

Range extension of the tanaidid *Zeuxo holdichi* (Bamber, 1990) along the northern coasts of France?

Aurélie FOVEAU^{1*}, Jean-Philippe PEZY¹, Noémie BAUX¹, Alexandrine BAFFREAU¹, Quentin BACHELET¹, Bastien CHOUQUET², Chloé DANCIE², Thierry RUELLET³ and Jean-Claude DAUVIN²

(1) Normandie Univ., UNICAEN, UNIROUEN, Laboratoire Morphodynamique Continentale et Côtière, UMR CNRS 6143 M2C, 24, rue des Tilleuls, F-14000 Caen, France

(2) CSLN, Cellule de Suivi du Littoral Normand, 53, rue de Prony, F-76600 Le Havre, France

(3) GEMEL, Groupe d'Etudes des Milieux Estuariens et Littoraux, 115, quai Jeanne d'Arc, F-80230 Saint-Valery-sur-Somme, France

*Present address: Ifremer, Laboratoire Environnement Ressources Bretagne Nord, 38 rue du Port Blanc, F-35801 Dinard, France

Corresponding author: aurelie.foveau@ifremer.fr

Abstract: The tanaidacean crustacean, *Zeuxo holdichi* was first described from Arcachon Bay, France, by Bamber in 1990. Since then, this species has been recorded several times in Europe, from Iberian Peninsula to Germany. In this present study, we report new records of this species along the northern coasts of France bordering the English Channel. It is hypothesized that *Z. holdichi* is being spread because of aquaculture activities.

Résumé : *Extension géographique du tanaïdide Zeuxo holdichi (Bamber, 1990), le long des côtes du nord de la France ?* Les premières descriptions du tanaïdide *Zeuxo holdichi* proviennent du bassin d'Arcachon, France, par Bamber en 1990. Depuis, cette espèce a été signalée dans plusieurs autres sites européens depuis la péninsule ibérique jusqu'aux côtes allemandes. Dans cette étude sont rapportés de nouveaux signalements de cette espèce le long des côtes septentrionales de la Manche (côté français). *Z. holdichi* pourrait être dispersé par les pratiques aquacoles.

Keywords: Crustacea • Tanaids • *Zeuxo holdichi* • English Channel • Northern distribution

Introduction

Tanaidaceans are benthic micro-crustaceans that are very diverse and ecologically important in the marine environment (Larsen et al., 2014). In December 2016, the

order contained 40 families, 300 genera and 1,400 species (Anderson, 2013 & 2016), and their number continues to increase with the discovery of new species (Błażewicz-Paszkowycz et al., 2012; Anderson, 2013 & 2016; EMRS, 2017).

The Tanaididae family Nobili, 1906 contains, inter alia, the genus *Zeuxo* Templeton, 1840, who described this genus from Mauritius (Templeton, 1840). Since the monograph of Sieg (1980), many species have been added (Bamber, 1990,

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2005, 2006, 2008 & 2010; Bamber & Bird, 1997; Edgar, 2008; Bamber & Chatterjee, 2010; Larsen, 2014; Tzeng & Hsueh, 2015; Bird, 2015). *Zeuxo* is one of the most common and species-rich genera (containing 33 species) of this family (ERMS, 2017). Its littoral and shallow-water distribution extends over the Atlantic, Indian and Pacific oceans, but has never been found in Polar Regions. At present, only one species is described from Atlantic European waters (ERMS, 2017). Species of the genus *Zeuxo* are brood-caring, semi-sedentary animals with poor swimming capacity, having a low dispersal potential (Larsen et al., 2014). All the described species are small (less than 6 mm).

Tanaidaceans, and especially the genus *Zeuxo*, are considered as very difficult to identify, and confusion can arise with species of the same genera, because of factors such as sexual polymorphism, as well as the presence of cryptic (and sometimes sympatric) species (Larsen, 2001). However, species-level identification of fauna, and recovery of new records are necessary for understanding species diversity and biogeographic patterns. In Europe, there have been some misidentifications of *Zeuxo* species.

Recent studies (Larsen et al., 2014) using molecular techniques revealed that *Z. normani* is a species complex comprising five species (*Z. normani* is in fact distributed in the western Atlantic). One of the species of this complex is *Zeuxo holdichi* Bamber, 1990, which is only found in European waters (East Atlantic; Bird, 2001); it was first described by Bamber from Arcachon Bay, France and was redescribed by Larsen et al. (2014). This redescription of *Z. holdichi* helps in the morphological identification of our specimens. Bamber (2011) also reported the presence of *Z. holdichi* in Galicia (northwest Spain), the Ria de Aveiro (Portugal) and northern Brittany (France) as well as Plymouth and the Scilly Isles (southwestern Britain).

Our study documents the presence of *Z. holdichi* on the northern coasts of France bordering the English Channel.

Material and methods

Zeuxo holdichi specimens were collected along the French coast of the English Channel in nine locations (Fig. 1; Table 1):

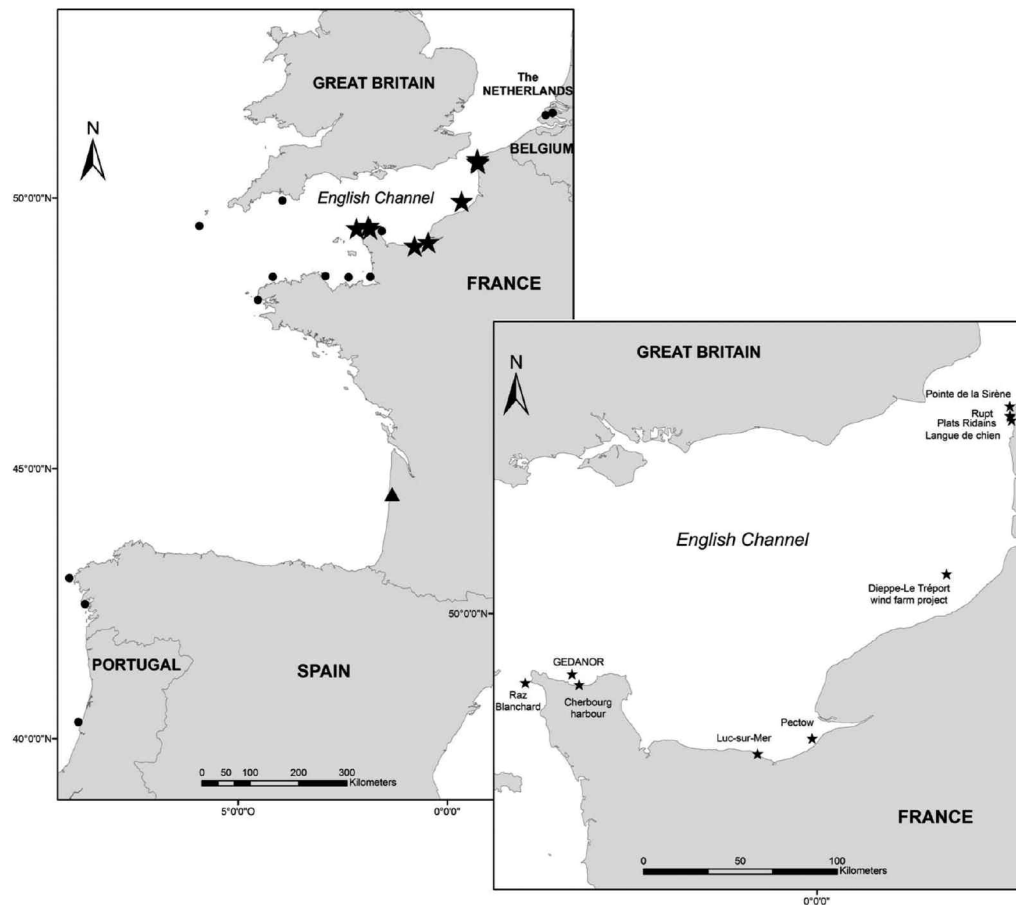


Figure 1. *Zeuxo holdichi*. Recorded distribution in France and in Europe. Stars: this study. Filled circles: previous records. Triangle: type locality.

Table 1. *Zeuxo holdichi*. Specimens collected in the northern coasts of France.

Date	Number	Location	Substrate	Division
03/2014-07/2016	> 100,000	Luc-sur-Mer	Red seaweed, concrete	Intertidal
10/2013-06/2014	480	Cherbourg Harbour	Sand, hydroids	Subtidal (11 m)
04/29/2015	2	Raz Blanchard	Rocks, hydroids	Subtidal (60 m)
7/1/2016	1	Plat Ridain	Mussel beds	Intertidal
01/13/2016	2	Pointe de la Sirène	Mussel beds	Intertidal
01/14/2016	2	Langues de Chien	Mussel beds	Intertidal
1/2/2016	1	Bay of Seine	Gravelly and shelly sands	Subtidal (4.5 m)
9/2/2016	1	Plat Ridain	Mussel beds	Intertidal
11/2/2016	4	Langues de Chien	Mussel beds	Intertidal
02/24/2016	7	Rupt	Mussel beds	Intertidal
5/3/2016	1	Dieppe-Le Tréport windfarm project	Coarse sand	Subtidal (28 m)

- RECIF project, Luc-sur-Mer beach, Bay of Seine (Foveau et al., 2015);
- GEDANOR project, Rade de Cherbourg, North Cotentin (Baux et al., 2017);
- Dieppe-Le Tréport project in the eastern part of the English Channel (Pezy, 2017);
- Pile & Tide project: in the Raz Blanchard, North Cotentin (Foveau & Dauvin, 2017);
- Pectow 2016 survey in the eastern part of the Bay of Seine (unpublished data);
- Four mussel beds monitoring, along the Opal coast (unpublished data).

Except for the RECIF project, where sediment was sieved through a 0.5 mm square mesh, all the other samples were sieved through a 1 mm circular mesh. During field surveys, the samples were preserved in buffered 10% formalin solution. After sorting, samples were stored in 98% ethanol. Determinations were carried out at the laboratory to species level (if possible), by using a binocular magnifier and microscope and consulting the relevant literature.

For the identification of *Zeuxo holdichi*, we used the following publications: Sieg & Winn, 1981; Bamber, 1990; Larsen, 2014. The important criteria that allowed us to distinguish the genus were: short uropods with articles twice (rarely three times) as long as broad, terminal articles of uropods normal, pleon with five pleonites plus pleotelson, coxa of pereopod 1 with or without protuberance, pereonites 1-3 large (longer than broad), cephalothorax of male normal, first article of antenna 1 greater than 2.5 times (often 3 times) length of second article. The criteria used to distinguish species are: antenna article 2 with small dorsal spines; left mandible with only one spiniform seta under the lacinia mobilis; labial basis with spines; cheliped dactylus with small inner spines; carpus of pereopod 2 with four spiniform setae while pereopods 3-6 have five; pereopod 3 dactylus with small proximal seta; endopod of pleopod 1 and 2 with three plumose inner setae, while pleopod 3 only has two. Bamber

(1990) and Larsen (2014) both noted variations of the uropod article number of this species.

Results

Our species identification was validated by Patricia Esquete (Aveiro University) during an identification workshop on tanaidaceans organized by the French RESOMAR (Réseau des Stations et Observatoires Marins) network at Dinard in May 2017.

During the surveys, both females and males were found (Fig. 2); the minimal size of collected juveniles was 1.02 mm; the maximal size recorded is 5.51 mm for females and 4.03 mm for males.

Apart from the RECIF project (for which the mesh size was smaller and where more than 100,000 specimens were collected) and the Rade de Cherbourg (484 specimens), most of sites were in the intertidal zone (on the mid-littoral area) (Table 1).

**Figure 2.** *Zeuxo holdichi*. A. Brooding female. B. Male.

Specimens were collected on and between shells, on sediments, on red algae, on and between hydrozoans, on and between mussel beds and on concrete (artificial reef structures). The tanaids live inside parchment tubes they build.

Discussion

The specimens of *Z. holdichi* collected in these studies were distinguished from the other tanaids of northwest Europe and from *Sinelobus stanfordi* (Richardson, 1901) recently recorded in the Raz Blanchard (Foveau & Dauvin, 2017) and *Sinebolus vanhaari* Bamber, 2014 by the presence of a 7-articulated uropod and five pleonites without dorsal fringe setae (van Haaren & Soors, 2009; Bamber, 2014).

In their genetic study, Larsen et al. (2014) indicated that *Z. holdichi* has closer genetic relationships with the Pacific *Z. normani* (Richardson, 1905) specimens than with other North Atlantic species. They also stated that *Z. holdichi* belonged to the *Zeuxo normani* species complex. As proposed by Kettle et al. (2011) for cold-water taxa, *Z. holdichi* may have retreated to southern refuge during the last glaciations (Iberian Peninsula, for example). Bamber (2011) reported the presence of *Z. holdichi* in Galicia (northwest Spain), and the Ria de Aveiro (west Portugal). However, this species had perhaps started recolonizing more northern latitudes, since we find them in the northern parts of the English Channel and spreading to Dutch waters (Faasse, 2013).

In 2005, Larsen stated that *Z. holdichi* with low intrinsic dispersal could spread over great distances by rafting, human transport via ballast water or fouling. In this study, all the locations where we found *Z. holdichi* are close to shellfish culture areas or harbours with marinas. Aquaculture is recognized as a pathway in the dispersal of non-native species (Minchin, 2007). The traffic of smaller vessels could also play an important role in the secondary spread of species to neighbouring areas (Marchini et al., 2015). In accordance with Faasse (2013), we suggest that shellfish culture and recreational navigation may account for subsequent dispersal from south to north. Algae attached to boats or shellfish pockets can serve as supports for the species and thus allow their dispersion (Błażewicz-Paszkowycz et al., 2012). However, it is still not clear whether our observations concern newly settled populations or older populations that we are just beginning to identify.

Since *Z. holdichi* is a small and recently described species, it is likely that its presence in northeastern Atlantic waters will be recorded at numerous locations in the future, due to increased attention paid to the identification of tanaidaceans. *Zeuxo holdichi* remains rare at most of the locations sampled in this study, except at Luc-sur-Mer

where the species is very abundant. The reason for the high abundances at this location remain enigmatic, perhaps associated with its complex 3D habitat structure of algae, hydroids, etc.

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