

# NOBANIS - Invasive Alien Species Fact Sheet

## *Phoxinus phoxinus*

---

**Authors of this fact sheet:** Trygve Hesthagen and Odd Terje Sandlund, Norwegian Institute for Nature Research, Tungasletta 2, NO-7485 Trondheim, Norway. T: +47 70801400. E-mails: [trygve.hesthagen@nina.no](mailto:trygve.hesthagen@nina.no); [odd.t.sandlund@nina.no](mailto:odd.t.sandlund@nina.no)

**Bibliographical reference – how to cite this fact sheet:**

Hesthagen, T. and Sandlund, O.T. (2010): NOBANIS – Invasive Alien Species Fact Sheet – *Phoxinus phoxinus*. – From: Online Database of the European Network on Invasive Alien Species – NOBANIS [www.nobanis.org](http://www.nobanis.org), Date of access x/x/201x.

### Species description

**Scientific names:** *Phoxinus phoxinus* (Linnaeus, 1758), Cyprinidae

**Synonyms:** none

**Common names:** European (Common or Eurasian) minnow (GB), střevle potoční (CZ), elritse (DK), Elritze (DE), Lepamaim (EE), mutu (FI), mailite (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, Unpubl. data). 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 (Museth *et al.* 2007). 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.

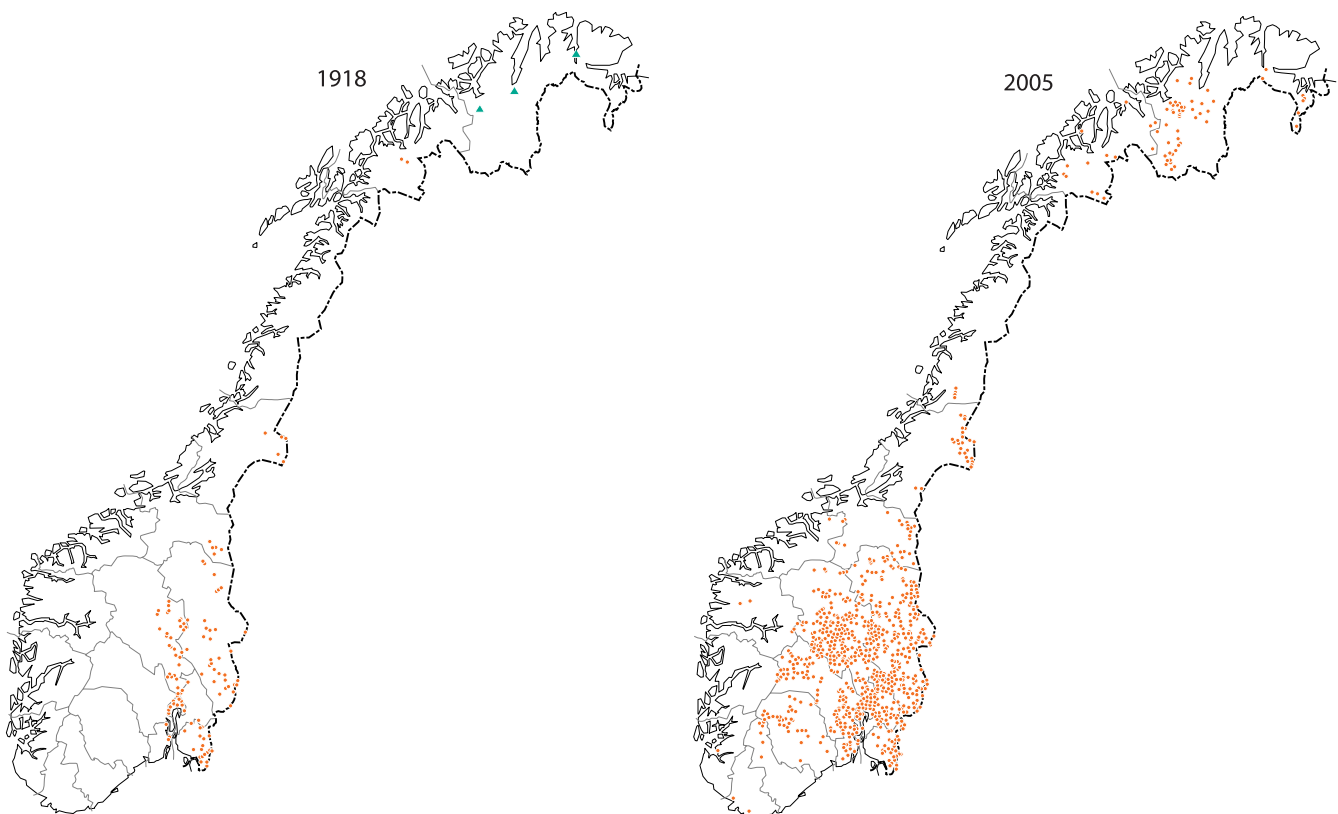
### Pathways of introduction

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 (*Esox 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 widely distributed, but both the number of populations and the size of each population decreased during the last century, mainly due to reduced environmental conditions. At present the negative development has stopped (Carl and Berg 2010). 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 |
|-------------------------|-----------|-----------------|--------|--------|--------|-------------|-----------|
| Austria                 |           |                 |        |        | Native |             |           |
| Belgium                 |           |                 |        |        | Native |             |           |
| Czech republic          |           |                 | X      |        |        |             |           |
| Denmark                 |           |                 |        |        | Native |             |           |
| Estonia                 |           |                 |        |        |        | Native      |           |
| European part of Russia |           |                 |        |        |        | X           |           |
| Finland                 |           |                 |        |        | Native |             |           |
| Faroe Islands           | X         |                 |        |        |        |             |           |
| Germany                 |           |                 |        |        | Native |             |           |
| Greenland               | X         |                 |        |        |        |             |           |
| Iceland                 | X         |                 |        |        |        |             |           |
| Ireland                 |           |                 |        | Native |        |             |           |
| Latvia                  |           |                 |        |        |        | Native      |           |
| Lithuania               |           |                 |        |        |        | Native      |           |
| Netherlands             |           |                 | 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](http://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  $\geq 30$  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<sup>2</sup> 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. The case of Lake Øvre Heimdalsvatn is summarized in Brittain and Borgstrøm (2010, eds.)

### **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  $\geq 9$  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; Næstad and Brittain 2010). 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). The degree of diet overlap and declining growth rates of both brown trout and *P. phoxinus* in Lake Øvre Heimdalsvatn indicate substantial competitive interactions between the two fish species (Museth *et al.* 2010).

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* (Borgstrøm *et al.* 1996). There was also a significant reduction in annual individual length increment after the establishment of *P. phoxinus* (Borgstrøm *et al.* 2010). The reduction of trout recruitment was probably due to direct interactions with *P. phoxinus* in the littoral zone and possibly in the nursery streams (Museth *et al.*

2010), and also as an indirect effect of interspecific competition in the littoral zone resulting in increased brown trout cannibalism (Borgstrøm *et al.* 2010).

A review of standard gill net catches of brown trout in more than 400 lakes in Norway indicates the general impact of *P. phoxinus* on brown trout biomass (Museth *et al.* 2007). Gill net catches of brown trout were on average 35% lower in lakes where minnow had been introduced. These findings 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 a 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. The effort also has to be maintained over time, as a new equilibrium with lower *P. phoxinus* biomass appears not to become established. 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 raising public awareness, 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**

#### **Contact persons**

Wolfgang Rabitsch (AT), Umweltbundesamt, Naturschutz, Spittelauer Lände 5, 1090 Wien, Austria  
Phone: +43- (0) 1-313 04/3340, E-mail: wolfgang.rabitsch@umweltbundesamt.at

Radek Šanda (CZ), Department of Zoology, National museum, Václavské náměstí 68, 115 79 Praha 1, Czech Republic, E-mail: radek\_sanda@nm.cz

Stefan Nehring (DE), Federal Agency for Nature Conservation, Konstantinstrasse 110, D-53179 Bonn;  
Phone: +49-228-84911444; E-mail: stefan.nehring@bfm.de

Søren Berg (DK). Technical University of Denmark, National Institute of Aquatic Resources, Section of Freshwater Fisheries and Ecology. Vejløvej 39, DK-8600 Silkeborg, Tel: +4589213100, E-mail: sbe@dfu.min.dk

Herki Tuus (EE), Estonian Ministry of Environment, Fisheries Department, Narva mnt 7a, Tallinn, Estonia, E-mail: herki.tuus@envir.ee

Lauri Urho (FI) Finnish Game and Fisheries Research Institute, P.O. Box 2, FIN-00791 Helsinki, Finland, Phone +358 205 751 258, E-mail: lauri.urho@rktl.fi

Colette O' Flynn (IE) National Biodiversity Data Centre, WIT West campus, Carriganore, Waterford, Ireland, Phone: +353 (0) 51306240, E-mail: coflynn@biodiversityireland.ie

Gudni Gudbergsson (IS), Institute of Freshwater Fisheries, Keldnaholti, 112 Reykjavik, Iceland. Tel: +354 5806300. Fax: +354 5806301, E-mail: [gudni.gudbergsson@veidimal.is](mailto:gudni.gudbergsson@veidimal.is)

Agnese Priede (LV), Nature Conservation Agency, Meza maja, Kemeru, Jurmala, LV-2012, Latvia, Phone: +371 29640959, E-mail: [agnesepriede@hotmail.com](mailto:agnesepriede@hotmail.com)

Trygve Hesthagen (NO) Norwegian Institute for Nature Research, Tungasletta 2, NO-7485 Trondheim, Norway. Tel: +47 70801400, E-mail: : [trygve.hesthagen@nina.no](mailto:trygve.hesthagen@nina.no)

Odd Terje Sandlund (NO). Norwegian Institute for Nature Research, Tungasletta 2, NO-7485 Trondheim, Norway. Tel: +47 70801400, E-mail: [odd.t.sandlund@nina.no](mailto:odd.t.sandlund@nina.no)

Yury Dgebuadze (RU), Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Leninsky prospekt, 33, Moscow, 119071, Russia, E-mail: [dgebuadze@sevin.ru](mailto:dgebuadze@sevin.ru)

Melanie Josefsson (SE) Swedish Environmental Protection Agency, SE 106 48 Stockholm, Sweden. Tel: +46 18 67 31 48, fax: +46 18 67 31 56, E-mail: [Melanie.Josefsson@snv.slu.se](mailto:Melanie.Josefsson@snv.slu.se)

## Links

Fish base – [species summary](#)

## References

- Borgstrøm, R. 1973. Spredning av ørekyt. Jakt - Fiske - Friluftsliv 102: 28-29.
- Borgstrøm, R., Garnås, E. and Saltveit, S.J. 1985. Interactions between brown trout, *Salmo trutta* L. and minnow, *Phoxinus phoxinus* (L.) for their common prey, *Lepidurus arcticus* (PALLAS). Verh. Internat. Verein. Limnol. 22: 2548-2552.
- Borgstrøm, R., Brittain, J.E., Hasle, K., Skjølås, S. and Dokk, J.G. 1996. Reduced recruitment in brown trout *Salmo trutta*, the role of interactions with the minnow *Phoxinus phoxinus*. Nordic Journal of Freshwater Reserach 72: 30-38.
- Borgstrøm, R., Museth, J. & Brittain, J.E. 2010. The brown trout (*Salmo trutta*) in the lake, Øvre Heimdalsvatn: long-term changes in population dynamics due to exploitation and the invasive species, European minnow (*Phoxinus phoxinus*). Hydrobiologia 642: 81-91.
- Brittain, J.E. & Borgstrøm, R. (Eds) 2010. The subalpine lake ecosystem, Øvre Heimdalsvatn, and its catchment: local and global changes over the last 50 years. Hydrobiologia 642 / Developments in Hydrobiology 211: 126 pp.
- Brittain, J.E., Brabrand, Å., Saltveit, S.J., Bremnes, T. and Røsten, E. 1988. The biology and population dynamics of *Gammarus lacustris* in relation to the introduction of minnows, *Phoxinus phoxinus*, into Øvre Heimdalsvatn, a Norwegian subalpine lake. Rapp. Lab. Ferskv. Økol. Innlandsfiske 109: 1-30.
- Brittain, J.E., Brabrand, Å. and Saltveit, S.J. 1995. Effekt på fisk og næringsdyr ved introduksjon av ørekyt. - In: Spredning av ferskvannsorganismer. Seminarreferat. DN-Notat 1995-4: 146-148.
- Carl, H. and Berg, S. 2010. Redlist for Freshwater Fish. The Danish National Redlist / Fagdatacenter for Biodiversitet og Terrestrisk Natur (B-FDC). – National Environmental Research Institute, University of Aarhus. [Web publication](#)
- Halleraker, J.H. and Hesthagen, T. 1994. Kategorisering av innlandsfiskesystemer i deler av Glommavassdraget. NINA Oppdragsmelding 302: 1-18.
- Hartvigsen, R. 1997. Spredning av parasitter ved innvandring og/eller introduksjon av nye fiskearter: spredning av ørekyt (*Phoxinus phoxinus*) til ørretvassdrag. NINA Oppdragsmelding 466: 1-14.
- Hesthagen, T. and Sandlund, O.T. 1997. Changes in the distribution of European minnow, *Phoxinus phoxinus*, in Norway: causes and effects. NINA Fagrapport 13: 1-16.
- Hesthagen, T., Sevaldrud, I.H. and Berger, H.M. 1999. Assessment of damage to fish populations in Norwegian lakes due to acidification. Ambio 28:12-17.
- Hesthagen, T., Walseng, B. and Karlsen, L.R. 2002. Effekter av forsurening og kalking på fisk og krepsdyr i innsjøer i Enningdalsvassdraget, Østfold. NINA Oppdragsmelding 761:1-42.
- Hesthagen, T. and Østborg, G. 2004. Utbredelse av ferskvannsfisk i Troms og Finnmark, med kartlegging av naturlige fiskesamfunn og fisketomme vatn. NINA Oppdragsmelding 805: 1-30.

- Holthe, E., Lund, E., Finstad, B., Thorstad, E.B. and Mckinley, R.S. 2005. A fish selective obstacle to prevent dispersion of an unwanted fish species, based on leaping capabilities. *Fisheries Management and Ecology* 12: 143–147
- Huitfeldt-Kaas, H. 1918. Ferskvandsfiskenes utbredelse og indvandring i Norge med et tillæg om krebsen. Centraltrykkeriet, Kristiania. 106 pp.
- Huusko, A. and Sutela, T. 1997: Minnow predation on vendace larvae: intersection of alternative prey phenologies and size-based vulnerability. *Journal of Fish Biology* 50: 965-977.
- Jacobsen, O.J. 1979. Substrate preference in the minnow (*Phoxinus phoxinus*). *Polskie Archiwum Hydrobiologie* 26: 371-378.
- LANU 2002. Die Süßwasserfische und Neunaugen Schleswig-Holsteins - Rote Liste. Landesamt für Natur und Umwelt des Landes Schleswig-Holstein: 1-58.
- Lura, H. and Kålås, S. 1994. Ferskvassfiskane si utbreiing i Sogn og Fjordane, Hordaland og Rogaland. Rapport Universitetet i Bergen, Zoologisk Museum.
- Maitland, P.S. 2004. Keys to the freshwater fish of Britain and Ireland, with notes on their distribution and ecology. Freshwater Biological association. Scientific Publication No 62.
- Mills, C.A. 1988. The effect of extreme northerly climatic conditions on the life history of the minnow, *Phoxinus phoxinus* (L.). *Journal of Fish Biology* 33: 545-561.
- Mills, C. A. and Eloranta, A. 1985: The biology of *Phoxinus phoxinus* (L.) and other littoral zone fishes in Lake Konnevesi, central Finland. *Ann. Zool. Fennici* 22: 1-12.
- Museth, J. 2001. Effects of *Ligula intestinalis* on habitat use, predation risk and catchability in European minnows. *Journal of Fish Biology* 59: 1070-1080.
- Museth, J. 2002. Dynamics in European minnow *Phoxinus phoxinus* and brown trout *Salmo trutta* populations in mountain habitats: effects of climate and inter- and intraspecific interactions. Agricultural University of Norway. Doctor scientiarum these 2002: 29.
- Museth, J., Borgstrøm, R., Brittain, J.E, Herberg, I. and Naalsund, C. 2002. Introduction of the European minnow into a subalpine lake: habitat use and long-term changes in population dynamics. *Journal of Fish Biology* 60: 1308-1321.
- Museth, J., Borgstrøm, R., Hame, T. and Holen, L.Å. 2005. Predation by brown trout: a major mortality factor for sexually mature European minnows. *Journal of fish Biology* 62: 692-705.
- Museth, J., Hesthagen, T., Sandlund, O.T., Thorstad, E. and Ugedal, O. 2007. The history of the European minnow in Norway: from harmless species to pest. *J. Fish Biology* 71 (Supplement D): 184-195.
- Museth, J., Borgstrøm, R. & Brittain, J.E. 2010. Diet overlap between introduced European minnow (*Phoxinus phoxinus*) and young brown trout (*Salmo trutta*) in the lake, Øvre Heimdalsvatn: a result of abundant resources or forced niche overlap? *Hydrobiologia* 642: 93-100.
- Myllylä, M. Torssonen, M., Pulliainen, E. & Kuusela, K. 1983. Biological studies on the minnow, *Phoxinus phoxinus*, in northern Finland. *Aquilo Ser. Zool.* 22: 149-156.
- Næstad, F. & Brittain, J.E. 2010. Long-term changes in the littoral benthos of a Norwegian subalpine lake following the introduction of the European minnow (*Phoxinus phoxinus*). *Hydrobiologia* 642: 71-79.
- Taugbøl, T., Hesthagen, T., Museth, J., Dervo, B. and Andersen, O. 2002. Effekter av ørekyteintroduksjoner og utfiskingstiltak – en vurdering av kunnskapsgrunnlaget. NINA Oppdragsmelding 753: 1-31.
- Tammi, J., Appelberg, M., Hesthagen, T., Beier, U., Lappalainen, A. and Rask, M. 2003. Fish status survey in Nordic lakes: effects of acidification, eutrophication and stocking activity on present fish species composition. *Ambio* 32: 98-105.
- Thorstad, E. B., Sandlund, O. T., Heggberget, T. G., Finstad, A., Museth, J., Berger, H. M., Hesthagen, T. and Berg, O. K. 2006. Ørekyt I Namsenvassdraget. Utbredelse, spredningsrisiko og tiltak. NINA Rapport 155:1-69.
- Vøllestad, A., Refseth, U.H., Nesbø, C.L. and Jakobsen, K.S. 1999. Slekskap og kolonisering hos ørekyt. Rapport Biologisk Istitutt, Universitetet i Oslo.
- Vøllestad, L.A. and Hesthagen, T. 2001. Stocking of freshwater fish in Norway: management goals and effects. *Nordic Journal of Freshwater Research* 75: 143-152.

**Date of creation/modification of this species fact sheet: 09-08-2006/ 16-12-2010**