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Rapid Communication

The Pacific amphipod *Monocorophium uenoi* (Stephensen, 1932) introduced to The Netherlands (NE Atlantic)

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Abstract

Examination of mud from crevices beneath Pacific oysters *Crassostrea gigas* (Thunberg, 1793) in The Netherlands revealed the presence of the Pacific amphipod *Monocorophium uenoi* (Stephensen, 1932), which was not recorded previously from the Atlantic. The most likely introduction vector to The Netherlands was import of shellfish. The only location where the amphipod was found was the center of shellfish trade, Yerseke.

Key words: *Monocorophium uenoi*, introduction, Atlantic, shellfish

Introduction

The delta area in the southwest of The Netherlands is a hotspot for marine and estuarine species introductions. Regular assessment surveys specifically aimed at introduced species are not conducted in this area; thus, records of newly introduced species often are the by-product of surveys with different aims.

The fauna from mud in crevices beneath Pacific oysters *Crassostrea gigas* (Thunberg, 1793) in The Netherlands was surveyed during July and August 2013. During this survey, a number of amphipods that were not identifiable with manuals for NE Atlantic fauna were detected. The present study identified the corophiid amphipod species collected from beneath the oysters and provides a description to assist researchers in recognising this newly introduced species, *Monocorophium uenoi* (Stephensen, 1932).

Materials and methods

Study area

Five locations in the southwestern delta area of The Netherlands were selected for the survey (Appendix 1). Locations include sites along the shellfish culture area Oosterschelde (Yerseke, Goesse Sas, Zierikzee) and along the Westerschelde, shipping route to the port of Antwerp (Borssele, Vlissingen). Locations also include a site close to the water discharge of shellfish storage basins (Yerseke) and a site with artificial warming of seawater by a power plant (Borssele). Yerseke is the national centre of shellfish trade of The Netherlands. It is situated along the Oosterschelde, a former estuary and now an embayment of the southern North Sea. The Oosterschelde is an important blue mussel (*Mytilus edulis* Linnaeus, 1758) culture area as well. Its shores are lined with stone dykes, near and below the low water

mark at most places protected with boulders. Naturalized Pacific oysters cover an important proportion of the intertidal and subtidal boulder area.

Sampling

At each location, 10 Pacific oysters occuring < 1 m above the low water line were selected. Oysters were dislodged from boulders with a sturdy screwdriver at low tide. The hard mud in crevices under the oysters was removed and taken apart in the field with forceps in strong sunlight, which induced most invertebrates to move. The process was repeated until all particles larger than about 1 mm were broken up. All invertebrates encountered were collected and preserved in 70% ethanol. As no sieves were used, the smallest organisms may have been missed.

Identification and photography

For identification of *Monocorophium* specimens to genus, the key in the publication by Bousfield and Hoover (1997) was used. For identification to species, keys in Crawford (1937), Lincoln (1979), Bousfield and Hoover (1997) and Kim (2011), the description of *M. uenoi* and the description of *M. josei* Valério-Berardo and Thiago de Souza, 2009 were consulted. A new key for *Monocorophium* species occurring in NW Europe has been constructed. Photographs were taken with a Canon 500D consumer grade reflex camera attached to a Standard Zeiss microscope.

Results

Yerseke is the only location where amphipods were collected from beneath Pacific oysters. The sampling location is a small area of boulders at the foot of the dyke at Yerseke, close to the water discharge of shellfish storage basins. The corophiid amphipods were identified as *Monocorophium uenoi* (Stephensen, 1932). On 16 July 2013, a single specimen was collected and, on 18 July 2013, 23 specimens were collected. Seventeen specimens collected on 18 July 2013 were deposited in the collection of Naturalis Biodiversity Center, Leiden with reg. no. RMNH.CRUS.A.5047.

Males of *Monocorophium uenoi* in NW Europe will be most likely confused with the congener *M. insidiosum* (Crawford, 1937), which is, however, a predominantly brackish-water species. Females of *M. uenoi* are most easily confused with female *M. insidiosum* or *M. sextonae* (Crawford, 1937), depending on the feature considered. Both males and females of the congener *M. acherusicum* (Costa, 1851) are rather different. Below a key to NW European *Monocorophium* species is given.

Key to NW European *Monocorophium* species, based on Crawford (1937), Lincoln (1979), Hirayama (1990) and Chapman (2007), combined with observations by the author:

1.- antenna 2, article 4 with ventrodistal tooth (Figure 1) (males)……2

- antenna 2, article 4 without ventrodistal tooth; ventrodistal spine may be present (Figure 2) (females)……5

2.- rostrum surpassing lateral lobes (Figure 3), uropod 1 inner margin with only distal spine (Figure 4), antenna 2 article 5 distally with ventromedial process……3

- rostrum not surpassing lateral lobes, uropod 1 inner margin with at least 3 spines, antenna 2 article 5 distally without ventromedial process..4

3.- antenna 1 article 1 without medial process, antenna 2 article 4 proximally with ventromedial spine, article 5 proximally with ventral process ……..*M. uenoi*

- antenna 1 article 1 with medial process, antenna 2 article 4 proximally without ventromedial spine, article 5 proximally without ventral process ……..*M. insidiosum*

4.- antenna 1, article 1 with maximum of three ventral teeth……..*M. acherusicum*

- antenna 1, article 1 with at least five ventral teeth……..*M. sextonae*

5.- antenna 2, article 4 with row of single spines (Figure 2)……...6

- antenna 2, article 4 with row of paired spines; distally in row a single spine may be present…..7

6.- antenna 2, article 4 without conspicuous medioventral flange (Figure 2), uropod 1 peduncle inner margin with only distal spine (Figure 4) ……..*M. uenoi*

- antenna 2, article 4 with conspicuous medio-ventral flange, uropod 1 peduncle inner margin with at least 3 spines……..*M. sextonae*

7.- antenna 2, article 4 with at least three pairs of spines, uropod 1 peduncle inner margin with at least 3 spines……*M. acherusicum*

- antenna 2, article 4 with 2 pairs of spines and a single distal spine, uropod 1 peduncle inner margin with one (distal) spine…....*M. insidiosum*

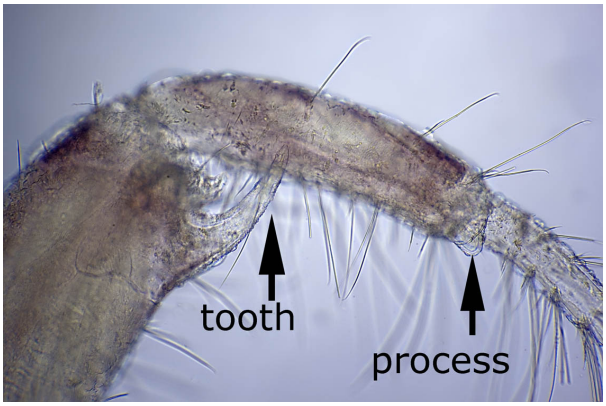

Figure 1. *Monocorophium uenoi*, antenna 2 peduncle article 4 and 5, male, 8/07/2013, Yerseke. Photograph by M.A. Faasse.

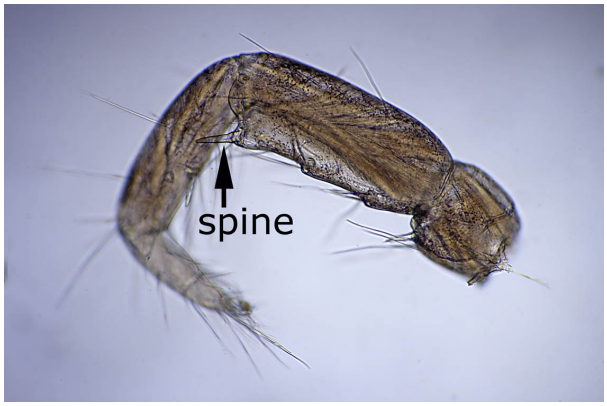

Figure 2. *Monocorophium uenoi*, antenna 2 female, 18/07/2013, Yerseke. Photograph by M.A. Faasse.

Figure 3. *Monocorophium uenoi*, male, antenna 1 removed, 18/07/2013, Yerseke. Photograph by M.A. Faasse.

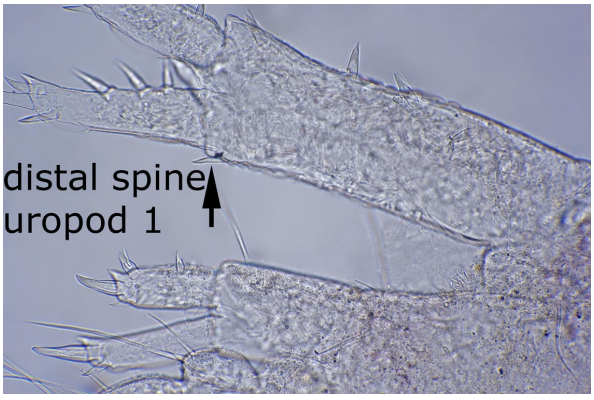

Figure 4. *Monocorophium uenoi*, uropod 1 and 2 female, 18/07/2013, Yerseke. Photograph by M.A. Faasse.

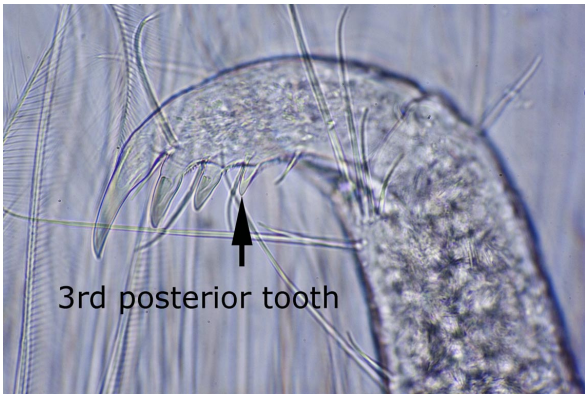

Figure 5. *Monocorophium uenoi*, gnathopod 2 dactylus, female, 18/07/2013, Yerseke. Photograph by M.A. Faasse.

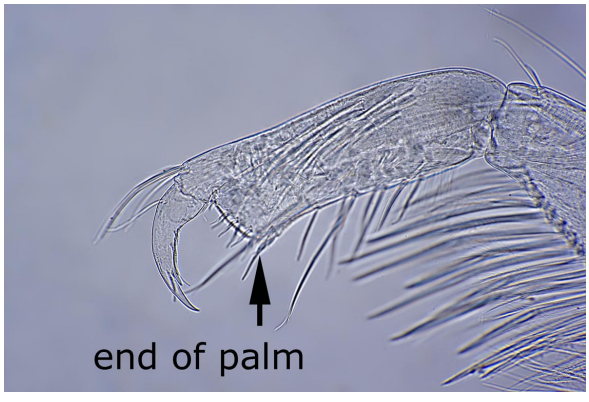

Figure 6. *Monocorophium uenoi*, gnathopod 1, dactylus and propodus, female, 18/07/2013, Yerseke. Photograph by M.A. Faasse.

Discussion

Identification

The identification key may not always distinguish between juvenile males of *M. uenoi* and *M. insidiosum*. Bousfield and Hoover (1997) give much weight to the number of posterior teeth on the dactylus of gnathopod 2. In both sexes of *M. uenoi*, the dactylus of gnathopod 2 has three or four posterior teeth (tip of dactylus not counted as tooth) (Figure 5). According to Chapman (2007), this character is too variable for species distinctions within *Crassicorophium* and *Monocorophium*. The dactylus of gnathopod 1 significantly surpasses the palm in most specimens of *M. uenoi* (Figure 6), but not in all.

Until now, *M. uenoi* had not been found in subtidal samples in The Netherlands (Faasse and van Moorsel 2000; Faasse and Stikvoort 2002), whereas *Monocorophium* species recorded previously from the NE Atlantic almost exclusively occur subtidally. *Monocorophium insidiosum* occurs predominantly in brackish waters, whereas *M. uenoi* occurs in fully saline waters, although it can withstand a lower salinity (Carlton 1979). This means that the identity of *Monocorophium* occurring intertidally in fully marine NE Atlantic waters deserves special attention.

The key does not accomodate *M. insidiosum* with two spines on the inner margin of uropod 1 as depicted by Bousfield and Hoover (1997) as these have not been reported from the NE Atlantic (Lincoln 1979; Myers 1982).

Ecology

The specimens of *M. uenoi* that Stephensen (1932) used for his description of the species originated from a tidepool. Carlton (1979) mentions mostly inshore locations and shallow depths for *M. uenoi* in the NE Pacific, but a few locations in the open sea at depths down to 24 m (Monterey Harbor) as well. Carlton (1979) apparently was in doubt with respect to records in the open sea ("if correctly identified") and thinks that they likely originate from intertidal populations. Barnard (1966), who mentions the Monterey Harbor record from 24 m as well, writes: "rarely occurring in the open sea, more often in lagoons or estuaries (…), intertidal to 2 m". Moore (1990) refers to specimens from hard substrata over a range of exposure conditions, mainly fairly sheltered, in tidepools and among algae in upper half of shore.

Interactions of *M. uenoi* with other biota have not been described in literature. To date, *Monocorophium uenoi* has only been found intertidally in The Netherlands. As *M. insidiosum*, *M. acherusicum* and *M. sextonae* have only been found subtidally in this country it will meet no competition of congeners in its current habitat. However, future competiton in the shallow subtidal and lower littoral, here or elsewhere in the NE Atlantic, cannot be ruled out. Amphipod species co-occurring with *M. uenoi* in crevices under Pacific oysters at Yerseke were *Hyale nilssoni* Rathke, 1843 and *Ptilohyale littoralis* (Stimpson, 1853) (Faasse, unpublished data). However, only *M. uenoi* was found in mud and hyalids are known as free-swimming during high tide (Bousfield and Hendrycks 2002).

Introduction to the NE Atlantic

Monocorophium uenoi was described from Japan (Stephensen 1932). The NW Pacific is generally considered as its native area (Bousfield and Hoover 1997). Its NW Pacific distribution encompasses Japan, Korea and Hong Kong (Moore 1990). In 1946, it was collected in the NE Pacific (Newport Bay, California) for the first time and afterwards at many locations along the Californian coast (Carlton 1979). Its occurrence in the NE Pacific has been ascribed to introduction, possibly with imported shellfish (Carlton 1979). Pacific oysters were planted in Newport Bay in 1932 and 1937 (Carlton 1979).

When and how *M. uenoi* reached the NE Atlantic is an open question. The present survey suggests the distribution of *M. uenoi* may be extremely limited, possibly as a result of a recent introduction. However, the limited survey effort precludes definitive conclusions. Comprehensive surveys of intertidal hard substrata in the Oosterschelde area are lacking, which makes any estimate of the year of introduction to the Oosterschelde unreliable. Surveys of intertidal hard substrata in nearby shellfish culture areas and port areas are few. A survey for introduced species on all kinds of substrata in a shellfish culture area, the Wadden Sea in the north of The Netherlands, did not reveal the presence of *M. uenoi* (Gittenberger et al. 2010). An ecological survey in the port of Rotterdam (Paalvast 1998) and a more recent survey for introduced species in several port areas (Faasse, unpublished data) did not detect *M. uenoi* either. However, in none of these surveys were Pacific oysters dislodged to collect invertebrates from under the oysters.

The present record from The Netherlands, near the centre of shellfish trade and culture, close to outlets of shellfish storage basins, and its absence in samples from four other locations, including two locations along the shipping route to the international port of Antwerp, suggests it was introduced here with imported shellfish. It is forbidden to release shellfish from outside of Europe into the environment in The Netherlands. Assuming that traders follow this rule, there are two possibilities. First, sloppiness with debris originating from imports outside of Europe. Second, introduction of *M. uenoi* from a European area where it has been introduced from the Pacific unnoticed. Only surveys in shellfish culture areas in different European countries will be able to shed light on this question.

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Appendix 1. Details of sampling sites and samples. One sample of 10 Pacific oysters was taken per date. N = number of specimens of *Monocorophium uenoi* per 10 Pacific oysters.

Location name	Geographic coordinates	Sampling date	N
Goesse Sas	51°32'39.17"N, 3°55'18.09"E	05/07/2013	0
Goesse Sas	51°32'39.17"N, 3°55'18.09"E	06/07/2013	0
Goesse Sas	51°32'39.17"N, 3°55'18.09"E	08/07/2013	0
Vlissingen	51°26'32.89"N, 3°36'13.40"E	10/07/2013	0
Borssele	51°25'34.28"N, 3°43'07.28"E	13/07/2013	0
Yerseke	51°29'43.36"N, 4°03'14.39"E	16/07/2013	1
Yerseke	51°29'43.36"N, 4°03'14.39"E	18/07/2013	23
Zierikzee	51°37'46.44"N, 3°53'49.47"E	31/08/2013	0