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RESEARCH

New Records of Non-Indigenous Crustaceans from Sicily (Central Mediterranean Sea)

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Abstract
The non-indigenous crustaceans *Erugosquilla massavensis* (Stomatopoda, Squillidae), *Penaeus aztecus* (Decapoda, Penaeidae) and *Portunus segnis* (Decapoda, Portunidae) are reported for the first time from the southern Tyrrhenian Sea (Gulf of Castellammare, NW Sicily) as a consequence of distribution range expansion. Their size and weight are provided along with the main distinguishing morphological characters. The presumed impacts on the ecosystem and the possible effect on the small-scale fishery of the Gulf of Castellammare are briefly discussed.

Keywords Alien species · Biodiversity · Stomatopoda · Decapoda · Tyrrhenian Sea · Gulf of Castellammare

Introduction

The Mediterranean Sea is considered a hotspot for marine non-indigenous species (NIS) (Galil et al. 2014). About 1000 species have been validated as alien taxa, and among them the number of established species has dramatically increased in the last decade (Zenetos et al. 2022). The high number of NIS, higher than in any other single European sea (Galil et al. 2014), is due to a large extent to the presence of the Suez Canal, which has represented a doorway to many species from the Red Sea through the so-called lessepsian migration (Golani 2010). Crustaceans rank third among the most numerous groups of NIS recorded in the Mediterranean with 210 species (including some questionable records), most of which by now are considered established (Zenetos et al. 2022).

Due to its central position in the Mediterranean, the island of Sicily represents a potential crossroads of the expansion pathways of NIS in the basin, also due to the proximity of the Strait of Sicily that facilitates the exchange of water masses and biota between the eastern and western sub-basins, and between Sicily and Tunisia that represents the western limit for many lessepsian species (Deidun et al. 2021; Mosbahi et al. 2021). Several non-indigenous marine crustaceans, both of lessepsian and west Atlantic origin, have been recorded from around the island: *E. massavensis* (SE Sicily: Corsini-Foka et al. 2017; Gianguzza et al. 2019; Ragkousis et al. 2023), *Trachysalambria palaestinensis* (Steinitz 1932) (SE Sicily: Insacco et al. 2017), *Callinectes sapidus* Rathbun, 1896 (first finding in S Sicily: Lipej et al. 2017, followed by several other records from the island, see Castriota et al. 2024), *P. aztecus* (SE Sicily: Kampouris et al. 2018; Stern et al. 2019; S Sicily: Scannella et al. 2017; Ragkousis et al. 2023), *P. segnis* (S Sicily: Katsanevakis et al. 2020; Lampedusa, Strait of Sicily: Maggio et al. 2022; E Sicily: Ragkousis et al. 2023).

The Gulf of Castellammare is a semi-circular bay almost 400 km^2 wide located in NW Sicily (southern Tyrrhenian Sea), characterized by rocky substrates along the eastern and western edges and mostly soft substrates in the central part, and by the presence of a few streams and minor rivers (Fig. 1). Due to the presence of several small harbours that host a small-scale fishing fleet, and of a field research facility of CNR-IAS in Castellammare del Golfo, a long-lasting and fruitful collaboration between fishermen and researchers has allowed the collection of neonative, cryptogenic and non-indigenous species (Andaloro et al. 2005; Pipitone et al. 2020, 2024) that were not recorded during extensive

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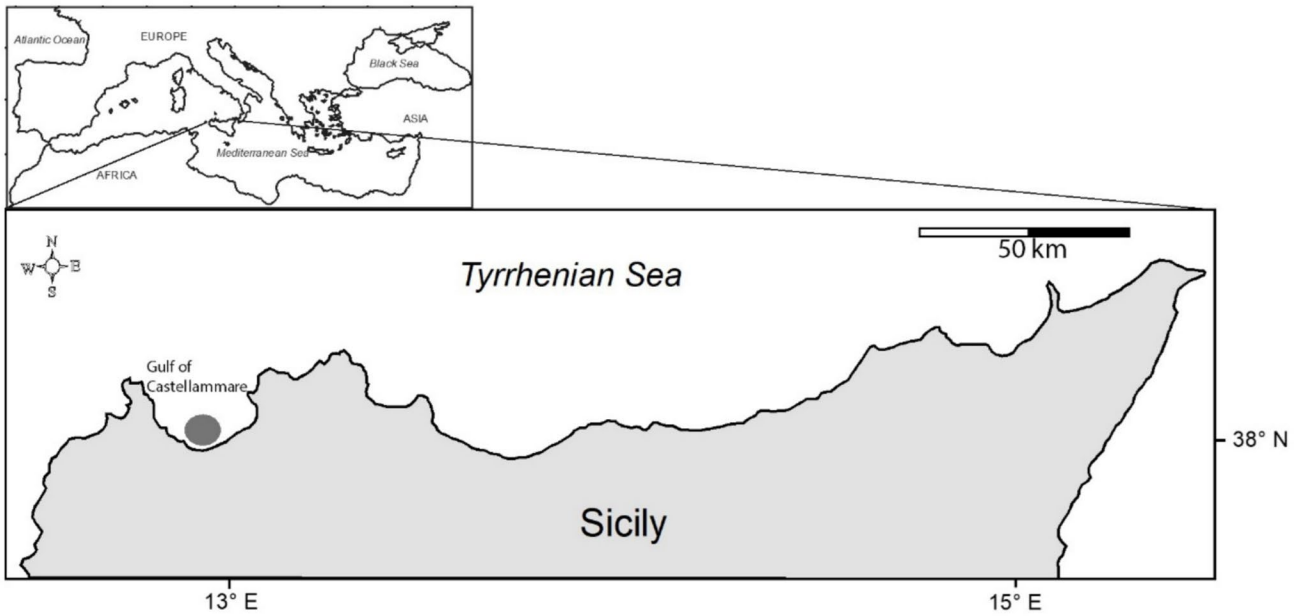

Fig. 1 Map of the study area. The grey circle represents the area of collection of *Erugosquilla massavensis*, *Penaeus aztecus* and *Portunus segnis*

multi-annual scientific surveys carried out in the Gulf (e.g.: Pipitone et al. 2023).

This paper reports on the finding of three non-indigenous crustacean species collected by professional fishermen in the Gulf of Castellammare.

Materials and Methods

In the summer of 2024 a mantis shrimp, a swimming crab, and a small box with thirteen large-sized penaeid shrimps, all of them different from the crustaceans commonly caught in the Gulf of Castellammare, were brought to the CNR-IAS laboratory in Castellammare del Golfo by two local professional fishermen. All specimens were caught with trammel nets over a sandy bottom off the San Bartolomeo river outlet (Fig. 1) in July 2024 at a depth of about 5 m (approx. 38.03°N 12.90°E: swimming crab) and in August 2024 at about 20 m (approx. 38.04°N 12.90°E: mantis shrimp, penaeid shrimps). The three species were identified as the Massawan mantis shrimp *Erugosquilla massavensis* (Kossmann, 1880) (Stomatopoda, Squillidae) (Fig. 2), the brown shrimp *Penaeus aztecus* Ives, 1891 (Decapoda, Penaeidae) (Fig. 3), and the Red Sea blue crab *Portunus segnis* (Forskål, 1775) (Decapoda, Portunidae) (Fig. 4).

Each individual was weighed and the following measurements at the nearest mm were taken with a vernier caliper: total length (TL, from the tip of the rostral plate to the tip of the telson submedian spines) and carapace length (CL, from the tip of the rostral plate to the dorsal posterior margin of carapace) in *E. massavensis*; carapace length (CL, from the eye socket to the dorsal posterior margin of carapace) in *P. aztecus*; carapace width (CW, between the tips of the last anterolateral teeth) and carapace length (CL, from the

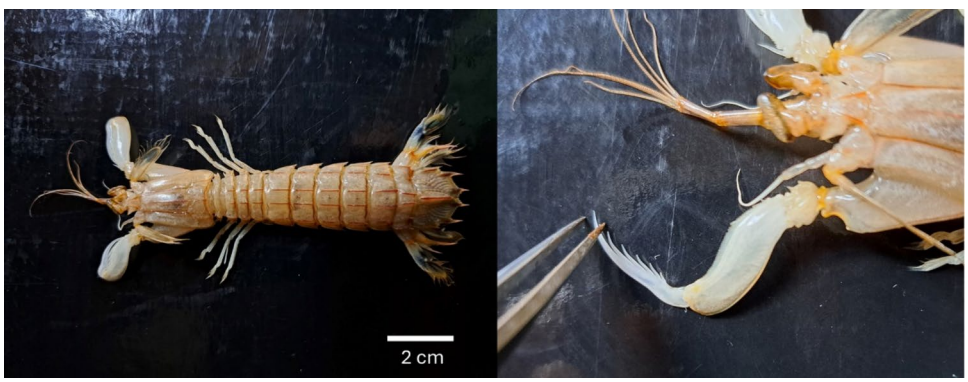

Fig. 2 *Erugosquilla massavensis* collected in the Gulf of Castellammare. On the right: detail of the claw dactylus

Fig. 3 *Penaeus aztecus* collected in the Gulf of Castellammare. On the right: detail of the rostrum

Fig. 4 *Portunus segnis* collected in the Gulf of Castellammare. On the right: ventral side

rostral teeth to the dorsal posterior margin of carapace) in *P. segnis*. The sex was identified in *P. aztecus* by the presence of petasma in males, and in *P. segnis* by the shape of the abdomen. No sex identification was done in *E. massavensis* since the specimen went lost before further morphological analysis could be done.

The following bibliographic references were used for the identification of the specimens: Froglia and Manning (1989) for *E. massavensis*, Perez Farfante (1988), Tavares (2002), Fransen (2014) and Froglia and Scanu (2023) for *P. aztecus*, Holthuis (1987) and Lai et al. (2010) for *P. segnis*.

Results

The identification of the three species was based on the analysis of the images and of the main macroscopical characters reported in the scientific literature, in particular those that distinguish them from other similar autochthonous or non-indigenous species occurring in the Mediterranean. *E. massavensis* was identified by the presence of a median carina and numerous intermediate marginal denticles in the telson, six teeth in the claw dactylus, and armed anterolateral angles of carapace. *P. aztecus* was identified by the presence of two teeth on the ventral margin of the rostrum, a dorsolateral sulcus in the last pleonite, the unarmed telson, the aspect of petasma (in males) and thelycum (in females), the dark rose color of the body and the reddish margins of uropods. *P. segnis* was identified by the presence of four very small frontal teeth, three spines on the anterior margin of the merus of chelipeds and two strong teeth on the cheliped carpus, by a regularly triangular abdomen in males, by blue cheliped fingers and distal pereiopod articles, and by the dark green color of carapace with many small whitish spots that may merge into reticulated patterns.

The measurements, weight and sex of all specimens are reported in Table 1. In agreement with the literature (e.g., Stergiou et al. 2014) female *P. aztecus* had a larger mean size than males (F = mm 37.14 ± 7.95; M = mm 26.83 ± 1.72).

Discussion

The most recent comprehensive research on the crustacean fauna of the seas around Sicily includes a study on the decapods and stomatopods of the Strait of Sicily (Pipitone and Tumbiolo 1993) and a checklist of Sicilian decapods (Pipitone and Arculeo 2003). While the former did not include any non-indigenous decapod, the latter mentioned only two "exotic" species: the nimble spray crab *Percnon gibbesi* (H. Milne Edwards, 1853), now considered a cryptogenic or crypto-expanding species (Zenetos et al. 2022), and the

Table 1 Morphometric data and sex of non-indigenous crustaceans collected in the Gulf of Castellammare

Species	TL (mm)	CL (mm)	CW (mm)	Weight (g)	Sex
Erugosquilla massavensis	93	21		9.5	
Penaeus aztecus		24		13.5	M
Penaeus aztecus		26		15.4	M
Penaeus aztecus		27		17.6	M
Penaeus aztecus		27		16.6	M
Penaeus aztecus		28		15.2	M
Penaeus aztecus		29		19.5	M
Penaeus aztecus		30		23.9	F
Penaeus aztecus		31		25.4	F
Penaeus aztecus		33		27.6	F
Penaeus aztecus		34		29.7	F
Penaeus aztecus		35		34.4	F
Penaeus aztecus		48		70.2	F
Penaeus aztecus		49		71.2	F
Portunus segnis		82	141	197	M

TL Total length, *CL* Carapace length, *CW* carapace width

blue swimming crab *Portunus pelagicus* (L., 1758), whose Mediterranean specimens were successively assigned to *P. segnis* after the systematic revision by Lai et al. (2010). The three non-indigenous crustaceans described in this paper are reported for the first time from the southern Tyrrhenian Sea, even though they had already been recorded from the southern and eastern Sicilian coast. *E. massavensis* and *P. segnis* are of lessepsian origin, while *P. aztecus* is of west-Atlantic origin and its presence in the Mediterranean is supposed to derive from ship transportation or escapement from aquaculture facilities (Servello et al. 2019). The pathway of these species to the Gulf of Castellammare can be considered a further range expansion around Sicily, and is not easy to ascertain. Since the Gulf of Castellammare does not host large harbors that could justify a ship-mediated transportation, and the three species occur in S and SE Sicily and in N and S Tunisia (see Ragkousis et al. 2023 for a recent account of their findings in the area), we might speculate that they underwent a current-driven range expansion to NW Sicily.

A major concern about NIS is represented by their impact on the autochthonous biota, the human activities and the ecosystem services (Tsirintanis et al. 2022). This has been widely discussed for the Atlantic blue crab *C. sapidus*, a highly invasive species (Castriota et al. 2024) whose predatory activity has been shown to have a dramatic impact on commercial shellfish stocks in the N Adriatic and the Catalan coast (Azzurro et al. 2024; Prado et al. 2024). For this reason it has been considered for monitoring and management by regional fisheries management bodies along with *P. segnis* (GFCM 2023). The potential or actual impacts of the three non-indigenous crustaceans found in the Gulf of Castellammare are different. The mantis shrimp *E. massavensis* and the Red Sea blue crab *P. segnis* were suggested to have a possible negative impact on biodiversity and a positive impact as fishery resources, while the brown shrimp *P. aztecus* does not seem to have any negative impact but has a positive impact as a fishery resource (Tsirintanis et al. 2022).

Besides predation and the consequent impact on ecosystems and human activities (fishing in particular), NIS could alter the local biodiversity through direct competition with similar autochthonous species or even other NIS, e.g. via trophic niche overlap. To this purpose the trophic ecology of NIS in the biotic assemblage should be investigated, as done for *P. segnis* by Mancinelli et al. (2022). The autochthonous crustaceans that share to some extent morphology and habitat with our three species and that could therefore overlap with their trophic niche within the food web are the spot-tail mantis shrimp *Squilla mantis* (L., 1758), and the caramote prawn *Penaeus kerathurus* (Forskål, 1775). The invasive alien Atlantic blue crab *C. sapidus* might compete with *P. segnis*. The same reasoning applies to two non-indigenous fish recently found in the Gulf of Castellammare (Pipitone et al. 2024) such as the Por's goatfish *Upeneus pori* Ben-Tuvia and Golani 1989 and the reticulated leatherjacket *Stephanolepis diaspros* Fraser-Brunner, 1940, which share morphology and habitat with the autochthonous red mullet *Mullus barbatus* L., 1758 and grey triggerfish *Balistes capriscus* Gmelin, 1789, respectively. Ad hoc research should be developed in the area to investigate the trophic structure of the coastal sandy-bottom assemblage and the possible impact of the non-indigenous assemblage on biodiversity.

The three crustaceans studied might have a positive role as commercial resources for the small-scale fishery in the Gulf of Castellammare. Although *E. massavensis* and *P. segnis* do not seem to be yet established in the gulf, *P. aztecus*

is reported as a relatively frequent and highly priced catch by local artisanal fishermen, according to some informal and preliminary interviews carried out by the authors in the Castellammare del Golfo harbor. In the absence of dedicated monitoring programs, constant collaboration with professional and recreational fishermen may provide a useful support in the assessment of the occurrence and abundance of these and other NIS and help to assess their impact on the biological community and on ecosystem services.

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Authors Contribution C.P. wrote the main manuscript, all authors contributed to sample collection and reviewed the manuscript.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing Interests The authors declare no competing interests.

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