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Thodoros E Kampouris
Department of Marine Sciences, School of the Environment, University of the Aegean, Mytilene, Lesvos Island, 81100, Greece

Francesco Tiralongo
(1) Ente Fauna Marina Mediterranea, 96012 Avola, Italy
(2) Department of Biological, Geological and Environmental Sciences, University of Catania, 95124 Catania, Italy

Aleksander Golemaj
L. 29 Nentori, Rr. Petrit Bisha, Vlore, Albania

Ioannis Giovos
iSea, Environmental Organization for the Preservation of the Aquatic Ecosystems, 55438 Ag. Pavlos, Thessaloniki, Greece

Nikos Doumpas
iSea, Environmental Organization for the Preservation of the Aquatic Ecosystems, 55438 Ag. Pavlos, Thessaloniki, Greece

Ioannis E Batjakas
Department of Marine Sciences, School of the Environment, University of the Aegean, Mytilene, Lesvos Island, 81100, Greece

Correspondence
Thodoros E Kampouris
Department of Marine Sciences, School of the Environment, University of the Aegean, Mytilene, Lesvos Island, 81100, Greece

Penaeus aztecus Ives, 1891 (Decapoda, Dendrobranchiata, Penaeidae): On the range expansion in Sicilian waters and on the first record from Albanian coast

Thodoros E Kampouris, Francesco Tiralongo, Aleksander Golemaj, Ioannis Giovos, Nikos Doumpas and Ioannis E Batjakas

Abstract
New records of the alien species, *Penaeus aztecus* Ives, 1891, commonly known as the Northern brown shrimp, are reported from the Mediterranean Sea: first records from waters of Albania and Sicilian Ionian Sea, and new records from the southern coast of Sicily (from Mazara del Vallo to Pozzallo). The species appears well established in the southern coast of Sicily, in which it was first recorded (four specimens) in 2015. First records from Albania and Sicilian Ionian Sea suggest a range expansion of the species in the basin.

Keywords: Atlantic species, alien species, decapoda, fisheries, Mediterranean Sea, ballast water

1. Introduction
It is well acknowledged that Mediterranean Sea is a biodiversity hotspot with 309 different native decapod species to occur (Manfrin *et al*. 2018) [28]. Of these, 104 are recorded in Albania (Vaso and Gjiknuri 1993) [42]. Also, during the last years more than 86 non-indigenous decapod species were introduced by different vectors (Manfrin *et al*. 2018) [28]. The Northern brown shrimp, *Penaeus aztecus* Ives, 1891, is a penaeid prawn which is indigenous to the Atlantic coast of north America from Martha's Vineyard, Massachusetts to the Yucatan Peninsula, Mexico (Cook and Lindner 1970) [9] and it is one of the most important species of prawn fisheries at the Gulf of Mexico (Holthuis 1980, Caillouet *et al*. 2008) [16, 6]. In Mediterranean Sea, it was recorded for the first time in 2009-2010, off the Antalya coast, in Turkey (Deval *et al*. 2010) [11] and in a short period from various regions across the basin; Greece (Nikolopoulou *et al*. 2013) [33], Montenegro (Marković *et al*. 2014) [31], Tyrrhenian Sea (Cruscanti *et al*. 2015) [10], Gulf of Lion and southern Levantine Sea (Galil *et al*. 2017) [12], Sicily (Scannella *et al*. 2017) [39] and recently from Nile Delta, Egypt in ponds of a prawn farming unit and adjacent Mediterranean waters (Sadek, *et al*. 2018) [38]. In Greece, the Northern brown shrimp is considered as established in Ionian Sea (Zenetos and Giavasi 2015, Renda and Crocetta 2016) [43] and Aegean Sea, except Crete Island (see Kapiris and Maina 2016). Although *P. aztecus* has been reported in the Adriatic (Marković *et al*. 2014) [31] and Ionian (Renda and Crocetta 2016) [37] seas, has never reported from the Albanian coast.
Citizen science, although an old tool, is recently emerging to a substantial driver for monitoring biodiversity (Thiel *et al*. 2014, Scyphers *et al*. 2015, Kampouris *et al*. 2018) [41, 40, 18] and non-indigenous species (Cigliano and Ballard 2018) [8], particularly in the Mediterranean Sea (Kondylatos *et al*. 2017, Lageneck *et al*. 2017, Zenetos *et al*. 2017, Giovos *et al*. 2018a, Mannino and Balistreri 2018) [25, 26, 44, 45, 14, 29], although some scientists remain sceptical due to certain limitations (Katsanevakis and Moustakas 2018) [21]. The use of social media and smartphone technology have played an important role in the flourishing field of citizen science (Cardoso *et al*. 2017, Lageneck *et al*. 2017) [7, 26], enabling, in some cases, the detection of extremely rare species (Azzuro *et al*. 2013, Giovos *et al*. 2018a) [1, 14]
This study presents the range expansion of *P. aztecus* in Sicilian waters and reports the first record of the species from Albania, filling an important gap of its distribution in the Mediterranean Sea. The data of the current study were collected in the context of two citizen science projects.

2. Materials and methods

iSea, an environmental organisation based in Greece, in 2016, launched the citizen science project "Is it Alien to you? Share it!!!" aiming to monitor marine non-indigenous specie in the Greek and the adjacent seas. A Google Form, a Group on Facebook and a validation system were established to facilitate these reports. Citizen scientists could easily upload photographic material along with information on specimen size (length and/or weight), depth, number of specimens, exact location, date and type of observation (freediving, underwater photography, shore-based fishing, boat-based fishing, spearfishing). The project, in two years has contributed substantially to the inventory of marine non-indigenous species in Greece, presenting first records and expansion records of several species (Ragkousis *et al*. 2017, Giovos *et al*. 2018a, 2018b, Kleitou *et al*. 2018) [36, 14, 15, 24] while in this context has collaborated with scientists from Albania resulting in presenting the first records of marine species in the Albanian coast (Giovos and Bakiu 2017, Bakiu *et al*. 2018) [13, 3]. Ente Fauna Marina Mediterranea, an environmental organisation in Italy, runs a citizen science project for monitoring the biodiversity in Sicily. In this context, scientists of ENTE collaborate with local citizen scientists and fishermen retrieving valuable information on the local biodiversity. Further data were collected through interview to fishermen who operate with trammel nets along the southern coast of Sicily.

In the context of these two projects, citizens regularly report their findings with all the required information helping scientists learn more about the Mediterranean biodiversity and the issue of non-indigenous species introduction and expansion.

3. Results

On 21 May and 2 June 2018, two individuals of *P. aztecus* were caught by artisanal fishermen at Vlora Bay, Albania (Fig. 1A) by using trammel net with mesh size (inner panel) of 20–24 mm, in a depth of 30–35 m over sandy-muddy bottom. The specimens were caught together with *Penaeus kerathurus* (Forskål, 1775). The observation reported to the "Is it Alien to you? Share it!!!" with all the required information and visual identification of the species followed.

On 24 March 2018, one specimen of *P. aztecus* was caught at Marzamemi (36.725077 N; 15.137285 E) (Fig. 1B) with trammel net (inner-panel mesh size of 22 mm), over sandy bottom, together with the native prawn *P. kerathurus* at depth of 10–15 m. In the same month, other 3 specimens were caught in the same area. These records are the first for the Ionian coast of Sicily, more than 100 km -in straight line from the previous occurrence (Strait of Sicily). The specimen reported to the ENTE scientists with all the required information and visual identification followed. From interviews to fishermen of the southern coast of Sicily, the species appears well established in the area: yields can reach 12 kg per day (unpublished data, FT).

P. aztecus differs externally from *P. kerathurus* by the overall uniform creamy-beige or partially orange body coloration. It has no stipes or blotches. Other anatomic features such as the epigastric tooth and abdominal cicatrices are characteristic of the species (Pérez Farfante and Kensley 1997, Bakir and Aydin 2016) [34, 2] and therefore, identification through pictures is easy.

4. Discussion

This study fills a gap in the distribution of *P. aztecus* in the Mediterranean Sea by providing: 1. the first documented record of *P. aztecus* from Albania; 2. data on the range expansion of the species in Sicily, with first records for the Ionian Sea; 3. data supporting the establishment of the Northern brown shrimp in the Strait of Sicily. filling an important gap on its distribution within Mediterranean Sea. The species was most likely introduced by ballast water (Deval *et al*. 2010, Nikolopoulou *et al*. 2013, Marković *et al*. 2014, Bakir and Aydin 2016, Scannella *et al*. 2017) [11, 33, 31, 2, 39], although other studies suggest aquaculture as potential pathway (Crusanti *et al*. 2015, Galil *et al*. 2017, Sadek *et al*. 2018) [12, 38]. However, the latter seems slim since the prawn culture industry though that is active in Mediterranean is rather limited and mostly regards *P. japonicus* (Kevrekidis *et al*. 1996, Quigley *et al*. 2013 and references within) [23, 35]. Moreover, *P. vannamei* is cultured in Egypt (Sadek *et al*. 2018) [38] -with no reports of escapes, but there is not any evidence of *P. aztecus* farming in Mediterranean (Bakir and Aydin 2016, Scannella *et al*. 2017) [2, 39].

Besides Lessepsian migration, shipping -ballast water and hauling are considered the second-best introduction vector in east Mediterranean (Katsanevakis *et al*. 2014, Zenetos 2017) [21, 44, 45] for many taxa such as fishes (e.g. Batjakas *et al*. 2015) and decapods (e.g. Kondylatos *et al*. 2017) [25]. It is proposed that more than one ballast water release events are responsible for the species' occurrence in Mediterranean (Nikolopoulou *et al*. 2013, Scannella *et al*. 2017) [33, 39]. The current species' distribution in Mediterranean is in accordance with the general distribution pattern of "several hot-spot areas", like other alien species associated with shipping, as described by Katsanevakis *et al*. (2014) [21].

P. aztecus is reported from the southern coast of Sicily (Scannella *et al*. 2017) [39] and it is currently established in south coast of Sicily, since it is commonly caught from Marsala (37.634426 N; 12.532272) to Pozzallo (36.713757 N; 14.878856 E). Local fishermen of Pozzallo (36.713757 N; 14.878856 E) are reporting that the daily catch of *P. aztecus* can reach 12 kg. In the Ionian coast of Sicily, the species is sporadically caught between Portopalo of Capo Passero (36.668634 N; 15.136742 E) and Siracusa (37.103183 N; 15.309209 E) from about 5 years and begins to become common, demonstrating a clear range expansion. Besides *P. aztecus*, other decapod non-indigenous species occur in Sicily, like the Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 (Insacco and Zava 2017) [17] and *Percnon gibbesi* (H. Milne Edwards, 1853) (Mannino *et al*. 2017) [30].

The current record of *P. aztecus* is the first from Albania and enriches the relative knowledge, that is rather limited (Maiorano *et al*. 2011) [27]. Moreover, other non-indigenous decapod species established in the country are *P. gibbesi* (Katsanevakis *et al*. 2011) [22] and *C. sapidus* (Milori *et al*. 2017) [32].

Fig 1A: *Penaeus aztecus* Albanian coast, Vlora Bay

Fig 1B: *Penaeus aztecus* Sicilian coast, Marzamemi

5. Conclusions

All specimens were caught by artisanal fishermen by nets, together with *P. kerathurus*. Also, Scannella *et al*. (2017) [39] report that the species was caught by bottom trawlers and Nikolopoulou *et al*. (2013) [33] by decapod traps and hand nets within a lagoon in NW Aegean Sea. It seems that the species has a wide bathymetric range and a strong interaction with the native *P. kerathurus*, yet further and systematic research is required. From the results of this study, *P. aztecus* clearly show an invasive character and could further expand very fast its range in the Mediterranean Sea. New insights demonstrated that alien invertebrate species are most likely to increase their range, amplified by the impacts of climate change (Bellard *et al*. 2018) [5].

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