NOBANIS - Invasive Alien Species Fact Sheet

Phoxinus phoxinus

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Species description

Scientific names: *Phoxinus phoxinus* (Linnaeus, 1758), Cyprinidae
Synonyms: none
Common names: European (Common or Eurasian) minnow (GB), elritse (DK), Elritze (DE), Lepamaim (EE), mutu (FI), mailīte (LV), ørekyt (NO), strzebla potokowa(PL), elritse (SE).

Fig 1. *Phoxinus phoxinus* are shoaling fish that usually are most abundant in shallow waters, photo by Bjørn Ove Johnsen.

Species identification

Phoxinus phoxinus have very variable colouration, according to maturity stage, age, environment and season (Maitland 2004). Normally the dorsal side is brownish green, and is separated from the whitish grey ventral by a longitudinal series of blotches that may unite into a dark line (Figure 1). Males are

brightly coloured during the spawning season, with white spots on the fins, reddish pectoral and pelvic fins, black throat, greenish tinge along the sides, and a scarlet belly.

Native range

P. phoxinus is probably the most widely distributed member of the Cyprinidae family.
Its range encompasses almost the whole of Europe, from eastern Spain to eastern Siberia, and to Balkan and Italy in the south-east. It is also found on the British Isles, but not on Iceland (Mills 1988, Table 1). Their natural distribution area in Norway was mapped during the early 1900s (Huitfeldt-Kaas 1918). This study showed that *P. phoxinus* had a relatively restricted distribution area in Norway, being found in the south-eastern parts of the country, and in a few watersheds in Nord-Trøndelag county (draining eastwards into Sweden), and in Troms and Finnmark counties in Northern Norway (Figure 2). However, investigations carried out recently have shown that the natural distribution of *P. phoxinus* in Finnmark is much wider than previously known (Hesthagen and Østborg 2004). The limited distribution area of minnows in Norway is because they were a relatively late post-glacial immigrant, migrating from the Baltic westwards into southeastern watersheds, and northwards into watersheds in northern-Norway (Huitfeldt-Kaas 1918).

Alien distribution

History of introduction and geographical spread

The distribution of *P. phoxinus* in Norway has been changed by humans quite considerably during the past 100-140 years. The changes became particularly swift from 1950 onwards. *P. phoxinus* are now found in every county of Norway, after being introduced to eight counties where it previously did not occur. It is especially common in the southern counties of Telemark, Buskerud, Hedmark, and Oppland (Figure 2). The number of populations in lakes > 4 ha is presently estimated at 2,300, of which about 46% are reported as introduced (Tammi *et al.* 2003). *P. phoxinus* also occur in an unknown number of smaller lakes and streams.

Pathways of introduction

Originally, *P. phoxinus* was spread mainly because fishermen used it as live bait for catching species like brown trout (*Salmo trutta*), Arctic charr (*Salvelinus alpinus*), perch (*Perca fluviatilis*) and pike (*Exos lucius*) (Huitfeldt-Kaas 1918). This practice is considered to be the main reason for most introductions throughout the 1900s. However, *P. phoxinus* has also been accidentally introduced together with stocked hatchery-reared brown trout in a large number of lakes (Borgstrøm 1973, Lura and Kålås 1994, Kjell Mykkeltvedt, pers. comm.). Brown trout stockings have been routinely done especially in lakes modified as hydropower reservoirs in order to compensate for reduced natural recruitment (Vøllestad and Hesthagen 2001). These reservoirs are often located in the upper sections of watersheds. Whenever *P. phoxinus* were introduced, they were able to subsequently migrate downstream and become established in more lakes. This frequently occurred during the 1960s and 1970s. *P. phoxinus* has also been spread through tunnels between watersheds constructed for hydropower development. In a few cases *P. phoxinus* has also been intentionally introduced to provide forage fish for brown trout. In one case *P. phoxinus* was introduced as a control measure against the so-called Tune fly (Simuliidae) (Halleraker and Hesthagen 1994).

Alien status in region

In Norway, *P. phoxinus* has been and are still being translocated and introduced into new areas, developing dense populations in many localities. During the past decades acidification affected this species in some areas of southern Norway, and more than 100 populations have either been lost or damaged (Hesthagen *et al.* 1999). These populations are to a large extent located within their native distribution area. Acidification is no longer a threat to *P. phoxinus* in this region. Only a few of the lost populations have been re-established (Hesthagen *et al.* 2002). Habitat destruction of small streams might occasionally be a threat to minnow populations.

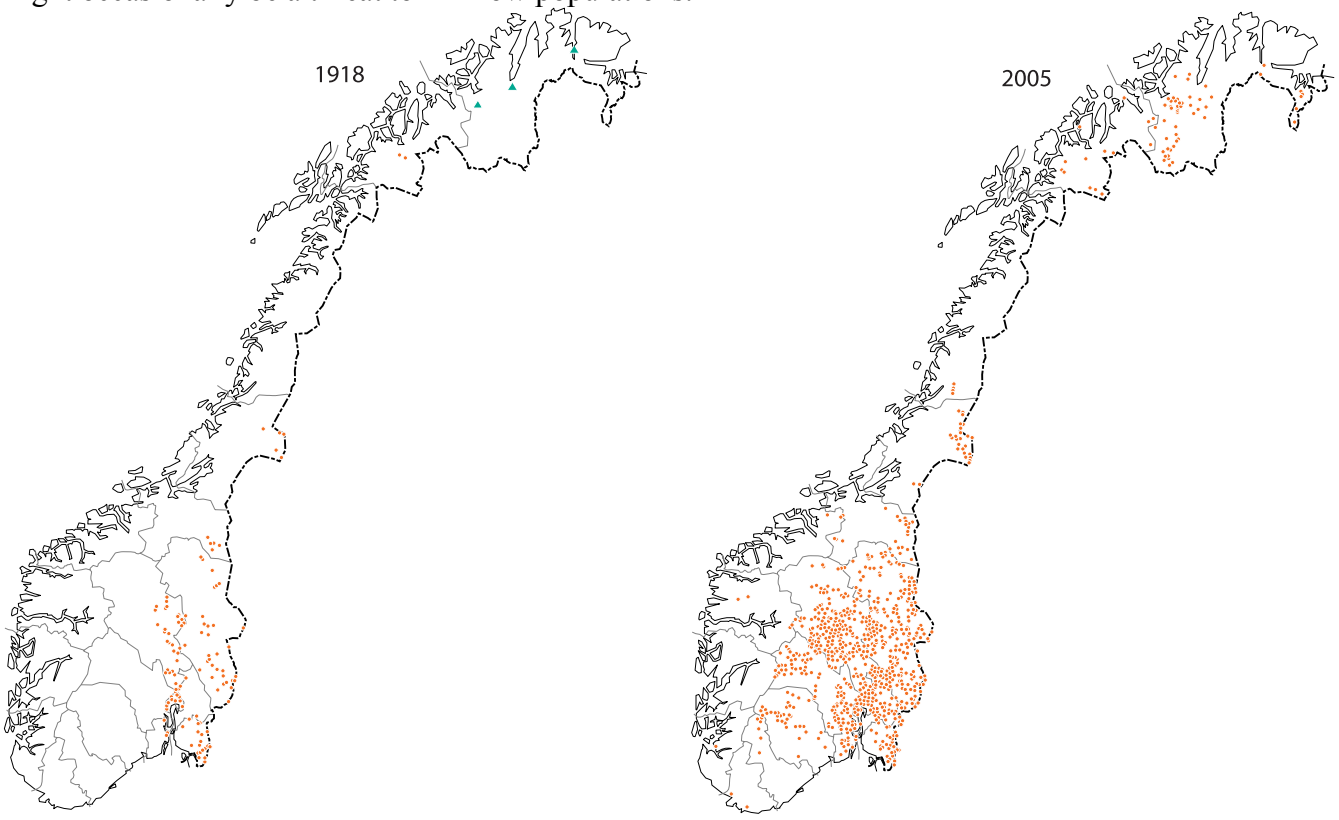

Fig. 2. Distribution of *P. phoxinus* in Norway per 1918 (Huitfeldt-Kaas 1918) and that in 2005. Their distribution in Finnmark county in northern Norway was not known in detail in the early 1900, but only identified to some of the largest watersheds shown by triangles on the map (*cf.* Huitfeldt-Kaas 1918).

On the Red List (IUCN), *P. phoxinus* are listed in the category "least concern globally". However, their status differs highly in different European countries. In Finland, the minnow occurs all along the coast and archipelago area in the Baltic Sea, as well as, in inland waters both rivers and lakes from south to north; however, the distribution is not even (Myllylä *et al.* 1983, Mills and Eloranta 1985, Huusko and Sutela 1997). In Denmark, *P. phoxinus* is considered rare and in Germany the species is listed as an endangered native species in all Federal states (Stefan Nehring pers. comm.). Within the scope of nature conservation measures this fish species is released to sustain natural populations in some areas of Germany, *e.g.* in the River Treene in Schleswig-Holstein (LANU 2002). In the Baltic countries, *P. phoxinus* is very common (Tomas Virbickas and Nora Kabuce, pers. comm.). The species is also reproducing in many brackish water areas of the northern Baltic Sea (Lauri Urho, pers. comm.). Furthermore it is found in many Latvian rivers, also in brooks and ditches, but not in lakes and coastal waters. See also table 1.

Country	Not found	Not established	Rare	Local	Common	Very common	Not known
Denmark			Native				
Estonia						Native	
European part of Russia					Native		
Finland					Native		
Faroe Islands	X						
Germany					Native		
Greenland	X						
Iceland	X						
Latvia						Native	
Lithuania						Native	
Norway					Native		
Poland						Native	
Sweden					Native		

Table 1. The frequency and establishment of *Phoxinus phoxinus* in some European countries (cf www.nobanis.org/search.asp). Legend for this table: **Not found** –The species is not found in the country; **Not established** - The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare** - Few sites where it is found in the country; **Local** - Locally abundant, many individuals in some areas of the country; **Common** - Many sites in the country; **Very common** - Many sites and many individuals; **Not known** – No information was available; **Native** – when a species is native in a country this is indicated in the table under the relevant frequency category.

Ecology

Habitat description

P. phoxinus are found in a variety of habitats over a wide geographical range throughout its native distributional area; in brackish water as well as in different types of freshwater, such as streams, rivers, ponds, and large lakes located from coastal areas to high mountains. Minnows are not doing well in eutrophicated areas (Lauri Urho, pers. comm.).

The distribution of European minnow reaches an altitude of 1.403 m a.s.l. in a lake in the central mountain area in southern Norway (Jotunheimen). The species is less numerous in steep, fast flowing rivers. It occurs most abundantly in shallow lakes and slow flowing streams and rivers where brown trout is the only fish species. *P. phoxinus* are also abundant in regulated lakes, even when the water level might vary by several metres throughout the year. Laboratory studies revealed a significant preference of *P. phoxinus* for stony substratum (grain diameter 5-50 mm) over sand (grain diameter 0.5-1.0 mm) (Jacobsen 1979). The preference for a stony substratum was strongest in old, schooling individuals, and significantly higher than in schools of 2-5 months old juveniles. Substrate selection in *P. phoxinus* is probably associated with shelter against predator fish. In Lake Øvre Heimdalsvatn, located at 1.090 m a.s.l. in southern Norway, where *P. phoxinus* were introduced in the late 1960s, brown trout preyed heavily on mature *P. phoxinus* shortly after the break up of the ice cover at the end of June, when *P. phoxinus* constituted 9 and 20% of the stomach volume within trout length groups 16-30 and ≥ 30 cm, respectively (Museth *et al.* 2005). Predation on *P. phoxinus* was only occasionally

detected during July, August and September. Brown trout selectively preyed on *P. phoxinus* infected by *Ligula intestinalis* (Museth 2001).

In Lake Øvre Heimdalsvatn, gillnet catches of *P. phoxinus* decreased significantly with increasing depth, being 32.1, 13.1 and 0.9 fish per 100 m^2 net area at 1.5, 3.0 and 6.0 m depths, respectively (Museth *et al.* 2002). The highest densities of *P. phoxinus* were obtained at depths of 0.2-0.5 m (Museth *et al.* 2002). Furthermore, the *P. phoxinus* captured by gillnets were restricted to the net area close to the bottom, and less than 1% were captured more than 50 cm from the bottom.

Reproduction and life cycle

P. phoxinus displays considerable variability in life-history traits, i.e. in age and size at sexual maturity, growth rate and longevity (Mills 1988). *P. phoxinus* becomes sexually mature at a smaller body size and at a lower age in lowland localities compared with those located at a higher altitude and latitude. In the River Utsjoki in Finnish Lapland, maturity was strongly size-dependent and delayed until the fish reached 5, 6 or even 7 years of age, with a maximum age of 13 years at a length of only 75 mm (Mills 1988). In Norway, sexual maturity in *P. phoxinus* occurs at an age of 2-15 years. In Lake Øvre Heimdalsvatn, *P. phoxinus* of age 4 and 5 years made up about 67% of the spawning stock (Museth *et al.* 2002). All mature individuals were larger than 50 mm in length, and only a few specimens were smaller than 55 mm.

P. phoxinus spawns mainly in June and July, depending on altitude and latitude. The fish spawn in shoals over stones and gravel, either in running water or in shallow areas close to the shore line. The adhesive eggs stick to the substratum. In Lake Øvre Heimdalsvatn, spawning activity was observed only 4-8 days after the break up of the ice cover in early June (Museth *et al.* 2002). The spawning period lasted about 3 weeks. The adhesive yellow eggs of about 1.0-1.5 mm in diameter hatch after 5-10 days. Individual fecundity is between 200 and 1,000 eggs. It may appear that sexually mature *P. phoxinus* change behaviour towards spawning time, becoming more susceptible to fish predation (Museth *et al.* 2005).

P. phoxinus grow slowly in Norwegian waters. In Lake Øvre Heimdalsvatn, the mean length of 3 and 4 year old fish was 50 and 60 mm, respectively (Museth *et al.* 2002). Growth continues up to old age, giving a length of 96/97 mm at ≥ 9 years.

Dispersal and spread

P. phoxinus disperse easily downstream, but extended river stretches with continuous swift currents may appear to constitute a barrier to downstream migration. In the River Sanddøla, a major tributary to the River Namsen in Nord-Trøndelag county, *P. phoxinus* were established in the headwater Lake Otersjøen around 1960. By 2005 it had still not spread downstream in Sanddøla, probably due to the continuous swift currents over a distance of more than 45 km (Thorstad *et al.* 2006). Based on the observation in several cases that downstream spread by *P. phoxinus* may cover 3-7 km per year, it may be speculated that the species requires appropriate habitats for feeding, overwintering and possibly reproducing (i.e. lakes, pools or slow flowing river habitats) at suitable intervals, Without such "resting habitats" at 5-10 km intervals, the individuals may not survive the downstream migration.

P. phoxinus are able to migrate against relatively strong currents for very short distances. In small streams it is possible to construct barriers that stop *P. phoxinus* but allow the passage of brown trout (Holthe *et al.* 2005). As *P. phoxinus* are quite tolerant to different sources of environmental stress, they

may be kept and transported alive in very small bodies of water with high temperatures and low oxygen contents. Unfortunately, this makes it easy for anyone to move the species between lakes or watercourses.

Impact

Affected habitats and indigenous organisms
P. phoxinus may introduce new parasites where they become established. In some subalpine lakes in southern Norway, *P. phoxinus* caused infection with new parasite species in snails, mussels and different insects, but not in brown trout (Hartvigsen 1997).

The abundance of important food items for brown trout may show a significant decline after the introduction of *P. phoxinus*. In Lake Øvre Heimdalsvatn, the introduction of *P. phoxinus* caused major changes in the benthic community (Brittain *et al.* 1988, 1995). Benthic diversity declined, with a marked increase in numbers of oligochaetes and small forms, especially chironomids. There was also a marked decline in numbers of *Gammarus lacustris*, especially the proportion of larger individuals. However, total benthic densities remained similar to pre-introduction. *G. lacustris* formed a major component of the *P. phoxinus*' diet, while its occurrence in brown trout stomachs declined greatly. *Lepidurus arcticus* also virtually disappeared from the trout diet, probably due to minnow predation. In a Norwegian reservoir, introduced *P. phoxinus* fed on the planktonic stages of *L. arcticus*, and after a few years adult specimens became an insignificant part of the diet of brown trout (Borgstrøm *et al.* 1985).

Introduction of *P. phoxinus* may also cause reduced recruitment in brown trout. In Lake Øvre Heimdalsvatn, the cohort size of age-class 4 was reduced by approximately 50 % during a period in sympatry with *P. phoxinus* compared to pre-introduction of *P. phoxinus*. There was no significant change in annual individual length increment (Borgstrøm *et al.* 1996). It is uncertain whether the reduction of trout recruitment was due to direct interactions with *P. phoxinus* in the nursery streams, or an indirect effect caused for example by increased brown trout cannibalism. These finding are only for waters where *P. phoxinus* have been introduced, and might not be valid in natural conditions.

Genetic effects
Vøllestad *et al.* (1999) has performed a genetic characterization of 34 populations of *P. phoxinus* throughout Norway. It was found that some of the alien populations of *P. phoxinus* on the Hardangervidda mountain plateau have a genetic history very different from that found among native *P. phoxinus*, with an unique mitochondrial DNA haplotype. These populations have probably been introduced from abroad. In the same mountain area, minnow populations were also found with a genetic background similar to that of native specimens. DNA fingerprint analyses showed a larger genetic variation within *P. phoxinus* populations which were assumed to be native, than among populations which have recently been introduced. However, large genetic variation was also found among some of the introduced populations, probably due to multiple invasions.

Human health effects
No human health effects are expected.

Economic and societal effects (positive/negative)
P. phoxinus is of no interest to fisheries or other human uses, except for the use as live bait. This is, however, illegal by law in Norway. It is also illegal to introduce fish species that are not native to the watercourse into Norwegian lakes or rivers.

Management approaches

Prevention methods
Norway has adopted national legislation dealing with the introduction and spreading of non-native fish species. However, no one has so far been prosecuted for offences against this legislation.

Eradication, control and monitoring efforts
Large scale attempts have been made to reduce or control the abundance of *P. phoxinus* by trap fishing. However, this mitigation measure has generally failed, except in a few cases involving small and shallow lakes (Taugbøl *et al.* 2002). This management measure is very time consuming, and a large fraction of the biomass needs to be removed in order to have any positive effects on the beneficiary species, i.e. brown trout. In a few places, chemical control using rotenone has been applied in an attempt to remove newly introduced populations of *P. phoxinus*. However, the authorities are very restrictive concerning the use of rotenone, and it is also a very expensive method. In a few cases, physical barriers have been built to prevent *P. phoxinus* from migrating further upstream. However, the effectiveness of this measure is limited, as high water flow may easily damage these installations. In order to be efficient their construction is expensive, as is the necessary annual maintenance. Thus, the use of barriers is restricted to small streams. On the Hardangervidda plateau, an earthen dyke has been built in order to prevent *P. phoxinus* from being spread across the water divide to new locations through flooding due to rain or snow melting. However, such barriers may be susceptible to high water flow, they constitute an encroachment in a natural area, and they do not prevent transport of fish by humans over the water divide. *P. phoxinus* are not part of any specific monitoring programme in Norway.

Information and awareness
Several attempts have been made towards public awareness raising, through information campaigns, brochures, posters and through television and radio. Environmental education in a few schools has also been attempted. However, these campaigns seem to have had little effect in terms of stopping anglers from spreading *P. phoxinus* to new locations.

Knowledge and research
There has been relatively little research on the effects on aquatic biota and other species of fish of introducing *P. phoxinus* in Norwegian waters. However, in recent years important knowledge of different aspects of these introductions have been gained, such as effects on different invertebrates (Borgstrøm *et al.* 1985, Brittain *et al.* 1988, 1995), effects on the recruitment of brown trout (Borgstrøm *et al.* 1996), dispersal and distribution (Hesthagen and Sandlund 1997), genetic characterization and colonization (Vøllestad *et al.* 1999), dynamics in sympatric *P. phoxinus* and brown trout (Museth 2002), and different management approaches to reduce their abundance (Taugbøl *et al.* 2002).

References and other resources

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Links

Fish base – species summary

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