Oceanological and Hydrobiological Studies

International Journal of Oceanography and Hydrobiology

Volume 50, No. 3, September 2021
pages (352-358)

sciendo

ISSN 1730-413X
eISSN 1897-3191

First record of the rare crab *Asthenognathus atlanticus* Monod, 1933 (Crustacea: Brachyura: Varunidae) in the North Sea

by

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DOI: **10.2478/oandhs-2021-0030**
Category: **Short communication**
Received: **December 7, 2020**
Accepted: **March 26, 2021**

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Abstract

Several species new to the area were collected while monitoring Dutch marine waters using a dredge. The varunid crab *Asthenognathus atlanticus* Monod, 1933 was recorded for the first time in the North Sea. Until 2008, this relatively rare crab was known from the west coast of Africa and the western Mediterranean to northern Brittany in the north. In recent years, its distribution range has expanded, as indicated by records from the Bay of the Seine and the area around Dieppe-Le Tréport. Our finding from Brown Bank (southern North Sea) indicates a further, northward expansion of its distribution range. We list the hosts with which the crab is associated. Earlier arguments for climate change as an explanation for the northward range expansion are supported.

Key words: *Asthenognathus atlanticus*, range expansion, climate change, new record, commensalism

online at www.oandhs.ug.edu.pl

1. Introduction

Representatives of the brachyuran family Varunidae occur in tropical to temperate regions throughout the world and currently include 150 identified species (Ng 2006). Varunid crabs are characterized by one of the most diverse habitat ranges, from freshwater to seawater and from shallow waters to the deep sea (Ng 2006; Ng et al. 2008). Some species occur in specific environments, such as anchialine caves and hydrothermal vents. Many species of Varunidae are known from only a few specimens due to their highly specialized habitats and often very cryptic habits (Ng 2006; Ng et al. 2008). According to Bos et al. (2016), only three species of Varunidae have been known so far from Dutch waters, namely *Eriocheir sinensis* H. Milne Edwards, 1853, *Hemigrapsus sanguineus* (De Haan, 1835) and *H. takanoi* Asakura & Watanabe, 2005. All three are East Asian species that were introduced into European waters in the last century and have become invasive (Schnakenbeck 1924; Noël et al. 1997; Breton et al. 2002; d'Udekem d'Acoz & Faasse 2002; Asakura & Watanabe 2005). In February and March 2019, a regular (performed once every three years) macrofaunal monitoring survey was carried out in ecologically highly valuable areas (Lindeboom et al. 2005) in the Dutch part of the North Sea, characterized by a high BISI (Benthic Indicator Species Index; Wijnhoven & Bos 2017). As part of this and other monitoring projects, Rijkswaterstaat, the executive agency of the Ministry of Infrastructure and Water Management, collects data to investigate the status and describe trends in important North Sea habitats. These data form the basis for the calculation of the Benthic Indicator Species Index (BISI), which is used for habitat assessments under the Marine Strategy Framework Directive, the Habitats Directive and Natura 2000 management plans with the goal to assess the effectiveness of conservation measures (Wijnhoven & Bos 2017). The objective of the monitoring research cruise, upon which this manuscript is based, was to assess the density and biomass of macrobenthic species larger than five millimeters. During the cruise, a specimen of *Asthenognathus atlanticus* Monod, 1933, a crab species not previously recorded from the North Sea, was caught on Brown Bank.

2. Materials and methods

Samples were collected from 187 locations in different areas of the Dutch Exclusive Economic Zone – from Brown Bank, Dogger Bank, Frisian Front, Oyster Grounds and north of the Dutch Wadden Islands – in February and March 2019. Sampling was carried out by NIOZ, Eurofins AquaSense and eCOAST, commissioned by Rijkswaterstaat, using the vessel "Arca".

All sites were sampled with a Triple-D dredge of NIOZ, which quantitatively samples larger, often more sparsely distributed and longer-lived in- and epifauna (Witbaard et al. 2013). At each sampling site, a strip of seabed was excavated to a depth of 20 cm (+/– 5 cm) below the sediment surface. The strip was 20 cm wide and about 100 m long (range within 90–110 m). The sediment was then washed through 5 × 5 mm meshes of a dredge case and a 7 mm stretched mesh net astern the dredge while towing the dredge through the sediment. If necessary, the contents of the dredge net were flushed over a 1 mm sieve on board to remove remaining mud and subsequently sorted on a table. Living organisms were sorted by species, counted and weighed. All organisms were subsequently discarded, except for three voucher specimens of each species at each of the sampling sites mentioned above and specimens unidentifiable on board, which were preserved in ethanol 70%. All dredge contents were examined by at least two analysts. Local field guides were used for identification, especially issues of the "Synopsis of the British Fauna". Specimens that could not be identified on board were taken to the laboratory for identification using other literature sources. The specimen of *A. atlanticus* was identified based on information provided by Monod (1933) and Bocquet (1963).

2.1. Study area

The study area, the areas of high ecological value and the sampling locations are shown in Figure 1. Soft sediments, sand and mud, dominate throughout the sampling area, while gravel, stones or boulders are extremely rare.

Brown Bank was visited as part of the sampling campaign. It is an area characterized by relatively high current velocities and sand waves in the north-south direction (van der Reijden et al. 2019). Brown Bank is located at the center of the southern North Sea (Fig. 1) and has an average depth of 32 m, with the shallowest part at 19 m. The ridges rise to approximately 20 m above the surrounding seabed. The sediment of Brown Bank consists of medium sand (Wentworth scale), with a median grain size varying between 250 and 300 μm, as well as clay and boulders between the sand ridges. Brown Bank is an area frequently visited by beam trawl vessels. The percentage of organic matter in the sediment is generally low and the oxidized sediment layer is roughly 20 cm thick (García et al. 2019). Large-scale sandbank structures, perpendicular sand

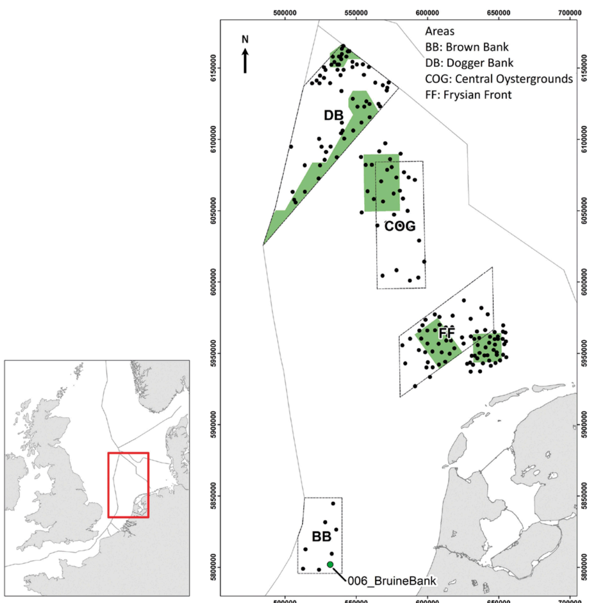

Figure 1

Map of the North Sea with areas of high ecological value on the Dutch Continental Shelf, proposed nature reserves (green), sampling locations in February and March 2019 (black dots), including the sampling location where *Asthenognatus atlanticus* was collected (green dot) on Brown Bank. Coordinate system WGS84 in a UTM 31N projection

waves and small sand waves are present on Brown Bank. Slopes of sand waves consist of finer sediments and sand wave valleys consist of coarser and more mixed sediments (van der Reijden et al. 2019).

3. Results

At one sampling site on Brown Bank (site code 006_BruineBank; dredge haul from 52°21′58.0788″N and 3°27′47.664″E to 52°21′55.5408″N and 3°27′51.3756″E; EPSG4258; average dredge haul depth of 32 m), one specimen of a crab species hitherto unknown from Dutch waters was collected on 24 March 2019 (Fig. 2). The sediment at this location was described during sampling as 'sand with shell grit'. In the laboratory, a crab with a carapace width of 7.5 mm was identified as *Asthenognathus atlanticus* Monod, 1933 (Grapsoidea: Varunidae: Asthenognathinae). Morphological characters of our specimen match those described by Monod (1933) and Bocquet (1963).

The main diagnostic characters of this small crab are as follows (described by Bocquet 1963): (1) irregularly hexagonal carapace (about 1.6 to 1.8 times wider than long); (2) relatively small chelipeds; (3) the second and especially the fifth pereopods strongly reduced in size; (4) merus, carpus and propodus of the third and fourth pereopods clearly enlarged (while quite thin in juveniles); (5) in live specimens, the second to fifth pereopods are held between parallel tangents, running along the anterior and posterior boundaries of the carapace; and (6) the second to fourth pereopods with a distinct wine-red colored band in the distal half of the propodus. In our specimen, this colored band is present throughout the propodus and on the second and third pereopods also on the distal half of the carpus. This difference may be related to its smaller size, as Bocquet (1963) found that coloration changes across developmental stages.

Figure 2

Asthenognathus atlanticus from Brown Bank; dorsal view. Scale bar = 10 mm. RMNH.CRUS.D.57968

Although not fully grown – the carapaces of the largest female and male found by Bocquet (1963) were respectively 14.5 mm and 12.9 mm wide, this crab was clearly a male specimen, as indicated by the narrow abdomen (Fig. 3). The propodus of the cheliped is enlarged, and the dactylus and finger of the propodus are relatively short as described for the male by Bocquet (1963).

Figure 3

Asthenognathus atlanticus; ventral view with chelipedes (Brown Bank). Scale bar = 10 mm. RMNH.CRUS.D.57968

Given the irregularly hexagonal carapace shape and the Atlantic distribution area of this small crab, we propose 'Atlantisch zeshoekkrabbetje' as the Dutch vernacular name. The single specimen of *A. atlanticus* has been deposited in the collection of the Naturalis Biodiversity Center, Leiden (RMNH.CRUS.D.57968).

4. Discussion

4.1. Identification and congeneric species

The genus *Asthenognathus* Stimpson, 1858, currently comprises three species, i.e. *Asthenognathus inaequipes* Stimpson, 1858 and *A. hexagonum* Rathbun, 1909, both from the Indo-West Pacific, and *A. atlanticus* Monod, 1933, from the eastern Atlantic, including the western Mediterranean (Ng et al. 2008; Naruse & Clark 2009).

Morphological differences between the three species of *Asthenognathus* are minor. Naruse & Clark (2009) stated that *A. atlanticus* has a *Gopkittisak*-type third maxilliped, with an oblique boundary between the merus and ischium and long setae on the dactylus, as is also the case in our specimen (Fig. 4). Perhaps the oblique boundary is currently the most distinct differentiating character, with the boundary being transverse in *A. inaequipes* and *A. hexagonum*.

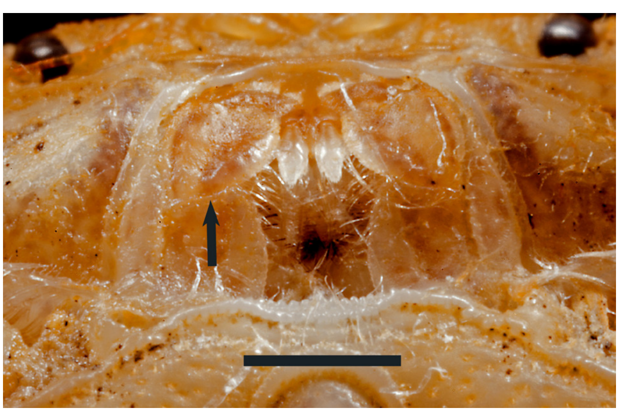

Figure 4

Asthenognathus atlanticus, third maxilliped, with a boundary between merus and ischium arrowed (Brown Bank). Scale bar = 1mm. RMNH.CRUS.D.57968

4.2. Distribution and climate change

A. atlanticus was originally described from the Atlantic side of Morocco by Monod (1933). Table 1 summarizes data on its current distribution. Until 2008, the northernmost records came from northern Brittany (Glémarec & Hily 1979). Since 2008, *Asthenognathus atlanticus* has been recorded from the Bay of the Seine (Jourde et al. 2012) and since 2015 it has been recorded from the Dieppe–Le Tréport area, even further north but still in the eastern English Channel (Pezy & Dauvin 2016). These are the northernmost records to date. Our record is the first one from the North Sea. This record does not prove the existence of an established population in the southern North Sea, but in light of recent range expansions in the eastern English Channel, it may be the first indication of an expansion into the North Sea.

In general, water temperatures in shallow seas further from the ocean are more similar to air temperatures than those in deeper waters closer to the ocean. For example, the shallow southern North Sea exhibits more extreme temperature fluctuations than more stable waters of the central and northwest North Sea (MacKenzie & Schiedeck 2007). The recent (1983 to 2012) increase in annual mean sea surface temperature in the North-East Atlantic Ocean is even more pronounced in the eastern English Channel and the southern North Sea (Dye et al. 2013). Perhaps the most convincing evidence of increased average temperature for Brown Bank and the surrounding area is provided by Hughes et al. (2017; Fig. 10). They demonstrated an average increase in sea surface temperature in the southern North Sea of 0.5 °C per decade over the years 1984–2014. This is higher than for any other region in the NE Atlantic (Hughes et al. 2017; Fig. 10). According to Pezy & Dauvin (2016), the impact of climate change is indeed greater in the eastern English Channel than in the western English Channel, which is one of the main reasons why they hold climate change accountable for the range expansion of *A. atlanticus* to the eastern English Channel. Jourde et al. (2012) have already suggested climate change as a possible explanatory factor for the range expansion of *A. atlanticus* from Brittany to the Bay of the Seine, with examples of other species exhibiting similar expansions. Pezy & Dauvin (2016) proved the plausibility of this phenomenon with data on larval duration and coastal current velocities and directions, and predicted a range expansion to the North Sea. There are several recent examples of invertebrates expanding their distribution range from the English Channel to the North Sea, in at least one case via larval transport. For example, in 2005, a sedentary juvenile of the mantis shrimp *Platysquilla eusebia* (Risso, 1816) was found on Dogger Bank in the North Sea, and larvae of this species had already been collected in the North Sea in previous years (Lewis & Gittenberger 2013). Another example of range expansion of a southern crab, i.e. *Liocarcinus vernalis* (Risso, 1827), to the North Sea was given by d'Udekem d'Acoz & Rappé (1991).

Table 1

Chronological distribution data and ecological data from the literature and our sampling

region	period	depth (m)	sediment	number	associates	source
Gold Coast (= Ghana) to Roscoff, including W Mediterranean Sea	1932–1977	0–200	mud, muddy sand, sandy mud	1–40	*Cerianthus membranaceus* (Gmelin, 1791), *Sipunculus nudus* Linnaeus, 1766, *Oestergrenia digitata* (Montagu, 1815)	Glémarec & Hily (1979), partly cited from earlier sources
Bay of the Seine	2008–2011	10–25	mud, muddy sand, sand	30	*Terebellides stroemi* Sars, 1835, *Lanice conchilega* Pallas, 1766, *Upogebia deltaura* (Leach, 1816)	Jourde et al. (2012)
Dieppe–Le Tréport	2015–2018	12–25	including coarse sand		*Chaetopterus variopedatus* (Renier, 1804), *Cerianthus lloydii* Gosse, 1859	Pezy & Dauvin (2016)
southern North Sea	2019	32	sand with shell grit	1	*Callianassa subterranea* and/or *Gilvossius tyrrhenus*, *Echinocardium cordatum*	this paper

4.3. Ecology

Data on the depth range of *A. atlanticus*, the inhabited sediments and the invertebrate species with which the crab appears to be closely associated in its burrow are summarized in Table 1. Few data on predation have been published. Glémarec & Hily (1979) report 21 specimens in the stomachs of thornback rays *Raja clavata* Linnaeus, 1758 in the Baie de Douarnenez. Pezy & Dauvin (2016) report two of 31 specimens from the stomachs of thornback rays.

In our sample, we found the crab together with parts of thalassinid decapods *Callianassa subterranea* (Montagu, 1808) and/or *Gilvossius tyrrhenus* (Petagna, 1792), and the irregular sea urchin *Echinocardium cordatum* (Pennant, 1777). One of these species may be a previously unknown host for *A. atlanticus*. We cannot rule out the possibility that the crab is able to live "free" or in self-constructed burrows. For example, Pezy & Dauvin (2016) found three out of 29 reported specimens in samples without large burrowing megabenthos species. Already Glémarec & Hily (1979) stated that commensalism of *A. atlanticus* with burrowing megafauna is not obligatory. *A. atlanticus* is usually collected as a single individual in a tube; however, Bocquet (1963) found a couple on two occasions. The crab appears to be relatively rare throughout its distribution range (Monod 1933; Bocquet 1963; Glémarec & Hily 1979; Jourde et al. 2012; Pezy & Dauvin 2016), which may be either a real phenomenon or an artifact caused by its concealed mode of life.

Acknowledgements

Jan van Dalfsen, Maarten Zwarts (tFC, the Fieldwork Company), Anke Engelberts, Saskia Honcoop and Erik Sanders (Eurofins AquaSense) were involved in sample processing on board. Evalien van Weerlee and David Huijsman (NIOZ) helped with sample processing and operated the dredge. The crew of the vessel "Arca" (Rijksrederij) is acknowledged for their assistance and hospitality. Edwin Verduin (Eurofins AquaSense) provided us with Figure 1. The comments of two anonymous reviewers are gratefully acknowledged.

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