NOBANIS - Marine invasive species in Nordic waters - Fact Sheet

Amphibalanus improvisus

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Species description

Species name
Amphibalanus improvisus (Darwin, 1854) – Bay barnacle (an acorn barnacle)

Synonyms
Balanus improvisus Darwin, 1854; *B. ovularis*

Common names
Brakvandsrur (DK); Slät havstulpan, Brackvattenlevande havstulpan (SE); Brakkvannsrur (NO); Merirokko (FI); Brakwaterpok (NL); Bay barnacle, acorn barnacle (all sessile species) (UK, USA); Ostsee-Seepocke, Brackwasser-Seepocke (DE); Pškla bałtycka (PL); Tavaline tõruvähk (EE); Jura zile (LV); Juros gile (LT); Morskoj zhelud (RU)

Identification
Amphibalanus improvisus has 6 smooth shell plates surrounding the body. It reaches a maximum size of 20 mm in diameter, but usually is less than 10 mm. The "mouth plates", called scutum and tergum, form a diamond-shaped center. The most characteristic feature is the calcareous base with radial pattern. This base remains on the substrate after removal of the animal. There are several other species of barnacles in Nordic waters, but only two have smooth shells, *A. improvisus* and *Balanus crenatus* Bruguière, 1789, and the latter does not have the radial pattern on the base plate. In areas with more pronounced tides there are also species of *Chthamalus*. In Danish waters there is another introduced barnacle, *Elminius modestus* (see separate fact-sheet), and on the Swedish west coast. *A. amphitrite* Darwin, 1854, has been found (Främmande Arter, 2006).

Amphibalanus improvisus on *Anodonta cygnea* from Poland.

Amphibalanus improvisus, 1 specimen separated from above with the 6 smooth plates clearly visible.

For more information about *Balanus crenatus* see:
http://www.marlin.ac.uk/speciesfullreview.php?speciesID=2718
For information about *Amphibalanus amphitrite* and other barnacles found introduced close to Nordic waters, see Introduction to barnacles

For more information about the native *Semibalanus balanoides* (Linnaeus, 1767) see:
http://www.marlin.ac.uk/speciesfullreview.php?speciesID=4328
For more information about *Chthamalus stellatus* (Poli, 1795) see:
http://www.marlin.ac.uk/speciesfullreview.php?speciesID=2982
and for *Chthamalus montagui* Southward, 1976 see:
http://www.marlin.ac.uk/speciesfullreview.php?speciesID=2981

Taxonomic note
Recently, there have been some genus name changes in the barnacles, and *Balanus improvisus* has been transferred to the genus *Amphibalanus* Pitombo, 2004. This genus has only been described in 2004, and apparently the name change has only recently been generally accepted (see e.g. Clare & Høeg, 2008). Since almost all of the older literature on ecology and distribution of this species have used the genus name *Balanus*, this has been included as a synonym. World Register of Marine Species (WoRMS; http://www.marinespecies.org/) has now changed the accepted genus name to *Amphibalanus* and hence this is the name used here.

Distribution

Native area
Most likely this species originates on the Atlantic coast of America, though it is uncertain whether North or South America is the source area. In some European countries, e.g. the United Kingdom, this species is considered native. Also, there are records of fossil specimens from the Pliocene in Spain (Kerckhof, 2002), and thus *A. improvisus* may have a history similar to that of *Mya arenaria* becoming extinct in Northeast Atlantic waters during the last glaciation and then re-introduced by human activities as the earliest transatlantic voyages took place. There is little genetic variation among populations in the Baltic; the U.K. and east coast of the USA (Furman, 1990).

Introduced area
This species has been found in European waters for 200 years or more and must be considered fully naturalized in Nordic waters, including the Baltic Sea. There is some discussion of the earliest records. Wolff (2005) mentions that it was found in the Netherlands in 1827, and Kerckhof & Cattrijsse (2001) found it in archaeological remains from the 17th century, but it was absent from a 9th century site in Belgium (Kerckhof, 2002). Darwin (1854), in his original description of the species, mentions that it was only found a few places in England and one locality in Scotland. At the present time its distribution remains restricted to estuaries (Furman et al., 1990). The first record from the German North Sea coast is from 1858 (Gollasch & Nehring, 2006). The first record from the Atlantic coast of France is from 1872 (Goulletquer et al., 2002). The earliest record from

Norway seems to be from 1900 when *A. improvisus* was found in Oslofjord, and until 1969 it was only found in this fjord. Later it has been found in several localities between Oslofjord and Stavanger, but not north of this (Sneli, 1972). It may have spread somewhat further north in recent years (Brattegard & Holthe, 1997; Hopkins, 2001). The first Swedish record is from the west coast in 1895 (Gislén, 1950). In Ireland it is only estimated to have arrived before 1950 (Minchin, 2007).

It is more certain that the introduction to the Baltic Sea has been through human activities. Darwin had borrowed the collection of Cirripedia from the Zoological Museum in Copenhagen when he was writing his monograph (Darwin, 1854), and he does not mention *A. improvisus* from this collection. The first record of *A. improvisus* is from 1844, when it was found at Kaliningrad, then Königsberg (Leppäkoski & Olenin, 2000). The first Danish record seems to be from 1880 in the harbor of Copenhagen (Krüger, 1927; Jensen & Knudsen, 2005). It was found on the Swedish Baltic coast in 1919 (Gislén, 1950). The first record from Finland appears to be 1868 near Turku (Leppäkoski & Olenin, 2000). Presently it occurs in the Baltic up to 64° N (Leppäkoski & Olenin, 2000).

Amphibalanus improvisus has also been introduced to the Black and Caspian Seas. It arrived in the Caspian Sea in 1955 (Grigorovich et al., 2003), presumably through the Volga-Don Canal (Zvyagintsev, 2003). The first record from the Black Sea dates back to 1844 (Gomoiu et al., 2002). There are no recent records from the Mediterranean, and it is unknown whether *A. improvisus* is established here (Zenetos et al., 2005). The first record may be from 1972 (Streftaris et al., 2005)

Amphibalanus improvisus has also been introduced to the west coast of North America, where it was first found in 1853 in San Francisco Bay (Carlton & Zullo, 1969). Presently it is found in California, Oregon and the state of Washington (Wonham & Carlton, 2005).

The occurrence of *A. improvisus* in Japan is most likely due to human introduction. It was first recorded in 1962, and it has been spreading slowly since that time (Iwasaki, 2006). In the Russian part of the Sea of Japan *A. improvisus* is considered established. The first record was in 1969 when it was found on hydrotechnical installations (Zvyagintsev, 2003; Ovsyannikova, 2008).

Along with several other species of Cirripedia *A. improvisus* was found on an oil platform, which had been transported from Japan to New Zealand (Foster & Willan, 1979). There are also som old records of this species from ships' hulls in Australian ports, but there are no records of its having become established in these waters.

Vector
Almost certainly hull fouling, though ballast water cannot be excluded for more recent introductions. As it also often grows on the shells of molluscs and large crustaceans, it may also be transferred with live commercial shellfish, and this is considered the most likely vector for the introduction to the Pacific coast of the USA (Carlton & Zullo, 1969).

Ecology

Amphibalanus improvisus attaches to almost any hard substrate available, such as rocks, jetties, ships’ hulls, bivalve shells, macroalgae, etc. In Florida it has been found on a brackish water turtle,

the diamond-backed terrapin (Ross & Jackson, 1972). In the introduced areas it will attach to the shells of local bivalves; in the Baltic it has been found on *Mytilus edulis* (Laihonen & Furman, 1986), *Mya arenaria* Linnaeus, 1958 (Olszewska, 2000) and even on the freshwater bivalve *Anodonta cygnea* (own observation), and in the Caspian Sea it uses an endemic bivalve *Didacna* sp. (Riedel et al., 2006). In the Sea of Japan it settles on the native *Corbicula japonica*, which may live in freshwater, and on *Crassostrea gigas*, but also on seagrass and macroalgae (Ovsyannikova, 2008). The settling stage, the cypris larva, is probably the most important because after settling the barnacle is unable to move for the rest of its life. *A. improvisus* occurs intertidally and in shallow subtidal waters, but in the Baltic it can be found at depths of more than 50 m (Leppäkoski & Olenin, 2000). It may occur in densities of several thousand per m² (Leppäkoski, 1999; Ovsyannikova, 2008).

Like all barnacles, *A. improvisus* is a suspension feeder, creating a feeding current by pumping movements of the opercular plates and regular beating of the "cirri", modified thoracic legs, and filtering edible particles with the setae on these cirri. The current speed and the strength of the beating of the cirri can be adjusted to the concentration and size of food particles (Crisp & Southward, 1961; Rainbow, 1984). In laboratory experiments they feed on phytoplankton, but had slower body growth than in the field (Costlow & Bookhout, 1953, 1957). When settling on *Mytilus* they prefer the posterior end of the shell, near the in- and exhalent openings of the mussel, so they can benefit from the feeding current of the mussel (Laihonen & Furman, 1986).

Growth is very fast; in three weeks a newly metamorphosed individual may have a diameter of 5 mm, and along the Swedish west coast the species may have three generations in one summer season (Stephensen, 1933). At Tvärminne in Finland they grew from 3 to a maximum of 16 mm in 10 weeks (Laihonen & Furman, 1986). *A. improvisus* molts every 2-4 days at 20° C (Costlow & Bookhout, 1953). The shell plates grow continuously as the body gets bigger. Molting can be induced and inhibited by the same hormones as in decapod crustaceans (Davis & Costlow, 1974).

Amphibalanus improvisus is highly euryhaline, living in almost freshwater in some localities in the native area, La Plata River (Darwin, 1854), and the introduced area, Baltic Sea lagoons (Poulsen, 1935; Leppäkoski & Olenin, 2000). There is some disagreement about the capacity of this species to osmoregulate at low salinities (Foster, 1970; Fyhn, 1976; Rainbow, 1984). It is also rather eurythermal, tolerating temperatures as low as -2° C and up to 35° C (Southward, 1957). Furthermore it is tolerant of low oxygen concentration, eutrophication and pollution (Poulsen, 1935; Leppäkoski & Olenin, 2000; Ovsyannikova, 2008).

On the east coast of North America the flatworm S*tylochus ellipticus* Girard is a dominant predator of *A. improvisus* (Branscomb, 1976). When epibiotic on blue mussels, *A. improvisus* may be eaten with the mussel by the crab *Carcinus maenas* (Wahl et al., 1997).

Reproduction

Like all barnacles, *A. improvisus* is hermaphroditic, but requires cross-fertilization, though self-fertilization has been described (Furman & Yule, 1990). Prior to copulation the barnacle acting as male briefly stops pumping water and beating the cirri, and the extremely long penis is extended into the mantle cavity of the recipient barnacle (Crisp & Southward, 1961). Egg size is about 180µm, and contrary to other species, there is little geographic variation in this size (Barnes & Barnes, 1965). *A. improvisus* may produce 1000 to 10,000 eggs per season (Costlow & Bookhout, 1957). Embryos are brooded in an ovisac inside the mantle cavity. Development to hatching takes

about 21 days at 18º C (Furman & Yule, 1990).

Larvae hatch as nauplii, and a new brood can be released every 5-6 days (Gamfeldt et al., 2005). There are six nauplius stages of which the first may be non-feeding, the others feeding in the plankton, and a non-feeding cypris stage (Barnes & Barnes, 1965; Zega et al., 2007). Nauplius larvae show strongly positive phototaxis, which decreases in the last nauplius stage (Lang et al., 1979). Both eggs and nauplii of *A. improvisus* are smaller than those of most other barnacle species (Barnes & Barnes, 1965; Ross et al., 2003). Development through the six nauplius stages takes about one week in the laboratory (O'Connor & Richardson, 1996; Dahlström et al., 2000), but this depends on temperature. Metamorphosis has been described and illustrated in great detail (Doochin, 1951). Cypris larvae are most prone to settling when they are 3-4 days old (Sjögren et al., 2008). Settlement increases in the presence of extract from adult conspecifics, and significantly more cyprids settled at 5 and 10 ppt than at other salinities between 2 and 35 ppt (Dineen & Hines, 1992). Also, the cyprids prefer rough surfaces over smooth ones, and preferentially settle in depressions (Rainbow, 1984).

Impacts

Like other barnacles, *A. improvisus* is part of the fouling community, attaching to ships' hulls and other man-made structures. It may form dense layers on the surface of these structures, inhibiting water flow, attracting associate fauna and producing organic debris (Leppäkoski, 1999). Hence many studies have been made on factors controlling settling (Dineen & Hines, 1992; O'Connor & Richardson, 1996; Gamfeldt et al., 2005; Zega et al., 2007) and developing antifouling agents. Larvae of *A. improvisus* are used on a regular basis in toxicity tests, especially in connection with antifouling substances (Berntsson et al., 2000; Dahlström et al., 2000; Sjögren et al., 2004, 2008; Toth & Lindeborg, 2008). Neurotransmitters play an important role in barnacle settling, but different neurotransmitters may be necessary for different species. For *A. improvisus* dopamine stimulates settling whereas in *A. amphitrite* serotonine is the stimulating agent (Zega et al., 2007). In the Baltic where *A. improvisus* is the only barnacle the fouling impacts may be considerable, e.g. the costs of cleaning pipes of power plants, etc. (Leppäkoski & Olenin, 2000). However, in other areas the same impacts are done by native barnacles.

Amphibalanus improvisus is a strong competitor for space (Dürr & Wahl, 2004; Gamfeldt et al., 2005), but it does not have a negative effect on community diversity in the Baltic (Dürr & Wahl, 2004).

Amphibalanus improvisus has been proposed as a biomonitor for heavy metals (Rainbow et al., 2000, 2002, 2004). However, it usually does not live longer than two years and thus has limited value for long-term studies.

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