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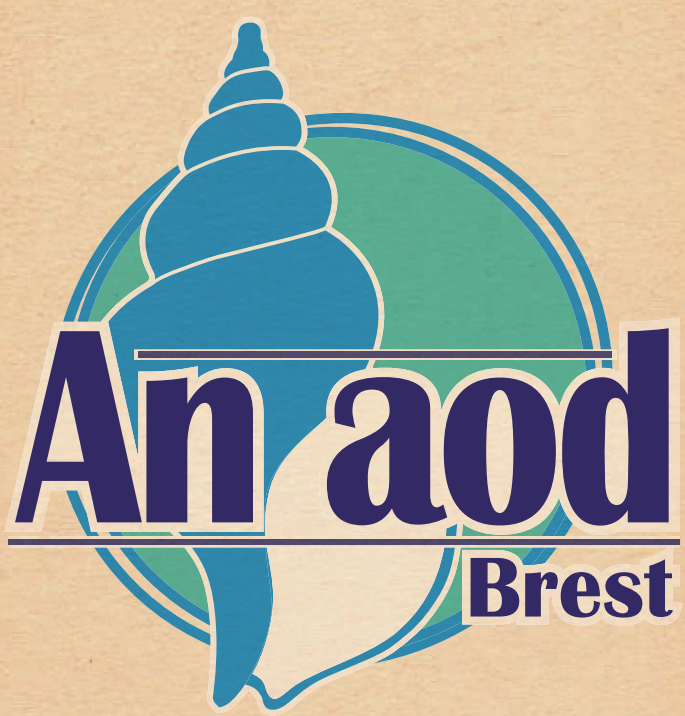

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Première mention en Bretagne de l'annélide *Boccardia proboscidea* Hartman, 1940

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Résumé

L'annélide *Boccardia proboscidea* a été observée à plusieurs reprises sur l'estran du nord de la Bretagne (Trégor, Côtes-d'Armor, France), entre novembre 2018 et mars 2019. Cette espèce, qui est considérée comme originaire des côtes de l'océan Pacifique, semble avoir profité des transports maritimes internationaux pour se propager mondialement. La dispersion des sites où cette espèce a été observée, son abondance dans certains de ces sites et la présence d'œufs permettent de penser que l'espèce est bien établie en Bretagne.

Mots-clés : *Boccardia proboscidea* ; Bretagne nord ; Côtes-d'Armor ; espèce introduite ; Spionidae

First record of the annelid *Boccardia proboscidea* Hartman, 1940 in Brittany (south-western channel, France)

Abstract

The annelid *Boccardia proboscidea* was observed repeatedly on the shore of northern Brittany (Trégor, Côtes-d'Armor, France), between November 2018 and March 2019. This species, considered as originating from the coasts of the Pacific Ocean, seems to have taken advantage of international maritime shipping to spread worldwide. The dispersal of the Breton sites where we observed the species, its locally high abundance together with the presence of eggs suggest that the species is steadily established in Brittany.

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Une espèce à large répartition géographique

L'espèce *Boccardia proboscidea* Hartman, 1940, annélide de la famille des Spionidae Grube, 1850, a été décrite de la côte ouest des États-Unis (Californie). Elle a été largement observée sur les côtes de l'océan Pacifique : Canada (Sato-Okoshi & Okoshi, 1997), États-Unis (Blake, 1996 ; Bailey-Brock, 2000), Japon (Sato-Okoshi, 2000), Australie (Blake & Kudenov, 1978). Au niveau des côtes de l'océan Atlantique, Bailey-Brock (2000) mentionne la présence d'huîtres (*Ostrea edulis* Linnaeus, 1758) infestées par *B. proboscidea* en 1990 sur les côtes du Maine aux États-Unis.

Elle est aussi notée depuis 2006, en Afrique du Sud où elle utilise les tubes d'autres spionidés creusant les coquilles d'ormeaux (Simon *et al.,* 2009). L'espèce a été observée en 2008 à Mar del Plata, en Argentine, à la sortie des égouts, formant un large récif où elle est considérée comme une espèce invasive (Jaubet, de los Ángeles Sánchez *et al.,* 2010). C'est en 1996 que l'espèce a été observée pour la première fois sur les côtes européennes, au Pays basque espagnol, dans la région de Saint-Sébastien (Martínez *et al.,* 2006). En 2011, l'espèce a été notée en Grande-Bretagne sur l'île de Skye (Atlantique nord-est) en bas d'estran sous des pierres posées sur de la vase (Hatton & Pearce, 2013) ainsi qu'en mer du Nord, en Belgique sur des épis de pierre et aux Pays-Bas, sous des huîtres (Kerckhof & Faasse, 2014).

En France les signalements, à notre connaissance, ne concernent que les côtes rocheuses proches de La Rochelle, sur les côtes des Charentes (Sauriau & Aubert, in Spilmont *et al.,* 2016) et à Wimereux, au nord de la Manche, en zone intertidale, sur des rochers largement couverts par des moules, en 2014 (Spilmont *et al.,* 2016).

Découverte de l'espèce en Bretagne nord

Nous avons observé et photographié de fortes concentrations de spionidés du genre *Boccardia* Carazzi, 1893 le 26 novembre 2018 au lieu-dit Nantouar (48°48′6″N 3°23′50″O) sur la commune de Louannec, dans l'anse de Perros. Par la suite, nous en avons observé également mais en moindre abondance le 6 décembre 2018 au lieu-dit An Hinkin (48°51′18″N 3°12′38″O), sur la commune de Plougrescant, dans l'estuaire du Jaudy. Ces données ont été collectées lors de prospections faune-flore menées bénévolement sur le littoral des Côtes-d'Armor pour la réalisation du site internet estran22 (https://nature22.com/estran22/estran.html), en collaboration avec l'association VivArmor Nature. Les photos prises alors ne semblaient pas correspondre à celles de *Boccardia polybranchia* (Haswell, 1885), espèce que nous avions observée en 2013 à Trébeurden, mais plutôt à l'espèce *Boccardia proboscidea*. En janvier 2019, des prélèvements ont été effectués en ces lieux et transmis à l'Institut Universitaire Européen

de la Mer où Gabin Droual en a confirmé l'identification. Ces observations constituent, à notre connaissance, les premiers signalements de l'espèce en Bretagne.

Critères d'identification

Chez *Boccardia proboscidea*, les branchies sont présentes au niveau des sétigères 2, 3 et 4 puis à partir du sétigère 6, et se prolongent au-delà de la moitié du corps (Figure 1). Son prostomium n'est pas bilobé (Figure 1B), ce qui permet de la distinguer facilement de *Boccardia semibranchiata* Guérin, 1990 qui, par ailleurs, ne possède des branchies que sur la moitié antérieure du corps et dont les soies du 5e sétigère sont de forme différente (Martínez *et al.,* 2006). Comme toutes les espèces du genre *Boccardia*, son 5e sétigère est modifié et porte deux types de soies (Figure 2B), contrairement aux espèces du genre *Boccardiella* Blake & Kudenov, 1978 chez lesquelles le 5e sétigère lui aussi modifié, ne porte qu'un seul type de soies (Ruellet, 2004). Chez *B. proboscidea*, le sétigère 1 possède des parapodes dont la partie supérieure comporte des soies, appelées notosoies (Figure 2A), ce qui le différencie de *B. polybranchia* qui est commun sur nos côtes (J. Grall, com. pers.). À partir du 7e sétigère les rames ventrales des parapodes portent des soies encapuchonnées et bidentées (Figure 2C).

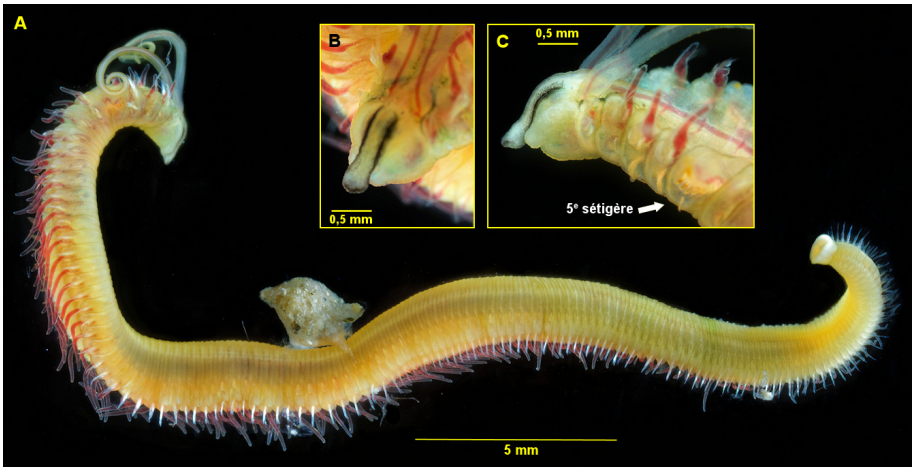

Figure 1 : *Boccardia proboscidea* Hartman, 1940, capturée à Nantouar le 10/01/2019 et photographiée vivante. A. Vue générale. B. Détail de la tête vue de face. C. Détail de la tête et des 5 premiers sétigères vus de profil.

Zone de présence et habitat

Suite à la découverte de *B. proboscidea* sur les sites de Nantouar et Plougrescant, des prospections ont été menées sur différents sites du Trégor (Figure 3A) et

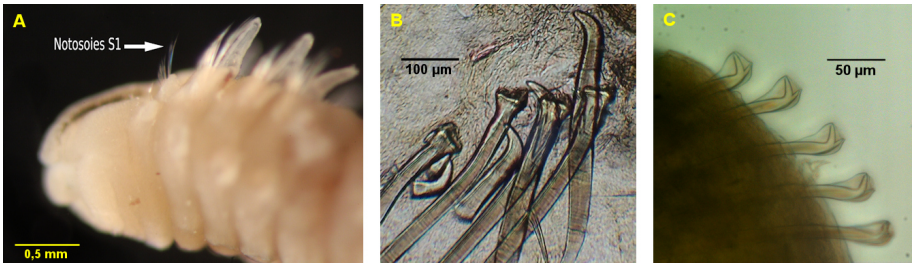

Figure 2 : *Boccardia proboscidea* Hartman, 1940, capturée à Nantouar le 10/01/2019. A. Notosoies sur le premier sétigère. B. 5e sétigère avec deux types de soies. C. Soies encapuchonnées et bidentées, présentes sur la partie inférieure des parapodes des sétigères 7 et suivants (photographies A et C : Gabin Droual).

la présence de l'espèce a été constatée au niveau de l'estuaire du Trieux (à Roc'h Couhart/Lanmodez le 21/01/2019 et à Roche Donan/Paimpol le 06/02/2019) ainsi que dans l'anse de Paimpol (pointe de Guilben/Paimpol le 06/03/2019). Deux spécimens ont été envoyés au Muséum National d'Histoire Naturelle de Paris et peuvent être consultés (MNHN-IA-PNT 90).

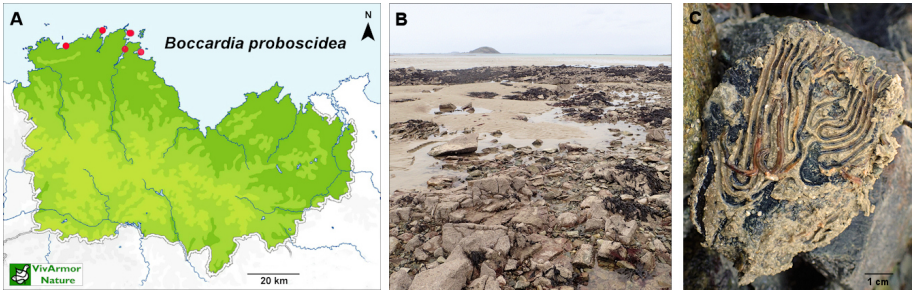

Figure 3 : A. Localisation des sites (points rouges) dans lesquels a été observée *Boccardia proboscidea* Hartman, 1940, de novembre 2018 à mars 2019, dans le département des Côtes-d'Armor (en vert). B. Vue de l'estran à Nantouar, où ont été observés les premiers spécimens de *B. proboscidea*. C. Bloc extrait des rochers à Nantouar, laissant voir à sa surface les galeries occupées par *B. proboscidea*.

Dans tous les cas, les spionidés se trouvaient dans des fentes de rochers avec sédiments sablo-vaseux (Figure 3B–C), légèrement en dessous de mi-marée, au niveau de la ceinture algale à *Fucus vesiculosus* Linnaeus, 1753 et de la balane *Semibalanus balanoides* (Linnaeus, 1767). Pour chaque site où des *B. proboscidea* ont été observées, leur abondance ainsi que les principales espèces associées présentes au niveau des mêmes fentes rocheuses sont indiquées dans le tableau 1.

Tableau 1 : *Boccardia proboscidea* Hartman, 1940, nombre d'individus observés et espèces associées, au niveau de chaque site.

Groupe taxinomique	Espèce	Nantouar	An Hinkin	Roc'h Couhart	Roche Donan	Pointe Guilben
Annélide	*Boccardia proboscidea* Hartman, 1940	> 50	> 5	2	1	> 5
Annélide	*Boccardia* cf. *polybranchia* (Haswell, 1885)					x
Annélide	*Eulalia clavigera* (Audouin & Milne Edwards, 1833)			x		x
Annélide	*Perinereis cultrifera* (Grube, 1840)	x				
Annélide	*Perinereis marionii* (Audouin & Milne Edwards, 1833)	x	x	x	x	x
Annélide	*Terebella lapidaria* Linnaeus, 1767	x	x			x
Insecte	*Aepopsis robinii* (Laboulbene, 1849)			x		
Crustacé	Sphaeromatidae Latreille, 1825	x	x			
Mollusque	*Cingula trifasciata* (J. Adams, 1800)	x	x	x	x	x
Mollusque	*Lasaea adansoni* (Gmelin, 1791)	x	x	x	x	x
Myriapode	*Hydroschendyla submarina* (Grube, 1872)		x	x	x	x

Quelques éléments sur son introduction et sa dispersion

Dans deux des sites visités (Nantouar et pointe de Guilben), des femelles ovigères ont été trouvées et, sur le site de Nantouar, en janvier 2019, des capsules d'œufs (Figure 4) étaient présentes en abondance le long des corps de femelles. D'après Gibson (1997), l'espèce présente plusieurs modes de développement larvaire : des larves planctoniques qui permettent une dispersion assez lointaine de l'espèce et des juvéniles non nageurs qui mangent les œufs non viables, ce mode de développement permettant l'accroissement de la population locale. L'existence de ces deux types de développement permet une reproduction particulièrement efficace et une dispersion rapide des populations à partir d'un point d'introduction. La provenance initiale des reproducteurs ne nous est pas connue mais deux vecteurs principaux d'introduction de l'espèce ont été cités dans d'autres localités : le transport de coquillages, huîtres entre autres (Bailey-Brock, 2000), ainsi que les salissures et les eaux de ballast des bateaux (Kerckhof & Faasse, 2014). On peut cependant remarquer que le site dans lequel *Boccardia proboscidea* a été observée avec la plus grande abondance (Nantouar), n'est proche ni de zones conchylicoles, ni d'un port avec un trafic commercial important. Il s'agit donc ici probablement d'une dispersion secondaire liée à une introduction initiale possiblement éloignée du lieu où l'espèce a été observée. Comme cela a été montré par plusieurs auteurs (Wasson *et al.,* 2001 ; Zabin *et al.,* 2014), cette dispersion secondaire peut être due aux courants marins transportant les larves mais aussi à la navigation de plaisance, très importante dans cette zone.

Figure 4 : capsules d'œufs de *Boccardia proboscidea* Hartman, 1940 observées à Nantouar en janvier 2019.

Conclusion

La présence d'œufs, l'abondance des individus trouvés à Nantouar et l'existence de plusieurs sites où *B. proboscidea* est présente laissent à penser que l'espèce est bien établie en Bretagne. Une recherche ciblée à l'est des Côtes-d'Armor et dans les départements voisins ainsi qu'un suivi annuel seraient souhaitables pour connaître l'étendue et la pérennité de cette présence. En effet, cette espèce a été caractérisée comme invasive en Argentine (Jaubet, Garaffo *et al.,* 2014) en raison de sa capacité de reproduction sur toute l'année et de colonisation de surface amenant à une compétition avec les communautés indigènes. Ce caractère « invasif » semble se manifester dans des environnements très riches en matière organique. Cela étant, grâce à son aptitude à coloniser des milieux divers, cette espèce est considérée comme dangereuse pour l'aquaculture de par sa capacité à parasiter les coquilles d'ormeaux (Simon *et al.,* 2009) ou les huîtres (Bailey-Brock, 2000 ; Read, 2004). Une espèce, donc, à surveiller dans les années à venir.

Remerciements

Nous tenons à remercier vivement l'Institut Universitaire Européen de la Mer et plus particulièrement Gabin Droual sans qui cette espèce serait restée avec une identification incertaine et aurait rejoint la liste des nombreuses espèces non déterminées rencontrées lors des inventaires de l'estran faits par les bénévoles que nous sommes.

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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 km^2. 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.

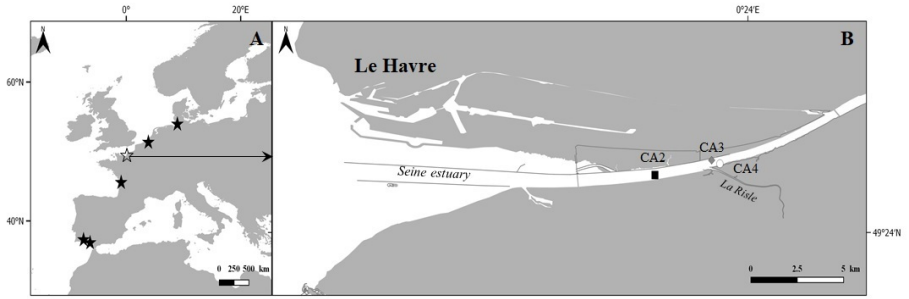

Figure 1: Records of *Synidotea laticauda* Benedict, 1897 from European waters. A. ★: previous records (see Nuño *et al.,* 2018), ☆: present study. B. detailed location of the stations in the Seine Estuary for the present study.

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
***S. laticauda* (density* ; %)**	1 ; 2.7	3 ; 0.2	1 ; 0.8
Dominant species (density* ; %)	*Crangon crangon* (16 ; 43.2)	*Neomysis americana* (438 ; 28.0)	*Mesopodopsis slabberi* (69 ; 51.9)
	Mesopodopsis slabberi (12 ; 32.4)	*Mesopodopsis slabberi* (377 ; 24.1)	*Palaemon longirostris* (30 ; 22.6)
	Gammarus salinus (4 ; 10.8)	*Boccardiella ligerica* (267 ; 17.1)	*Crangon crangon* (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 &

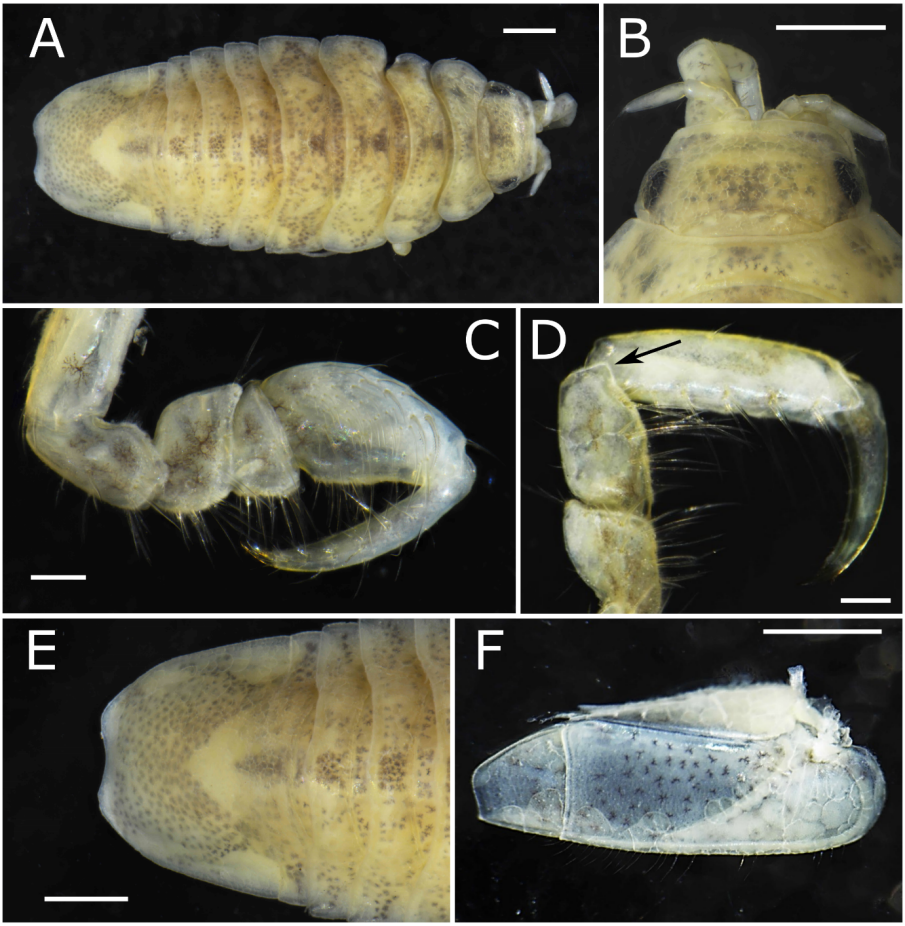

Figure 2: *Synidotea laticauda* Benedict, 1897, female specimen from Seine Estuary, France, body length: 9.6 mm. A. Dorsal view. B. Head, dorsal view. C. Pereopod 1, inner view. D. Pereopod 2, outer view with carpus distolateral lobe (black arrow). E. pleotelson, dorsal view. F. Right uropod, ventral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

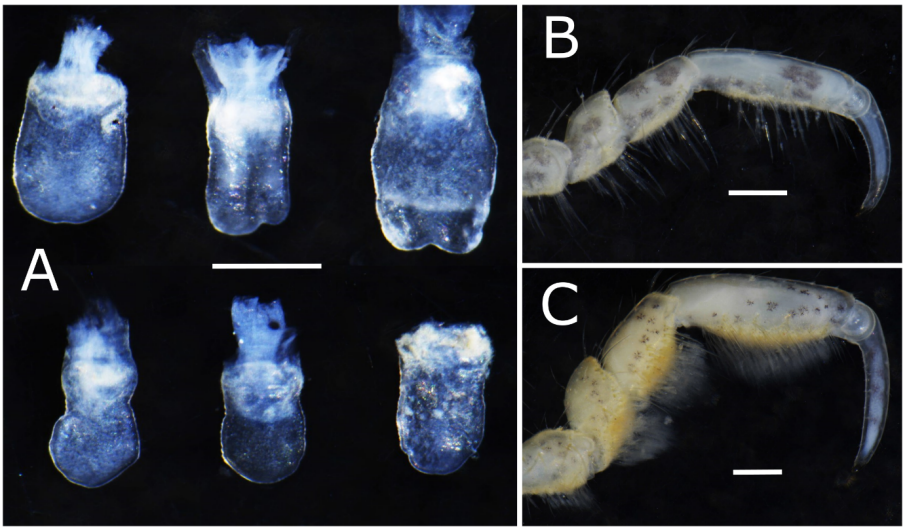

Figure 3: *Synidotea laticauda* Benedict, 1897, specimen from Gironde Estuary. A. Penial plate. B. Pereopod 2 female. C. Pereopod 2 male. Scale bars: 0.5 mm. Photos: B. Gouillieux.

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 & Fockedey, 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 & Fockedey, 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 (Gouillieux, 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 & Fockedey, 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 indetectable 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.

Aknowledgements

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Occurrence of *Ammothea hilgendorfi* (Böhm, 1879) a pycnogonid from the north Pacific, in Étel river

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Abstract

The pycnogonid *Ammothea hilgendorfi* from the north Pacific was introduced accidentaly to Europe where it is known from Southern England, Netherlands and the Venice lagoon. It was collected in rivière d'Étel, South Brittany (47°40′N 3°11′W) where it forms a locally dense population. This species was actively reproducing in late September and mid November. It is carnivorous, may be a scavenger and manifests a gregarious behaviour at least at low tide. It is likely to have a significant impact on its host environment due to its high density population. Its probable further spreading deserves to be monitored.

Keywords: alien species; *Ammothea hilgendorfi*; Étel river; pycnogonids

Présence d'*Ammothea hilgendorfi*, un pycnogonide originaire du Pacifique nord, en rivière d'Étel

Résumé

Le pycnogonide *Ammothea hilgendorfi*, originaire du Pacifique nord et introduit accidentellement en Europe où il est connu du sud de l'Angleterre, des Pays-Bas et de la lagune de Venise, a été récolté en rivière

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d'Étel, Bretagne sud (47°40′N 3°11′W) où il constitue une population localement dense. L'animal est observé en reproduction fin septembre et à la mi-novembre. Il est carnivore, voire charognard et manifeste un comportement grégaire au moins à basse mer. Cette espèce est susceptible d'avoir un impact non négligeable sur son milieu d'accueil et son expansion probable mérite d'être suivie.

Mots-clés : *Ammothea hilgendorfi* ; espèce introduite ; pycnogonides ; rivière d'Étel

Introduction

On September 28th 2019 a team of seven members of "Bretagne Vivante" (environmental protection association) carried out a preliminary inventory of the flora and fauna at Iniz er Mor islet in the Étel river (47°40′N 3°11′W), southern Brittany (Figure 1). The land part of the islet, managed by the association, is protected for its natural habitats (French arrêté de protection de biotope) particularly for accommodating a nesting tern colony. During this survey a species new to French fauna, the pycnogonid *Ammothea hilgendorfi* (Böhm, 1879) was collected. Later, on November the 17th, a search on the southern shore of Tog Ru, an islet located nearer to the outer mouth of the river, resulted in an abundant harvest of the same species (around 70 individuals).

Description of the sampling site

The Étel river is a marine ria of the southern coast of Brittany penetrating 12 km inland. The sites of Iniz er Mor and Tog Ru lie 6.6 km and 3.9 km respectively, north to its mouth.

Relatively strong tidal streams run to and fro along the river, however its shores may be considered as sheltered owing to the narrow fetch they are faced to in their almost landlocked situation.

North to Pont-Lorois, the shore is mostly muddy although the two sampled sites are dominated by rocky habitats including pebbles and boulders, the latter being more abundant at Tog Ru.

The mediolittoral zone is covered by the usual fucales belts of Brittany, whose extent however is seriously reduced by the grazing of limpets (*Patella vulgata* Linnaeus, 1758) on the eastern side of Iniz er Mor.

Many oyster farms, mainly devoted to the Pacific oyster *Magallana* (= *Crassostrea*) *gigas* (Thunberg, 1793) culture occupy the lower part of the mediolittoral and the upper part of the infralittoral zones.

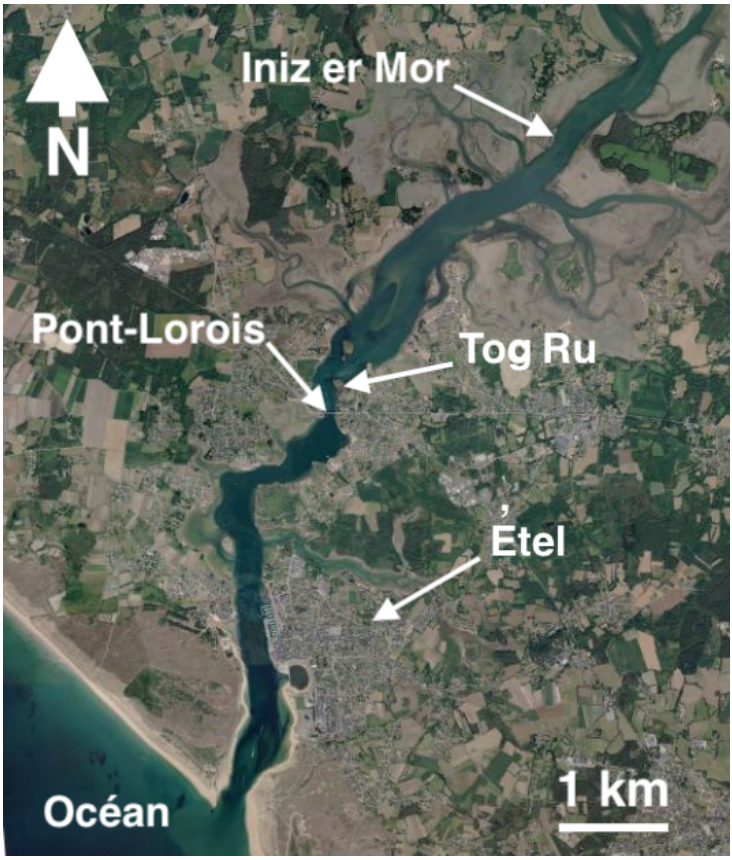

Figure 1: Aerial view of the Étel river near its mouth and position of the places referred to in the text. © IGN 2016, https://www.geoportail.gouv.fr.

Salinity as measured near Pont-Lorois from 2009 to 2018 by Ifremer (https://wwz.ifremer.fr/surval), has a mean value of 32.5 (maximum: 35.8; minimum: 22.7; n = 134; σ = 2.34), thus appearing to be relatively stable and within the characteristic range of marine waters.

The intertidal fauna is relatively rich at Tog Ru (132 species recorded in 2011 during a single low tide), on the contrary it appears impoverished at Iniz er Mor (only 81 species collected in September 2019), probably as a consequence of the algal belts regression and of the more confined environment of this site.

Ammothea hilgendorfi

Ammothea hilgendorfi is native to the west and east coasts of the North Pacific. It was introduced to Europe in the seventies and first found in UK on a Dorset (southern England) shore in 1978 (Bamber, 1985). It was more recently observed on the coast of the North Sea (Essex) (Bamber, 2012) and has also been recorded in the Venice lagoon (Krapp & Sconfietti, 1983) and on the coasts of the Netherlands in the Oosterschelde (Faasse, 2013) .

Morphological criteria for identification

The identification of *A. hilgendorfi* from Iniz er Mor is based on the description by Utinomi (1959, as *Lecythorhynchus hilgendorfi* (Böhm)) from Japanese samples as well as on morphological characters provided by the authors who identified specimens from Europe (see above) and particularly Bamber (2010) .

At Iniz er Mor two individuals were directly collected in the field and a third one was found later in a cluster of ascidians [*Molgula socialis* Alder, 1863 and *Polycarpa violacea* (Alder, 1863)] brought to lab for identification.

Amongst these, two individuals were immature whilst the third was an egg-ball carrying male, i.e. an adult. The latter being the specimen our description is mainly based on.

This adult male (see figure 2A) measures from tip to tip of its outstretched legs 20 mm, which corresponds to the maximum size reported by Faasse (2013). The literature does not mention any significant size differences between sexes. This seems to be corroborated in a Tog Ru sample where size ranges from 20 to 24 mm for males and from 22 to 23 mm for females (n = 9 for each sex). Note that the measurements are somehow approximate, depending on our ability to correctly extend the animal while keeping it into focus, which proved difficult. This is why size ranges instead of mean lengths are given.

The proboscis is approximately 1.8 mm in length, distally swollen, and obliquely positioned relative to the trunk, which is about 1.5 mm long (Figure 2A). The trunk segments are well separated, the first three having a transverse dorsal ridge on their posterior region (Figure 2B) as mentioned by Bamber (1985, 2010) and Faasse (2013). The short abdomen (about 0.5 mm) is almost at right angle upward to the trunk.

The chelifores (Figure 2A) are simple rounded tubercules, some 0.13 mm in length.

The palps whose proximal articles are applied against the proboscis are 9-articled (Figure 2C), the fifth one exhibits a setose flattened protuberance, as figured by Utinomi (1959), Krapp & Sconfietti (1983) and Bamber (2010). Segments 2 and 4 are longer than the others reaching 0.84 mm and 0.88 mm respectively. These measures are close to those deduced from the figures of Utinomi (1959) (0.90 mm and 0.85 mm) and of Krapp & Sconfietti (1983) (0.85 mm and 0.81 mm).

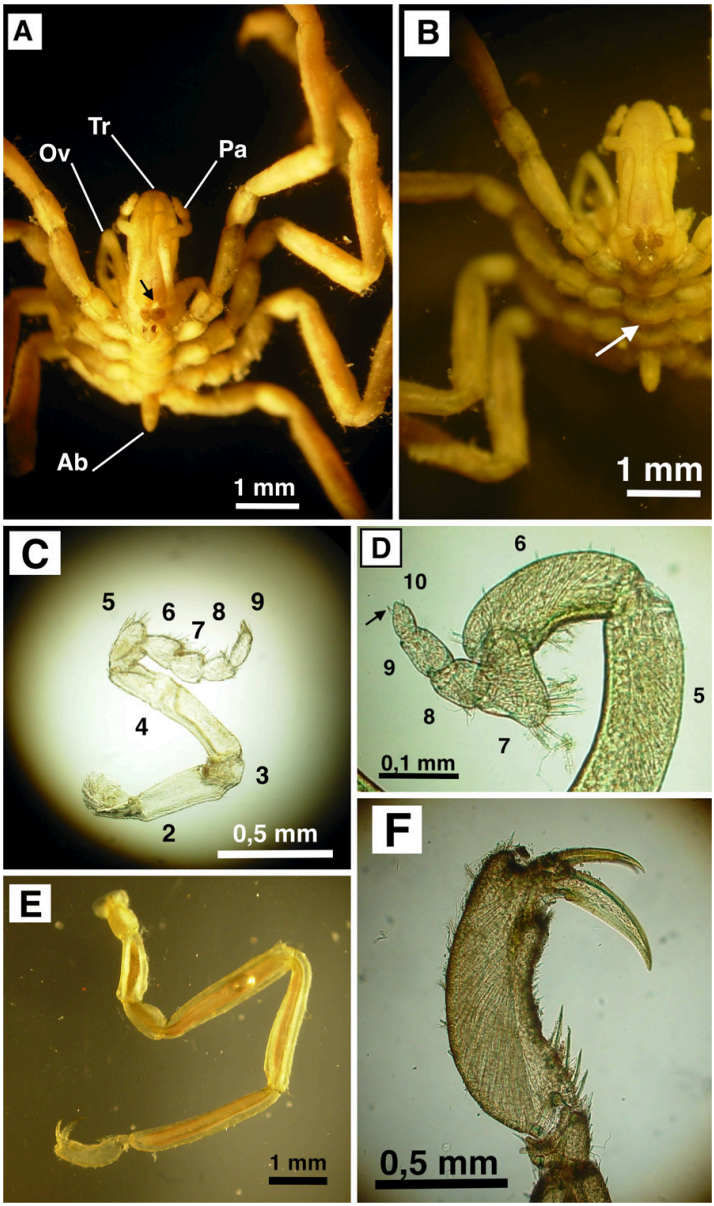

Figure 2: *Ammothea hilgendorfi* (Böhm, 1879), male collected at Iniz er Mor. A. Dorsal view. Ab, abdomen; Ov. Oviger; Pa. Palp; Tr. Proboscis. The black arrow points to the right chelifer. B. Oblique dorsal view hightlighting the transverse dorsal ridges (arrow). C. Palp. The numbers correspond to the rank of the articles. The proximal part of the second article is crushed. D. Oviger. The numbers correspond to the rank of the articles. The arrow points to the compound setae of the 10th article. E. Third leg. F. Propodus and claws. The two accessory claws seem separated only at their tips.

The ovigers (Figure 2D) are 10-articled. On article 7, an apophysis clearly figured by Bamber (2010) is adorned with 12 stiff setae. As mentioned by this author the three distal articles bear two short compound spines (see arrow in figure 2D). Moreover article 8 bears, opposed to these spines, 4 long setae, the same type as those of the 7th.

The legs (Figure 2E) measure about 0.9 mm in length (3rd leg) and are terminated by a large main claw and two accessory claws (Figure 2F) as illustrated by Utinomi (1959), Krapp & Sconfietti (1983) and Faasse (2013).

So, the main morphological characters are in close accordance with those described in *A. hilgendorfi*, species to which we attribute our specimens.

Colour

The general colouring pattern of *A. hilgendorfi* results from two principal components. On the one hand a more or less dark reddish-brown pigmentation of the tegument as detailed below, on the other hand the digestive tract, of a dark hue, which is visible through the tegument if not concealed by its pigmentation. It appears in legs segments up to the 6th (tibia 2). Furthermore the legs are speckled with white dots, and allow the observation in live of the flow of whitish blood globules as well as, in breeding females, the whitish eggs (Figure 3B).

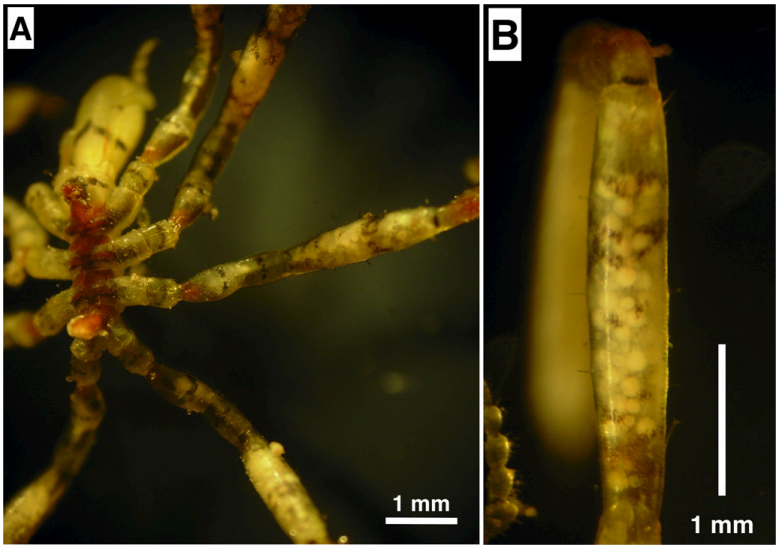

Figure 3: *Ammothea hilgendorfi* (Böhm, 1879) (female). A. Colour pattern. Ovules appear in the femurs. B. Femur letting appear the ovules more clearly. Up, on the tibia 1 a black dot is to be noticed at the joint level.

A nearly black stripe around the proximal third of the proboscis describes a conspicuous inverted V on its dorsal side (Figure 3A). This feature may however be re-

duced and even absent (2 cases observed). The third article of the palp bears a black dot (see figure 3A).

The dorsal side colour of the body, at the exception of the lateral processes, is of a dark reddish-brown that conceals most of the digestive tract. This colour extends almost to the tip of the abdomen. A dark band marks the posterior margin of the three dorsal transverse ridges of the trunk somites while their lateral parts are much clearer.

Each of the three articles of the coxae exhibits a dark ring more obvious on the dorsal side. The colouring of the three following articles (femur, tibia 1, tibia 2) appears more scattered, blotchy and variable. A dark spot is located on the base of the 5th and 6th articles (tibia 1 and tibia 2), otherwise the legs are mottled with white dots. The 6th article is generally weakly coloured. The 8th article (propodus), almost devoid of pigmentation, is very clear, whitish, in live specimens.

Figure 4, taken in the field shows the living appearance of the animal.

Figure 4: *Ammothea hilgendorfi* (Böhm, 1879). Colour pattern on the live and natural conditions (photo: Yves Le Bail).

The above colouring pattern is quite in agreement with that of the californian individuals shown by P.J. Bryant website (http://nathistoc.bio.uci.edu/Pycnogonida/Ammothea.htm), as well as with that from the UK (see D. Fenwick's website: http://www.aphotomarine.com/marine_other_sea_spider_ammothea_hilgendorfi.html).

The legs colours of our specimens are less contrasted than those from Faasse's

figure 1, this may be in account with the fact that Faasse's picture was taken after animal death.

In Bamber's figures (1985, 2010) the proboscis V, the palp 4th article dot, the coxae 1 ring are lacking while the legs present large uniformly grey or black patches. These minor differences with the above description may be ascribed to drawing simplifications.

The colouring pattern confirms the attribution of our specimens to the species *A. hilgendorfi* out of morphological characters.

Remarks on the biology of *Ammothea hilgendorfi*

Habitat

A. hilgendorfi lives on the underside of boulders on the lower part of the *Fucus serratus* Linnaeus, 1753 belt and further down the shore to the infralittoral. Individuals may be found alone although at Tog Ru (Figure 5A–B) most specimens were generally gathered in groups of 10 or more in little hollows at the rock surface or against reliefs formed by oyster shells or polychaete tubes. In this case, they tightly huddle motionless, with the legs intermingled. At first sight the group looks like a heap of vegetal debris. We suppose that such gatherings probably occur only at low tide. *A. hilgendorfi* may reach high densities as we counted some 70 individuals on some 20 square metres.

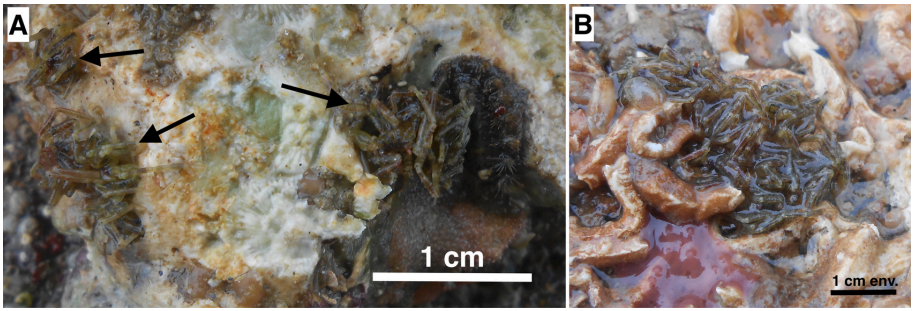

Figure 5: *Ammothea hilgendorfi* (Böhm, 1879). A and B. Groups on the underside of boulders (arrows in A). B. Approximate scale bar.

Reproduction

In a sample of 55 animals, 26 were males, 25 females while 4 were immature which gives a sex ratio close to 1. The low number of immatures suggests that young animals might somehow be segregated from adults. Indeed, no larva was observed on the rock surface or upon some hydranths of *Clytia hemisphaerica* (Linnaeus, 1767),

a hydroid unwittingly picked up with the pycnogonids. This campanulariid species could be in Europe a convenient host for *A. hilgendorfi* which, according to Russel & Hedgpeth (1990), is parasitic on a hydroid of the same family, *Orthopyxis* (= *Eucopella*) *everta* (Clark, 1876) in California.

Faasse (2013), the only available reproduction reference from Europe, reports the presence of reproductive specimens in late August. Out of 13 males observed the day after their collection at Tog Ru, 4 bore egg-balls on their ovigers while 10 out of 16 females had numerous visible eggs in their femurs (Figure 3A–B). Hence the breeding season was going on in autumn (late September at Iniz ar mor; November at Tog Ru). Brittany shows a mild climate with e.g. seawater temperatures, recorded close to the sampling station (Pont-Lorois), in November, from 2010 to 2018 (see https://wwz.ifremer.fr/surval/) ranging from 10 to 16 °C (mean for 11 data = 12.9 °C, σ = 2.1). Interestingly, it has to be noticed that out of the 17 males observed after two and a half days of captivity, none bore egg-balls while many exhibited one or two severed ovigers suggesting that eggs and lacking appendage articles had been devoured by their fellows.

Feeding

Pycnogonids diet is rather poorly known (Bamber, 2010). They are generally considered as predators or merely as parasites since their feeding may kill or leave their preys alive. Preys are potentially very diverse, consisting of a wide variety of invertebrate species from sponges to ascidians, but very often of cnidaria (Dietz *et al.,* 2018). In Japan, *A. hilgendorfi* was reported as an ectoparasite on holothurids (Oshima, 1927, quoted by Russel & Hedgpeth, 1990).

We did not observe any specimen acting as a predator in the field at Tog Ru. However, some 4 hours after collecting, one of them was ingesting the naked rear part of an annelid *Spirobranchus* sp. whose tube was broken. The day after, another *Ammothea* diligently attacked the naked body of the barnacle *Verruca stroemia* (O.F. Müller, 1776). However the meat of the bivalve *Hiatella arctica* (Linnaeus, 1767) fed to a group that had been starved for 3 days did not induce any activity in any specimen that were some 2 centimetres away. However, when the meat was drawn directly into contact with them some individuals applied their proboscis on it and seemed to ingest the food while others stood quiet at first but eventually, after one to two hours, many of them took part to the meal.

Added to the probable cannibalism through egg and appendage consumption mentioned above these observations suggest that *A. hilgendorfi* might be an opportunistic carnivore able to act as a scavenger. Yet, its food preferences have still to be determined.

Behaviour when disturbed

When insistently disturbed *A. hilgendorfi* stops in a characteristic standstill position: the legs coxae are turned down ventrally while the rest of the appendages is raised up dorsally. The femurs then form a conical cage above the body, while the succeeding articles group in a narrow bundle, looking like a club or a lantern handle (Figure 6A).

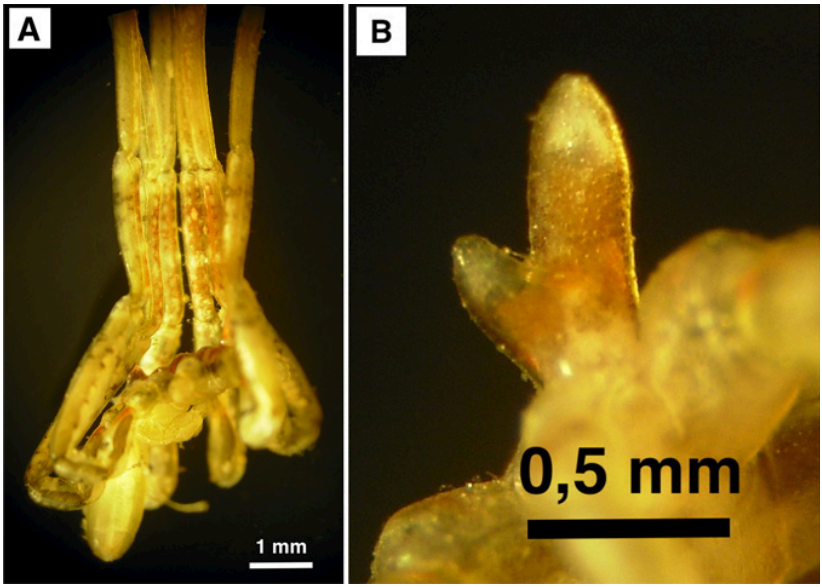

Figure 6: *Ammothea hilgendorfi* (Böhm, 1879). A. Animal with folded appendages. The proboscis appears at the bottom left. B. Abnormally bifurcated abdomen.

As an abnormality let us mention a bifurcated abdomen, of which only one branch seems to be functional (Figure 6B).

Conclusion

It has been hypothesized that *A. hilghendorfi* would have been brought to Europe through commercial shipping (Krapp & Sconfietti, 1983; Bamber, 1985).

However, Bamber (1985) gives an alternative hypothesis of the way of introduction to English waters via the transportation of Japanese oysters *M. gigas* originating from France where it has been intensively cultured from the 1970's. We believe this is rather unlikely to have happened since, so far, the pycnogonid has not been recorded in any French oyster farming site (notably Étang de Thau, Bassin d'Arcachon, Pertuis Charentais) despite its tendency to form rather dense populations and the fact that these sites are under close surveillance for benthic fauna communities.

According to Faasse (2013) its presence in the Netherlands could result either from intercontinental shipping if it is a primary introduction, or if not, it has probably been introduced through recreational shipping or shellfish transportation.

The origin of the Étel river population is currently unknown. Although unlikely, a primary direct introduction through illegal oyster importation from Japan cannot be excluded. However, considering that the species has been present in Europe for almost 4 decades, together with the unceasing shellfish exchanges between culture basins in France and its neighbouring countries, it is very likely that *A. hilgendorfi* has been introduced either from the Adriatic or the Netherlands through oysters or mussels farming activities. Furthermore, this means we can predict that it will soon be scattered through the same vectors along the coasts of Brittany and France.

The effects of the introduction of *A. hilgendorfi* to a newly colonized environment are still largely to be unveiled. Owing to its relatively small size it could be hypothesized that its effects would be negligible. However such point of view appears rather unreasonable because every organism although being small and apparently harmless can be the vector of viruses, bacteria or protozoan that may potentially bring various diseases to indigenous invertebrate species. Moreover considering the densities observed in Étel river, this small predator might have serious effects on its preys populations, small- or large-sized ones as well, by destroying any life stage i.e. eggs, larvae or juveniles and adults. This could induce negative effects on large populations, on the trophic web and in turn on the whole habitat.

The proliferation observed at Tog Ru may correspond to the boom frequently noticed among newly introduced populations, thus likely to be a transitory situation. However high densities were also observed in the UK by Bamber (2010) as well as in the Netherlands by Faasse (https://www.nederlandsesoorten.nl/+Ammothea+hilgendorfi) which suggests the dense population reported here might be established for a while.

The presence of *A. hilgendorfi* in the Étel river raises many questions. Considering its population density a thorough study of its biology as well as a monitoring of its expansion would be required.

Acknowledgement

The authors thank Nancie and Jacques Renaut for their warm welcome and for their lending of boats to row to Iniz er Mor. They are grateful to Bretagne Sud University, particularly to Christine Mehring (university library of Vannes) and to Jacques Grall for providing documentation. Thanks again to Jacques Grall for his help in translating this paper in English.

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Assessment of the presence of *Gracilipurpura rostrata* (Gastropoda: Fasciolariidae) along the northern coasts of Brittany (France)

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Abstract

One specimen of *Gracilipurpura rostrata* (Olivi, 1792) was found in 2017 in Penvénan (Northern Brittany), an intermediate site between two bays where this mediterranean introduced species had been already recorded. We precise here the ecology of the species, and discuss the primary and secondary vectors of the spread of the species along the coasts of northern Brittany.

Keywords: Fasciolariidae; introduced species; northern Brittany

État des lieux de la présence de *Gracilipurpura rostrata* (Gastropoda : Fasciolariidae) sur les côtes de Bretagne nord (France)

Résumé

La découverte d'un spécimen de *Gracilipurpura rostrata* (Olivi, 1792) dans un secteur où cette espèce méditerranéenne introduite n'était jusqu'alors pas répertoriée, permet de dresser un état des lieux de sa présence sur les côtes nord de la Bretagne et de préciser son écologie. Les vecteurs de propagation de cette espèce dans la région sont également discutés.

Mots-clés : Bretagne nord ; espèce introduite ; Fasciolariidae

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On the 18th November 2017, we have found a living specimen of the Fasciolariidae gastropod *Gracilipurpura rostrata* (Olivi, 1792) (= *Fusinus rostratus* (Olivi, 1792)) in Penvénan (Côtes-d'Armor). The specimen was collected at the bottom of a jetty (48°50′35.3″N 3°16′29.4″W) in the vicinity of the village of Buguélès (near Penvénan) among a pile of *Pecten maximus* (Linnaeus, 1758) shells freshly cleaned out by fishermen.

The specimen was quickly identified by its red-orange flesh color and its opened and relatively long siphonal canal (0.8 cm) typical of *Gracilipurpura rostrata*. The shell is 32 mm length with 7 whorls (protoconch broken) and 13 mm maximum width (Figure 1). It is encrusted by bryozoans (genus *Turbicellepora* Ryland, 1963), the polychaete *Spirobranchus triqueter* (Linnaeus, 1758) and the cirriped *Balanus balanus* (Linnaeus, 1758).

Figure 1: *Gracilipurpura rostrata* (Olivi, 1792): living specimen collected on the 18th November 2017 near Buguélès (Penvénan, Côtes-d'Armor, France). Scale bar: 10 mm.

G. rostrata is a Mediterranean endemic species, present all over the basin although it is more frequent in the Northern and Central Adriatic, in the Tyrrhenian Sea as well as in the Sicily Canal (Russo, 2014; Scaperrotta *et al.,* 2016). However it is also present on the Atlantic coasts from Morocco southward to Cantabria northward and including the Canary Islands (Poppe & Goto, 1991; Serrano *et al.,* 2006; Goulletquer, 2016). The presence of *G. rostrata* was also reported from Mauritania althouh those records might be doubtful (Serrano *et al.,* 2006; Buzzurro & Russo, 2007).

The species lives on various muddy substrates including muddy-sandy and muddy-detritic bottoms (Poppe & Goto, 1991; Buzzurro & Russo, 2007; Scaperrotta *et al.,* 2016). Generally, it is reported from depths around 20 meters but it ranges from a few meters (lagoon of Venice) to more than 800 m (12 km southwest Isle of Marettimo, Italy) (D'Amico, 1912; Poppe & Goto, 1991; Buzzurro & Russo, 2007; Le Duff *et al.,* 2009; Russo, 2012). The species is carnivorous, feeding on polychaetes, gastropods

and bivalves although lacking the ability to drill shells (Goulletquer, 2016).

On the south Channel coast, it has been reported from two areas. Firstly in October 2007, from the bay of Morlaix (Finistère nord), within a heterogeneous-mud habitat (mud mixed with dead *Crepidula fornicata* (Linnaeus, 1758) and dead maerl fragments) at 9 m to 10 m depth (Le Duff *et al.,* 2009; Nolf, 2009). Secondly in September 2009, a specimen was collected by D. Halleux on a muddy-sand beach, on the east of the pointe du Roselier, in the bay of Saint-Brieuc (Côtes-d'Armor) (Le Quément, 2010). Since 2010, it has been recorded in several localities in this bay: from a beach in the north of Plouha, around the pointe du Roselier (Plérin), in the anse de Morieux, from sandy and muddy-sand bottom (Gully & Cochu, 2020) (Figure 2).

Consequently, our specimen is the first record of this introduced species reported outside from these two bays.

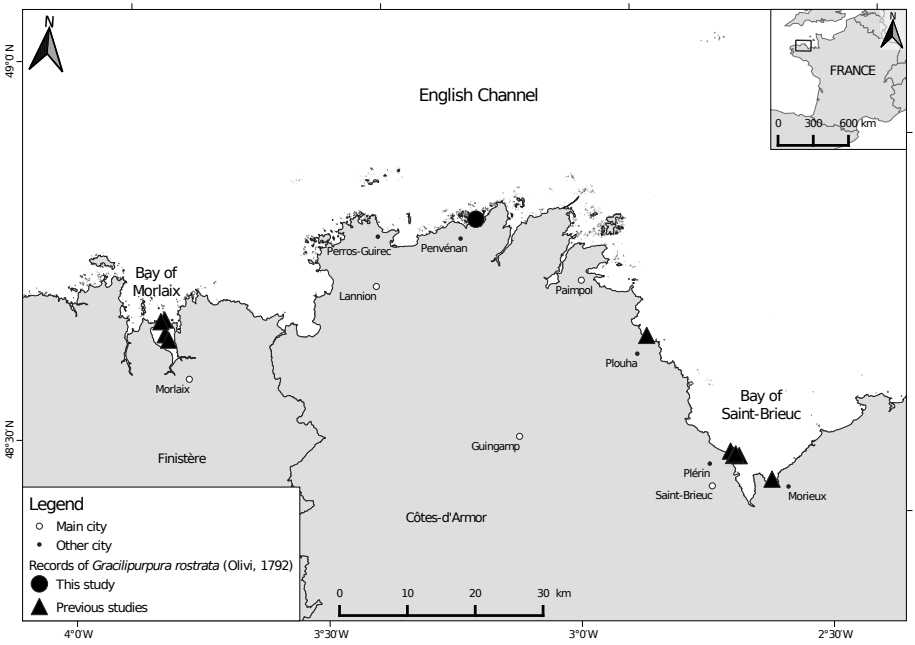

Figure 2: Map showing the records of *Gracilipurpura rostrata* (Olivi, 1792) reported from northern Brittany (this study and the literature): Le Duff *et al.* (2009) and Nolf (2009) for the bay of Morlaix, Le Quément (2010) and Gully & Cochu (2020) for the bay of Saint-Brieuc.

Two non exclusive hypotheses can be put forward to explain the presence of this species in a place where it was previously unknown. The first assumes that *G. rostrata* might have been introduced by the way of oyster culture and more precisely through oyster translocations between several aquaculture areas. Indeed, the Bay of Morlaix, where 7 specimens were found by Le Duff *et al.* (2009), as well as the bay of Saint-

Brieuc (including Paimpol area) are major areas of oyster aquaculture in Brittany, with 704 ha and 836 ha of oyster farms, respectively.

The second hypothesises that the propagation of the species was caused indirectly by professional fishing activities.Indeed, the western maritime area of the Côtes-d'Armor department is one of the major king scallop french fishery. The bay of Saint-Brieuc holds today the largest stock of this area with a total yearly catch of 5 600 t spread over more than 150 000 ha. Closer to the site where we found our specimen of *G. rostrata*, in the secondary fishery of Perros-Guirec, 165 t were catched during the 2017 fall season. *P. maximus* is catched by dredging over a very short period of time (45 min by day in Bay of Saint-Brieuc) and the fished stock is often sorted out from the dredge non passed fraction and cleaned out at the harbour (this task is forbidden at sea).

In our case, *G. rostrata* have been found on pebbles at the bottom of a jetty, among *P. maximus* shells freshly cleaned out by fishermen (some pieces of fresh flesh were present on some shells). This localisation on the upper shore at low water is not coherent with the environmental preferences of this subtidal species living on muddy habitats. Therefore, we believe that the specimen we found was probably accidentaly catched together with *P. maximus* in front of Penvénan and discarded there with *Pecten* valves on the shore where we found it. The question of its ability to come down the shore and settle on the coasts of Penvénan stands.

Gracilipurpura rostrata seems to be well established along the french Channel coasts, between the bay of Morlaix and the bay of Saint-Brieuc. We hypothesize *G. rostrata* populations could be now present almost continuously between these two bays. Considering that constant oysters transportation between oyster farms from the french Channel-Atlantic seabord (Le Bihan *et al.,* 2017), the presence of *Gracilipurpura rostrata* should be carefully researched within other oyster farms basins, such as the gulf of Morbihan (southern Brittany), the Marennes-Oléron basin (Charente-Maritime) or the Bassin d'Arcachon (Gironde). These ecosystems already show substantial numbers of introduced species, brought there predominantly by aquaculture activities.

The gastropods species *Crepidula fornicata*, *Gibbula albida* (Gmelin, 1791), *Ocenebra erinaceus* (Linnaeus, 1758), *Rapana venosa* (Valenciennes, 1846) and hence *Gracilipurpura rostrata* are but a few examples of the species introduced through aquaculture activities along the french coasts of the Channel. This is an ongoing process. Therefore one may wonder on the identity of the forthcoming species that will be introduced to theses ecosystems. But overall the issue regards their potential impacts on biodiversity as well as on ecosytems functionning of there areas. How many other introductions will happen along our coasts? And which will be the consequences for the ecosystems?

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One-step beyond: northernmost record of *Berghia verrucicornis* (Costa, 1867)

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Abstract

The nudibranch *Berghia verrucicornis* (Costa, 1867) was sampled during a citizen science survey along the Brittany coast as part of a macrofaunal species monitoring in the intertidal area. This note reports for the first time the occurrence of *B. verrucicornis* in Brittany. In addition, it is also the northernmost record for this species. Its distributional range is thereby increased by 200 km to the north.

Keywords: *Berghia verrucicornis*; Brittany; citizen science; new record; nudibranch

Un pas en avant : signalement septentrional de l'espèce *Berghia verrucicornis* (Costa, 1867)

Résumé

Le nudibranche *Berghia verrucicornis* (Costa, 1867) a été échantillonné lors d'une sortie de science participative le long des côtes bretonnes, dans le cadre d'un suivi de la macrofaune des estrans. Cette note rapporte pour la première fois l'occurrence de *B. verrucicornis* en Bretagne. De plus, il s'agit du signalement le plus septentrional pour cette espèce. Son aire de distribution s'agrandit de 200 km vers le nord.

Mots-clés : *Berghia verrucicornis* ; Bretagne ; nouveau signalement ; nudibranche ; science participative

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Introduction

The "OBservatoire du Changement sur les Estrans" (OBCE, literal translation: "Observatory of the intertidal modifications") citizen science program was created in 2018 by Bretagne Vivante - SEPNB, an association aiming to protect the nature in Brittany. OBCE monitors several marine species whose distributional ranges reach their northern or southern limit on the coasts of Brittany. Gathering all marine enthusiasts naturalists and some scientists experts of Brittany, the project also aims to record any taxa which might newly occur either naturally or as introduced by humans activities within the area (Hily, 2018).

Recently, several sea slugs species have been reported either for the first time in Brittany, such as for the small species *Trinchesia genovae* (O'Donoghue, 1926), either as a northernmost record for *Spurilla neapolitana* (Delle Chiaje, 1841) or for both reasons like *Babakina anadoni* (Ortea, 1979) and *Felimida krohni* (Vérany, 1846) (Delemarre *et al.,* 2016; Droual, 2018; Grall *et al.,* 2015). Unfortunately, the naturalist knowledge is currently decreasing in research laboratories as well as funding allocated for biodiversity assessment. In such context, citizen science might appears as a useful tool to help the scientists to cope with the lack of time and knowledge. Combined with the technology (e.g. passionate groups on social media), citizen marine naturalists might then act as early detectors of non-indigenous species or new distributional records (Giovos *et al.,* 2019; Kleitou *et al.,* 2019). In this study, we present such an example: *Berghia verrucicornis* is recorded in Brittany for the first time, a record which correspond to its northernmost record, during an OBCE field survey.

Methods

Macrofaunal biodiversity assessment were made without strict protocol. The specimen was sampled under a rock boulder close to the kelps level at the mean low water level the 20th February 2019 at 'La Pointe du Diable', Plouzané, France (48°21′17″N 4°33′29,5″W) (Figure 1). The alive specimen was examined under a Zeiss Stemi 2000-C stereomicroscope and photographed with a Canon EOS 600D mounted on stereomicroscope. After identification, the specimen was fixed in 96 % alcohol, freshened up three times and kept at ambient temperature.

The specimen is available at the Paris National Museum of Natural History under the collection number MNHN-IM-2013-86089.

Results

Material examined: one specimen, maximal length around 20 mm (specimen stretched out), Pointe du Diable, Plouzané, Brittany, France, the 20th February 2019.

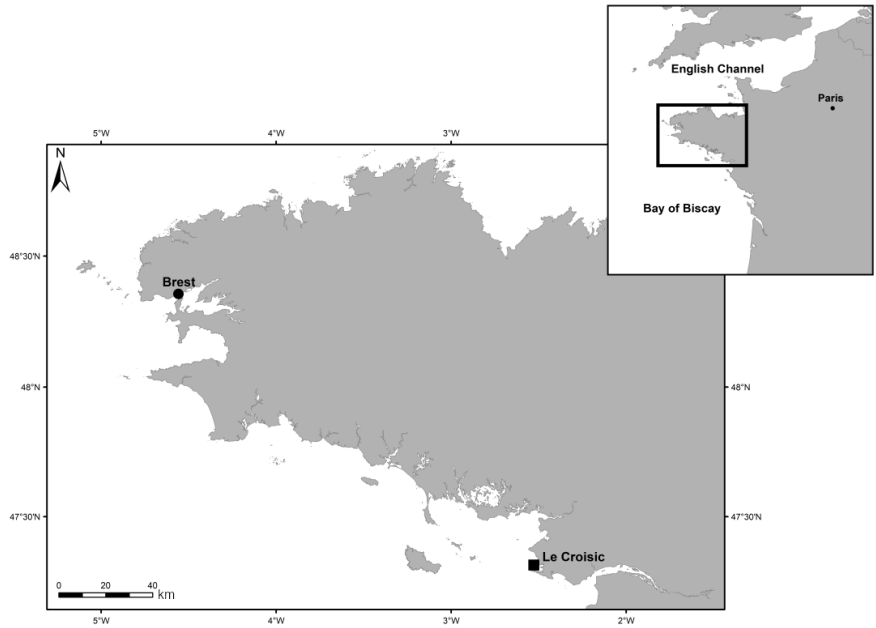

Figure 1: Map showing the northern historical sighting site (black square) of *Berghia verrucicornis* (Costa, 1867) at Le Croisic made by Labbé (1931) and the current northern record (black circle) at La Pointe du Diable close to Brest city.

Identification

The species level have been reached thanks to all recent diagnosis available through the literature (Ballesteros *et al.,* 2012; Calado & Silva, 2012; Carmona *et al.,* 2014; García-Gómez *et al.,* 2011).

Diagnostic criteria (Figure 2)

Papillate rhinophores short and orange with white tips; two obvious orange bands from the rhinophores to the oral tentacules; two eyes clearly visible. Behind eyes, fade orange triangle linked to the pericardic region. Orange spot on pericardic area; orange line continuing to the cerata group 4. Cerata with white tip; subapical bright orange ring.

Discussion

Berghia verrucicornis distribution, before the record here reported, ranges from the Mediterranean Sea to the Atlantic. In the Eastern Atlantic, it lives from Le Croisic

Figure 2: *Berghia verrucicornis* (Costa, 1867), alive specimen from 'La pointe du Diable', Plouzané near Brest, 20th February 2019, MNHN-IM-2013-86089. Scale bar: 5 mm.

(Labbé, 1931) in France to the African coasts (Edmunds, 1968; Muniain & Ortea, 1999). The northern limit of *B. verrucicornis* now reaches the Iroise Sea at the entrance of the Bay of Brest. Such localization expands the former northernmost locality by some 200 km to the north (Figure 1).

Among the numerous abiotic parameters impacted by climate changes, seawater temperatures experience strong increase over the last decades, especially in the European seas (Belkin, 2009). Modification of the seawater isotherms is usually considered as the main driver causing shifts of distributional ranges and rescheduling phenology at large spatio-temporal scales (Burrows *et al.,* 2014). Species are expected to adjust their geographical distribution to face these forthcoming environmental changes (Burrows *et al.,* 2014; Stuart-Smith *et al.,* 2017). Some studies demonstrate that marine species will track the isotherms velocities mainly poleward even if some species might go further south or show no responses, depending on their physiology, dispersal abilities, population size, but also from physical barriers, habitat or food suitability

(Burrows *et al.,* 2014; Pinsky *et al.,* 2013). According to a meta-analysis, benthic Mollusca (post-larval stages for gastropods, bivalves, chitons) leading edge is increasing by almost 20 km per decade (Poloczanska *et al.,* 2013). The extension of *Berghia verrucicornis* is here reported 200 km from its last northern historical record almost 10 decades ago (Labbé, 1931) which seems coherent with the results of Poloczanska *et al.* (2013). However, because the temperature started to increase noticeably later than the last report of *B. verrucicornis*, the species might have expand recently its distributional range at a rate higher than 20 km per decade (Belkin, 2009; Cheng *et al.,* 2019). The expansion of the geographical distribution of *Berghia verrucicornis* probably results from the effect of climate change on seawater isotherms distribution rather than from a local introduction.

It also has to be noticed that new records of small nudibranch species along Brittany coast are not surprising, as this taxon has received poor attention during the last decades in this area. Indeed, the last large focused scientific study on nudibranchs in Brittany was published more than 40 years ago (Bouchet & Moreteau, 1975) and has never been updated since. During most of benthic monitoring projects, the identification of nudibranchs usually does not reach the species level since the organisms lose their colours and cerata and are often in bad condition when stored in formalin (Droual, 2018). Additionally, as discussed above, climate change induce locally new distributional ranges for some taxa and lead to the establishment of new allochthone nudibranch species. This group should thus receive specific attention during campaigns or biodiversity assessment fieldworks, especially on live material, to acquire more data and to update species checklists (work in progress). Range shifts induced by climate change are usually easier to observe on the intertidal zone compared to the deeper waters, thereby programs like the OBCE project may be essential tools to improve biodiversity monitoring at large scales and in areas under-monitored by scientists (Garcia-Soto *et al.,* 2017; Wethey & Woodin, 2008).

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CONSIGNES AUX AUTEURS

Dernière révision : septembre 2018

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La présente revue, propriété de l'Institut Universitaire Européen de la Mer - Université de Bretagne Occidentale, vise à faciliter la publication et la diffusion de nouvelles naturalistes maritimes et marines vers un public aussi large que possible, ce qui devrait être favorisé par son accès gratuit et en ligne. Elle est dédiée aux inventaires, à la description et à la biogéographie de tous les groupes taxinomiques associés aux eaux estuariennes, côtières et du large de la Bretagne. Son emprise est donc très large, allant de la faune et la flore benthique ou pélagique, côtière ou profonde jusqu'à la végétation des vases salées soumises aux marées. Cependant, les frontières géographiques ne sont pas arrêtées et les données pourront s'étendre aux côtes de la Manche et de l'Atlantique (dans la limite d'une cohérence biogéographique).

An Aod accepte les articles originaux de recherche, les observations inédites, les inventaires et les synthèses régionales. Les études présentant la biologie ou l'écologie de certaines espèces ayant un intérêt particulier pourront être acceptées.

Chaque manuscrit sera évalué et critiqué par un ou plusieurs membres du comité éditorial. Le cas échéant, il pourra être transmis à des experts externes pour revue. Le comité de rédaction se réserve, seul, le droit d'accepter ou de refuser la version finale du manuscrit. Les articles seront publiés en ligne avec une fréquence de parution officielle semestrielle (deux numéros, constituant un volume, par année). Si le comité de rédaction le juge utile, un troisième numéro spécial pourra être publié.

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Les articles soumis pourront être rédigés en français ou en anglais, selon le choix de l'auteur. Ils pourront être soumis en format Microsoft Word (.doc ou .docx), OpenDocument (.odt) ou LaTeX (.tex).

L'espacement interligne sera de 1,5 et les lignes seront numérotées.

Si des sigles ou des acronymes sont utilisés, ils devront être spécifiés en totalité dès leur première apparition.

Les tableaux et les illustrations, avec leur légende, devront être incorporés à la fin du document soumis. Les illustrations devront également être jointes séparément dans leur format original matriciel de bonne qualité (.tiff, de préférence, ou .jpeg) ou vectoriel (.eps, .ps, .svg ou .pdf) afin de faciliter la mise

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La page de titre doit comporter les éléments suivant :

— **titre** : il doit être rédigé en français et en anglais. Il doit être aussi court que possible ;

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Texte

Seuls les noms scientifiques des espèces devront être en italique, et leur première mention suivie par l'autorité et l'année.

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Les figures peuvent être en nuances de gris ou en couleurs. Cependant, la palette de couleurs de type « arc-en-ciel » ne doit pas être utilisée. Les auteurs privilégieront les palettes telles que « viridis » ou « cividis », aisément perceptibles par les personnes souffrant de troubles de perception des couleurs.

Elles doivent être numérotées en chiffres arabes et leur référence dans le texte doit apparaître sous la forme « figure 1 ». Si une figure se compose de deux ou plusieurs sous-figures, ces dernières doivent être distinguées par une lettre capitale (« figure 1A » par exemple).

La taille d'un élément photographié doit être indiquée sous la forme d'une barre d'échelle sur la photo et non par un grossissement dans la légende. Une carte doit obligatoirement comporter : une flèche du nord, une échelle et une légende. Les symboles et abréviations utilisés devront être clairement explicités dans la légende. En règle générale, une figure doit se suffire à elle-même.

Tableaux

Les tableaux ne doivent pas être de taille excessive. Ils doivent être numérotés en chiffres arabes. Les en-têtes de colonnes doivent apparaître en gras et être aussi clairs et concis que possible.

Les symboles et abréviations utilisés devront être clairement explicités dans la légende. En règle générale, un tableau doit se suffire à lui-même.

Le tableau ci-dessous est un exemple de mise en forme.

Tableau 1 : Richesse phytocœnotique des différents compartiments écologiques du pré-salé.

Compartiment écologique	Richesse phytocœnotique (anse d'Yffiniac)				
	Années				Rich. phyt. max.
	1979	2002	2011	2012	
Haute slikke	3	2	2	3	3
Bas schorre	1	1	1	1	1
Schorre moyen	4	4	4	5	5
Haut schorre	5	7	6	7	8
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Les références bibliographiques doivent être listées par ordre alphabétique (auteur-date) à la fin du manuscrit. Les références mentionnées dans le texte, et seulement celles-ci, doivent apparaître dans la liste des références bibliographiques. Les titres d'articles et de journaux doivent être écrits en entier (pas d'abréviations). Tous les auteurs doivent apparaître. Les références doivent comporter les éléments suivants :

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INSTRUCTIONS TO AUTHORS

Revised September 2018

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This journal, property of the European Institute for Marine Studies - University of Western Brittany aims to facilitate publication and diffusion of marine naturalist data to a wide audience, through free and open access. It is dedicated to the publication of species lists, but also to the description and biogeography of any taxon associated to estuarine, coastal and open ocean waters offshore Brittany. Its field of interest thus encompasses benthic as well as pelagic fauna and flora, from the intertidal (including salt marsh and mudflats) coastal to deeper waters of the continental shelf. We also intend to consider any data from waters surrounding Brittany (i.e. Channel or Atlantic coasts of France).

An Aod welcomes original research papers, species observations, inventories and regional syntheses. Studies dealing with the biology and/or ecology of species of interest will be considered.

Manuscripts will be reviewed by one or several members of the editorial board and may be sent to external reviewers. The redaction committee is the only habilitated to accept or refuse the final version of the manuscript. The official publication frequency is two issues (constituting one volume) by year. A third special issue could be published whenever the committee deems appropriate.

General

Papers must be written in French or in English. They should be submitted in Microsoft Word (.doc or .docx), OpenDocument (.odt) or LaTeX (.tex) format.

Text should be written on A4 paper and one half-spaced. Lines should be numbered.

If acronyms are used they must be specified in full on their first occurrence.

Tables and illustrations, with their legend, should be included at the end of the submitted document. Moreover, illustrations should be attached in a separate file and in their original format: good quality raster (.tiff preferably or .jpeg) or vector (.eps, .ps, .svg or .pdf).

Titlepage

The authors should indicate the following elements on the titlepage:

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Text

Scientific names should be italicized and their first mention followed by the authority and the year.

Figures

Figures should either be in grey scale or in colour. However, the rainbow colour scale should not be used. Authors should prefer scales such as "viridis" or "cividis" colour scales because they can be easily perceptible by colour-blind people.

Figures are numbered in Arabic numerals and reference in the text appears as 'figure 1', 'figure 2', etc.

Size must be indicated by a scale bar on photographs, not by a magnification factor in the legend. A map must necessary have a north arrow, a scale bar and a legend. Symbols and acronyms must be clearly explained in the legend.

Tables

Tables should not be excessive in size. They are numbered in Arabic numerals and reference in the text appears as 'table 1', 'table 2', etc. Column headings are bold and must be as clear and short as possible.

Symbols and acronyms used must be clearly explained in the legend.

The following table gives an example of layout.

Table 1: Richesse phytocœnotique des différents compartiments écologiques du pré-salé.

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Total	20	19	19	22	25

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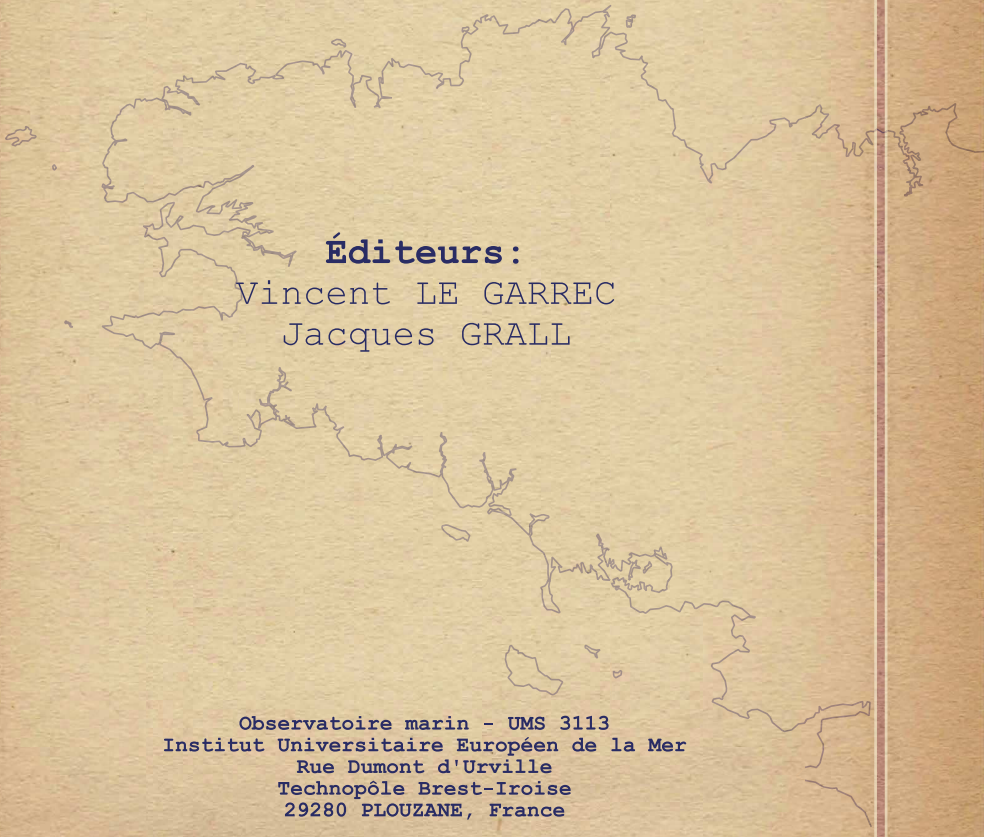

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