First record of the non-native species *Grandidierella japonica* Stephensen, 1938 (Crustacea: Amphipoda: Aoridae) along the French Basque coast

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Abstract

The non-native species *Grandidierella japonica* Stephensen, 1938 is reported for the first time along the French Basque Country. Specimens were collected in 2015, 2016 and 2017 from the Figuier Bay and the Nivelle and Adour estuaries. This amphipod, native to the Sea of Japan, may have been introduced along the French Basque Country with recreational boats from Hossegor lagoon or Arcachon Bay and/or with international shipping.

Keywords: Adour estuary; amphipod; Aorid; exotic species; Figuier Bay; French Basque country; *Grandidierella japonica*; international shipping; Nivelle estuary; recreational boats

Premier signalement de l'espèce introduite *Grandidierella japonica* Stephensen, 1938 (Crustacé : Amphipode : Aoridae) au Pays basque dans sa partie française

Résumé

L'espèce exotique *Grandidierella japonica* Stephensen, 1938 est signalée pour la première fois au Pays basque, dans sa partie française. Des individus ont été échantillonnés en 2015, 2016 et 2017 dans la baie du Figuier et les estuaires

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de la Nivelle et de l'Adour. Cet amphipode de la famille des Aoridae, natif de la mer du Japon, a pu être introduit au Pays basque français par les activités de plaisance depuis Hossegor voire Arcachon mais également via le trafic maritime international.

Mots-clés : activités de plaisance ; amphipode ; Aoridae ; baie du Figuier ; espèce exotique ; estuaire de l'Adour ; estuaire de la Nivelle ; *Grandidierella japonica* ; Pays basque français ; trafic maritime international

Introduction

Grandidierella japonica Stephensen, 1938 is an Aorid amphipod species (Crustacea: Amphipoda: Aoridae), native to the Japan Sea (Nagata, 1960; Nagata, 1965). It was first reported outside its natural range in 1966 in San Francisco Bay (Chapman & Dorman, 1975). *Grandidierella japonica* is now distributed in intertidal and subtidal sediments from bays and estuaries of the west coast of the United States (Greenstein & Tiefenthaler, 1997), in Mexico (Okolodkov *et al.,* 2007), Hawaii (Coles *et al.,* 1999) and Australia (Myers, 1981). More recently, the species has appeared in Europe: first in South-east England (Smith *et al.,* 1999; Ashelby, 2006), then on the French Atlantic coast in Marennes-Oléron Bay and in Arcachon Bay (Jourde *et al.,* 2013; Lavesque *et al.,* 2014), in Sweden (Berggren, 2015), in the Mediterranean basin along Italian coasts (Marchini *et al.,* 2016; Munari *et al.,* 2016) and finally in Brittany (Droual *et al.,* 2017).

This paper reports the first record of this species in French Basque Country, Bay of Biscay, in the Figuier Bay and the Nivelle and Adour estuaries.

Material and methods

The French Basque coast extends from the Adour to the Bidassoa estuaries. Along this coast, the Adour, Bidassoa and Nivelle are the three main rivers flowing to the Atlantic Ocean (Augris *et al.,* 2009) (Figure 1).

A total of 45 soft-bottom stations were sampled on these three estuarine systems including their opening, with four seasons per year during two years (from August 2014 to June 2016) for the Nivelle and Bidassoa estuaries and during three years (from August 2014 to June 2017) for the Adour estuary. At each station, three samples were collected. Sediments were collected using a Van Veen grab (0.1 m^2). Grab contents were sieved through a 1 mm mesh size. Material retained on the sieve was directly fixed in ethanol (99.9 %).

Species were examined under a Nikon SMZ 25 stereomicroscope and a Nikon Eclipse E400 microscope and photographed with a Nikon DS-Ri2 camera. Body length (BL) was measured with NIS-Elements Analysis software from anterior margin of head to posterior end of telson.

Specimens of *G. japonica* were collected only during six field campaigns (August 2015, December 2015, March 2016 and 2017, June 2016 and 2017) and on eight stations: four located in the Nivelle estuary (anchorage area and fishing harbour), one in the Figuier Bay and three in the Adour estuary (international shipping harbour).

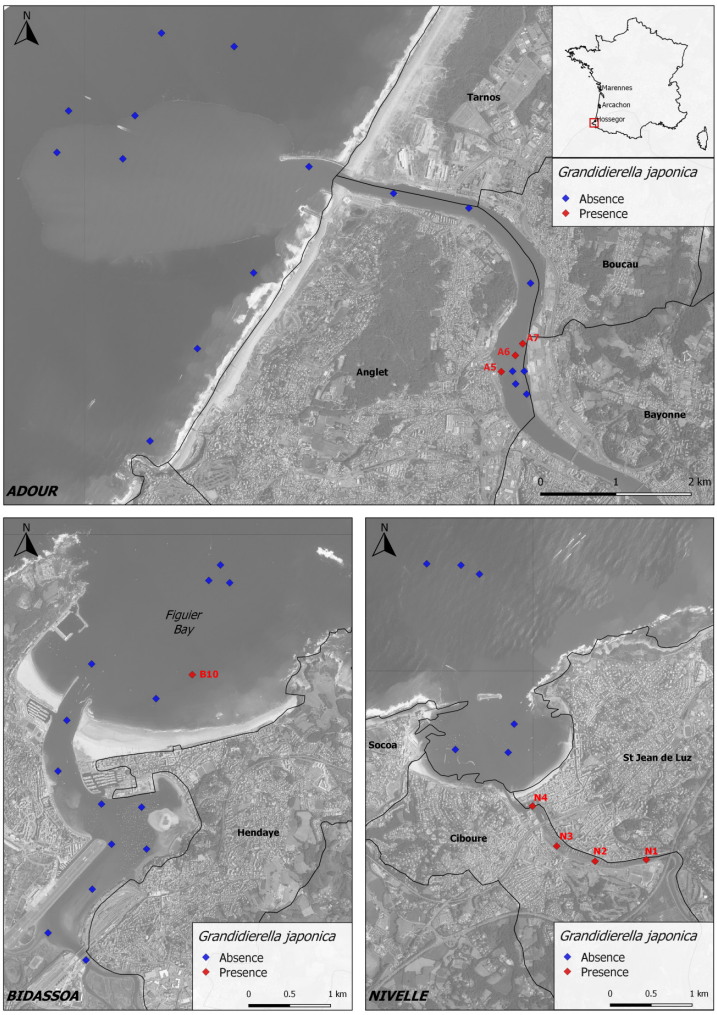

Figure 1: Maps of the study areas with location of sampling stations. Blue dots: absence, red dots: presence of *Grandidierella japonica* Stephensen, 1938.

Results

Identification of the different specimens was relatively complex, in particular due to the lack of a description of this species in the identification keys commonly used for the French Atlantic coast (Chevreux & Fage, 1925; Lincoln, 1979). In our first analysis, individuals were compared to the genus *Microdeutopus* Costa 1853, but differs by uropod 3 rami: *Microdeutopus* has biramus uropod 3 whereas *Grandidierella* has uniramous uropod 3 (Figure 2).

Figure 2: *Grandidierella japonica* Stephensen, 1938 from Figuier Bay. Adult male, BL = 6.21 mm, right uropod 3, dorsal view. Scale bar: 0.1 mm.

A total of 122 specimens of *Grandidierella japonica* were sampled along the French Basque Country. The majority of specimens were collected from various soft substrates, ranging from mud to heterogeneous gravels, in the Nivelle anchorage zone (Nivelle estuary) and at the fishing harbour of Saint-Jean-de-Luz/Ciboure. At the shipping harbour of Bayonne, 33 specimens were collected in 2017 during the 2 last field campaigns. Only one individual was sampled on the fine sands of station B10, located in Figuier Bay (Figure 3).

Figure 3: *Grandidierella japonica* Stephensen, 1938 from Figuier Bay. Adult male, BL = 6.21 mm, lateral view. Scale bar: 1 mm.

Within Aoridae, most genera display a strong sexual dimorphism. The presence of mature males is thus generally required to identify specimens at the species level. Gnathopod 1 of the mature males sampled (Figure 4) has stridulating ridges on the anterior margin of the carpus and 3 teeth (1 main and 2 accessories) on the posterior distal angle of the carpus, which are the specific characters of the species *G. japonica*.

Figure 4: *Grandidierella japonica* Stephensen, 1938 from Figuier Bay. Adult male, BL = 6.21 mm. A. Left gnathopod 1, inner view; B. detail of anterior margin of the gnathopod 1 carpus, arrows show the transverse ridges; C. left gnathopod 1, inner view of carpus (in part), propodus and dactylus, arrows show the teeth. Scale bars: A: 0.5 mm; B, C: 0.1 mm.

Discussion

Ecology

In previous studies, *Grandidierella japonica* was described as an eurytopic species (Marchini *et al.,* 2016) able to colonize a multitude of habitats characterized by a large range of substratum and salinity levels: muddy and sandy shores in the Pertuis Charentais (Jourde *et al.,* 2013), seagrass beds (*Zostera (Zosterella) noltei* (Hornemann)) in the Arcachon Bay (Lavesque *et al.,* 2014) and in *Ficopomatus enigmaticus* (Fauvel, 1923) reefs in the marina of Viareggio (Marchini *et al.,* 2016).

In our study, *G. japonica* specimens (26 ind. 0.3 m^2) were mostly collected in the subtidal zone of the Nivelle estuary, at the anchorage zone, in August 2015 (Figure 1). The substrate consisted in heterogeneous gravels with silt and clay fraction below 10 %. This species was also sampled in a polyhaline zone in the subtidal fine sands of Figuier Bay and the subtidal muddy bottoms of the harbours of Saint-Jean-de-Luz and Bayonne (Table 1, Figure 1).

Thus, this new records broadens again the spectrum of the ecological requirements of this species.

Pathway of introduction

Previous records of *Grandidierella japonica* outside its native range have been commonly explained by shellfish farming industry (Chapman & Dorman, 1975; Okolodkov *et al.,* 2007; Munari *et al.,* 2016). Especially along the French coasts, farming of the Japanese

Table 1: Specimens of *Grandidierella japonica* Stephensen, 1938 collected in the Figuier Bay, the Nivelle estuary and the Adour estuary.

Site	Stations	Density (ind. 0.3 m^2)	Date	Sediment
Figuier Bay	B10	1	August 2015	Fine sands
Nivelle estuary	N1	3	August 2015	Fine sands
	N2	26	August 2015	Heterogeneous gravels
	N3	9	August 2015	Heterogeneous gravels
	N4	2	August 2015	Mud
	N1	1	December 2015	Fine sands
	N2	10	December 2015	Gravelly mud
	N3	21	December 2015	Heterogeneous gravels
	N2	1	March 2016	Muddy heterogeneous gravels
	N3	9	March 2016	Heterogeneous gravels
	N4	1	March 2016	Gravelly mud
	N2	1	June 2016	Heterogeneous gravels
	N3	1	June 2016	Heterogeneous gravels
	N4	3	June 2016	Mud
Adour estuary	A5	3	March 2017	Sandy mud
	A7	2	March 2017	Sandy mud
	A5	3	June 2017	Muddy sand
	A6	6	June 2017	Muddy sand
	A7	19	June 2017	Sandy mud

oyster *Magallana gigas* (Thunberg, 1973) is the most likely hypothesis for the introduction of *G. japonica* (Jourde *et al.,* 2013; Lavesque *et al.,* 2014; Droual *et al.,* 2017). Successive epizootics events in the seventies encouraged oyster industry to import massively *M. gigas* from Japan to counter the oyster stocks collapse (Grizel & Héral, 1991). In this way, the first hypothesis to explain presence of *G. japonica* in French Basque Country could be oyster farming and the proximity of the Hossegor lagoon (15 km north). The species was actually identified at 2 intertidal stations in this site, during Water Framework Directive (WFD) monitoring in 2016 (H. Blanchet, pers. comm.).

A second pathway of introduction could be linked to recreational boating between Basque coast and Hossegor lagoon and/or Arcachon Bay (130 km north). Indeed, recreational boating is considered to be an important way of transfer and of secondary spread of marine non-native species (Davidson *et al.,* 2010; Clarke Murray *et al.,* 2011; Ros *et al.,* 2013; Zabin *et al.,* 2014). Marchini *et al.* (2016) proposed this vector of introduction to explain the presence of *G. japonica* on the northwest coast of Italy, in the marina of Viareggio. Bidassoa, Nivelle and Adour are the 3 estuaries including marinas along the French Basque coast.

According to previous reports (Coles *et al.,* 1999; Smith *et al.,* 1999; Ashelby, 2006; Okolodkov *et al.,* 2007), the occurrence of *G. japonica* could also be related to international shipping (ballast water and fouling). The commercial harbour of Bayonne is the 9th largest

harbour in France based on traffic volume.

In order to better understand the invasive dynamics of aquatic non-indigenous species, molecular biology can be considered as a performant tool (Geller *et al.,* 2010). Thus, a study on *G. japonica* populations has been carried on several estuaries on the North American Pacific coast and concludes in the existence of different clades (Pilgrim *et al.,* 2013). Specimens collected during this study are going to be sequenced for COI (Cytochrome C Oxidase subunit I) and compared with sequences issued from European and Japan specimens. These results will give us an image of the colonization dynamic of this species.

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