

Short Communication

Westward expansion of the brown shrimp *Penaeus aztecus* Ives 1891 (Decapoda: Penaeidae) in the Mediterranean Sea: a review on the Mediterranean distribution and first record from Spain

Andrea Spinelli¹, Pau Sendín Baquero¹, Francesco Tiralongo^{2,3,4*}

Abstract - *Penaeus aztecus* Ives 1891, commonly known as the brown shrimp, is a well-established invasive alien species of Atlantic origin in the Mediterranean Sea. Here we report on the presence of the species in the Balearic Sea, eastern Mediterranean coast of Spain, where seven specimens were caught in 2023 (February, May and July). Our records represent the first from Mediterranean Spanish waters, as well as the westernmost for this species in the whole basin. Furthermore, on the basis of the data collected, we suggest the presence of a well-established population in this part of the basin. We provide a review on the Mediterranean distribution of the species with discussion on possible pathways of introduction and implications for the ecosystem and fisheries.

Keywords: biological invasions, fishery, invasive alien species, Mediterranean Sea, range-expanding species.

Riassunto - L'espansione verso ovest della mazzancolla americana *Penaeus aztecus* Ives 1891 (Decapoda: Penaeidae) nel Mar Mediterraneo: revisione della distribuzione mediterranea e prima segnalazione in Spagna.

Penaeus aztecus Ives 1891, comunemente noto come mazzancolla americana, è una specie esotica invasiva di origine atlantica ben consolidata nel Mar Mediterraneo. Di seguito riportiamo la presenza della specie nel Mar delle Baleari, costa mediterranea orientale della Spagna, dove nel 2023 (febbraio, maggio e luglio) sono stati catturati sette esemplari. Le nostre segnalazioni rappresentano le prime nelle acque spagnole del Mediterraneo, nonché le più occidentali per questa specie nell'intero bacino. Inoltre, sulla base dei dati raccolti, si ipotizza

la presenza di una popolazione ben radicata in questa parte del bacino. Forniamo una revisione della distribuzione mediterranea della specie con discussione sui possibili percorsi di introduzione e implicazioni per l'ecosistema e la pesca.

Parole chiave: invasioni biologiche, Mar Mediterraneo, pesca, specie esotiche invasive, specie in espansione.

With about 17,000 species, the Mediterranean Sea is one of the most important biodiversity hotspots in the world (Coll *et al.*, 2010). However, its native biodiversity is threatened by the presence of invasive alien species (IAS) (Zenetos *et al.*, 2017).

The brown shrimp *Penaeus aztecus* Ives 1891 is a penaeid species native to the western Atlantic, whose distribution extends from Massachusetts to the Gulf of Mexico and north-western Yucatán (Pérez-Farfante & Kensley, 1997). This species inhabits sandy bottoms between 5 and 170 m depth, but is more abundant between 10-55 m (Williams, 1984; Frogliola & Scanu, 2023).

In the Mediterranean Sea, since its first record in 2009 in the Bay of Antalya (Turkey) (Deval *et al.*, 2010), *P. aztecus* has rapidly expanded in the eastern part of the basin, reaching the Aegen Sea in the period 2013-2014 (Kevrekidis, 2014), Israel and Egyptian coasts in 2017-2020 (Galil *et al.*, 2017; El Deeb *et al.*, 2020) and Libya in 2020 (Abdulrazziq *et al.*, 2021). At the same time, the species has also spread in the central and central-western part of the basin (Kampouris *et al.*, 2018; Gönülal & Türetken, 2019; Abdulrazziq *et al.*, 2021; Ugarković & Crocetta, 2021; Frogliola & Scanu, 2023), reaching to the south its westernmost limit in Tunisia – Gulf of Gabès (Ben Jarray *et al.*, 2019), and in France – Gulf of Lion, at south and north of the Mediterranean Sea, respectively (Galil *et al.*, 2017). As regards the Gulf of Lion (France), based on the record of a single specimen, this represented to date the westernmost northern record of the species in the whole Mediterranean Sea. Hence, the records here reported from Altea, Moraira and Cullera (Spain) are of great relevance, representing not only the first records of the species from Spain, but also its rapid colonization of the entire basin in a few years (2009-2022).

On 24th February 2023, four “strange shrimps” were caught along the Altea coast, eastern Spain (38°31.339

¹ Research Department, Fundació Oceanogràfic de la Comunitat Valenciana, Oceanogràfic, Ciudad de las Artes y las Ciencias, 46013 Valencia, Spain.

² Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Università degli Studi di Catania, Via Androne 81, 95124 Catania, Italia.

³ Ente Fauna Marina Mediterranea, Associazione naturalistica culturale scientifica di ricerca e conservazione della biodiversità marina, Via Mario Rapisardi 34, 96012 Avola (Siracusa), Italia.

⁴ Istituto per le Risorse Biologiche e le Biotecnologie Marine, CNR, Largo Fiera della Pesca 2, 60125 Ancona, Italia.

* Corresponding author: francesco.tiralongo@unict.it

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N, 0°01.548 W) during trawling operations on sandy bottom at a depth of 55 m, by a professional fisherman.

Intrigued by the unusual find, the skipper of the fishing boat sent some photos to one of the authors (AS) asking about the identity of the species. When AS realized that the shrimp characters did not match with those of the native shrimps commonly caught in the area, he asked the fishermen to keep one specimen, which was handed over to the researchers immediately after landing. The specimen was immediately photographed (Fig. 1a) and its morphology carefully examined. The Altea specimen measured 6.5 cm of carapace length, with a weight of 51.7 g (Fig. 1a). Meristic, morphometric and color pattern characters of the specimen agreed with the description of *P. aztecus* reported in the literature (Perez-Farfante, 1988; Tavares, 2002). Morphometric data of the specimen are listed in Table 1.

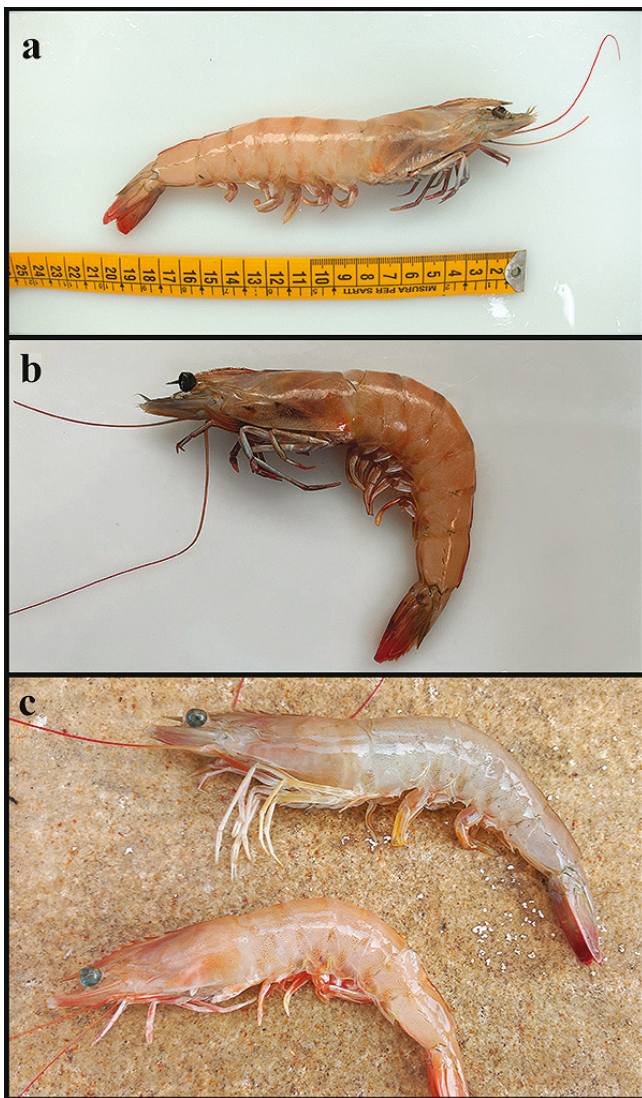


Fig. 1 - Specimens of *Penaeus aztecus* caught in Spain. a) The specimen caught at Altea. b) The specimen caught at Moraira. c) The specimens caught at Cullera. See site nr. 27 (red circle) in Fig. 2. / Esemplari di *Penaeus aztecus* catturati in Spagna. a) L'esemplare catturato ad Altea. b) L'esemplare catturato a Moraira. c) Gli esemplari catturati a Cullera. Si veda il sito n. 27 (cerchio rosso) nella Fig. 2.

Tab. 1 - Morphometric characters of *Penaeus aztecus* captured in February 2023 at Altea, eastern coast of Spain. / Caratteri morfometrici dell'esemplare di *Penaeus aztecus* catturato nel febbraio 2023 ad Altea, sulla costa orientale della Spagna.

Morphometric characters	
Sex	F
Total length (cm)	19.5
Ocular length (cm)	15.8
Cephalothorax length (cm)	6.5
Weight (g)	51.7

On 24th May 2023, one more specimen of *P. aztecus* was captured by another professional fisherman during trawling operations on muddy bottom, at a depth of 70 m, along the Moraira coast, eastern Spain (38°66.804 N, 0°17.745 O) (Fig. 1b).

On 17th July 2023, two additional specimens were collected with trawls at Cullera (39°10.543 N, 0°12.197 W), at a depth of 60 m. (Fig. 1c).

Four out of seven specimens recorded were collected, frozen and stored in the laboratory of the Fundación Oceanográfica Valencia for further analysis: one from Altea, one from Moraira and two from Cullera.

All known Mediterranean records of the species are summarized in Fig. 2. Even today it is not clear how this species was introduced in the Mediterranean Sea, although several authors indicated ballast waters as the most likely vector for the introduction of the brown shrimp in the basin (Deval *et al.*, 2010; Nikolopoulou *et al.*, 2013; Minos *et al.*, 2015). Alternatively, some authors suggested illegal introductions (Cruscanti *et al.*, 2015). In any case, the species may have been introduced several times and perhaps also through different pathways (Frogliola & Scanu, 2023). So, whatever the mode of introduction of *P. aztecus* into the Mediterranean, its extraordinary ability to colonize the basin in a few years, makes this shrimp one of the most invasive species in the Mediterranean. For this reason, the species could be nicknamed the "Atlantic sprinter", having had a feat similar to that of the bluespotted cornetfish, *Fistularia commersonii* Rüppell 1838, nicknamed the "Lessepsian sprinter" (Karachle *et al.*, 2004), although the origin and colonization patterns of the two species are different. However, concerning the first records from Spain here reported, which also represent the westernmost records of the species in the Mediterranean (Fig. 2), the most likely dispersion pathway is the unaided dispersal from neighboring countries such as France, also if other introduction ways cannot be ruled out (Galil *et al.*, 2017).

The brown shrimp already represents an additional resource for Mediterranean fishery, even if still at local level. For example, it is fished in large quantities by bottom trawling and trammel nets in Turkey and Italy, whe-

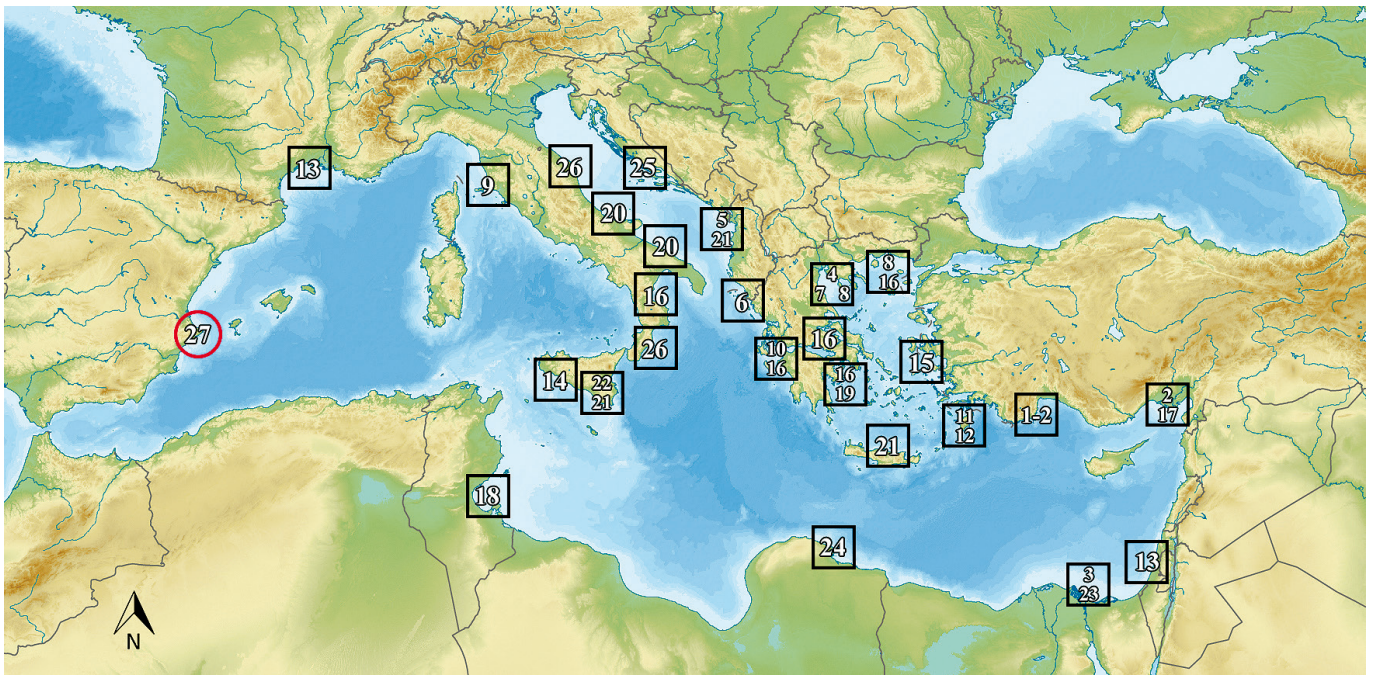


Fig. 2 - Known distribution of *Penaeus aztecus* in the Mediterranean Sea (in chronological order). Black squares indicate published records, the red circle the area of the three records reported in this study. / Distribuzione nota di *Penaeus aztecus* nel Mar Mediterraneo (in ordine cronologico). I quadrati neri indicano i record pubblicati, il cerchio rosso l'area dei tre records riportati in questo studio: 1) Antalya, Turkey, (Deval *et al.*, 2010); 2) Finike, Antalya, Adama, Mersin, Iskenderun Turkey (Bilecenoglu *et al.*, 2013); 3) Damietta, Egypt, (Sadek *et al.*, 2018); 4) Thermaikos Gulf, Greece (Nikolopoulou *et al.*, 2013); 5) Boka Kotorska, Montenegro (Marković *et al.*, 2014); 6) Corfu Island, Greece (Kapiris *et al.*, 2014); 7) Thermaikos Gulf, Greece (Kevrekidis, 2014); 8) Thermaikos Gulf, Nestos river estuaries, Greece (Minos *et al.*, 2015); 9) Castiglione, Italy (Cruscanti *et al.*, 2015); 10) Kyllini, Greece (Crocetta *et al.*, 2015); 11) Chalki Island, Greece (Kondylatos & Corsini-Foka, 2015); 12) Faliraki Rhodes, Greece (Kondylatos *et al.*, 2020); 13) Gulf of Lion, France and Palmahim, Israel (Galil *et al.*, 2017); 14) Mazara del Vallo, Porto Empedocle e Gela, Italy (Scannella *et al.*, 2017); 15) Ildir Bay, Turkey (Bakır & Aydin, 2016); 16) Golfo di Corigliano, Italy, Kerkyraikos Gulf, Maliakos Gulf, North Ionian Sea, Patraikos Gulf, Saronikos Gulf, South Ionian, Thracian-Limnos, Lakonikos Gulf, Kyklades (Syros Island), Greece (Mytilineou *et al.*, 2016); 17) Mersin Bay-Iskenderun, Turkey (Özcan *et al.*, 2019); 18) Gulf of Gabes, Tunisia (Ben Jarray *et al.*, 2019); 19) Central Aegean Sea, Greece (Kapiris & Minos, 2017); 20) Termoli and Mola di Bari, Italy (Zava *et al.*, 2018); 21) Marzamemi, Italy, Albania, Erakleion Crete, Greece (Kampouris *et al.*, 2018); 22) Augusta, Italy (Stern *et al.*, 2019); 23) Alexandria, Egypt (El Deeb *et al.*, 2020); 24) Umm-Ufayn, Libya (Abdulrazziq *et al.*, 2021); 25) Hvarski kanal, Neretvanski kanal, Viski kanal, Murtesko more, Cavtat, Adriatic Sea, Croatia (Ugarković *et al.*, 2021); 26) Ancona and San Benedetto del Tronto, Roccella Ionica, Italy (Frogliã & Scanu, 2023). ed circle indicates the present record: 27) Altea, Moraira, Cullera, Comunitat Valenciana, Spain (present study).

re it is sold at high prices as a delicacy (Bakır & Aydin, 2016; Frogliã & Scanu, 2023; M. Tedesco, pers. comm.). In Italy, according to what fishermen documented photographically, this new resource is very abundant in the Gulf of Taranto and nearby areas of the northern Ionian Sea, with daily yields for trawls sometimes reaching 40-50 kg per day. Furthermore, particular attention should be paid on the ecological competition with the commercially relevant native congeneric shrimp *Penaeus kerathurus* (Forskål 1775); in fact, some fishermen in the area of the Gulf of Taranto are already noticing a sharp decline of the native shrimp, as a possible consequence of the similar ecology of the two congeneric species, which would therefore compete for the same resources (Jaziri *et al.*, 2015). Hence the urgency of targeted studies to assess the impact of this species on native ones, on fishing activities (also considering the positive effect from the commercial point of view) and marine ecosystem in general. The same attention should also be paid to species with dramatic invasive behavior, such as the blue crab *Callinectes sapidus* Rathbun 1896, another

sea food delicacy that shares its native range (Western Atlantic Ocean) with the alien shrimp *P. aztecus* (Falson *et al.*, 2020; Tiralongo *et al.*, 2021; Marchessaux *et al.*, 2023). Furthermore, the possibility that invasive Lessepsian species spreading in the Mediterranean Sea could reach the eastern Atlantic Ocean by crossing the Strait of Gibraltar, with all the ecological implications this could entail, should be carefully considered. (Azzurro & D'Amen, 2022). In conclusion, on the basis of the data here reported, we hypothesize the presence of a well-established population of *P. aztecus* from the investigated area of Spain.

Our study also supports how citizen science and fishermen knowledge can greatly contribute to the monitoring and early detection of non-indigenous species in the Mediterranean Sea (Tiralongo *et al.*, 2019, 2020; Azzurro & Tiralongo, 2020; Osca *et al.*, 2020; Al Mabruk *et al.*, 2021; Perzia *et al.*, 2022).

Hence the urgent need to study and monitor biological invasions and non-indigenous species distribution over time.

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