a perennial aquatic plant, with floating and emergent leaves. It roots in the shallow margins of slow-flowing waters and has stems floating in water or creeping onto shorelines. Stems are slender and root freely from nodes. Leaves are alternate, emergent on long fleshy stalks and may reach a diameter of 18 cm in suitable habitats. Leaf stalks may grow up to 35 cm. Flowers are white, with 5–10 grouped together in a small group, borne on a leafless stalk. Floating pennywort reproduces primarily by vegetative reproduction. Seed production is reported within Europe, but little is known about the viability of the seeds and their germination in the field. The species occurs at the margins of still or slow-flowing watercourses, at both high and low altitudes.

Distribution

Floating pennywort originates from North, Central and South America and has been introduced to Australia and Europe. There are also 19th Century records for east Africa and west Africa which are difficult to explain. Present day occurrences in western Europe are linked to an introduction from North America at the end of the 20th century. Shortly after introduction floating pennywort became invasive in one Member State; the Netherlands. It has now been recorded in eight Member States (Belgium, France, Germany, Hungary, Ireland, Italy, Portugal and Spain). Severe winter conditions and summer drought may limit its further establishment in Europe.

Illustration: *Hydrocotyle ranunculoides* (Floating pennywort)

Pathways

The main pathway of introduction for floating pennywort was through the horticulture trade as an aquatic plant. Present day spread through the aquatic plant trade may still occur as a result of mislabelling or contamination of other aquatic plants with floating pennywort. Local spread is largely the result of the fragile stems that are easily fragmented and spread via boats or management equipment that is not properly cleaned.

Impact

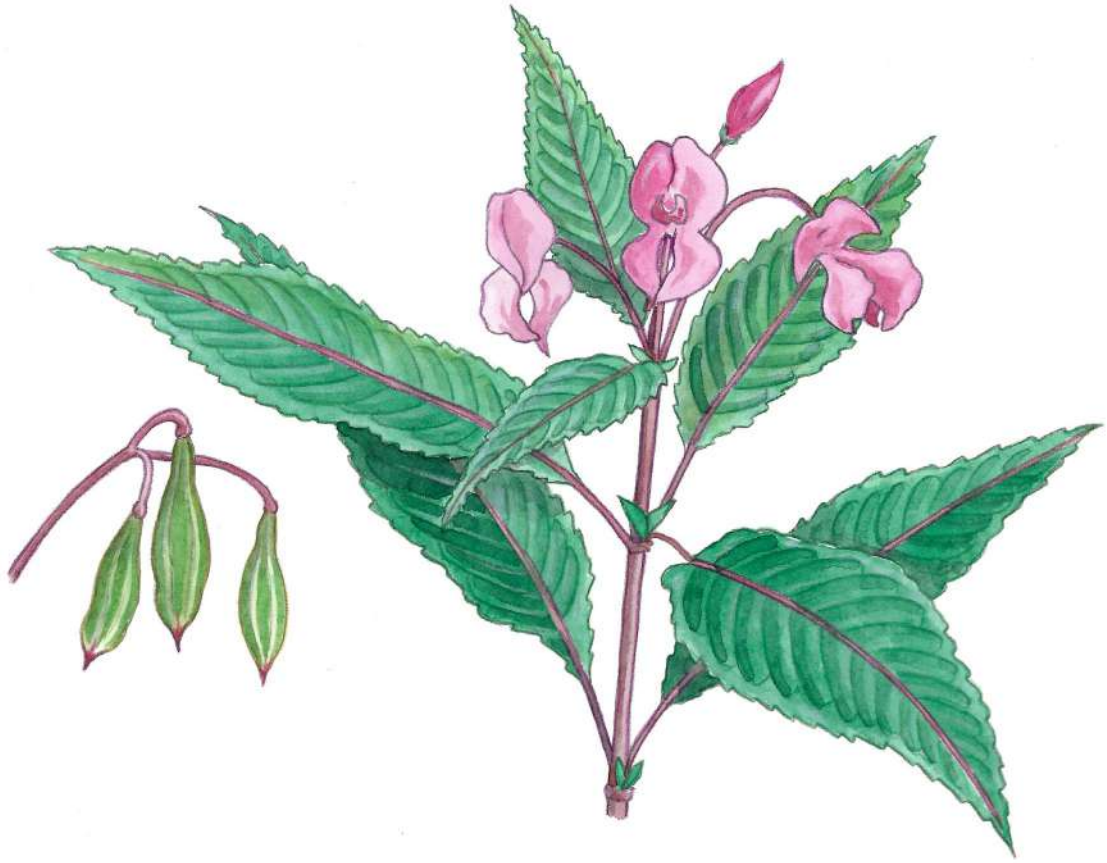
By its rapid growth and ability to form a thick floating mass, floating pennywort rapidly chokes ponds, ditches and even larger watercourses. This reduces both the quality and flow of water, thereby increasing the risk of flooding and preventing light and oxygen from entering the water column. This has drastic consequences for the ecosystem and its biodiversity. When these dense mats decay, the available oxygen in the water may be depleted and cause foul-smelling water. The resulting low oxygen conditions can lead to fish mortality and can harm other aquatic organisms. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling and swimming. This plant accumulates heavy metals, making disposal of plant material problematic.

Management

The control and eradication of floating pennywort is very difficult, and thus it is important to act as soon as possible, when a new infestation is found. Early detection can be achieved through intensive surveying, including citizen science. If found, rapid eradication of new invasions can be achieved through hand weeding. Due to the easy fragmentation and high regeneration capacity of the species, management is difficult, and care should be taken to prevent species spread via fragments during the management activities. As such, for established populations, a detailed management plan is needed and, although herbicides and biological control can be used where permitted, mechanical control followed by hand weeding is considered the best practice to manage large infestations.

Photo: *Hydrocotyle ranunculoides* (Floating pennywort) © Dick Culbert, Creative Commons Attribution 2.0 via Wikimedia

Impatiens glandulifera
Himalayan balsam



Description

Himalayan balsam is an annual herb with showy, pink flowers, and green leaves, reaching a height of up to 250 cm. The conspicuous flowers later turn to capsules, which burst when fully ripe and the seeds are then ejected and can grow very quickly. The species has shallow roots. Although Himalayan balsam grows at high altitudes within its native range, in its invaded range it is restricted by climate to middle elevations. Early winters shorten the species' life cycle and lower fecundity, with the plant flowering until the first frost. In addition, the plant can also spread by regenerating from plant fragments. Most often, in the introduced range, the species is found in disturbed habitats, especially on river and stream banks. In recent years, there has been a clear shift to shaded areas in the forest understory.

Distribution

The native range of Himalayan balsam covers the foothills of the Himalayas from northwest Pakistan to northern India, Nepal and Bhutan. The species has been introduced and is invasive in much of Europe, North America, and New Zealand, and has been reported in Japan. Within the EU, the species has established in 22 Member States (Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Romania, Slovakia, Slovenia, Spain and Sweden) and is capable of establishing within all regions of Europe.

Illustration: *Impatiens glandulifera* (Himalayan balsam)

Pathways

In Europe, Himalayan balsam was first introduced as an ornamental plant of gardens and parks in the mid-19th century and further expanded as a honey-bearing and forage plant. Natural dispersal is highly likely, with seeds easily dispersed along watercourses, especially with sediment. Human assisted dispersal is also highly likely, with vehicles facilitating the movement of contaminated soil and with seeds sticking to tyres and machinery. There are a large number of non-native balsam species cultivated as ornamental species within the EU and some of these are expected to become established in the near future.

Impact

Himalayan balsam is a highly competitive plant species. The seedlings grow in early spring and can quickly overgrow native vegetation, altering the species composition and the diversity of invaded vegetation, ranging from negligible to strongly negative. During winter the vegetation dies back and this can disturb river bank stability and increase the risk of erosion by exposing bare soil. In addition, the species impacts pollinator competition due to the high nectar production, and can alter soil properties and soil biota.

Management

Given the wide distribution of the species, its dynamics and ease of dispersal, eradication of this species at large scale is not realistic. Priority is given to the management of conservation priority sites, where it is necessary to limit impacts on biodiversity. In addition, new and isolated populations may be prioritised to remove source populations and prevent further spread. The recommended management measure is hand pulling, removing the whole plant, with the roots. It is necessary to repeat the intervention at sites several times during the season due to the species high regeneration capacity. For stands where eradication is not being pursued, reduction of seed production by means of routine landscape maintenance should be used e.g. mowing, grazing.

Photo: *Impatiens glandulifera* (Himalayan balsam) © Maja Dumat, CC BY 2.0 via Wikimedia

Koenigia polystachya
Himalayan knotweed

Description

The Himalayan knotweed, also known as *Polygonum polystachyum*, is a perennial herb, which grows up to 40-120 cm. It has solid reddish-brown stems with lanceolate leaves, smooth above and hairy below. The flowers are creamy-white and sometimes pink in colour with small brown seeds. The species can grow in high altitude regions and in moist and dry zones. Habitats include rocks and slopes, grassy meadows, bushy ground, wet forest, marshes and riparian zones. Reproduction is either through seeds or from extensive rhizomes, with root and stem fragments as small as 1 cm able to form new plant colonies. Increased and prolonged temperatures, as a result of climate change, will increase the growth of the rhizome structures below ground, enhancing the potential invasiveness of the species.

Distribution

The Himalayan knotweed is native to central and eastern Asia and has been introduced to North America, New Zealand and Europe. The species has established populations in six States within the USA and two Provinces in Canada, with reports in additional regions. Within the EU, the species has established populations in nine Member States (Austria, Belgium, the Czech Republic, France, Germany, Ireland, Italy, the Netherlands and Poland) with records also from Denmark and Sweden.

Illustration: *Koenigia polystachya* (Himalayan knotweed)

Pathways

The only relevant pathways of introduction into the EU are as escapes from horticulture and as a contaminant in the transport of habitat materials (soil, vegetation), as only a small amount of rhizome is needed to produce a viable plant. However, although the horticulture trade is the main historic pathway, there is no evidence that large volumes of the species are being imported into the EU. Natural spread within Member States is a possibility as the species can disperse up to 1 km per year through wind, water or animal movements. Human-assisted dispersal through the dumping of garden waste or movement of soil is also a possibility.

Impact

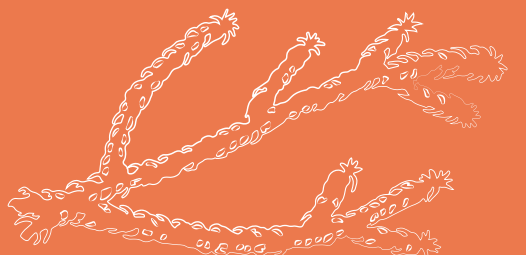
In Belgium, Ireland and France it grows vigorously and creates large, dense and persistent colonies that exclude native vegetation. In France, this causes significant changes in habitat composition, structure and/or ecosystem function and in Belgium this prevents the establishment of tree seedlings, causes the erosion of river banks and greatly alters natural ecosystems (although these impacts have not been scientifically evaluated). Areas most impacted include riparian habitats, meadows, forest edges, road verges, transportation networks (e.g. railway systems) and urban habitats. It can also have social impacts, having negative implications for home sellers and buyers in the UK as its presence can prevent banks from lending money.

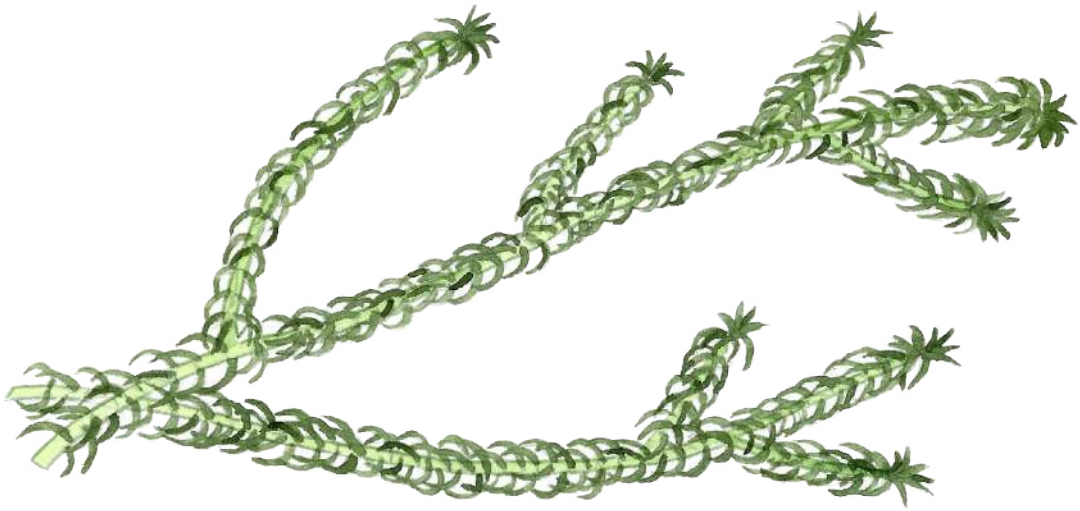
Management

Preventing the establishment of Himalayan knotweed should be a priority as eradication can be extremely difficult and expensive. Prevention measures include phytosanitary inspections and biosecurity measures for imported soil. Measures should also focus on early detection and eradication of the species where it occurs. The extensive creeping rhizome underground network, produced by the species, makes eradication problematic. However, management practices for other knotweed species include covering with thick black plastic, chemical control, manual removal, mechanical removal (mowers, shears, etc.), or excavations of the rhizomes and deposit in registered land fill. Control measures for established populations are the same, but root barriers can also be implemented for containment.

Photo: *Koenigia polystachya* (Himalayan knotweed) © Vinayaraj, CC BY-SA 4.0 via Wikimedia commons

Lagarosiphon major
Curly waterweed





Description

Curly waterweed is a perennial, submerged aquatic plant that prefers clear, standing or slow-flowing water, moderately rich in nutrients and up to 6 m deep, but it can also occur in shallow, turbid water. Rhizomes of the plant are embedded in a muddy or sandy substrate with up to 50 cm long roots. The stems are long and sparsely branched until they reach the water surface and prolific branching starts. The leaves are spirally arranged, closer together towards the top of the stem and are dark green, stiff, strongly curved, minutely toothed, with an acute tip, growing to 5-20 mm long. Curly waterweed plants in Europe are all female and occasionally produce inconspicuous pinkish flowers that float on the water surface.

Distribution

Curly waterweed originates from southern Africa and has been introduced to Australia, New Zealand and Europe. Curly waterweed has established in ten EU Member States (Austria, Belgium, France, Germany, Hungary, Ireland, Italy, the Netherlands, Portugal and Spain) with varying levels of abundance. Considering the species' climate requirements, it is less likely to establish in Member States with a more continental climate and cold winters.

Illustration: *Lagarosiphon major* (Curly waterweed)

Pathways

Curly waterweed was a popular oxygenating plant amongst ornamental pond and garden enthusiasts, because of its easy growth and hardiness. Therefore, the primary pathway of introduction into the EU was as an oxygenating plant in the aquarium trade. Curly waterweed has now been largely replaced by other species. Local spread is largely the result of the fragile stems that are easily fragmented and spread by boats, or management equipment that is not properly cleaned.

Impact

By its rapid growth and ability to form a thick entangled mass, curly waterweed rapidly chokes ponds, watercourses, and even lakes. This reduces both the quality and flow of water and prevents light and oxygen from entering the water column. This has drastic consequences for the ecosystem and its biodiversity. Curly waterweed is also known to modify water pH and CO^2 concentrations, creating stressful conditions for other aquatic organisms. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits. Also, by blocking waterways, it may also impede hydroelectric intakes or increase the risk of flooding.

Management

The control and eradication of curly waterweed is very difficult, thus it is important to act as soon as possible when a new infestation is found. Early detection and rapid eradication is crucial. Early detection is best achieved if the public is informed about the species and if there is a well-coordinated program with public awareness campaigns to identify new infestations. Eradication of small infestations is possible with hand weeding, benthic barriers, suction dredging, or by a combination of control measures. Eradication of large infestations is difficult to achieve. Once fully established in larger systems, maintenance and prevention of spread can be achieved by mechanical mowers, rake boats or hydro-jet equipment and the installation of physical barriers.

Photo: *Lagarosiphon major* (Curly waterweed) © Davide Grigoletto, CC BY-NC via iNaturalist

Lespedeza cuneata
Chinese bushclover

Description

Chinese bushclover is a perennial, shrubby legume, which can grow to 2 m tall. Trifoliate leaves are divided into 1.2–2.5 cm long leaflets that are produced along the stem. The flowers, which range from cream to purple in colour, grow on short stalks in-between the leaves. Flowers can be found singly or in groups of 2-4 and can self-fertilise and fertilise via pollinators. This species produces many seeds, with individual stems producing over 1 000 seeds which remain viable in the soil for decades. Its deep taproot allows it to grown in dry soils, but it is also tolerant of moist conditions, and can survive frosts. It is found as a weed in both cultivated and uncultivated fields, in marshes, grassland, pastures and meadows.

Distribution

The native range of this species stretches over a large area from Afghanistan and Pakistan, India and most of south-eastern Asia, including Korea and Japan, to the Philippines, New Guinea and the eastern states of Australia. It was introduced to North America in 1896, where it has a scattered distribution in the central and eastern federal states from the north to the Gulf of Mexico. Additional records are known from the Caribbean (Dominican Republic), the Caucasus region (Armenia, Azerbaijan and Georgia), and Africa (South Africa), and unconfirmed records in Brazil. The species is not yet recorded within any EU Member States and is rarely planted as an ornamental in gardens. Model predictions show that in northern Europe cool summer temperatures limit suitability, with the species preferring warmer regions.

Illustrations: *Lespedeza cuneata* (Chinese bushclover)

Pathways

Chinese bushclover is rarely used in horticulture, but is available as an ornamental plant, including through online sales. It has been introduced into other regions for hay and fodder, soil stabilisation and greening mining areas. Once introduced, this species can spread fairly quickly, with both wind and animals dispersing seeds through their fur and faeces. Human-assisted spread could also occur via vehicles and machinery, or through the movement of manure between farms and gardens.

Impact

Within its invaded range in the USA, Chinese bushclover forms dense patches, reducing light availability for other plant species and may also compete for water in the soil. It has been shown to reduce both plant and invertebrate species richness, native plant biomass, and affect (both positively and negatively) small mammal abundance and diversity. Where dominant in the USA, a reduction in bobwhite quail (*Colinus virginianus*) summer survival is observed. As a nitrogen fixing legume, it can increase soil fertility and consequently result in changes of plant species composition, leading to changes at the ecosystem level.

Management

In the USA, burning, followed by grazing (especially with goats) and fertilisation is used to manage this species on rangelands. Burning in non-rangeland areas is less effective. The deep roots mean that it can be difficult to remove this species through pulling or excavation. Mowing and ploughing, where this plant grows in large areas and outside of pastures on difficult terrain, can be unfeasible and can negatively affect native species due to the non-selective method. Herbicides are the most commonly used methods in managing growth and spread of this species in the USA and can be used following mowing. Simulated herbivory studies showed that biocontrol with a webworm species was unlikely to be successful. The most successful control is through a combination of methods.

Photo: *Lespedeza cuneata* (Chinese bushclover) © Katja Schulz, CC BY 2.0 via Flickr.com

Ludwigia grandiflora
Water primrose

Description

Water primrose is a perennial, aquatic plant. It roots in the shallow margins of slow-flowing waters from stems which float in the water or creep onto shorelines. It is mainly aquatic and can be found in waters up to 3 m deep, but is also able to colonise damp terrestrial habitats such as riverbanks or wet meadows. Along these exploratory floating stems adventitious roots are produced prolifically, to absorb nutrients as well as to facilitate oxygen uptake. The leaves are spirally arranged and early growth consists of rosette-like clusters of rounded leaves on the water surface. When a dense floating mat is formed, erect branches are produced up to 80 cm tall, leaves lengthen to a lanceolate or elliptical shape, becoming dull green and somewhat hairy with flat triangular stipules at the base and large showy yellow flowers are produced.

Distribution

Water primrose originates from South and Central America. It was first introduced into Europe as an ornamental plant and curiosity in the 19th century and later on entered the aquatic plant trade. Water primrose has established populations in six Member States (Belgium, France, Germany, Italy, the Netherlands and Spain) and has been recorded in Ireland. Considering climate requirements it is less likely to establish in Member States with a more continental climate and cold winters.

Illustration: *Ludwigia grandiflora* (Water primrose)

Pathways

Due to the showy yellow flowers, easy growth and hardiness of water primrose, it was a popular plant amongst ornamental pond and garden enthusiasts, and this was the primary pathway of introduction. As a pond plant it has now been largely replaced by other species. Local spread is largely the result of the stems that are easily fragmented and spread by boats, or management equipment that is not properly cleaned.

Impact

Due to its rapid growth and ability to form a thick floating mat, water primrose invades wetlands, rapidly choking ponds, watercourses, and even lakes. This reduces both the quality and flow of water and prevents light and oxygen from entering the water column with drastic consequences for the ecosystem and its biodiversity. When these dense mats decay, the available oxygen in the water may be depleted and cause foul-smelling water. By blocking waterways it may increase sedimentation and the risk of flooding. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits.

Management

The control and eradication of water primrose is very difficult and so early detection and rapid eradication is crucial. Very small infestations can be eradicated using manual control by hand-pulling and/or digging with hand tools, but as the species establishes manual or mechanical methods are required. For larger infestations, mechanical control by excavating the plants and topsoil, followed by manual removal in order to extract the remaining plants, is most effective. For the long-term control or containment of populations, a combination of mechanical and manual control is the most cost-effective measure. Environmental control by shading, by limiting eutrophication and by controlling water level and salt concentration can also be efficient in combination with mechanical measures.

Photo: *Ludwigia grandiflora* (Water primrose) © Eduardo Alfredo, CC BY-NC 4.0 via iNaturalist

Ludwigia peploides
Floating primrose willow

Description

Floating primrose willow is a perennial, aquatic plant. It roots in the shallow margins of slow-flowing waters from floating stems in water or creeping onto shorelines. It is mainly aquatic and can be found in waters up to 3 m deep, but is also able to colonise damp terrestrial habitats such as riverbanks or wet meadows. Along these exploratory floating stems, adventitious roots are produced prolifically to absorb nutrients as well as to facilitate oxygen uptake. The leaves are spirally arranged and early growth consists of rosette-like clusters of rounded leaves on the water surface. When a dense floating mat is formed, erect branches are produced up to 80 cm tall, leaves lengthen to a lanceolate or elliptical shape, shining green with swollen round stipules at the base and large showy yellow flowers are produced.

Distribution

Floating primrose willow originates from South and Central America. It was first introduced into Europe as an ornamental plant and curiosity in the 19th century and later on entered the aquatic plant trade. Floating primrose willow is reported for seven Member States (Belgium, France, Greece, Italy, the Netherlands, Portugal and Spain) with varying levels of abundance and invasiveness. Considering climate requirements, it is less likely to establish in Member States with a more continental climate and cold winters.

Illustration: *Ludwigia peploides* (Water primrose willow)

Pathways

The primary pathway of introduction for the floating primrose willow was through the horticulture trade, as it was a popular plant amongst ornamental pond and garden enthusiasts due to its showy yellow flowers, easy growth and hardiness. As a pond plant it has now been largely replaced by other species. Local spread is largely the result of the stems that are easily fragmented and spread by boats, or management equipment that is not properly cleaned.

Impact

Due to its rapid growth and ability to form a thick floating mat, floating primrose willow invades wetlands and rapidly chokes ponds, watercourses, and even lakes. This reduces both the quality and flow of water and prevents light and oxygen from entering the water column. This can have drastic consequences for the ecosystem and its biodiversity. When these dense mats decay, the available oxygen in the water may be depleted and cause foul-smelling water. By blocking waterways it may increase sedimentation and the risk of flooding. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits.

Management

The control and eradication of floating primrose willow is very difficult and so early detection and rapid eradication is crucial. Very small infestations can be controlled through manual control by hand-pulling and/or digging with hand tools is preferred. For larger infestations, mechanical control by excavating the plants and topsoil, followed by manual removal in order to extract the remaining plants, is the most effective measure. For the long-term control or containment of populations, a combination of mechanical and manual control is the most cost-effective measure. Environmental control by shading, by limiting eutrophication and by controlling water level and salt concentration can also be efficient in combination with curative measures.

Photo: *Ludwigia peploides* (Water primrose willow) © Cricketsblog, Creative Commons Attribution 2.0 via Wikimedia

Lygodium japonicum
Japanese climbing fern

Description

Japanese climbing fern is a perennial rhizomatous vine, which can climb up to 30 m from the underground stem (rhizome). The leaves (fronds) have many compound leaflets that are triangular, with a rounded contour and light green colour. The fern can propagate by spores and fragments of rhizome. Warm climates favour this vine-like fern, but it can survive in cold climates and frost. The species prefers moist soils, but it can be found in very dry habitats also. In its invasive range, it colonises both natural and disturbed habitats, including different types of forest formations, scrubs, pine plantations, road edges, ditches and culverts.

Distribution

Japanese climbing fern is native from South and South East Asia to the Far East and Oceania (Papua New Guinea). It has been introduced and established in Singapore, Australia, south-eastern USA and Hawaii. It is also present in Mexico, Puerto Rico and South Africa, where it is not widely established. Within the EU, the species was first introduced in the 18th century and is present in botanical gardens and private collections, however, the species does not yet occur in the wild.

Illustrations: *Lygodium japonicum* (Japanese climbing fern)

Pathways

The main pathway of introduction for Japanese climbing fern was the horticulture trade. However, unintentional introduction has been recorded in the Netherlands, detected as a contaminant in the growing media of bonsai, imported from China. Potential secondary pathways of introduction and spread can be the transportation of plant material via machinery, equipment, timber and wood products, and clothes and footwear of tourists. Spores can also be naturally dispersed by wind and water.

Impact

Major negative impacts of Japanese climbing fern have been seen especially in the USA, related to an alteration in fire regimes and a modification of native biota. Dense masses of the vine-like fern can smother other plants, and so environments can be drastically changed. These impacts can be highly detrimental to plants and animals which can be displaced. Risks for biodiversity and ecosystems can also come from an increase in fire severity due to the mass of climbing fern. All these factors contribute to a loss of provisioning (e.g. timber and wood products), regulation (fire, primary production) and cultural ecosystem services (landscape change, free access to areas).

Management

Customs and vendors inspections of imported plants, for the horticulture trade, should prevent the unintentional introduction of Japanese climbing fern as a contaminant. Biosecurity measures should avoid the potential entry of the plant through imported machinery and equipment, clothes and footwear of travellers. If timber and wood products are imported from invaded areas, a “Japanese climbing fern free” certification should be required. Awareness campaigns for vendors and citizens should help in active surveillance. In case of detection in the wild, vine-like fern can be hand pulled at an early stage of colonisation while, if more widespread, chemical control or an integrated strategy (mechanical and chemical control) is required.

Photo: *Lygodium japonicum* (Japanese climbing fern) (c) Greg Tasney, CC BY-SA via iNaturalist

Lysichiton americanus
American skunk cabbage

Description

American skunk cabbage is a distinctive, slow growing perennial herb species. It grows to 60 cm high, has large, shiny leaves up to 1.5 m long and a bright yellow spathe of up to 35 cm tall surrounds each spadix (inflorescence). The spadix itself can grow to 12 cm high and has small flowers growing at the bottom. Flowering usually occurs before leaves appear and, once fertilised, develop into green berries. Each spadix can produce up to 650 berries, creating a large seed bank viable for at least nine years. This plant grows in the margins between aquatic and terrestrial habitats, often in areas of high conservation interest, on a range of soil types and is able to tolerate temperature lows of -15 °C as it originates from mountainous regions.

Distribution

The native range of the species is in North America, where it is distributed from Alaska, all along the west coast to California. The species has been introduced outside its native range to a few places on the east coast of North America. It was introduced to Europe in 1901 for cultivation in the UK. Currently, it is considered established in northern and western Europe within eight EU Member States (Belgium, Denmark, France, Finland, Germany, Ireland, the Netherlands and Sweden) and it is found within cultivation in the Czech Republic. Populations in Austria and Slovenia have been successfully eradicated. Models suggest that most parts of northern, central and western Europe are climatically suitable for establishment of the species, whereas the south appears too warm and dry.

Illustration: *Lysichiton americanus* (American skunk cabbage)

Pathways

The main pathway of introduction for the American skunk cabbage into the EU was through the horticultural trade, with the species being introduced into Europe for ornamental purposes. The species has also been introduced unintentionally, escaping into the wild from abandoned nurseries and escaping from planted areas via streams that connect to natural water courses. Birds and small mammals may also aid the spread of seeds by ingesting the berries. Human-assisted spread is also possible through the inappropriate, and potentially unintentional, disposal of contaminated garden waste.

Impact

This very large plant forms dense patches, outcompeting and displacing native wetland and woodland vegetation, through the blocking of sunlight. This can bring about changes in the structure of the plant community. Within its invaded range within the EU, American skunk cabbage is mostly found growing in habitats of high conservation interest, for example in wetlands, wet woodlands, moorlands, lakesides and pond margins. As such, this plant has the ability to affect many rare and endangered species, such as orchids and shade sensitive mosses. Both leaves and berries of this plant are moderately toxic to livestock.

Management

This species is difficult to eradicate. Removing the heads of flowers in spring before seed set prevents the plant spreading. Manually removing the plants and rhizomes is a potential method for eradication. If small roots are left and exposed to light the plant can regenerate, but if these roots are kept in the dark, they can be left in the soil and the plants will die. Management can take place throughout the year, but is best in early summer, with a second treatment later in summer or in autumn. The large numbers of seeds, and the longevity of viable seeds in the soil, means that eradication attempts may take some time. Depending on legal provisions, herbicides can be used in control. This conspicuous plant can be easily observed and early warning and rapid response actions have resulted in the successful eradication within two Member States, Austria and Slovenia.

Photo: *Lysichiton americanus* (American skunk cabbage) © iStockphoto/randimal

Microstegium vimineum
Japanese stiltgrass

Description

Japanese stiltgrass is an annual grass which grows to heights of 0.6-1.5 m, with creeping stems growing to 2 m long, rooting at nodes. The light green leaves are long (5-8 cm) and narrow (2-15 mm) with a silvery, furry surface. This plant can self-fertilise and cross-fertilise. It flowers in summer and autumn and can produce thousands of seeds per plant, which can be viable for five years in the soil. It tolerates a wide range environmental conditions. This plant can grow in shady areas and forms dense stands, where no other species can exist. It is a fast growing species preferring moist soils growing along rivers and streams, in wetlands, but also along forest edges and along roadsides. The species can invade susceptible areas, for example after flooding or farming, and although it grows in temperate to warm continental climates it can survive temperatures of -23 °C.

Distribution

The native range of the species stretches from the western Himalayas, to southern China and most of South East Asia to Java in the south, Philippines in the east and the Primorye region of Russia in the northeast. It was introduced to North America, where it is widely distributed along the central and eastern federal states, Central America and the Caribbean, Africa, central Asia where it is recorded in Turkey, the Caucasus regions of Azerbaijan, Georgia and Russia, and Iran. The Japanese stiltgrass is not currently present within any EU Member States, but the temperate to warm continental climates are suitable to the species and the Mediterranean region appears particularly susceptible.

Illustrations: *Microstegium vimineum* (Japanese stiltgrass)

Pathways

The main pathways of introduction for the Japanese stiltgrass is as a contaminant via humans on shoes and clothes or on vehicles and machinery, in soil, hay or bird seed. Its use as a packing material is thought to have been a pathway of introduction to the USA. The seeds of this species can be spread by natural dispersal by wind and water, which supports its spread into wetland areas. The fur of mammals may also play a role in the dispersal of the seeds of this plant.

Impact

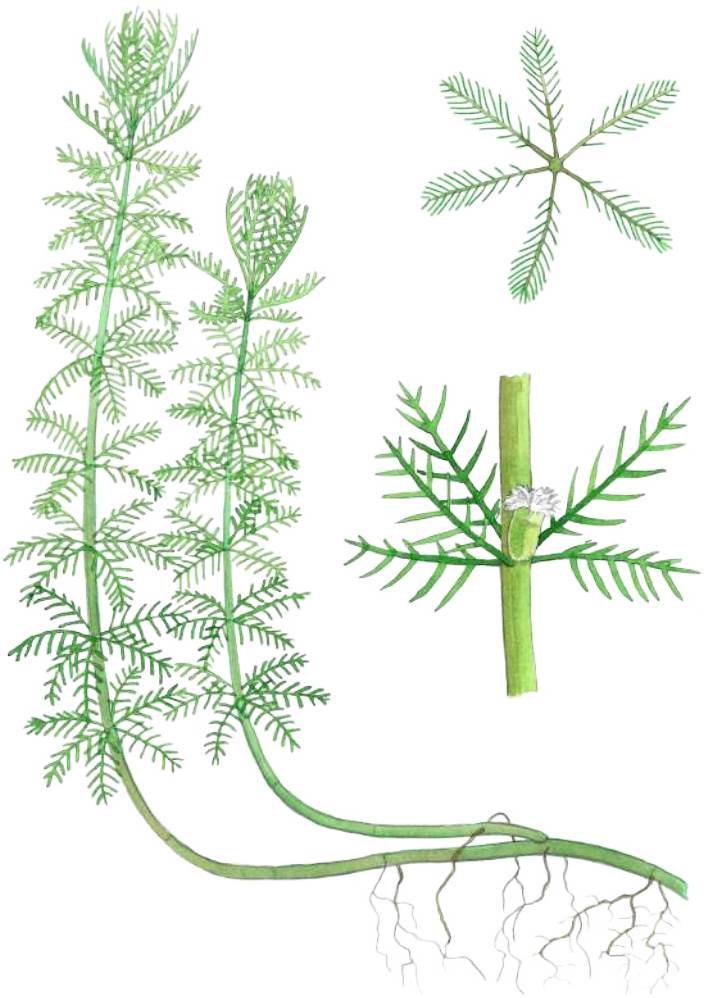
Japanese stiltgrass negatively affects diversity, productivity and composition of native plant communities. It outcompetes native plant species by shading and altering the cycling of carbon in soil and where dense stands are present, natural regeneration of native tree species is less likely. It has adverse impacts on the species richness and abundance of arthropods and causes reductions in woodland breeding birds. This plant has indirect negative impacts on nesting birds by providing suitable nesting habitat for rats, which can prey on bird eggs and nestlings. Where this species has invaded, fires burn hotter and higher than in non-invaded areas and in the following seasons after a fire, biomass of Japanese stiltgrass increases.

Management

Reducing the amount of viable seeds through preventing flower production and eliminating corridors of spread from existing populations should both form part of the management of Japanese stiltgrass. Manual weeding of the species, before seed set, is effective and mowing is also a viable method in areas that are easy to access. Grazing is not an effective option for this species as it is unpalatable to livestock such as cattle and goats. Burning in autumn is a possible method for control and depending on legal provisions, herbicides can be used. Repeated actions over several years are necessary for effective management, and success is related to the size of the invaded area, as it becomes increasingly difficult with increasing size of the invaded area.

Photo:Microstegium vimineum (Japanese stiltgrass) © NY State IPM Program at Cornell University, CC BY 2.0 via Wikimedia

Myriophyllum aquaticum
Parrot's feather



Description

Parrot's feather is an emergent rooted, perennial aquatic plant, having both submerged and emergent leaf forms. Submerged leaves are feather-like, usually tinged red and fragile, with up to 25-30 segments up to 7 mm long, the lower leaves usually decaying rapidly. Emergent leaves are feather-like, dull greyish-green or blue in colour, densely covered in glands and stiff, arranged in whorls of 4-6 leaves. When stems reach the surface they continue to grow horizontally and produce vertical branches. Plants usually grow in stagnant or slow flowing waters, rivers, irrigation channels, ponds, lakes, canals and damp ditches. In Europe there are exclusively female plants present, only vegetative propagation by detached (parts of) rhizomes or stems is possible.

Distribution

Parrot's feather is native to South America and has been introduced to all continents except Antarctica. Within the EU it has established in 12 Member States (Austria, Belgium, France, Germany, Hungary, Ireland, Italy, Luxembourg, Portugal, Romania, Spain and the Netherlands), with no records in any other Member States. Based on the climatic and habitat requirements, parrot's feather is less likely to establish in northern Member States.

Illustrations: *Myriophyllum aquaticum* (Parrot's feather)

Pathways

The primary pathway of introduction for parrot's feather was through the horticulture and aquarium trade, as it was a popular aquarium and pond plant species, promoted as an oxygenating plant. There was major production of the species for the European market both within Member States and from South East Asia. It has now been introduced to the wild through unintentional disposal of surplus aquarium and pond material. Once established, the fragile stems are easily fragmented and spread by boats, or management equipment that is not properly cleaned.

Impact

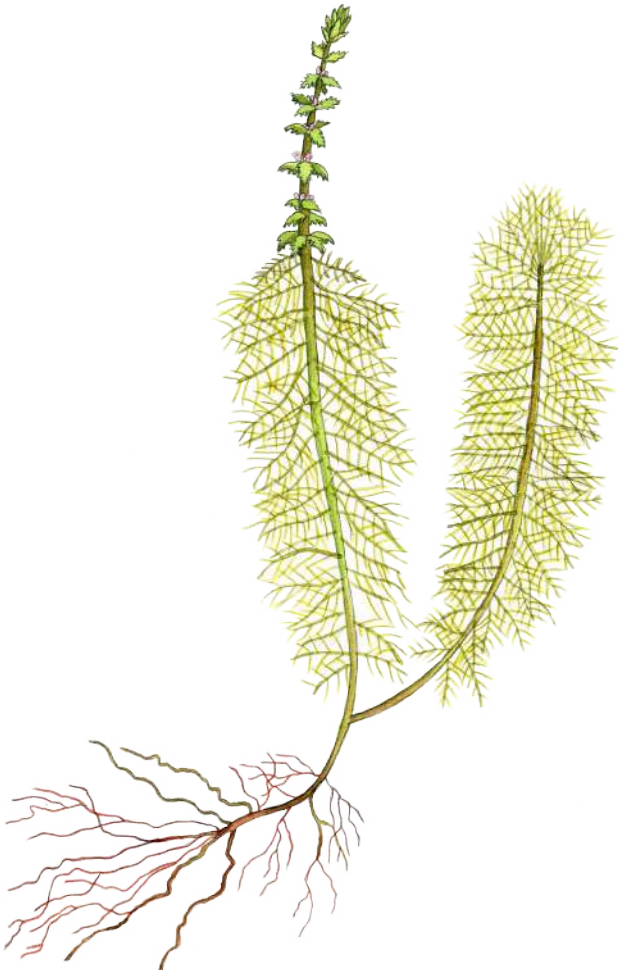
By its rapid growth and ability to form a thick floating mass, parrot's feather rapidly chokes ponds, ditches and even larger watercourses, reducing both the quality and flow of water. This increases the risk of flooding and prevents light and oxygen from entering the water column, with drastic consequences for the ecosystem and its biodiversity. When these dense mats decay, the available oxygen in the water may be depleted and cause foul-smelling water. The resulting low oxygen conditions can lead to fish mortality and harm other aquatic organisms. Cultural services can also be degraded by the infestation of scenic waterbodies, and can impact on recreational activities including boating, angling, swimming and other leisure pursuits.

Management

The control and eradication of parrot's feather is very difficult, and thus it is important to act as soon as possible when a new infestation is found. Early detection can be achieved through intensive surveying, including citizen science and rapid eradication of new invasions can be achieved through hand weeding. For established populations, a detailed management plan is needed and, although biological control methods are being further developed, mechanical control followed by hand weeding is considered the best practice to manage large infestations. Once fully established in larger systems, maintenance and prevention of spread can be achieved by mechanical mowers, rake boats or hydro-jet equipment and the installation of physical barriers.

Photo: *Myriophyllum aquaticum* (Parrot's feather) © iStockphoto/Linjerry

Myriophyllum heterophyllum
Broadleaf watermilfoil



Description

Broadleaf watermilfoil is a submerged rooted, perennial aquatic plant, having both submerged and emergent leaf forms. Submerged leaves are feather-like and each have 4-10 segments (2-5 cm long and 2-4 cm wide). Emergent leaves can take two forms, either a terrestrial form which is expressed when growing on damp mud, or an emergent leaf form on a stem on which flowers are produced. Plants usually grow in stagnant or slow flowing waters, rivers, irrigation channels, ponds, lakes, canals and damp ditches. A semi-terrestrial form can be found on mudflats and boggy land, but this is a survival strategy rather than a preferred growth form, when water levels drop. Broadleaf watermilfoil is able to grow in water up to 9.5 m in depth.

Distribution

Broadleaf watermilfoil is native to the eastern USA, and is considered invasive in other western and northern States. Within the EU it is seriously invasive in two Member States (France and the Netherlands), and has been reported with varying levels of invasiveness in six more (Austria, Belgium, Croatia, Germany, Hungary and Spain). Based on the climatic and habitat requirements of broadleaf watermilfoil, it is less likely to establish in northern Member States.

Illustration: *Myriophyllum heterophyllum* (Broadleaf watermilfoil)

Pathways

The main pathway of introduction for broadleaf watermilfoil was through the horticulture trade as the species is a popular aquarium and pond plant, promoted as an oxygenating species. Surprisingly it was traded under a variety of names, but hardly ever under its proper name. It has been introduced to the wild through unintentional disposal of surplus aquarium and pond material. Once established, the fragile stems are easily fragmented and spread by boats or management equipment that is not properly cleaned.

Impact

By its ability to form dense mats, broadleaf watermilfoil rapidly chokes ponds, small watercourses, and even lakes. This reduces both the quality and flow of water and prevents light and oxygen from entering the water column, with drastic consequences for the ecosystem and its biodiversity. The plant stays in the water column during winter and can survive, with only sections of the stem that are embedded in ice dying or breaking apart when the ice cover melts. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits. Flood risk is also increased as the species can increase sedimentation and reduce flow in water-bodies.

Management

Once established, the management of broadleaf watermilfoil is complicated, therefore, early detection by a well-coordinated citizen science programme is very important. Containment of existing populations and prevention of further spread is critical. The essential point of effective broadleaf watermilfoil management is the removal of the rhizomes. Choice of control method mainly depends on the size of the infestation and the local situation. Rapid eradication of small infestations (<100 m²) is possible by shading the waterway for a full growing season or manually through divers or mechanical means e.g. suction dredging. Once fully established in larger systems, maintenance and prevention of spread can be achieved by mechanical mowers, rake boats or hydro-jet equipment and the installation of physical barriers.

Photo: *Myriophyllum heterophyllum* (Broadleaf watermilfoil) © Leslie J. Mehrhoff, University of Connecticut, Bugwood.org, Creative Commons Attribution 3.0 via Wikimedia

Parthenium hysterophorus
Whitetop weed

Description

Whitetop weed can grow as an annual and short-lived perennial. This plant can grow up to 2.5 m, is upright with a branched, grooved stem when mature and is coated in fine hair. Its deeply divided leaves are a green-grey colour, grow to 4-8 cm wide and up to 20 cm in length. It has small (4 mm), wide, star shaped, cream-white coloured flowers. This plant is highly prolific, with a single plant producing 15 000-20 000 (up to 100 000) seeds per year, that are viable for at least two years. Germination can occur at a range of temperatures between 8-30 °C. This species also grows very quickly and colonises disturbed areas, such as river banks and floodplains as well as roadsides, agricultural areas and recreation areas.

Distribution

The native range of whitetop weed stretches from Mexico, Central America and the Caribbean through most of South America. It is considered introduced in North America. It is further introduced to southern and eastern Africa, Madagascar, large areas of tropical Asia, eastern China, Korea, Japan, north and east Australia and Hawaii. The species is not currently established within any EU Member States, but it has been recorded in Belgium and Poland. Within Europe, the Mediterranean region is particularly suitable for the establishment of the species.

Illustration: *Parthenium hysterophorus* (Whitetop weed)

Pathways

The main pathways of introduction for whitetop weed are as a stowaway on agricultural machinery or as a contaminant in pasture seed, bird seeds or soil. It can spread naturally by wind, water or by animals and via human-assisted dispersal through the transportation of soil, gravel, sand, or garden waste and also via vehicles or machinery. Other pathways include its use as an ornamental plant in gardens, as packing material for transportation and as a green manure.

Impact

Whitetop weed degrades natural ecosystems, causing significant changes in grasslands, woodlands, floodplains and riverbanks in its invaded range. This species outcompetes native vegetation, decreasing plant species diversity and abundance. It is allelopathic, meaning it releases chemicals which suppress the growth of other plants, and it can alter soil chemistry. This can also enter water systems and can negatively affect aquatic organisms. The species can act as a reservoir host for plant pathogens and insect pests of crop plants and affects agricultural land and crop production. The plant causes internal lesions and dermatitis and ultimately death in grazing animals, and it is poisonous and can cause death in humans who are allergic to it.

Management

Due to the large seed production, cutting off flowering heads or preventing flowering through destroying the plant is crucial. Manual uprooting is effective, but poses health risks to workers. Mechanical treatment is not suitable for this species as it may encourage seed spread and regeneration. Control by fire is possible, but this method creates open areas in which seeds of whitetop weed can germinate. Chemical control is effective, but where infestations cover large areas, this can be expensive and application depends on legal provisions. Biological controls through other allelopathic plants, insects and fungal pathogens have been applied effectively outside the EU.

Photo: *Parthenium hysterophorus* (Whitetop weed) © iStockphoto/Whiteway

Pennisetum setaceum
Fountain grass

Description

Fountain grass is an attractive, long lived, perennial, clump-forming grass (up to 20 years) with erect to arching culms growing over one metre in height, hence the English common name. It is characterised by distinctive cream, pink or purple coloured inflorescences up to 32 cm long. Flowers appear almost white in bright light. The long-lasting feathery inflorescence makes fountain grass an extremely valuable garden plant for use en masse or as individual specimens. Fruits are small and adorned with long showy bristles. Leaves are narrow and long (30 cm) with curved, linear blades and a beautiful light green cast; or brown depending on water availability and season. The species has morphological and genetic traits similar to the ornamental species of the same genus, such as *Pennisetum advena*, but this species has some differing characteristics e.g. drooping inflorescence and wider and flatter leaf blades.

Distribution

Native to northern Africa and introduced worldwide, fountain grass was first introduced into Europe as an ornamental plant but has since escaped into the wild. Within the EU, It is currently established in five EU Member States (France, Italy, Malta, Portugal and Spain), with records also on the Greek island of Lesvos, in Bulgaria and Slovenia. The risk of the plant increasing its spread throughout the Mediterranean area is high due to the species' natural dispersal abilities.

Illustrations: *Pennisetum setaceum* (Fountain grass)

Pathways

The main pathway of introduction was the horticulture trade as fountain grass is a popular landscape ornamental plant, and was also used for soil stabilisation. In Las Palmas (Islas Canarias), it is thought that seeds were introduced during the construction of the airport via machinery coming from Western Sahara. Seeds are dispersed by the wind, water and possibly birds. Seeds may also spread accidentally via vehicles, machinery, and livestock.

Impact

Fountain grass is an aggressive invader of arid and semiarid coastal habitats such as thermo-xerophilous grasslands and shrublands in the Mediterranean and Macaronesian bioregions. It establishes almost monospecific stands and causes long-lasting ecological consequences. For example, these stands can outcompete native plants and have negative impacts on vulnerable native species, especially in protected areas, by reducing available space, water and nutrients. The fountain grass is also a very inflammable species, increasing risk and the intensity and spread of fires, and spreading even faster in the growing season following a fire. There is also an economic impact, causing a reduction in natural pastures for livestock.

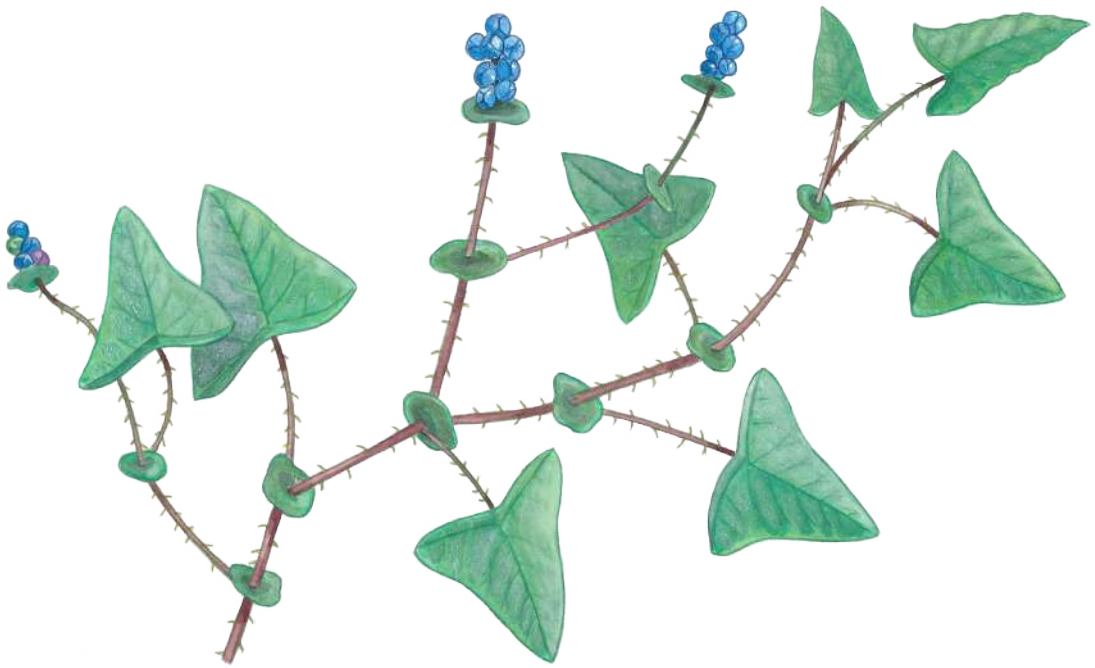
Management

The prolific production of long-lived seeds hinders control efforts once fountain grass is established. Control strategies should be included in dedicated strategic management plans, focusing on removing seed heads and reducing seed production. Management should prioritise small or sporadic infestations upon otherwise healthy sites, followed by larger infestations. A combination of mechanical and chemical control (such as foliar spray) should be considered. Choice of control method depends on the current land use and site conditions; accessibility, terrain, and climate; density and degree of infestation; non-target flora and fauna present and Member States legislation. Other considerations include treatment effectiveness, cost, and the number of years needed to achieve control.

Photo: *Pennisetum setaceum* (Fountain grass) © Dinesh Valke, Creative Commons Attribution-Share Alike 2.0 via Wikimedia

Persicaria perfoliata

Polygonum perfoliatum - Asiatic tearthumb



Description

Asiatic tearthumb can be both an annual or perennial, prickly vine that can grow up to 6 m by scrambling over shrubs and trees. It has light green to grey-green almost triangular-shaped leaves, 2–5 cm wide and 3–7 cm long, with prickles on the leaf mid-vein underneath. Small white flowers cluster in groups of 10–15 on a flower spike that can grow to 2 cm long. The plant flowers between July and November. The fruits are shiny and metallic blue berries and seeds can persist in the soil for up to four years. This plant grows rapidly, as much as 10 m in one year. It grows well in moist soil but can tolerate drier areas and invades woodlands and woodland edges, grassy slopes, meadows, banks of streams, and wetlands. It also invades road and rail edges.

Distribution

The native range extends from Turkey and the Caucasus region to India, most of South East Asia, including New Guinea, and eastern China, Korea, Japan, and reaching the Primorye region of Russia in the northeast. The status and origin of the occurrences in Turkey and the Caucasus however is unclear. It is introduced to the west (first recorded in 1890) and east coasts of the USA, but is considered to be able to colonise much larger areas. There are currently no established populations or records of Asiatic tearthumb within the EU, but models suggest that parts of the Mediterranean region and the southern Atlantic and Continental regions are climatically suitable for the species.

Illustration: *Persicaria perfoliata* (Asiatic tearthumb)

Pathways

The main pathway of introduction for Asiatic tearthumb is as a contaminant in soil or growing media. Natural dispersal can occur through water systems, with buoyant fruits being carried downstream. Birds and small mammals can also spread the species through eating the fruits, and seeds may also be distributed by ants. Human-assisted dispersal is possible, with seeds being transported by logging machinery or contaminated hay, or the disposal of parent plant material. The introduction as a seed contaminant, with other species, is unconfirmed.

Impact

Due to the early emergence of this species, Asiatic tearthumb rapidly smothers the vegetation over which it grows in dense mats, forming a monoculture and thus killing or restricting the plants growing underneath. It reduces the diversity of plant species through competitive dominance for sunlight, negatively impacting perennial species, natural regeneration and succession. The species also has allelopathic properties, meaning that it releases chemicals which suppress the growth of other plants. It has economic impacts by reducing the regeneration of commercial forest species and where it grows in agricultural areas, orchards or nurseries.

Management

Manual pulling can be part of the management of Asiatic tearthumb, but this is best done before the sharp prickles form on the plant or with thick gloves and protective clothing. Foliage should be removed and the area repeatedly checked for new seedling growth, because the species can regrow easily from the seedbank. Once the plant has started fruiting, removal of vegetation may risk dispersing the seeds and so is not recommended. Mowing or cutting can prevent seed set by prevention of flowering and thus halt the further spread of this species. In the USA, biocontrol is achieved by a weevil (*Rhinoncomimus latipes*). Depending on legal provisions, chemical control of this species is also possible. Maintaining stable communities of vegetation can help prevent the establishment of this species.

Photo: *Persicaria perfoliata* (Asiatic tearthumb) © Ashley M Bradford, CC BY-NC via iNaturalist

Pistia stratiotes
Water lettuce

Description

Water lettuce is a free-floating plant, which forms colonies with large feathery root systems, which hang freely in the water. The leaves are light green and velvety-hairy and form rosettes up to 40 cm across in its native range. Flowers are few, unisexual, lack petals, and are hidden in the middle of the plant amongst the leaves. The species grows in slow moving rivers and reservoirs, irrigation channels, ponds, lakes, canals and ditches, under varying physical and chemical conditions. Optimal conditions for water lettuce are temperatures between 22-30 °C and high nutrient conditions; although plants still develop at temperatures as low as 10 °C. Water lettuce is widespread across the world and appears on the list of the world's worst weeds.

Distribution

Water lettuce is generally thought to be native to South America, in spite of having a pan-tropical range. It has been introduced to Africa, Asia, Europe, North America and Oceania. Within the EU, water lettuce has established populations in four Member States (France, Germany, Italy and Slovenia), with records also from Austria, Belgium, Croatia, the Czech Republic, Hungary, the Netherlands, Portugal, Romania and Spain.

Illustration: *Pistia stratiotes* (Water lettuce)

Pathways

The main pathway of introduction into the EU was via horticultural trade, being sold as an ornamental plant both in shops and online. Plant materials could subsequently be released unintentionally into the wild through the inappropriate disposal of aquarium contents. Other less likely pathways include as a contaminant within horticultural materials or on leisure equipment (e.g. fishing or canoeing gear). The species can establish in both natural and artificial water bodies e.g. hydro-electric power plants, irrigation channels, reservoirs, etc., but it is unable to survive in areas with frosts. Natural dispersal of daughter plants will facilitate spread between connecting water bodies or long distance via waterfowl.

Impact

Water lettuce completely transforms trophic dynamics and alters nutrient cycles, resulting in long-term changes. It forms dense mats at the surface of the water which can directly impact native plant communities through competition and indirectly impact native species by reducing light and dissolved oxygen levels. This could have impacts for protected freshwater and wetland habitats protected by EU Legislation (i.e. the Habitats Directive and the Water Framework Directive). It can impact ecosystem services by restricting access for recreation and tourism and can reduce the water quality, especially for drinking water. Socio-economic impacts include impeding transport, irrigation and drainage, which can damage flood control structures and encourage disease-carrying mosquitoes.

Management

Public campaigns can raise awareness of the movement of invasive alien plants via recreational activities and have been run successfully (Belgium, UK and the USA) e.g. “Stop Aquatic Hitchhikers” campaign (USA) or the “Check, Clean and Dry” campaign (UK). Rapid eradication is crucial for effective management of floating plants. Eradication can be achieved with hand weeding for early infestations or using mechanical harvesters for large dense infestations, ensuring biomass is disposed of appropriately and away from other water bodies. Harvesters have been used for the successful eradication of large infestations of water hyacinth (*Pontederia crassipes*) in Portugal. However, for all eradications, follow-up management measures are needed until the last plant has been successfully removed.

Photo: *Pistia stratiotes* (Water lettuce) © Forest and Kim Starr, CC BY 2.0 via Flickr.com

Pontederia crassipes (Eichhornia crassipes)*
Water hyacinth

Description

Water hyacinth is a free-floating aquatic plant which reproduces both vegetatively, through daughter plant production, and via seeds and displays two different morphologies depending on conditions. In dense stands with nutrient-rich waters and devoid of herbivores, the petioles are elongated, up to 1 m in length, with circular leaves. Where the plants are more sparse or along the edge of infestations, the petioles are short (< 30 cm) and bulbous, with kidney shaped leaves. The 6–10 smooth leaves are arranged in basal rosettes and the showy flowers are pale blue or violet, which can produce large numbers of long-lived seeds that can remain viable for up to 20 years in sediment. It inhabits tropical and sub-tropical freshwater lakes and rivers, especially those enriched with nutrients.

Distribution

Water hyacinth is native to the Amazonia basin in Brazil. Since the 19th century it has been traded as an ornamental plant and is now found in more than 50 countries on all continents except Antarctica. In the EU it is established in three Member States (Italy, Portugal and Spain) and has been recorded in France, Germany and Hungary. Water hyacinth is likely to establish widely in the Mediterranean region, according to future climate projections.

Illustration: *Pontederia crassipes* (Water hyacinth)

*Scientific name as indicated in the Commission Implementing Regulation

Pathways

Because of its attractive purple flower, water hyacinth is a favourite amongst ornamental pond and garden enthusiasts. As a result, humans have spread it widely and due to its fast growth rate it now flourishes in six continents. Most spread can be attributed to deliberate planting of water hyacinth in ponds or dams as an ornamental, use in aquariums or for its water cleaning properties. An emerging mode of spread is via internet sales to aquarium owners and water gardeners.

Impact

By its rapid growth and ability to form thick mats, water hyacinth rapidly chokes ponds, watercourses, and even lakes, reducing both the quality and flow of water. This prevents light and oxygen from entering the water column with drastic consequences for the ecosystem and its biodiversity. When dense mats of water hyacinth decay, the available oxygen in the water may be depleted and cause foul-smelling water. The resulting low oxygen conditions can lead to fish mortality and harm to other aquatic organisms. Cultural services can be degraded by infestation of scenic waterbodies and can impact on recreational activities including boating, angling, swimming and other leisure pursuits. Presence of water hyacinth can cause serious damage to agriculture through increased water loss.

Management

The management of established water hyacinth is complicated and extremely costly, therefore, early detection by a well-coordinated citizen science programme is very important. This should be combined with monitoring of high-risk sites. Manual removal by hand can be used to eradicate small infestations. For larger infestations, eradication can potentially be achieved with the use of mechanical harvesters to remove the bulk of the biomass, but then hand control will still be required for inaccessible areas. For any eradication attempt, long term monitoring and repeated treatments are critical. However, attempts to eradicate the species have largely failed, and control options are limited. Biological control has been successful in the tropics, but has not been as effective in more temperate regions.

Photo: *Pontederia crassipes* (Water hyacinth) © iStockphoto/Bkamprath Eriocheir sinensis

Prosopis juliflora
Mesquite

Description

Mesquite is a thorny shrub of 3-5 m or thorny small tree and is deeply rooted. It has a thick, rough grey-green bark that becomes scaly with age. The plants are often multi-stemmed and with many large and very sharp thorns measuring up to 5 cm. Leaves are light green in colour and twice-compound (bipinnate). It usually begins to flower and fruit after 2-3 years, and the flowers are fragrant golden-yellow, in dense spikes. The fruit is a cylindrical or slightly irregularly curved green pod which turns yellow upon ripening and contains 10-20 hard oval or elliptic seeds. The species occurs in wasteland, forests, managed and natural grasslands, coastal areas (including coastal dunes), wetlands, abandoned fields, and urban areas but is frost sensitive and so limited by temperature.

Distribution

Mesquite is native to Mexico, South America, and the Caribbean and has been introduced to every continent, except Antarctica. Within the EU, it has established in one Member State, Spain (Almeria and Canary Islands), introduced in 1988, with no records in any other Member States. Suitable habitats include largely frost-free, coastal, and low-lying inland areas, and therefore, it could spread to suitable areas of the Macaronesian and Mediterranean biogeographic regions.

Illustrations: *Prosopis juliflora* (Mesquite)

Pathways

In the EU the main pathway of introduction was through the horticulture trade as an ornamental plant. Once introduced and established, mesquite seeds can be spread by animals or via water. However, its spread globally has primarily been human assisted, commonly for afforestation and soil protection. Mesquite was - and in part still is - globally considered a very valuable multi-purpose tree (timber, fuelwood, fodder, etc.) and therefore planted intentionally outside the species' native range, although this has not occurred within Europe.

Impact

Mesquite is a very aggressive invader with the potential to outcompete and replace native vegetation. Once established, dense thorny thickets invade rangelands, limit access to irrigation channels and roads, limit movement of cattle and people, and lead to a complete degradation of rangelands. It can also have large impacts on ecosystem services, primarily water resources, nutrient cycling, and successional processes. In the EU, in frost-free coastal and low-lying inland areas of Cyprus, Greece, Italy, Malta, Portugal and Spain, potential impacts on biodiversity and ecosystem services are expected to be similar to those impacts seen in other countries. With the exception, potentially, of significant impacts on communities and local livelihoods.

Management

Public awareness campaigns to prevent spread from existing populations or botanical gardens in countries at high risk are necessary. National and international management coordination is recommended, as the species can spread easily. In order to manage the potential spread into new regions of the EU, surveillance programmes should be put in place to ensure early detection and rapid response, using citizen science and national authorities' surveillance systems. For localised populations, mechanical control by felling trees and uprooting stumps should be employed. For established populations several integrated programmes, combining mechanical, chemical and fire measures have had reasonable success, but are costly and require a high level of management input.

Photo: *Prosopis juliflora* (Mesquite) © Dinesh Valke, CC BY-SA 2.0 via Flickr.com

Pueraria montana var. *lobata*
Kudzu vine

Description

Kudzu vine is a perennial vine with hairy stems growing to 15 m in length and large root tubers. The leaves are light green on the top and light grey underneath, comprised of three hairy leaflets, 5–19 cm wide and 8–20 cm long. This species is in the *Leguminosae* (pea) family with purple-pink flowers of 2 cm length in a cluster on an inflorescence 10-25 cm long; it flowers between July and August. The hairy fruit pods contain up to 10 seeds and reach 10 cm in length.

It is extremely fast growing (as much as 15 m in a year), forming new roots where the nodes make contact the soil. The spread of this plant is primarily vegetative as it does not have good seed viability in its introduced range and can grow up to 25 cm per day. It grows in forests and plantations and along rivers, roads, field edges, fences, on poles and wires and over abandoned structures.

Distribution

The native range extends from India through south and South East Asia to New Guinea and the northern Territories of Australia. It is introduced in all continents, excluding Antarctica. In North America it is distributed along the east coast and in southcentral States, and in South America in northern Argentina. It is also recorded from Hawaii. It is widespread in Africa, except for the north, and reported from the Caucasus region, and the east of Australia. Within the EU, it has established populations in two Member States (Italy and Slovenia), with no records in any other Member States. Suitable habitats are widespread across Europe and further spread is possible, especially with milder winters due to climate change.

Illustration: *Pueraria montana* var. *lobata* (Kudzu vine)

Pathways

The main pathway of introduction for the kudzu vine, into the USA, was via the horticulture trade as an ornamental plant and via agriculture e.g. as a fodder crop. It has also been used for erosion control. Human-assisted spread can occur through the movement of soil, sand and gravel and by dumping garden waste. It can also spread naturally, vegetatively and over larger distances via seed dispersal by birds and mammals (rodents).

Impact

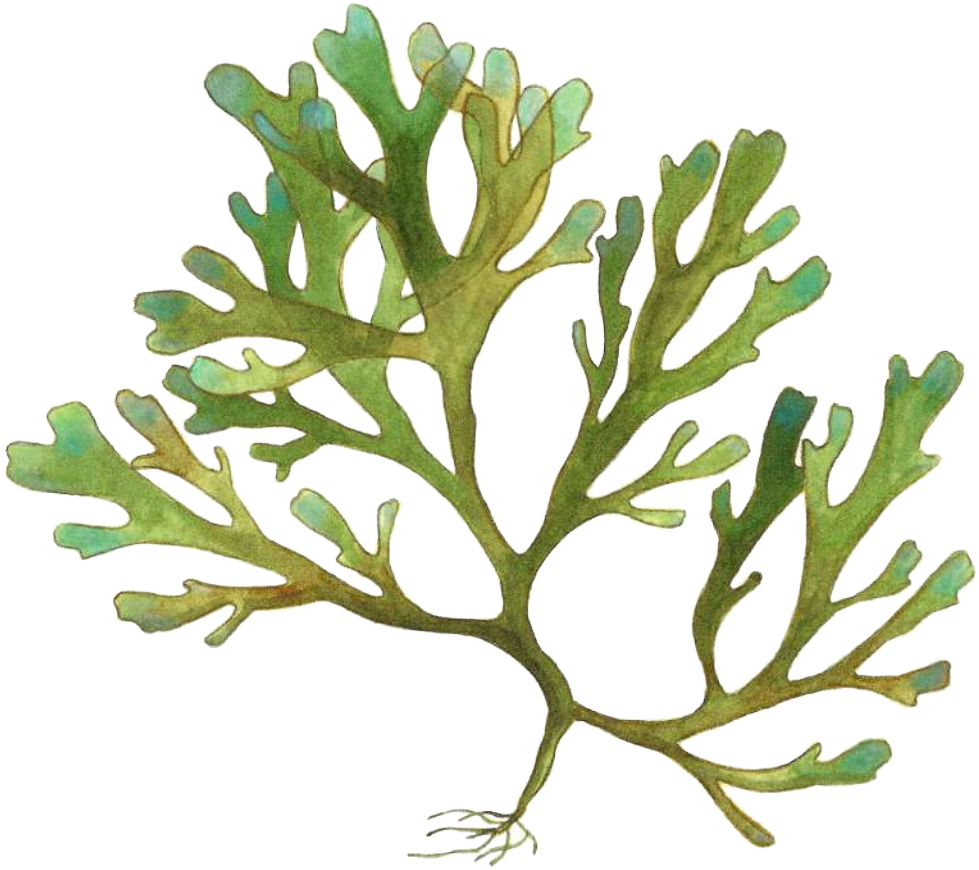
This fast growing species is primarily a problem for agriculture and forestry or disturbed areas, where it can smother crops, orchards and plantations. However, it can also cause problems in natural environments, with the dense cover shading out the light and replacing native vegetation, such as trees and herbs. Kudzu vine has been shown to reduce diversity for plant species but also arthropod assemblages in infested areas. As a legume, this plant also alters soil nutrient levels by increasing the amount of nitrogen in the topsoil and is moderately toxic. Overgrown areas might become unattractive for recreation, and damage to power and phone lines has been documented.

Management

Kudzu vine can be controlled by mowing in areas that are easily accessible with machinery. In less accessible areas, it can be controlled through intensive grazing e.g. cows, horses, pigs and goats. Depending on legal provisions, chemical control of this species is possible and older plants will require more chemical application than smaller, younger plants. Management must reach all parts of the plant as regrowth from root-crowns is possible. An integrated approach to management, utilising grazing, burning and the use of chemicals can be effective. The use of biocontrol insects and pathogens is in the experimental stage. Occurrences in Europe are still fairly restricted and emphasis should be laid on surveillance with dedicated early warning and rapid response measures in place.

Photo: *Pueraria montana* var. *lobata* (Kudzu vine) close-up © iStockphoto/Joe_Potato34

Rugulopteryx okamurae
Okamura's brown alga



Description

This brown alga is a marine species which inhabits subtidal areas up to 30 m in depth, on well-lit horizontal surfaces, but also in the shadowed areas of intertidal pools and can establish where temperatures remain above 15 °C. Part of the species' success is its high reproductive rate of vegetative and asexual structures and its ease of dispersal. Thalli can grow directly over hard substrates but also on other seaweeds, as an epiphyte, or even on animals such as sea urchins and sea cucumbers. The invasive potential of a single thallus is substantial, with 100 spores and 25 propagules in 1 cm^2, with each being capable of generating a new clone individual. In Europe, thallus appears to be produced throughout the year but peaks between May-August.

Distribution

The alga is native to the Pacific Ocean along the temperate coasts of Japan, China, Korea, Taiwan and the Philippines. Outside its native range, it has been reported in Mexico and the Gulf of California (USA). The alga has established populations in two EU Member States (Spain and France), with no records within any other Member States, as well as in Gibraltar and Morocco. The species has the potential to invade the Andalusian Atlantic coast, the entire Mediterranean coast and the Black Sea based on sea surface temperatures.

Illustration: *Rugulopteryx okamurae* (Okamura's brown alga)

Pathways

The main pathways of introduction are via ship/boat ballast water, as this species can survive up to three weeks in the darkness, and as a contaminant within marine aquaculture, associated with oyster imports. Hull fouling of ships/boats is a possible pathway as algae are capable of adhering to ship hulls, but is less likely. Natural dispersal is likely, travelling short to medium distances through marine currents or long distances via human activities e.g. fishing gear, marine tourism activities or marine litter.

Impact

The alga has an extraordinary competition and colonisation ability, monopolising marine ecosystems. These abilities cause the loss of marine biodiversity and alteration of community structures, e.g. in algal forests and coralline, algal communities, through the physical displacement of species. This results in few species remaining within the ecosystem, potentially within just one year, impacting protected habitats such as the Natura 2000 Network. Several species of conservation interest are affected, such as the red coral (*Corallium rubrum*) and the protected ferreous limpet (*Patella ferruginea*). There are also major economic impacts, caused by the accumulation of detached biomass, to fishing through the disruption of equipment, and tourism through the disruption of recreational and touristic activities and the need for organised removals from beaches.

Management

Due to its enormous spreading capacity in the marine environment, eradication attempts are likely to fail. Therefore, the most effective way of mitigating impacts is to prevent its introduction. Effective ballast water and biofouling management, and measures for shellfish imports and transfers, could prevent further introductions. Secondary spread via fishing gear, tourism or marine litter could be prevented through public awareness-raising activities with fishers, tourists, etc. Due to its enormous spreading capacity, eradication or control campaigns of established populations are likely to fail. Manual removal is the only measure that is realistically available for this species following early detection or for long-term control, though even this measure is likely to be ineffective.

Photo: *Rugulopteryx okamurae* (Okamura's brown alga) © Sylvain Le Bris, CC BY-NC via iNaturalist

Salvinia molesta
Giant salvinia

Description

Giant salvinia is a free-floating fern, with two opposite floating leaves flat or infolded along the central stem, depending on the growth stage. On their upper side, it has egg-beater-shaped hairs which distinguishes the alien fern from *Salvinia natans*, native to Europe. Giant salvinia has a submerged dangling frond similar to roots. It is a hybrid, reproducing only asexually through clones and fern fragments. Tropical and warm climates are optimal for it, but in temperate climates the fern can survive occasional freezing temperatures. It preferably colonises still or slow-flowing waters of lakes, watercourses, wetlands, channels and ditches. In nutrient-rich waters and suitable climates its growth is very rapid, doubling the size of its leaves in a couple of days.

Distribution

Giant salvinia is native to southern Brazil and has been introduced outside its native range in Brazil as well as Africa, Asia, North, Central and South America, (including Hawaii), and Oceania. Within the EU it has not established in any Member State, but has been recorded in Austria, Belgium, France, Italy, Germany, the Netherlands and Portugal but with occurrences apparently of limited extent. It was also recently recorded in Switzerland. Due to climate and eradication efforts, giant salvinia is considered transient in Europe, however, locally it can be abundant.

Illustrations: *Salvinia molesta* (Giant salvinia)

Pathways

The main pathway of introduction is as an ornamental plant for aquaria and ponds. More recently, the species has become more popular for its water cleaning properties and so this could potentially be a new pathway of introduction. It can also be imported as a mislabelled plant (sold with erroneous or generic names) or a contaminant of other aquatic plants. Giant salvinia can easily escape from cultivation, either released as an amenity plant or through contaminated aquarium water. Human-assisted dispersal via leisure equipment (e.g. fishing) or vessels and natural dispersal via water, wind and aquatic animals are possible.

Impact

No negative impacts of giant salvinia are known within Europe, but it is one of the most invasive aquatic plants across the globe. It can rapidly cover whole water bodies, harming biodiversity, reducing ecosystem service values and damaging human activities relying on water. Environmental and chemical parameters in freshwater can be drastically altered e.g. light, pH, oxygen, as well as the food web. Native plants can be displaced and animals can decline. Wide mats of the fern block flowing water, increasing the risk of flooding and interfering with irrigation systems and locks. It can degrade drinking water, hinder access to water for livestock and people and reduce the aesthetic value of landscapes. It can also host unwanted and disease-vector insects e.g. mosquitoes.

Management

Inspections by customs and vendors should prevent its unintentional introduction as a contaminant or mislabelled plant. Checks and cleaning of equipment and vessels can halt the involuntary dispersal of giant salvinia and other aquatic alien species. Awareness campaigns should inform citizens about the fern and the correct code of conduct to adopt. In Europe, early detection of new sites and their rapid eradication are key in avoiding the establishment of giant salvinia; local authorities, professionals and citizens should be involved. If found, the site should be enclosed with floating barriers, after which the fern can be manually or mechanically removed.

Photo: *Salvinia molesta* (Giant salvinia) © Harry Rose, CC BY 2.0 via Flickr.com

Triadica sebifera
Chinese tallow

Description

The Chinese tallow is a medium-sized and quick-growing deciduous tree, 20 to 30 m in height. The bark is grey, brown, and rough and it exudes a milky sap. Twigs are slender, leaves are alternate, simple, and typically oval to round. Chinese tallow flowers from April to June, producing both male and female flowers. Fruits are 1 cm three-lobed capsules expected to mature in the autumn. They contain three wax-coated seeds, 8 mm long and chalky white. Each tree can produce large amounts of seed. The lifespan of Chinese tallow stems seems to be less than 100 years, although roots may live longer. Importantly, there are no related species within the EU Member States and more generally throughout Europe.

Distribution

The Chinese tallow is native to China and Japan, where it is found in disturbed habitats at low densities, but due to its commercial applications and popularity as an ornamental plant, it has been introduced to Europe, North America, South America, Africa, Asia, and the Australian continents. In many introduced regions it is invasive. There are currently no established populations in the wild or records within any EU Member States, it is present only in cultivation e.g. botanical gardens.

Illustrations: *Triadica sebifera* (Chinese tallow)

Pathways

The Chinese tallow was first planted for commercialisation in the EU in the 19th century, due to its commercial applications and popularity as an ornamental plant, both in France and Italy, and successively in other countries, where it can be found also in botanical gardens. Its rapid growth, precocious, prolific seeding, and adaptability to a wide variety of soil conditions, has increased its popularity as an ornamental plant, as well as in other commercial sectors. However, the species is naturally dispersed by animals and water, and so it could establish and spread in suitable areas of the EU. These include coastal habitats, woodland and forests, grasslands, and heathland, particularly in the Mediterranean and in the Black Sea biogeographic regions.

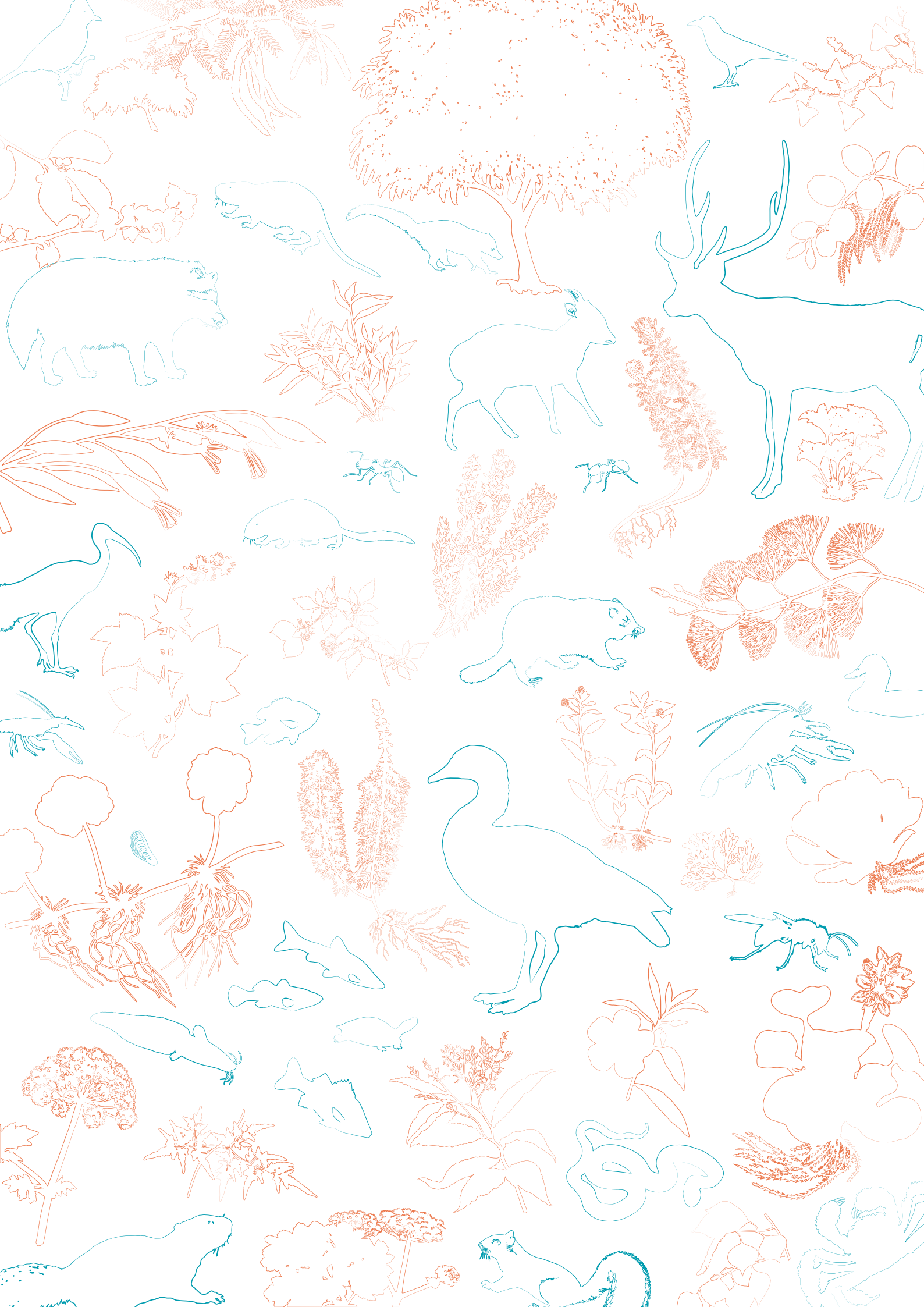
Impact

Once suitable areas are invaded, the Chinese tallow can displace native plant species and establish dominant stands, for instance, transforming grasslands into woody thickets. Furthermore, the species' leaf decay is toxic to both terrestrial and aquatic environments, with native amphibian and arthropod diversity affected. Therefore, the Chinese tallow can disrupt ecosystem processes, decrease biodiversity, and alter community structure.

Management

As the Chinese tallow is currently absent from the natural environment within the EU, preventive measures should be put in place, including dedicated surveying at sites where it might still be in cultivation or in abandoned fields. Control of the Chinese tallow is very expensive because the species can easily regrow if the aboveground vegetation is killed, quickly reproduce, and disperse. To prevent establishment of the species and support early detection within the EU, campaigns are needed to educate horticulturalists, natural resource professionals and citizen scientists. Homeowners who have this species in their gardens should cut down the tree or have it professionally removed but the stump should be immediately treated to avoid regrowth.

Photo: *Triadica sebifera* (Chinese tallow) © Tatters, CC BY-SA 2.0 via Flickr.com



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