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Rapid Communication

First report of Northern brown shrimp *Penaeus aztecus* Ives, 1891 in Strait of Sicily

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Abstract

Four specimens of the northern brown shrimp *Penaeus aztecus* Ives, 1891, a West Atlantic species, were unexpectedly caught by bottom trawlers along the South coast of Sicily between Porto Empedocle and Mazara del Vallo (Central Mediterranean). The dispersal and transport of shrimp eggs and larvae via surface water circulation is suggested as the likely cause of its rapid westward spread since its first appearance in the Gulf of Antalya (Turkey) in 2009. The settlement of *P. aztecus* in Mediterranean coastal habitats may result in competition with the native caramote prawn *Penaeus kerathurus* (Forskål, 1775). Some aspects of the species geographical distribution in Mediterranean are briefly discussed in relation to the circulation pattern of surface waters.

Key words: alien species, Mediterranean, distribution, ballast water, ecological corridor

Introduction

In the last few decades, marine biodiversity in the Mediterranean Sea has been subject to diverse changes as result of the direct and indirect human impacts on marine ecosystem (Galil 2007). Direct effects can include habitat loss, shipping, trade, aquaculture, and fishing while indirect effects include global climate change and warming. Combing these factors would be facilitating the arrival and settlement of alien species mainly thermophilic organisms (Goulletquer et al. 2014). Whilst the Eastern Mediterranean was colonized by Lessepsian migrants, alien species entering through the Suez Canal, in the Western Mediterranean the main vectors of introduction are mariculture and shipping (Katsanevakis et al. 2013). Although present numbers are higher, a recent checklist identified 986 alien species in the Mediterranean: 775 in the eastern Mediterranean, 249 in the central Mediterranean, 190 in the Adriatic Sea and 308 in the Western Mediterranean (Zenetos et al. 2012).

The effects of alien species on Mediterranean fisheries, which are particularly important to the local economies, are an issue of high interest. For example, Lessepsian species now constitute about 40% of landings of artisanal vessels in Lebanon (Carpentieri et al. 2009). Recent reports identified fourteen non-indigenous penaeids in Mediterranean, eight of which probably were introduced through the Suez Canal (Galil et al. 2015). Indeed, alien commercial penaeid shrimps are becoming an increasingly important resource given their high commercial value. Two Indo-Pacific penaeids: the jinga shrimp *Metapenaeus affinis* (H. Milne Edwards, 1837) and the speckled shrimp *Metapenaeus monoceros* (Fabricius, 1798) represent interesting examples of development of commercial fisheries. In İzmir Bay-Turkey, *M. affinis* was first recorded in 2008 and its commercial importance and popularity have rapidly increased in local fisheries compared with the native Caramote prawn *Penaeus kerathurus* (Forskål, 1775) (Dinçer and Aydin 2014). Since the late 1990s,

Table 1. Catch location (decimal degrees, DD), sex (F = female; M = male), carapace length (CL), total length TL), and wet weight (W) for *Peneaus aztecus* caught in the Strait of Sicily.

Catch Date	Latitude (DD)	Longitude (DD)	Depth (m)	Sex	Maturity	CL (mm)	TL (mm)	W (g)
3 Nov 2015	37.26666	13.33333	70	M	Petasma fully developed	30	160	229
3 Nov 2015	37.26666	13.33333	70	F	Ovary recovering	45	209	669
9 Nov 2015	37.58333	12.55000	40	F	Ovary recovering	58	258	127.5
12 Nov 2015	36.95350	14.30033	22	F	Ovary recovering	43	202	51.0

M. monoceros has been the main target species for commercial, coastal, fisheries in the Gulf of Gabes, Tunisia (Fiorentino et al. 2015). Similarly, *Penaeus pulchricaudatus* (Stebbing, 1914) and *Penaeus semisulcatus* (De Haan, 1844) currently comprise much of the shrimp catch on the Mediterranean coast of Egypt and in the Nile delta lagoons (Galil 2007).

The northern brown shrimp *Penaeus aztecus* Ives, 1891 is not a Lessepsian species but is native to the western Atlantic Ocean from Massachusetts through Florida, and into the Gulf of Mexico to the lower Belize (http://www.sealifebase.org). It was also recorded in Canada and has been introduced in Oceania (New Caledonia and French Polynesia) for aquaculture purposes. The species lives in a water depths between 1 and 165 m, with highest adult densities found in the range 27–55 m (Williams 1984). It is the most important species for the shrimp fisheries off the East coast of USA and the Gulf of Mexico with an average annual landing of 50,000 tons (NOAA 2013).

In the Mediterranean Sea, the northern brown shrimp was collected for the first time in 2009 in the Antalya Bay, Turkey (Deval et al. 2010). Since then, the species quickly spread along the coasts of southern Turkey (Gökoğlu and Özvarol 2013), the Aegean Sea (Nikolopoulou et al. 2013; Kevrekidis 2014; Minos et al. 2015; Kondylatos and Corsini-Foka 2015), the East Ionian Sea (Kapiris et al. 2014; Zenetos and Giavasi 2015), the South Adriatic (Marković et al. 2013), and Tyrrhenian Sea (Cruscanti et al. 2015). It was recently found in Israel and Gulf of Lion (Galil et al. 2016, Figure 1). In the present study, we report the first record of the northern brown shrimp in Sicily, between Porto Empedocle and Mazara del Vallo (Central Mediterranean Sea) on the south coast, and discuss the ongoing, rapid, spread of the species in the Mediterranean.

Methods

In late autumn 2015, four specimens of *P. atzecus* were caught by commercial trawlers fishing in waters 22 to 70 m deep at locations three miles offshore from the south coast of Sicily (Table 1, Figure 1). The specimens were identified according to Tavares (2002) and photographed (Figure 2). The total length (TL in mm) was measured from tip of rostrum to posterior margin of telson. Carapace length (CL in mm) was measured as the distance from posterior margin of orbit to posterior hind edge of the carapace. Wet weight (W) was measured to the nearest 0.1 g. All samples were fixed in 80% ethanol and preserved as collections of IAMC-CNR of Mazara del Vallo (three specimens) as well as Museo Civico di Storia Naturale in Comiso (one specimen).

Results

The four specimens were identified as *P. atzecus* based on: a smooth carapace, rostrum armed with 8 to 10 dorsal teeth (the epigastric spine included) and 2 ventral teeth; adrostral sulcus reaching almost to posterior margin of carapace; broad dorso-lateral sulcus on 6th abdominal somite; and telson with a deep dorsal sulcus (Deval et al. 2010) (Figure 2). The three females ranged between 43 to 58 mm CL and 202 to 258 mm TL. The male was 30 mm CL and 160 mm TL (Table 1).

All four specimens were adults. The females showed ovaries in post-spawning recovering stage. The male displayed a fully-developed petasma, with the two halves medially united.

Discussion

A growing body of literature shows that the warming of the Mediterranean Sea (Skliris et al. 2012) is coupled with an increasing occurrence and expansion of "warm" species originating mostly from Red Sea and Atlantic Ocean, a phenomenon described as tropicalization of the Mediterranean (Bianchi 2007; Bianchi et al. 2012). The increasing number of new records of alien species in Mediterranean Sea, along with their geographical expansion, is clear evidence of a rapidly changing ecosystem. The Strait of Sicily plays a key role in the spatial dynamics of alien species in the region because it represents the main West-East transition zone both from hydrodynamic

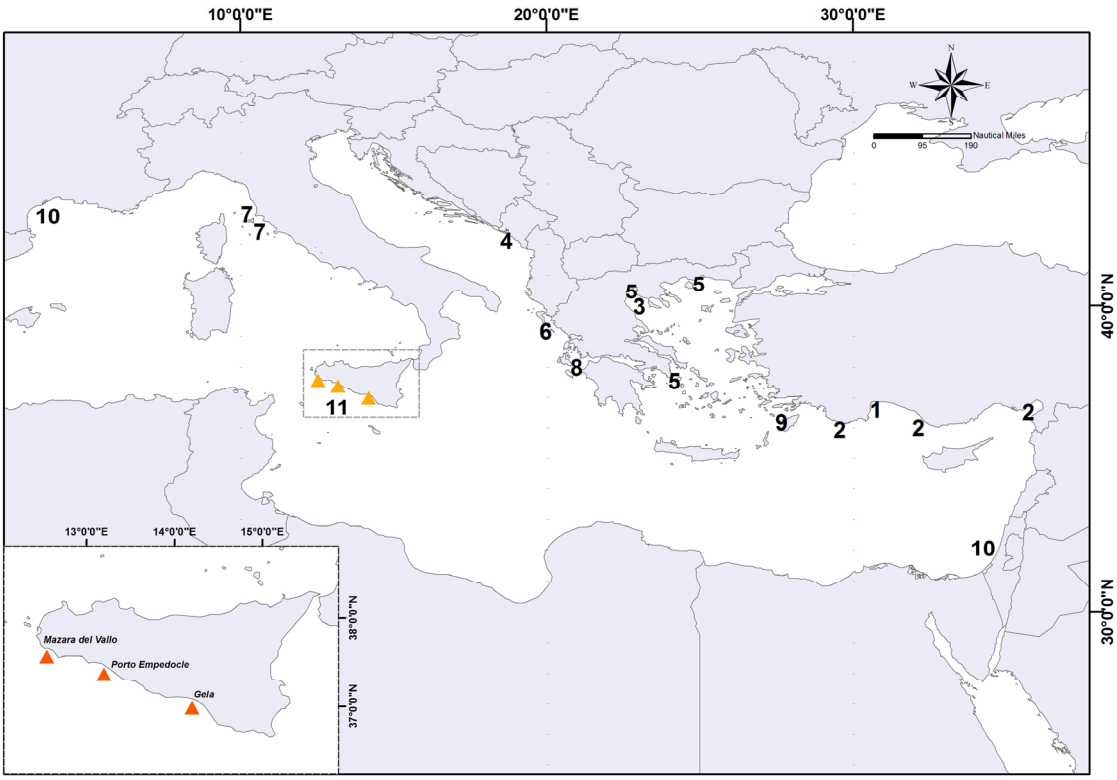

Figure 1. Updated map showing locations of records of *Penaeus aztecus* in the Mediterranean Sea, in chronological order: "1" December 2010 (Deval et al. 2010); "2" June 2011 (Gökoğlu and Özvarol 2013); "3" January 2012 - September 2013 (Nikolopoulou et al. 2013; Kevrekidis 2014); "4"September 2013 (Marković et al. 2013); "5" November 2013 – March 2014 (Minos et al. 2015); "6" November 2013 (Kapiris et al. 2014); "7" August – November 2014 (Cruscanti et al. 2015); "8" October 2014 (Zenetos and Giavasi 2015); "9" November 2014 (Kondylatos and Corsini-Foka 2015); "10" April – October 2015 (Galil et al. 2016); "11" November 2015 (present paper). For details see supplementary Table S1.

and biogeographical perspective, and it also functions as an ecological corridor for non-indigenous marine species (Bianchi et al. 2012; Azzurro et al. 2014). For example, the crab *Percnon gibbesi* (H. Milne Edwards, 1853) is an Atlantic migrant that quickly became wide-spread along the superior infralittoral fringe of both Eastern and Western Mediterranean (Katsanevakis et al. 2011). This crab species first appeared in 1999 in Linosa Island (Relini et al. 2000) and in the Balearic archipelago (Garcia and Reviriego 2000). Similarly, the Lessepsian bluespotted cornetfish, *Fistularia commersonii* Rüppell, 1838 was recorded off Israel in 2000, and colonized the Mediterranean Sea spreading from the Levant Sea to the West along a southern and a northern route of migration at speeds reaching 1,000–1,500 km year^{-1}, with a clear decrease in the rate of spread at the Sicily Strait (Azzurro et al. 2013). Three species, among the eight thermophilic Lessepsian peneids recorded in the Mediterranean Sea, have spread along the African (southern) route and have already established populations off southern Tunisia, but none has been recorded on the north side of the Strait of Sicily. Also there are few occasional records of Lessepsian peneids north of the Dodecanese Islands (southern Aegean Sea), confirming that temperature is a key factor in the distribution of Red Sea immigrants (Pancucci-Papadopoulou et al. 2012).

This record of northern brown shrimp in three locations off the South coasts of Sicily, presented in this paper, is consistent with the role of ecological corridor of the Strait of Sicily. *P. aztecus* is a warm-temperate species that is already established in Eastern Mediterranean and might find a suitable habitat in Central and Western Mediterranean coastal waters as indicated by recent records of the species north of Sicily in the Tyrrhenian Sea and in the Gulf of Lions (Cruscanti et al. 2015; Galil et al. 2016).

Ships ballast waters were considered the most likely vector of the introduction of *P. aztecus* in the Mediterranean Sea (Deval et al. 2010). The rapid expansion of the species westward in the Aegean Sea,

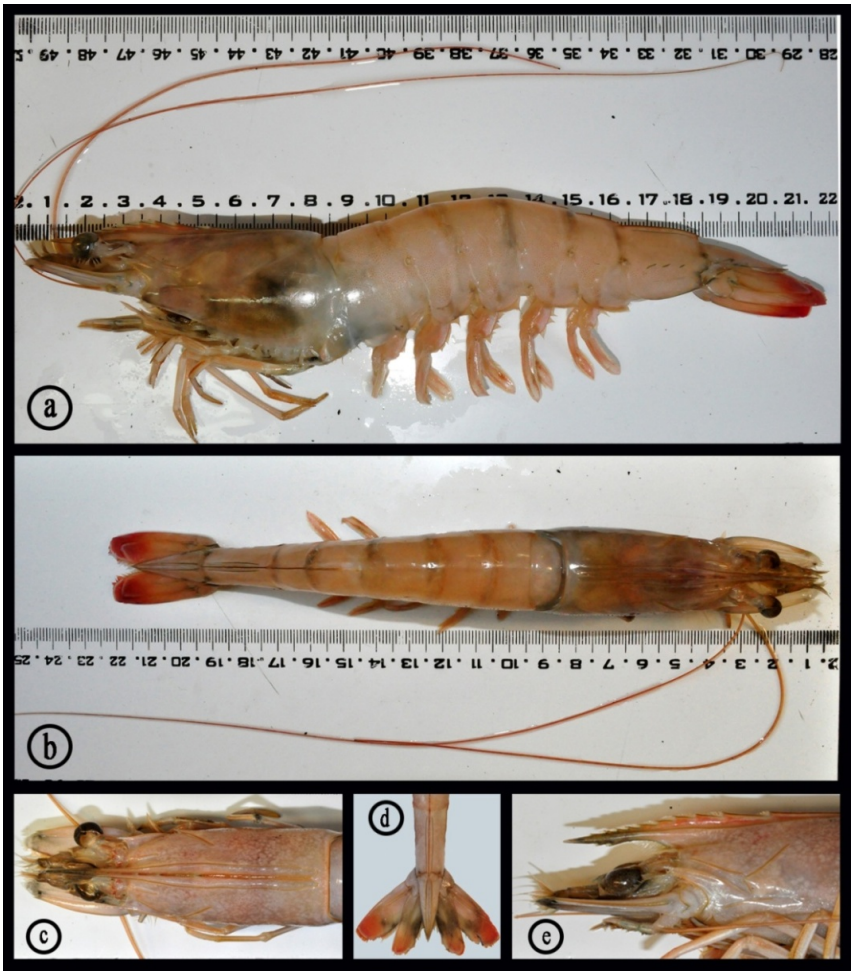

Figure 2. *Penaeus aztecus* from the southern coast of Sicily, Italy: (a) lateral view of sixth abdominal somite with 3 cicatrices; (b) dorsal view; (c) dorsal view of cephalothorax; (d) dorsal view of sixth abdominal somite with adrostral sulcus; (e) lateral view of rostrum. Photographs by Danilo Scannella.

east Ionian Sea, south-eastern Adriatic Sea, and now the northern sector of the Strait of Sicily may be related to dispersal and transport of shrimp eggs and larvae along the main paths of surface water circulation (anticlockwise) in the east and central Mediterranean Sea (see Poulain et al. 2012). However, it is possible that there were additional transfers in ballast waters from the population established in the Turkish Mediterranean. There also could have been additional transfers from the native populations in the USA, particularly in the case of the recent finding of the species in the north Tyrrhenian Sea, Israel, and Gulf of Lions (Galil et al. 2016). Lastly, Cruscanti et al. (2015) suggest the presence of *P. aztecus* and other non-Lessepsian penaeids in the Mediterranean Sea, could be the result of escape or release from undisclosed aquaculture activity. Although aquaculture activities are known for the northern brown shrimp in other parts of the world (Cook and Lindner 1970; Holthuis 1980), there is no evidence for this activity in the Mediterranean Sea. According to Deval et al. (2010) the species is not a good candidate for aquaculture in the Mediterranean due to its slow growth rate. Similarly, it is unlikely that the presence of species like *Rimapenaeus similis* (Smith, 1885), a small-sized penaeid present in Tunisian waters (Ben Hadj Hamida-Ben Abdallah et al. 2010) can be linked to aquaculture activities.

In terms of ecosystem effects, the establishment of *P. aztecus* might result in competition with the native caramote prawn *P. kerathurus*, taking into account the similarities in their life cycles (Kevrekidis 2014). Both species reproduce in coastal waters, and post-larvae enter in estuaries and coastal lagoons where juveniles grow and later return to the marine environment. In addition, the northern brown shrimp may be a vector of spread for the parasite *Epipenaeon ingens ingens* Nobili, 1906. This Indo-Pacific bopirid parasitizes a variety of penaeid shrimps, and it was first recorded in the Mediterranean Sea on

P. semisulcatus (by Bourdon 1968) and was recently observed on *P. aztecus* (Korun et al. 2013).

From a fishery perspective, it is worth to note that *P. aztecus* is one of the most important species for the commercial shrimp fishery off the east coast of the U.S.A. and in the Gulf of Mexico (NOAA 2010); consequently, it may become a new resource for Mediterranean coastal fisheries. The unknown at this time is whether the overall effect on the shrimp fisheries will be positive or negative.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Catch location, carapace length, total length, and wet weight for *Penaeus aztecus* recorded in the Mediterranean.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2017/Supplements/BIR_2017_Scannella_etal_Supplement.xls