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First record of the non-indigenous Isopoda *Synidotea laticauda* Benedict, 1897 in the Seine Estuary (Normandy, France)

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Abstract

The northeastern Pacific isopod *Synidotea laticauda* Benedict, 1897 is reported for the first time in the French part of the English Channel. Specimens have been found in 2017 in a pebble habitat of the Seine Estuary (Normandy, France). Its occurrence in the Seine Estuary is probably related to international maritime traffic, which is important around the major seaports of the Seine Estuary: Le Havre and Rouen.

Keywords: isopod; non-indigenous species; Seine Estuary

Premier signalement de l'isopode non indigène *Synidotea laticauda* Benedict, 1897 dans l'estuaire de la Seine (Normandie, France)

Résumé

L'isopode *Synidotea laticauda* Benedict, 1897 originaire du Pacifique nord-est est signalé pour la première fois dans la partie française de la Manche. Des spécimens ont été récoltés en 2017 dans l'estuaire de

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la Seine (Normandie, France), dans un habitat constitué de cailloutis. La présence de cette espèce est probablement liée au trafic maritime international important au niveau des grands ports maritimes de cet estuaire : Le Havre et Rouen.

Mots-clés : espèce non indigène ; estuaire de la Seine ; isopode

Introduction

International shipping is one of the major way for non-indigenous species introduction (Molnar *et al.*, 2008; Seebens *et al.*, 2013). Commercial port areas are thus considered as hot spots of non-indigenous species introduction. More than 10 and 30 non-indigenous species have been listed in Rouen and Le Havre harbors, respectively (Breton, 2014). Yet, new records are regularly reported in the Seine Estuary or in the Bay of Seine where these two harbors are located (e.g. Guyonnet, 2017; Berno *et al.*, 2018; Massé *et al.*, 2018).

Seine Estuary is the largest macrotidal estuary of the English Channel and the third largest one in France, with a high-tide surface of 150 km². It is characterised by two salinity gradients: 1) longitudinal with the marine water penetration from downstream to upstream and 2) lateral with the submersion of wetlands by estuarine waters and freshwater inputs by runoff (Lesourd *et al.*, 2012). These gradients induce a mosaic of habitats for various species. Seine Estuary is also characterised by the presence of two major commercial seaports: Le Havre and Rouen. Ships that arrive in these two ports come from all over the world. There are around 6 000 and 2 500 annual stopovers in Le Havre and Rouen, respectively (<http://www.haropaports.com>).

Despite the existence of 61 species of the genus *Synidotea* Harger, 1878 (WoRMS, 2018), none is native from European waters. They have been originally described from the Gulf of Mexico (Schotte & Heard, 2004), Japan, western USA, South Africa, Australia (Poore, 1996), Hawaii (Moore, 2004), Singapore (Cai & Teo, 2012) or Korea (Song & Min, 2017). The present paper deals with the first record of *Synidotea laticauda* Benedict, 1897 in the Seine Estuary.

Materials et methods

Specimens of *Synidotea laticauda* have been sampled in three station in the upstream channel of the Seine Estuary (Figure 1) during a general environmental monitoring for the Rouen Port Authority (Grand Port Maritime de Rouen, GPMR) in March and September 2017 using a Rallier-du-Baty dredge towed at 2 knots during 2–5 minutes. Sampled sediments were then sieved (1 mm mesh). The remaining fraction was fixed in 4 % formalin solution and preserved in 70 % ethanol. The whole benthic fauna was then sorted, identified and counted to determine biological characteristics (specific richness and density, expressed in ind · 30 L⁻¹, Table 1). *Synidotea laticauda*

specimens were examined under a Nikon SMZ25 stereomicroscope and photographed with a Nikon DS-Ri 2 camera. Measurement was assessed with the NIS-Elements Analysis software from anterior margin of head to the posterior end of pleotelson.

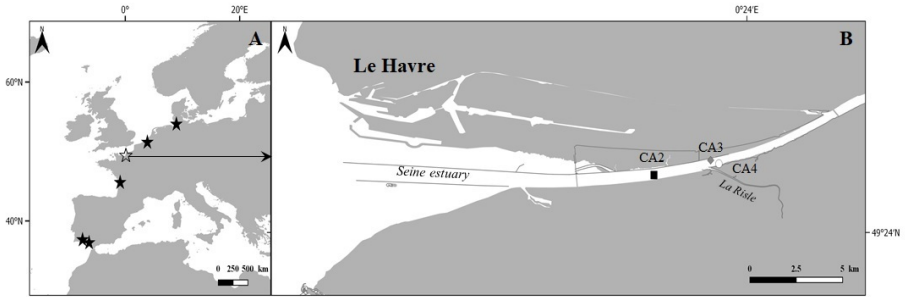


Figure 1: Records of *Synidotea laticauda* Benedict, 1897 from European waters. A. ★: previous records (see Nuño *et al.*, 2018), ☆: present study. B. detailed location of the stations in the Seine Estuary for the present study.

Temperature and salinity data have been assessed using a multiparameter probe HANNA HI 9828, at each station.

Table 1: Density (ind·30 L⁻¹) of the most abundant species at the three stations where *Synidotea laticauda* Benedict, 1897 was collected in the Seine Estuary. *: density excluding *Amphibalanus improvisus*.

Station	CA2	CA3	CA4
Species richness	8	14	11
Total density	501	9893	5067
Total density*	37	1563	133
<i>S. laticauda</i> (density* ; %)	1 ; 2.7	3 ; 0.2	1 ; 0.8
Dominant species (density* ; %)	<i>Crangon crangon</i> (16 ; 43.2)	<i>Neomysis americana</i> (438 ; 28.0)	<i>Mesopodopsis slabberi</i> (69 ; 51.9)
	<i>Mesopodopsis slabberi</i> (12 ; 32.4)	<i>Mesopodopsis slabberi</i> (377 ; 24.1)	<i>Palaemon longirostris</i> (30 ; 22.6)
	<i>Gammarus salinus</i> (4 ; 10.8)	<i>Boccardiella ligerica</i> (267 ; 17.1)	<i>Crangon crangon</i> (7 ; 5.3)

Results

Four specimens of *Synidotea laticauda* have been collected: 2 adult females, a juvenile and a very damaged adult identified as a male (Table 2). Female specimens from Seine Estuary were characterised by (Figure 2): 1) presence of dark chromatophores; 2) head in dorsal view transverse with a depression in front of eyes; 3) pereopod 1 dactylus reaching merus-carpus suture; 4) pereopod 2 carpus with distolateral lobe; 5) ischium-propodus setae on ventral margins of pereopods about 1.5 as long as article width; 6) uropodal peduncle with 1 oblique ridge and 7) uropodal exopod wider than long (length/width = 0.82 to 0.89). Male specimens can be distinguished from female specimens by the presence of penial plate ventrodistally on pereonite 7 and dense stuff of long setae on pereopods.

Table 2: Geographical and ecological parameters recorded the 28th September 2017 in the Seine Estuary at stations where *Synidotea laticauda* Benedict, 1897 specimens were collected. Sampling gear: benthic dredge. St.: station, Lat.: latitude, Long.: longitude, T: temperature, N: number, juv.: juvenile.

Site	St.	Lat. (N)	Long. (E)	Habitat	T (°C)	Salinity	N	Sex
Upstream channel	CA2	49°26.108'	0°19.859'	Pebbles and mud	17.7	10.7	1	♀
Upstream channel	CA4	49°26.527'	0°22.754'	Pebbles and gravels	17.5	18.0	1	♂
Upstream north slope	CA3	49°26.653'	0°22.385'	Pebbles and mud	17.5	16.7	2	♀, juv.

The upstream channel of the Seine Estuary is characterised by a range in salinity and temperature of 10.7–18.0 and 17.5–17.7 °C, respectively (Table 2). Habitat was composed of pebbles mixed with mud (stations CA2 and CA3) or gravels (station CA4), (Table 2).

Discussion

Identification

Synidotea laticauda specimens from Seine Estuary correspond to the description given by Poore (1996). As pointed by Monod (1931) and Menzies & Miller (1972), the species, belonging to the “*Synidotea hirtipes* group”, is characterised by a smooth body, entire or slightly excavated front of the head, and excavated pleotelson apex. According to Cai & Teo (2012), this group is currently composed by 17 species: *S. brunnea* Pires & Moreira, 1975, *S. fluviatilis* Pillai, 1954, *S. fosteri* Schotte &

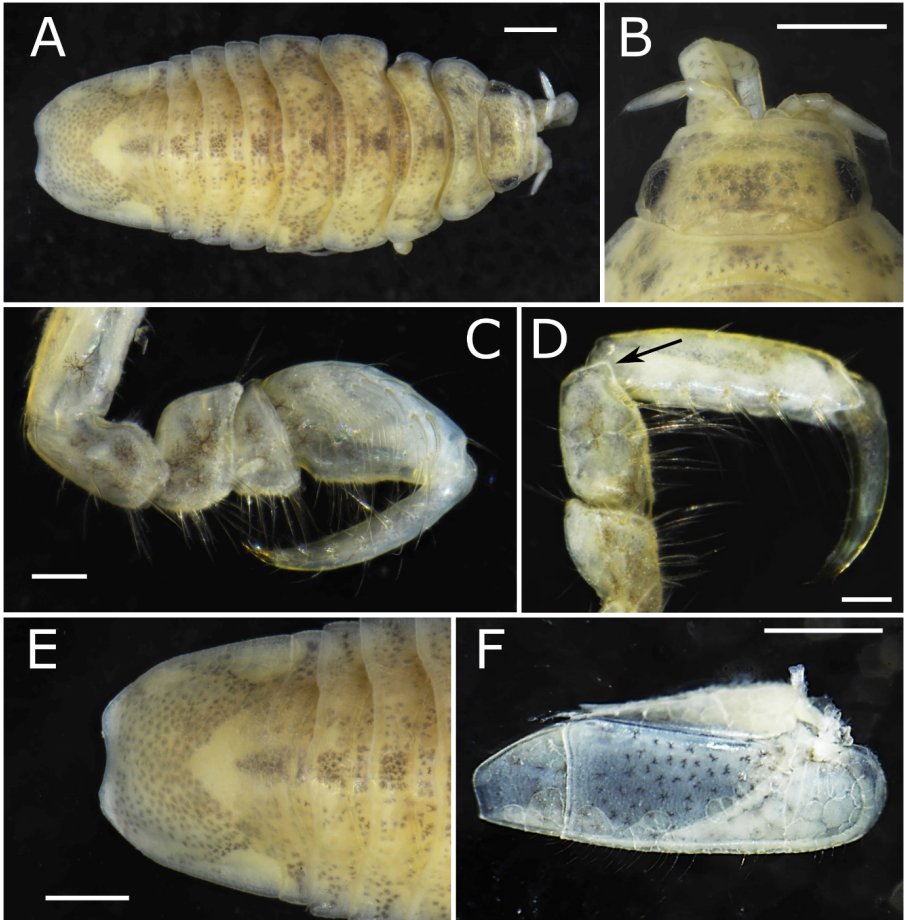


Figure 2: *Synidotea laticauda* Benedict, 1897, female specimen from Seine Estuary, France, body length: 9.6 mm. A. Dorsal view. B. Head, dorsal view. C. Pereopod 1, inner view. D. Pereopod 2, outer view with carpus distolateral lobe (black arrow). E. pleotelson, dorsal view. F. Right uropod, ventral view. Scale bars: A, B, E, F: 1 mm; C, D: 0.2 mm. Photos: B. Gouillieux.

Heard, 2004, *S. grisea* Poore & Lew Ton, 1993, *S. harfordi* Benedict, 1897, *S. hirtipes* (Milne Edwards, 1840), *S. hunumantharoei* Kumari & Shyamasundari, 1984, *S. innatans* Poore, 2012, *S. karumba* Poore, 2012, *S. keablei* Poore & Lew Ton, 1993, *S. laevidorsalis* (Miers, 1881), *S. laticauda* Benedict, 1897, *S. marplatensis* Giambiagi, 1922, *S. oahu* Moore, 2004, *S. poorei* Cai & Teo, 2012, *S. variegata* Collinge, 1917, and *S. worlinensis* Joshi & Bal, 1959. Some characters to distinguish the species are based on head anterior margin, pereonite and pleotelson sculptures, pereopod 1 dacty-

lus length compared to propodus-carpus-merus size, setation on pereopods (be careful with sexual dimorphism of this setation - Figure 3B–C), uropodal peduncle ridge and exopod size, and distribution pattern of chromatophores. Subtle characters used for identification suggest that some species are probably synonymous. Some authors used morphology of penial plate to distinguish male specimens from different species, but this character must be taken with caution because it could show some variability in a same population, as it was showed with examination of male specimens from the Gironde Estuary (Figure 3A) (specimens from Seine estuary were too damaged to be used).

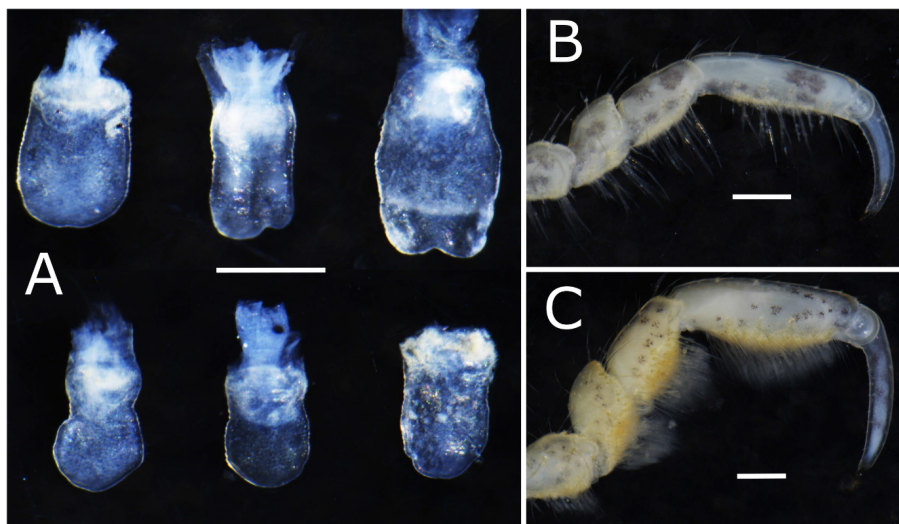


Figure 3: *Synidotea laticauda* Benedict, 1897, specimen from Gironde Estuary. A. Penial plate. B. Pereopod 2 female. C. Pereopod 2 male. Scale bars: 0.5 mm. Photos: B. Gouillieux.

Distribution and ecology

Synidotea laticauda was originally described from San Francisco Bay, Pacific coast of North America (Benedict, 1897). The species has been also reported in China in the Yangtze Estuary and probably in Korea (Liu *et al.*, 2017), on the Atlantic coast of America, in Delaware Bay (Bushek & Boyd, 2006). In European waters, *Synidotea laticauda* is distributed from the Atlantic coast of Southern Spain to the German coast of the North Sea (Nuño *et al.*, 2018). The species was first recorded in the Gironde Estuary and reported as *Synidotea laevidorsalis* (Mees & Fockedey, 1993). Later on, Poore (1996) provided some morphological distinction for 5 closely species and attributed Mees & Fockedey's (1993) identification to *S. laticauda*.

The species occurs in estuarine systems where the salinity ranges from 0.1 to 25.0, with the highest density of population with a range of salinity from 1 to 13, and where temperature ranges from 10 to 25 °C (Mees & Fockede, 1993; Nuño *et al.*, 2018). In this study, specimens have been collected in environmental conditions corresponding to what has been observed in other European estuaries (Mees & Fockede, 1993; Cuesta *et al.*, 1996; Soors *et al.*, 2010).

Synidotea laticauda specimens have been found from subtidal habitats, composed of pebbles mixed with mud or gravels. Apart from dense populations of the also non-indigenous crustacean cirriped *Amphibalanus improvisus* (Darwin, 1854), almost any other sessile organisms (fauna or flora) have been found on pebbles. These observations fit well with previous observations in Gironde Estuary where *S. laticauda* has been found in the same type of environment (Goullieux, pers. comm.). Associated biocenosis is typical from this part of the Seine Estuary, with low to medium species richness and medium to high densities (Table 1). In the three sampled stations, abundances were dominated by *Amphibalanus improvisus*. Other crustacean species co-occurring with *Synidotea laticauda* are typical estuarine species such as the amphipod *Gammarus salinus* Spooner, 1947, the carideans *Crangon crangon* (Linnaeus, 1758) and *Palaemon longirostris* H. Milne Edwards, 1837, the mysids *Mesopodopsis slabberi* (Van Beneden, 1861) and *Neomysis americana* (S.I. Smith, 1873). The latest one has been recently reported as first record of non-indigenous species in the Seine Estuary as well (Massé *et al.*, 2018).

Three hypotheses could explain the low occurrence of *S. laticauda* in the Seine Estuary comparatively to what could be observed in other estuarine systems such as in the Gironde Estuary (reaching 288 individuals per trawl; Mees & Fockede, 1993) and its absence during a similar sampling session performed in March 2017 at the same sites: 1) The species reached the Seine Estuary between March and September 2017 and we caught the first specimens introduced. 2) The species has reached the Seine Estuary in a short past (one or two years) date, as suggested by the record of a juvenile specimen, and the population is currently establishing and we expect it rises in incoming years. 3) The species has been established since an unknown date in a later past, although not developing the important populations reported from other estuaries, and remains at low abundance. The first hypothesis is quite unlikely as the probability to catch the very first introduced specimens of a so small species seems to be very low, moreover in three different samples. Whereas the two remaining hypotheses are in agreement with the phenology of the species which reaches very high abundance at the end of the summer while rare to almost undetectable during February and March in several locations, where it is common such as the Delaware Bay in the USA (Bushek & Boyd, 2006) or the Guadalquivir Estuary in Spain (Ruiz-Delgado *et al.*, 2016). Given these hypotheses, we could not assess whether this species is in an early stage of colonisation in the Seine Estuary and would become invasive in the future, as suggested by Chapman & Carlton (1991), or whether it have been integrated in the ecosystem for a long time without being invasive. It thus would be important to

monitor the evolution of *S. laticauda* in the Seine Estuary to detect a possible increase of densities and avoid possible impacts on the ecosystem.

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