

Wild cyprids metamorphosing in vitro reveal the presence of *Balanus amphitrite* Darwin, 1854 in the German Bight basin

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Abstract

Balanus amphitrite has not been recorded in the German Bight until now. However, harbour water from the East Frisian Island Norderney contained cyprids identified as *B. amphitrite*. Following these observations in summer 2002 the search for adult individuals in the German Bight, especially in the harbour of Norderney was enhanced with regular inspections until 2007. The consistent absence of adult individuals indicates that the cyprids are unable to settle under the environmental conditions in the German Bight. In contrast, wild cyprids settled and metamorphosed spontaneously within one day after transfer into the laboratory, where the temperature of the untreated seawater was raised from 18 to 27°C. The findings suggest that there is a threshold temperature critical for the successful recruitment of settling stages in the German Bight with the local water temperatures being currently too low.

Key words: *Balanus amphitrite*, alien species, North Sea, German Bight, settlement threshold

Darwin (1854) noted that *Balanus amphitrite* and a few other barnacles "seem to range over nearly the whole world (except the colder seas)". This cirripede has primarily spread as hull fouling organism on ships although it may also be transported with oyster shipments or in ballast water. Based on the presence of Pleistocene fossils this acorn barnacle is considered native to the Indian Ocean and the southwestern Pacific; and to have been introduced into the North Pacific and the Atlantic Oceans, for which no fossil records exist (Eno et al. 1997). Darwin (1854) mentioned this species inter alia from the Mediterranean and the Portuguese coast. It was found on the French Atlantic coast at La Rochelle in 1914 (Prenant 1929). When studying findings of *B. amphitrite* it seems reasonable that the barnacle reached the North Sea via the English Channel (see map, Figure 1). It was found in Shoreham Harbour on the south coast of

England in 1937 (Bishop 1950) before it was recorded in the North Sea. The first autochthonous record of *B. amphitrite* in the North Sea was in 1952 in the harbour of Oostende, Belgium, where it occurs now frequently. The cirripede was also found in Koksijde, first record 1995, near Oostende (Kerckhof 1996; Kerckhof and Cattrijsse 2001, see also the recent review by Kerckhof et al. 2007). Further east, in the Netherlands, *B. amphitrite* was only known from material washed ashore and from ships' hulls until the 1960s (Boschma et al. 1961). However, established specimens were found in the Dutch Delta area (Vlissingen) in a cooling water discharge canal in 1962, 1965, and 1967 (Borghouts-Biersteker 1969). From here it spread, invading Veerse Meer, first in 1970 and later reported as widely dispersed throughout this lake (Vaas 1975). Its present occurrence in the Netherlands seems to be rather limited.

Faasse (1996) states that the species has probably disappeared from the Kanaal door Walcheren and the Veerse Meer. There are no recent records of established populations in the Netherlands. The first appearance of *B. amphitrite* in the Netherlands is analogous to that in England, where it also invaded canals and harbours with artificially elevated water temperatures by cooling water discharges of power plants (Vaas 1975). *Balanus amphitrite* is now known to be established in Britain and

Ireland (Minchin and Eno 2002). Still, British records are limited to southern England and southern Wales, but there are no records from the British North Sea coast. Records show that *B. amphitrite* started to invade the North Sea half a century ago but is still limited to the Southern region (Belgian coast and The Netherlands-Delta area). It has never been recorded eastwards beyond the Frisian Islands including Danish waters (Jensen and Knudsen 2005) and the Baltic Sea (Leppäkoski and Olenin 2000).



Figure 1. Map of North Sea and adjacent waters showing records of *B. amphitrite* (for details see Annex 1)

Two juvenile barnacles were discovered after settling in an incubator, which was operated for the purpose of breeding brine shrimp. The first occurrence of one metamorphosed barnacle was in June 2002 and the second appeared approximately 3 weeks later. The *Artemia* incubator was filled with fresh unfiltered seawater taken from the port of Norderney (53°42.155'N, 7°09.781'E) as a daily routine. While the outside water temperature was between 18 and 22°C during the summer months, the water was heated to a temperature of 27–28°C in the incubator. The natural salinity was approximately 30 psu. The cypris larvae were accidentally introduced into the incubator. The time span available for the cyprids to settle was 1 day, after which the water was exchanged again. Upon discovering the

metamorphosed specimens, the barnacles were allowed to grow until they reached a base diameter of roughly 2 cm making their identification much easier. The two individuals were *B. amphitrite*.

The two larvae, which settled 3 weeks apart of each other in the laboratory, probably belonged to different cohorts meaning that the appearance of *B. amphitrite* larvae at Norderney was than just a coincidental. Observations indicate that *B. amphitrite* larvae might be frequent guests in the German Bight with the vector of shipping remaining speculative but may include water currents. Even though larvae are present in the water column, they do not seem to be able to settle. Field trials using exposure panels at Norderney have been conducted for a number of

years with constant observation of the macrofauna. However, so far no adult specimens of *B. amphitrite* were observed and no other records are known in the German Bight. The most recent checklist of aquatic alien species in Germany (Gollasch and Nehring 2006) does not include *B. amphitrite*.

Settlement and metamorphosis of cyprids into juveniles is a critical point during the ontogenesis of barnacles. The recruitment success of cyprids is strongly influenced by temperature and salinity (e.g. Qiu and Qian 1999), and it may be enhanced by the availability of high quality food/energy reserves accumulated during naupliar stages (e.g. Thiyagarajan et al. 2003). *Balanus amphitrite* larvae that were reared and fed in the laboratory were found to tolerate a wide range of temperatures (20–30°C) and salinities (10–45 psu) at the time of attachment (Konya et al. 1994). Rittschof et al. (1984) mentioned 28°C (at 30 psu) to be the optimum temperature for the metamorphosis of young cyprids of *B. amphitrite*. The latter coincides with the observations reported here. Cyprids settled in vitro at temperatures of 27–28°C. The spontaneous settlement and successful metamorphosis of the cyprids after their transfer into the laboratory indicate that their inability to settle in the field is strongly linked to low temperatures whereas a drop of energy reserves below a critical threshold level appears unlikely. The observations suggest that *B. amphitrite* requires temperatures of clearly more than 18°C to induce settlement under local conditions and 27–28°C being within the optimum range.

The new observations support the hypothesis that warm water species tend to immigrate into the German Bight. When found in nature, the occurrence of settled individuals of *B. amphitrite* in the German Bight will be an indicator of elevated temperatures in summer (if not indicating locally restricted areas of thermal pollution).

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Annex 1Records of *Balanus amphitrite* in the North Sea

Map Ref.	Location	Record coordinates		Record date	Reference
		Latitude, N	Longitude, E		
1	La Rochelle, France	46°09'	1°09'	1914	Prenant 1929
2	Shoreham, England	50°50'	0°17'	1937	Bishop 1950
3	Oostende, Belgium	52°46'	4°40'	1952	Kerckhof 1996
4	Vlissingen, Netherlands and other locations in Dutch Delta	51°27'	3°35'	1962	Borghouts-Biersteker 1969, Vaas 1975
5	Koksijde, Belgium	51°06'	2°39'	1995	Kerckhof 1996, Kerckhof and Cattrijsse 2001, Kerckhof et al. 2007
6	Norderney	53°42'	7°10'	2002	Present study