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First record of *Synidotea laticauda* Benedict, 1897 (Crustacea: Isopoda) in the Guadiana Estuary (SW Iberian Peninsula)

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ABSTRACT

First record of *Synidotea laticauda* Benedict, 1897 (Crustacea: Isopoda) in the Guadiana Estuary (SW Iberian peninsula)

The exotic isopod species *Synidotea laticauda* B. 1897 is first reported in the Guadiana Estuary, where it was detected, during 2009 and 2010, in the middle section (12-20 km from the mouth) and in the lower part of the upper sections (20-70 km from the mouth), where the species presented its optimal temperature and conductivity ranges between 11 ºC and 21 ºC and between 20 000 and 25 000 µS/cm. The absence of freshwater flood events due to the construction of the Alqueva Reservoir, and the intense ship traffic along the estuary may have been decisive for the introduction and establishment of this alien species.

Key words: *Synidotea laticauda*, Isopoda, Guadiana Estuary, exotic species

RESUMEN

Primer registro de* Synidotea laticauda *Benedict, 1897 (Crustacea: Isopoda) en el estuario del Guadiana (SO de la península ibérica)

El isópodo exótico Synidotea laticauda *B. 1987, ha sido localizado por primera vez en el estuario del río Guadiana. En un estudio realizado entre el año 2009 y 2010 fue encontrado en el tramo medio (12-20 km desde la desembocadura) y zona baja del alto estuario (20-70 km desde la desembocadura), presentando unos rangos óptimos de temperatura y conductividad entre 11 ºC y 21 ºC y entre 20 000 y 25 000 µS/cm. La modificación del régimen de caudales, debido a la construcción del embalse de Alqueva y el intenso tráfico de embarcaciones a lo largo del estuario, pueden haber contribuido a la introducción y establecimiento de esta especie.*

Palabras clave: Synidotea laticauda*, Isopoda, río Guadiana, estuario, especies exóticas*

INTRODUCTION

Synidotea laticauda Benedict, 1897 is native to the north-eastern Pacific region, where it was first described in San Francisco Bay, California (Benedict, 1897; Menzies & Miller, 1972), mainly developing in warm, oligo- or mesohaline shallow intertidal waters of estuarine systems (Boyd, 2008). It is commonly found in habitats with great bio-fouling development, like berths, buoys, bumpers and other submerged structures of port facilities. It is intolerant to drastic environmental fluctuations such as strong freshwater inputs as heavy rain events, which can drastically reduce salinity or rise temperature values above 25 ºC, increasing its mortality rate (Boyd, 2008). However, the species has been reported to have survived salinity increments of up to 30-35 g/l by the same author.

Outside its native range, *Synidotea laticauda* has been previously cited in the Atlantic coast of USA, in Delaware Bay (Bushek & Boyd, 2006), in the Yangtze Estuary, China (Liu *et al.*, 2017) and in Europe, in the estuary of the Gironde River, France (Mees & Fockedey, 1993), the estuary of the river Guadalquivir in the Iberian Peninsula (Cuesta *et al.*, 1996, Baldó *et al.*, 2001), the estuary of the Schelde River, Belgium (Soors *et al.*, 2010) and Netherlands (Faasse, 2011; Noël, 2011), and the port of Brunsbüttel, in the Elbe Estuary, Germany (ICES, 2016) (Fig.1). This note registers the first record of the exotic species *Synidotea laticauda* in the Guadiana Estuary, a meso-tidal 70 km long water body located in the southwest of the Iberian Peninsula.

Figure 1. Current known distribution of *Synidotea laticauda* in Europe: in order of date of first detection, 1. Gironde Estuary, (France, 1975); 2. Guadalquivir Estuary (Spain, 1991); 3. Schelde Estuary (Belgium-Netherland, 2003); 4. Guadiana Estuary (Spain-Portugal, 2009); 5. Elbe Estuary (Germany, 2014). *Distribución actual conocida de* Synidotea laticauda *en Europa: en orden de fecha de la primera detección, 1. Estuario de la Gironda (Francia, 1975); 2. Estuario del Guadalquivir (España, 1991); 3. Estuario de Schelde (Bélgica-Holanda, 2003); 4. Estuario del Guadiana (España-Portugal, 2009) y 5. Estuario del Elba (Alemania, 2014).*

MATERIAL AND METHODS

Ten sampling sites along the longitudinal axis of the Guadiana Estuary were selected, following a salinity gradient: 3 (S01, S02 y S03) in the middle estuary (mixing of fresh and sea water, 12 - 20 km from the mouth), and 7 (S04-S10) in the upper estuary (mainly freshwater, 20 - 70 km from the mouth). Benthic macroinvertebrates were sampled using artificial substrates (Table 1). Two samples per site were taken seasonally from January 2009 to February 2010. Not all sites could be analysed in all the dates (Table 1) due to the theft or loss of some of the substrates.

Each artificial substrate consisted of a 25 cm sided stainless steel cube covered by a plastic netting with 1 cm mesh size in the upper 2/3, and 1 mm in the lower 1/3, to avoid specimen loss when removing the trap from the bed. It was stuffed with organic and mineral materials, collected in the immediate surroundings (stones, reeds, etc.), and tied to the shore with a nylon line to pass unnoticed.

The retrieved substrates were cleaned by shaking them under a strong stream of water, then, using sieves, the coarser organic and inorganic matter was removed (stones, branches, twigs, etc.) after being properly cleaned. The remaining sample was fixated using ethanol (95 %) for later identification and estimation of the relative abundances in the laboratory.

At each substrate location a temperature-conductivity vertical profile from the maximum depth to the surface was performed, both in high and low tide regimes, with a multiparameter probe YSI 6600 V2. Mean values within the uppermost 4 metres (the depth range at which

Table 1. Location of artificial substrates and sampling dates. *Localización de los sustratos artificiales y fecha de muestreo.*

Artificial Substrates	Coordenates (UTM)	Estuary zones	January 2009	May 2009	August 2009	October 2009	February 2010
S01	29 S 639682 4125585	MIDDLE ESTUARY	x	x	x	x	x
S02	29 S 638310 4131581	MIDDLE ESTUARY	x	x			x
S03	29 S 638576 4136579	MIDDLE ESTUARY	x	x	x	x	x
S04	29 S 637233 4140675	UPPER ESTUARY	x	x	x	x	x
S05	29 S 636759 4143057	UPPER ESTUARY	x		x	x	x
S06	29 S 635560 4147155	UPPER ESTUARY	x		x	x	
S07	29 S 635377 4150654	UPPER ESTUARY		x	x		x
S08	29 S 633316 4152308	UPPER ESTUARY	x	x			x
S09	29 S 631553 4153972	UPPER ESTUARY	x	x	x	x	x
S10	29 S 630701 4156927	UPPER ESTUARY	x	x	x	x	x

substrates were submerged) were selected to characterize each sample.

The estimation of the optimal range of temperature and conductivity of *S. laticauda* in the estuary was determined according to the robust optima method (Cristobal *et al.*, 2014). This method is based on the median and the interquartile range. The calculation is made assuming that each value of the observed environmental variable is given with a probability proportional to the number of individuals found; the median and interquartile range of this discrete distribution is calculated. This is equivalent to defining the optimal as the median, and the tolerance as the interquartile range for the sample formed by each of the found individuals (Cristobal *et al.*, 2014).

Figure 2. Picture of *Synidotea laticauda* collected from the Guadiana Estuary. *Fotografía de* Synidotea laticauda *capturada en el estuario del Guadiana.*

RESULTS AND DISCUSSION

Over 300 individuals of *Synidotea laticauda* (Fig.2) were collected in 4 of the 10 sampled sites: three in the middle estuary (substrates S1 to S3) and one in the lower part of the upper estuary (S4 substrate) (Table 2).

The species presented its highest abundance in a temperature range from 10 to 25 ºC (Fig.3) and conductivities ranking from 500 to 33 800 µS/cm (Fig. 4), being its optimal ranges from 11 ºC to 21 ºC and from 20 000 to 25 000 µS/cm (Fig. 5). These data resemble those observed for the native distribution of the species (Boyd, 2008).

The most common species found to co-occur with *Synidotea laticauda* were the following: *Cyathura carinata, Leptocheirus pilosus*, *Balanus* sp., *Corophium* sp., *Gammarus* sp., *Palaemon longirostris*, *Carcinus maenas*, *Sphaeroma serratum*, *Ostrea* sp., *Oligochaeta*, *Hediste diversicolor* and *Nereis* sp.

Table 2. Artificial substrates where *Synidotea laticauda* has been found. *Sustratos artificiales donde se ha localizado* Synidotea laticauda.

Date	Substrate	Num. individuals	Conductivity (µS/cm)	Temp (ºC)
January 2009	S01	41	25916 – 25674	11.42 – 11.38
	S04	20	504 - 528	10.34 – 10.26
May 2009	S02	24	2550 - 6108	19.74 – 19.58
August 2009	S03	1	33810	24.95
October 2009	S03	8	30910	21.13
	S04	227	19540	21.22

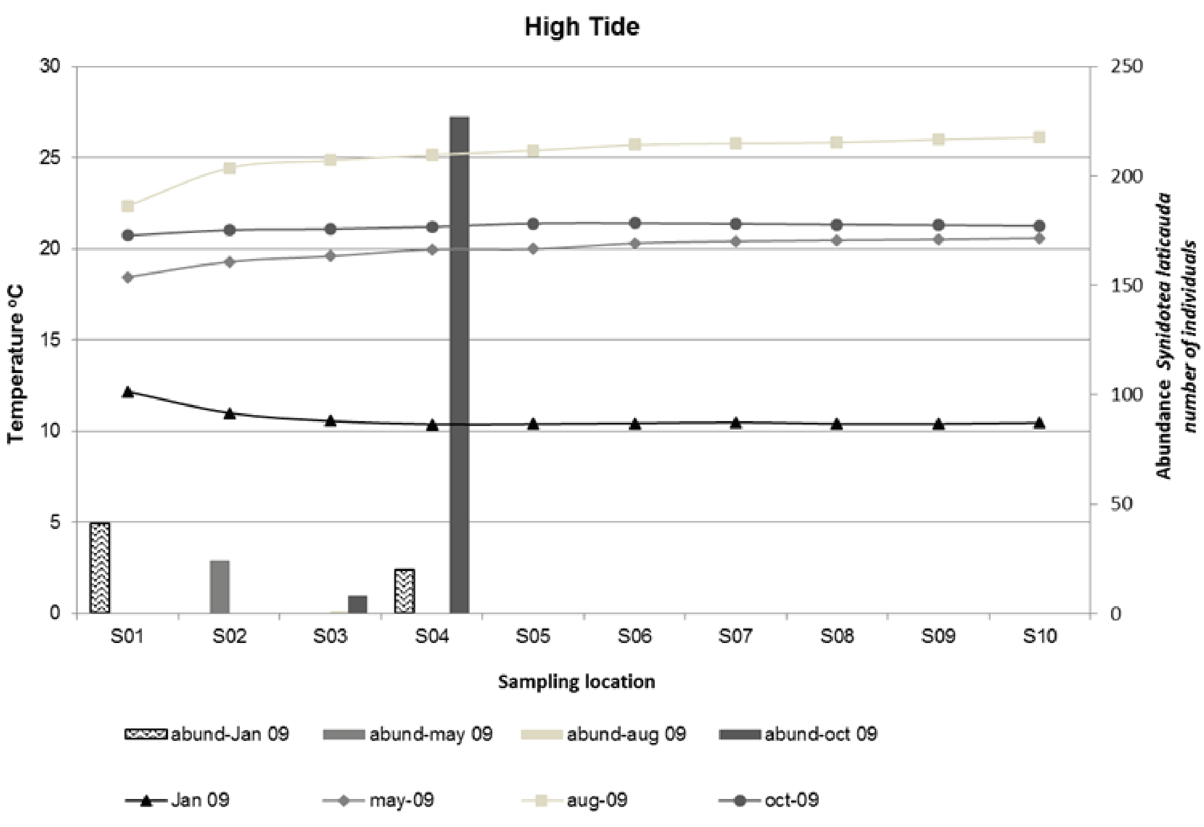

Figure 3. Abundance distribution of *Synidotea laticauda* in relation to the temperature gradient. *Distribución de la abundancia de* Synidotea laticauda *en relación al gradiente de temperatura.*

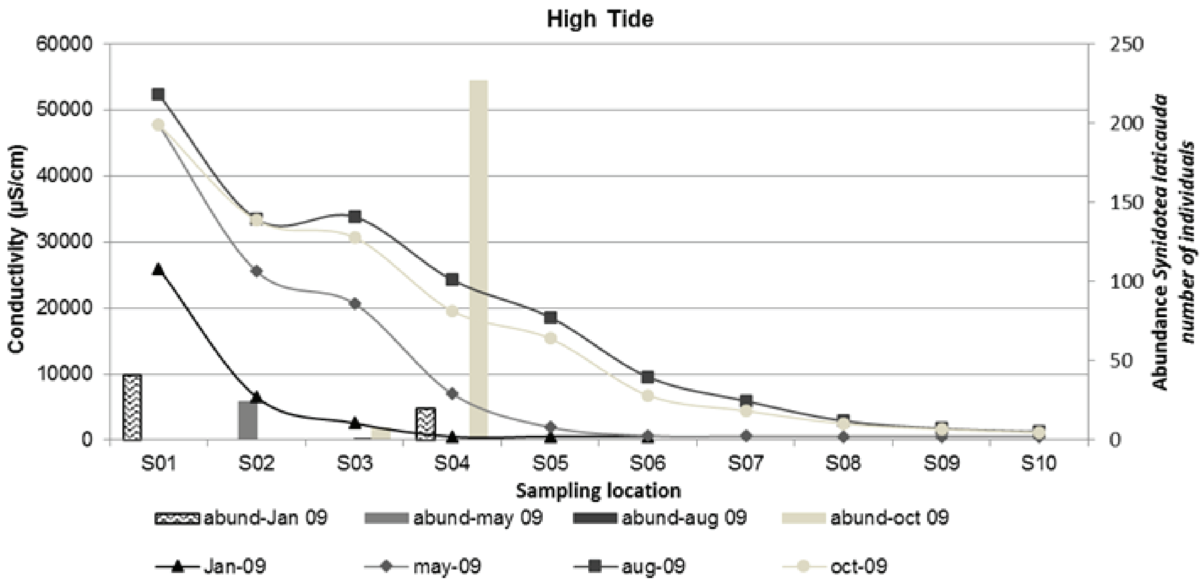

Figure 4. Abundance distribution of *Synidotea laticauda* in relation to the conductivity gradient. *Distribución de la abundancia de* Synidotea laticauda *en relación al gradiente de conductividad.*

Regarding the current presence of *Synidotea laticauda* in the studied area since 2010, only a local research group (University of Sevilla) has conducted a survey in 2016-2017 without finding the species (Sánchez-Moyano *pers. com.*). This fact indicates a less successful colonization in the Guadiana Estuary in comparison with the Guadalquivir Estuary, where the species can show very high densities (Ruiz-Delgado *et al.*, 2016).

In 2002 the Alqueva Reservoir was finished, located approximately 150 km upstream from the Guadiana River mouth, covering an area of 250 km^2 and holding up to 4150 hm^3 of freshwater. After its construction, a more homogeneous flow regime and a diminution of the magnitude and frequency of freshwater flood events has been reported (Morais *et al.*, 2009; Garel & Ferreira, 2015; Garel, 2017) as the cause of changes in macrobenthic crustaceans in the estuary (Leitão, 2008). This new homogeneous flow regime may have favoured the colonization and establishment of *Synidotea laticauda* in the Guadiana Estuary, as it has been the case in other studies (Bunn & Arthingthon, 2002; Johnson *et al.*, 2008). Shipping traffic of medium and small vessels along the lower 50 km of the Guadiana Estuary, mainly for recreational use, and coming from all over the world, could have acted as vectors for the accidental introduction of this species. Some authors have also reported recent alien species invasions and establishment in this estuary and nearby salt marshes, and have pointed to shipping traffic and flow regulation as potential causes (Chícharo *et al.*, 2009; Gonçalves *et al.*, 2017).

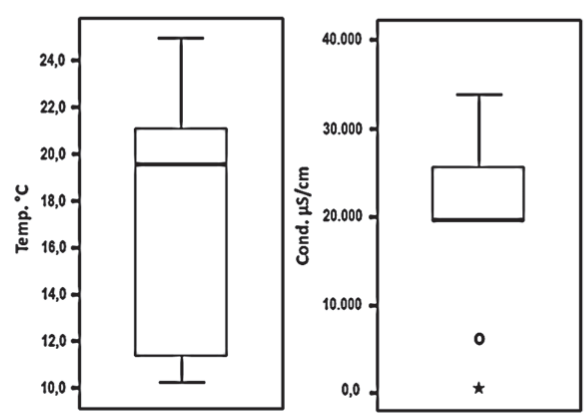

Figure 5. Optimum range of tolerance of *Synidotea laticauda* according to temperature and conductivity. *Rango óptimo de tolerancia de* Synidotea laticauda *con respecto a temperatura y conductividad.*

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