

Rapid Communication

First record of the Asian crab *Hemigrapsus takanoi* Asakura & Watanabe, 2005 (Decapoda, Brachyura, Varunidae) in the Baltic Sea

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Abstract

Twenty years after its initial introduction to Europe, the Asian brush clawed crab *Hemigrapsus takanoi* is now a successful invader of the European Atlantic and North Sea coasts from northern Spain to southern Denmark. In July 2014, this species was recorded in the Baltic Sea for the first time, as eight individuals were found in the inner Kiel Fjord, Schleswig-Holstein, Germany. To date, a total number of 19 individuals have been collected. Findings of an ovigerous female and of juvenile crabs among the collected individuals indicate that *H. takanoi* most likely already reproduces successfully in the Baltic Sea.

Key words: Asian brush-clawed crab, Brachyura, Baltic Sea, invasive, non-indigenous

Introduction

Since the mid-1990s, the Asian brush-clawed crab *Hemigrapsus takanoi* Asakura and Watanabe, 2005, native to the Western Pacific, has been invading the intertidal zone of the European Atlantic and North Sea coasts. Initially identified as *H. penicillatus* (DeHaan, 1835) (Gollasch 1999; Noël et al. 1997), the invasive populations in Europe were later reassigned to a newly-described sibling species of *H. penicillatus*, *H. takanoi* (Asakura and Watanabe 2005). Recent morphological and genetic studies confirmed the identification of *H. takanoi* as the invasive brush-clawed crab in Europe (Markert et al. 2014; Asakura et al. 2008; Yamasaki et al. 2011).

The first record of *H. takanoi* in Europe was based on several individuals found on a ship's hull at Bremerhaven harbour (Germany) in 1993 (Gollasch 1999). A reproducing population of *H. takanoi* was found close to La Rochelle (France) in 1994, from where it spread rapidly along the French and Spanish Bay of Biscay coast (Noël et al. 1997), expanding as far north as the Morbihan

Gulf in southern Brittany (Noël and Gruet 2008). In 1999, the species was found at Le Havre harbour (France) and in the Oosterschelde (Netherlands), together with another invasive Asian crab, *Hemigrapsus sanguineus* (DeHaan, 1835) (Breton et al. 2002; Gittenberger et al. 2010). Both species then almost simultaneously expanded their range along the French coast of the English Channel and northeastwards into the North Sea. *Hemigrapsus takanoi*, in particular, spread along the Bay of Seine coast to the eastern Cotentin peninsula and further north towards the Belgian frontier, while only single individuals were reported from the western Cotentin coast (Dauvin et al. 2009; Dauvin and Delhay 2010; Gothland et al. 2014). It reached Belgian waters in 2003 (Kerckhof et al. 2007), the Dutch Wadden Sea between 2004 and 2006 (Gittenberger et al. 2010), the German Wadden Sea in 2007 (Obert et al. 2007), and finally the islands of Rømø and Fanø (Denmark) in the northernmost part of the Wadden Sea in 2011/12 (K. Reise, Alfred-Wegener-Institute List/Sylt, pers. comm. 2014). Thus, the current distribution of *H. takanoi* in Europe includes the Atlantic coast

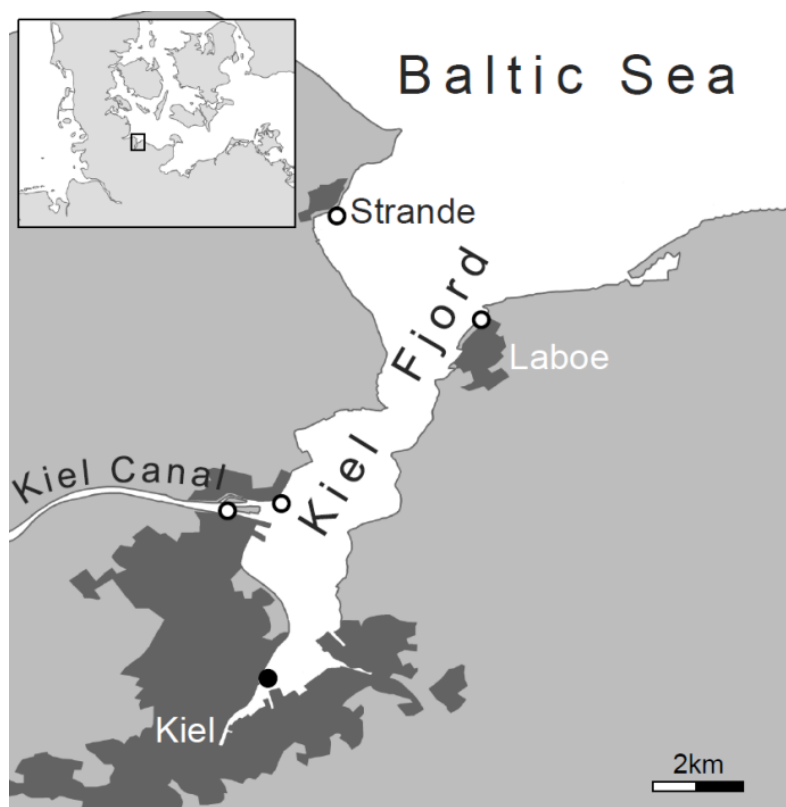


Figure 1. Kiel Fjord sampling sites in summer 2014. Solid circle: *H. takanoi* present; open circles: *H. takanoi* not present. Small map: situation of Kiel Fjord in the southwestern Baltic Sea.

from northern Spain to southern Brittany, the continental English Channel and southern North Sea coast from the Cotentin peninsula to the Dutch Delta, and the whole Wadden Sea.

The Baltic is, as a geologically young sea that underwent several major hydrological conversions, strongly influenced by the immigration and establishment of species from adjacent water bodies (Leppäkoski et al. 2002). Human-mediated introductions account for about 100 non-indigenous species that have invaded the Baltic Sea since the 19th century (Leppäkoski et al. 2002). Among these are two non-indigenous brachyuran crabs that developed invasive populations in the Baltic Sea over several decades: The North American mud crab *Rhithropanopeus harrisii* (Gould, 1841) initially found in the Kiel Canal in 1936 (Schubert 1936) and the Vistula Lagoon in 1948 (Jazdzewsky and Grabowski 2011); and the Chinese mitten crab *Eriocheir sinensis* (H. Milne Edwards, 1853), found for the first time in the Baltic Sea in 1926 (Jazdzewsky and Grabowski 2011). In this study, we report the first occurrence of *H. takanoi* as a third invasive brachyuran crab in the Baltic Sea.

Methods

The first crab specimens were collected 8 July 2014 while sampling seafloor and fouling communities on the quay walls and footbridge poles of a marina in the innermost part of Kiel Fjord, Schleswig-Holstein, Germany (54°19.669'N, 10°08.847'E; Figure 1) with a scraping scoop (mesh size 0.5 mm). Water depth at this site was about 2 m, and the seafloor consisted of fine sediment with scattered small boulders and mussel clumps. The water temperature in the inner Kiel Fjord ranges between 2.8 °C in February and 19.5 °C in July (1.5 m water depth, monthly average 2014; data provided by GEOMAR Helmholtz-Centre for Ocean Research Kiel, Research Division 1, Marine Meteorology 2015). The salinity in this part of the Baltic Sea (measured at Boknis Eck time series station) ranges between 13.5 in May and 19.2 in January and November (1 m water depth, 10-year average 2004–2014; Lennartz et al. 2014).

Additional sampling at the same site, as well as rapid assessment surveys around the Kiel Canal sluices and at Strande and Laboe at the entrance

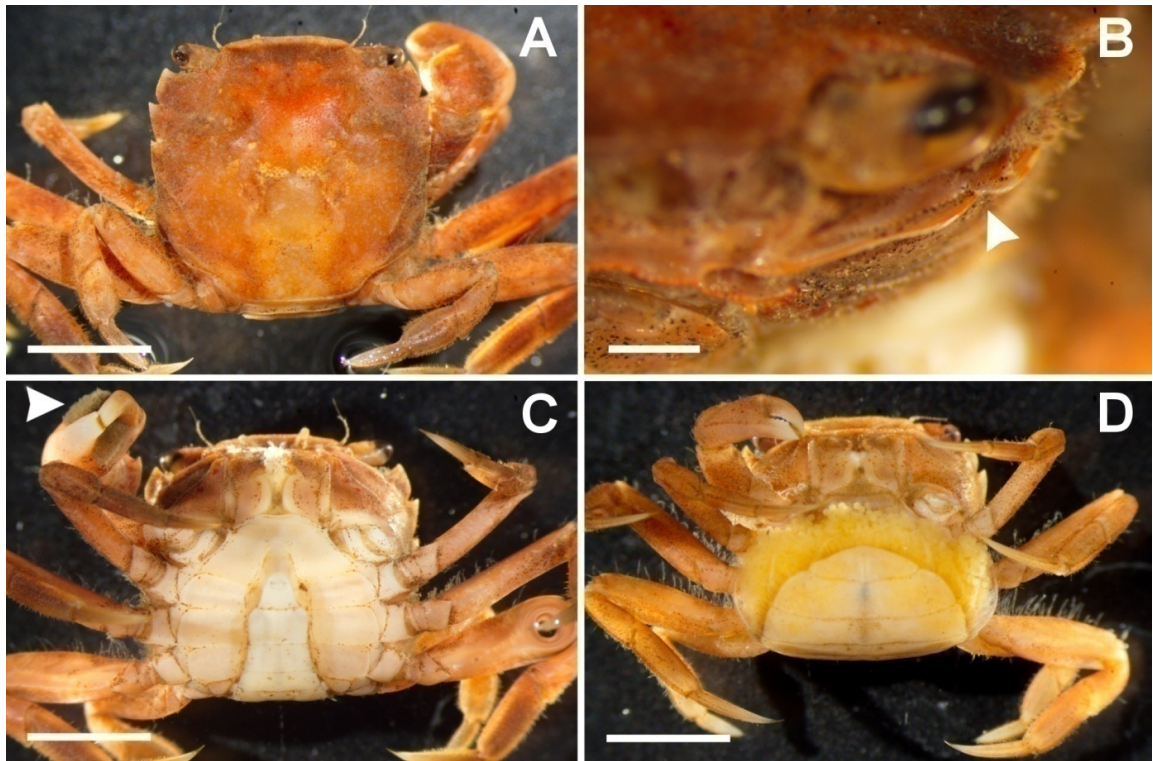


Figure 2. *Hemigrapsus takanoi* collected in Kiel Fjord 8 July 2014: A) male, dorsal view, scale bar 5 mm; B) male, detail of the cephalothorax, frontal view with interrupted suborbital ridge (arrow), scale bar 1 mm; C) male, ventral view with chelar setal patch visible (arrow), scale bar 5 mm; D) ovigerous female, ventral view, scale bar 5 mm. Photographs by J. Geburzi.

of Kiel Fjord, were performed in the following weeks (Figure 1; Appendix 1). These surveys were conducted by one or two collectors, sampling each site for 40 minutes (one collector) or 20 minutes (two collectors), respectively. Samples were taken from the seafloor, boulder revetments, and harbour buildings in near-shore shallow water up to 2.5 m depth, again using scraping scoops of 0.5 mm mesh size.

The collected crabs were identified, sex determined, and their carapace width (CW) was measured to the nearest 0.1 mm. For species identification, the characters given in Breton et al. (2002) and Asakura and Watanabe (2005) were used, especially the presence of three lateral spines on the dorsal carapace (Figure 2A), of an interrupted infraorbital ridge (both sexes; Figure 2B), and of a chelar setal patch (only in males; Figure 2C). All individuals were fixed in 12% formalin solution and stored in 75% ethanol at the Zoological Museum Kiel (catalogue numbers ZMK 3500 to ZMK 3503).

Results and discussion

During the summer 2014, the first records of *H. takanoi* in the Baltic Sea were made at a marina in the inner Kiel Fjord, 20 years after the species' initial invasion to Europe. Two individuals, an adult male (11.2 mm CW; Figure 2C) and an ovigerous (egg-carrying) female (10.2 mm CW; Figure 2D) were captured on 8 July 2014. Seventeen other individuals were captured from the same spot during subsequent samplings from July to early November. Among them were several juvenile crabs measuring less than 5 mm CW (see Appendix 1 for details). No *H. takanoi* were found during the snapshot-survey around the Kiel Canal sluices and also none at Strande and Laboe at the entrance of Kiel Fjord, even though these places offer suitable habitat with extensive boulder revetments and other hard structures in the littoral and shallow sublittoral zone.

In an earlier study, Noël et al. (1997) concluded that expansion of the distribution of *H. takanoi*

into the Baltic Sea was likely due to the species' tolerance of low salinity. The *H. takanoi* population in Tokyo Bay lives in waters with salinity values as low as 7 (Mingkid et al. 2006), which is considerably lower than the salinity of 16 recorded in the inner Kiel Fjord in July 2014 (monthly average, data provided by GEOMAR Helmholtz-Centre for Ocean Research Kiel, Research Division 3, Marine Ecology 2014). Thus, it can be assumed that *H. takanoi* will be able to establish a reproducing population in the western and southern Baltic Sea. The collection of an ovigerous female and of several juveniles (< 10 mm CW), the smallest measuring only 4.1 mm CW, supports this assumption. However, the further expansion of *H. takanoi* into the Baltic Sea might be restricted by the salinity gradient occurring from the south-western towards the northeastern part (Leppäkoski et al. 2002).

The Kiel Canal between Brunsbüttel on the Elbe estuary and Kiel, connecting the North and Baltic Seas, formed most likely the invasion pathway of *H. takanoi*. With more than 30,000 ships using the canal annually (Wasser- und Schifffahrtsdirektion Nord 2013), it is one of the most frequented artificial waterways worldwide and is assumed to be a major invasion pathway into the Baltic Sea (Leppäkoski et al. 2002). There are three possible ways how *H. takanoi* could have crossed the canal: First, crabs could have spread naturally along the canal from west to east. This appears to be unlikely because we would have expected to find *H. takanoi* around the sluices rather than in the innermost part of Kiel Fjord. Likewise, Landschoff et al. (2013) found no *H. takanoi* at Brunsbüttel, on the western entry to the canal. Second, crab larvae could have been transported in ballast water of ships coming in from one of the North Sea or European Atlantic ports. In such a case, the initial introduction would have happened in 2013 or earlier taking into account the findings of several adult and apparently reproducing crabs. Third, adult crabs could have been transported as hull fouling of a ship, probably a recreational boat or a cruise ship. We assume this vector to be the most likely due to the fact that the only spot where *H. takanoi* has been found to date is a marina in close proximity to cruise ship terminals. Recreational ship traffic plays an important role in the short- and medium-distance secondary spread of invasive crustaceans (Hänfling et al. 2011). During the summer months, the Kiel Canal is used extensively by recreational boats travelling between the Wadden and Baltic Seas.

The fact that *H. takanoi* was not reported from Kiel Fjord before summer 2014 suggests a recent introduction, while at the same time the collection of different size juvenile crabs indicates successful reproduction of *H. takanoi* for at least one season. These observations point towards an extremely rapid establishment of a reproducing population that was facilitated by the introduction of adult individuals.

The first occurrence of *H. takanoi* in Kiel Fjord offers an opportunity to study mechanisms and impacts of a crustacean invasion into a new ecosystem from its very beginning. A careful study of the population development and expansion of *H. takanoi* is suggested, including monitoring of suitable habitats, especially harbours, in the southwestern Baltic Sea during the next few years. Of particular interest are possible interactions of *H. takanoi* with the native European shore crab *Carcinus maenas* as well as with the two other brachyuran invaders, *Eriocheir sinensis* and *Rhithropanopeus harrisi*, as studies in the Netherlands (van den Brink et al. 2012) and France (Gothland et al. 2014) have already shown the strong competitive abilities of *H. takanoi* might have negative impacts on other crab species.

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Appendix 1. Records of *Hemigrapsus takanoi* in Kiel Fjord in summer and fall 2014, for locations see map (Figure 1); n: number of individuals, m: male, f: female, ov: ovigerous, j: juvenile, ZMK No.: catalogue number Zoological Museum Kiel.

Location	Sampling site coordinates		Date	n	CW [mm]	ZMK No.
	Latitude, N	Longitude, E				
inner Kiel Fjord	54°19.669'	10°08.847'	08 Jul 2014	1 m, 1 f (ov)	10.2–11.2	ZMK 3500
inner Kiel Fjord	54°19.669'	10°08.847'	17 Jul 2014	3 m, 2 f	11.1–15.1	ZMK 3501
Laboe, beach	54°24.638'	10°13.554'	19 Jul 2014	-		
Strande, harbour	54°26.093'	10°10.230'	19 Jul 2014	-		
inner Kiel Fjord	54°19.669'	10°08.847'	22 Jul 2014	1 m	12.4	ZMK 3502
Kiel Fjord, Holtenu	54°22.139'	10°09.259'	13 Aug 2014	-		
Kiel Canal, Holtenu	54°22.175'	10°08.211'	13 Aug 2014	-		
inner Kiel Fjord	54°19.671'	10°08.844'	26 Sep 2014	1 j	4.1	ZMK 3503
inner Kiel Fjord	54°19.671'	10°08.844'	01 Nov 2014	4 m, 2 f, 4 j	4.6–10.4	ZMK 3504