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First record of adult specimens of the Oriental shrimp *Palaemon macrodactylus* Rathbun, 1902 in the Venice Lagoon (north Adriatic Sea, Italy)

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Abstract

The first record of adult Oriental shrimps *Palaemon macrodactylus* Rathbun, 1902 in the Venice Lagoon (north Adriatic Sea) is presented based on six specimens collected in a shallow water habitat during May 2012. The record is discussed in the context of the widespread distribution of the species, taking into account the possible ways of introduction and the possible consequences of the presence of *P. macrodactylus* in the Venice Lagoon.

Key words: alien species, caridean decapod, ovigerous females

Introduction

Venice lagoon is one of the biggest estuarine ecosystems of the Mediterranean Sea. In their overview, Occhipinti-Ambrogi et al. (2010) listed 39 alien species established in the Venice lagoon, this being the highest number of marine aliens for the Italian coasts. In fact, the Venice lagoon can be considered a hotspot of alien species introduction in the Mediterranean region, and particularly in the Northern Adriatic Sea. The presence of the city of Venice and of the industrial harbour of Marghera, together with aquaculture activities and tourism, favour the introduction of alien species (Occhipinti-Ambrogi et al. 2010).

Since the second half of the 20th century, the Oriental shrimp *Palaemon macrodactylus* Rathbun, 1902 has been recorded from several locations outside its native range. Ashelby et al. (2013) listed at least six geographic regions in which this species was detected in the period 1957–2012. For the Mediterranean Sea, *P. macrodactylus* was first recorded in the Balearic Islands (off the east coast of Spain), where its larvae were found in plankton samples (Torres et al. 2012).

In this study, the first collection of adult *P. macrodactylus* specimens in the Venice Lagoon is reported. Concurrent with the present work, adult specimens were found for the first time elsewhere in the same general area of the Mediterranean Sea (Goro and Marano-Grado lagoons, North Adriatic sea) by Cuesta et al. (2014).

Materials and methods

The nekton community of the Venice Lagoon was sampled at 19 sites during May, July, and October 2012 (Figure 1). Fish and caridean crustaceans were collected by means of a beach seine. We measured the length and net opening for each tow in order to estimate species densities. Samples transported in the laboratory were frozen at - 24° C and, after species identification, each crustacean specimen was measured (post-orbital carapace length CL in mm) and weighed (to 0.1 mg). Specimens were identified using the identification keys of Gonzalez-Ortegon and Cuesta (2006), Ashelby et al. (2004) and the description provided by Newman (1963) and Béguer (2010) and then deposited at the Natural history Museum

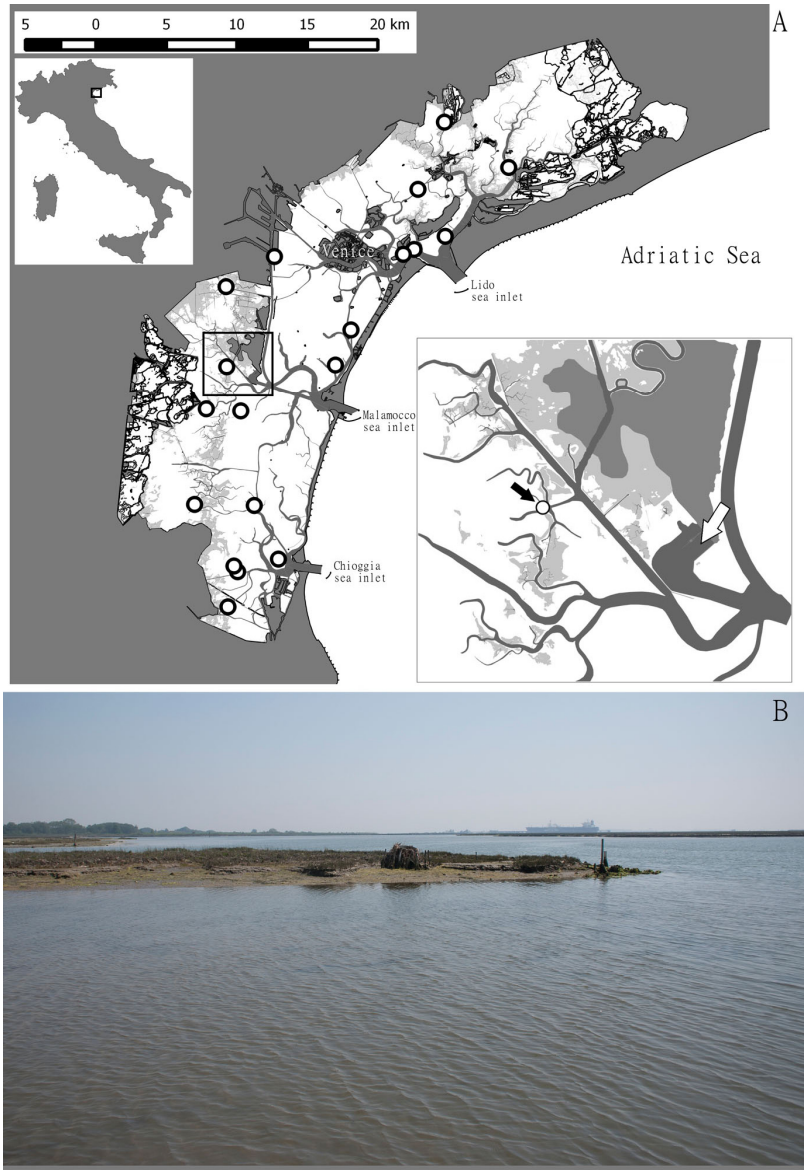

Figure 1. A) Location of the 19 sites sampled in 2012. In the magnified area, the black arrow indicates the site were *Palaemon macrodactylus* was collectd, the white arrow shows the location of San Leonardo commercial harbour; B) picture of the sampling site where specimens of *P. macrodactylus* was collected (photograph by M. Zucchetta).

of Venice (accession number MSNVE-23246). Sex was determined on the basis of the morphology of the endopod of the second pleopod. All specimens were preserved in 70% ethanol.

Results

In the samples collected on 11 May 2012 at one of sites (45.35954 N, 12.22241 E, Figure 1), six specimens of *P. macrodactylus* were collected from a swept area of 487.5 m^2 (density of 1.2 individuals 100 m^{-2}). The sampling site was located in a shallow-water area (1 m depth) within the central basin of the Venice lagoon, next to S. Leonardo harbour, in front of Malamocco sea inlet (Figure 1). At the sampling time, the main chemical-physical water parameters were: temperature 21.7°C, salinity 28.6, dissolved oxygen 7.5 mg L^{-1}, and turbidity 9.9 NTU. The sampling location was characterized by a muddy bottom, with a sand content of 13.3% and organic matter content of 14.9% (LOI 550).

The six specimens of *P. macrodactylus* were between 5.1 and 10.8 mm CL, with wet weights between 0.2872 and 1.2120 g (Table 1). Among the five females found, two were ovigerous. For

Table 1. Main morphometric measures of the six specimens of *Palaemon macrodactylus* recorded in the Venice lagoon. Number of dorsal teeth does not take into account the tooth of apical cleft; number in parenthesis indicates the number of teeth behind the posterior edge of the orbit. * Tip of the rostrum damaged.

Sex	Postorbital carapace length (mm)	Total wet weight (g)	Dorsal teeth
male	5.1	0.2872	9 (3)*
female	8.0	0.5623	11 (3)
female, ovigerous	8.2	0.5373	10 (3)
female	9.6	0.8527	10 (3)
female	9.7	0.8277	10 (3)
female, ovigerous	10.8	1.2120	10 (3)*

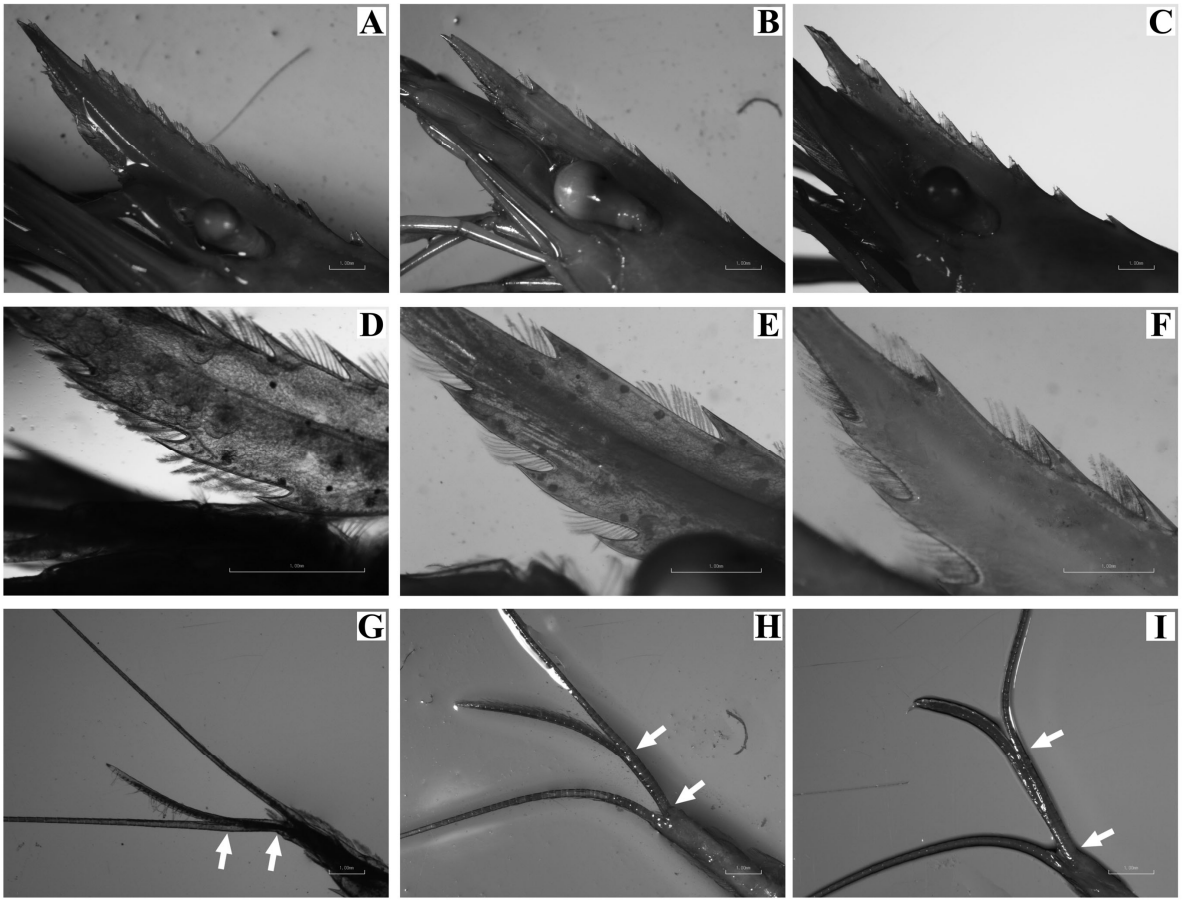

Figure 2. Main morphological traits used in the identification of *Palaemon macrodactylus* specimens, in comparison with *Palaemon adspersus* and *Palaemon elegans*. Number of dorsal teeth of the rostrum: 10 (nine to 15) in *P. macrodactylus* (A) 5 (five to six) in *P. adspersus* (B) and seven (seven to nine) in *P. elegans* (C); double row of plumose setae on the ventral margin of the rostrum in *P. macrodactylus* (D); single row of setae in *P. adspersus* (E) and *P. elegans* (F); the shorter ramus of the outer flagellum of antennula is fused for about 20% of its length in *P. macrodactylus* (G), for about one third in *P. adspersus* (H) and for about 50% in *P. elegans* (I). Photographs by F. Cavraro.

this study, it was necessary to distinguish between *P. macrodactylus*, *Palaemon adspersus* Rathke, 1837 and *Palaemon elegans* Rathke, 1837. The main characters to discriminate between the three species were: (1) the number of teeth on the dorsal margin on the rostrum, which ranged between 9 and 15 in *P. macrodactylus* (Figure 2A), between 5 and 6 in *P. adspersus* (Figure 2B) and between 7 and 9 in *P. elegans* (Figure 2C); (2) the presence in *P. macrodactylus* of a double row

of plumose setae on the ventral margin of the rostrum (Figure 2D), while in *P. adspersus* and *P. elegans* there is only a single row of setae (Figure 2E-F); and (3) the shorter ramus of the outer flagellum of the antennule, which is fused for about 20% of its length in *P. macrodactylus* (Figure 2G), for one third in *P. adspersus* (Figure 2H), and for about 50% in *P. elegans* (Figure 2I).

In the same sample, the most abundant caridean decapod was *Crangon crangon* (L.) (68.3 individuals 100 m^{-2}), while specimens of the congeneric *P. elegans* (5.7 individuals 100 m^{-2}) and *P. adspersus* (1.2 individuals 100 m^{-2}) were also found.

Discussion

Six specimens of *P. macrodactylus* were collected for the first time in the Venice lagoon in May 2012. The species was first recorded outside its natural range, which includes Japan, Korea and China coastal waters (Newman 1963 and citations therein), in San Francisco Bay in 1957 (Newman 1963). Subsequently, it was found in Australia (1967), on the Atlantic and North Sea European coasts (since 1992), in Argentina (2000), on the USA Atlantic coast (2001), and in the Black Sea (2002) (Ashelby et al. 2013 and citations therein). The latest introductions were recorded in the Mediterranean Sea, with the finding of zoeae in Mallorca waters (Torres et al. 2012) and the record of adult specimens in other North Adriatic lagoons (Cuesta et al. 2014).

Ship water ballast discharge is considered to be the most likely vector of introduction of this species (Carlton 1985; Béguer et al. 2007; Micu and Niţă 2009; Ashelby et al. 2013), and this could be true also for the introduction within the lagoon of Venice. The sampling station in which *P. macrodactylus* was found is near (2.3 km) the commercial port of S. Leonardo. The maritime traffic within the lagoon of Venice is quite intense, with 2000–3000 large ships (length > 100 m) passing in the nearby channel every year (Rapaglia et al. 2011) and this species has never been found in all the monitoring activities conducted almost every year since 2001 (P. Franzoi, unpublished data), suggesting a recent introduction in the Venice lagoon. Nevertheless other causes (i.e. errors in identification, nocturnal behaviours, presence of the species in non-sampled habitats, seasonal variation in abundance, etc.) could have led to a late finding.

From the literature (Newman 1963; González-Ortegón et al. 2006), the species is known to have wide environmental tolerances with regards to water chemical-physical conditions (e.g., temperature, salinity and dissolved oxygen), thus easily colonising a broad set of estuarine habitats outside its natural geographic range even though, in its native range, *P. macrodactylus* is commonly found in seagrass beds (Omori and Chida 1988). Also within the Venice lagoon, despite the presence of wide seagrass meadows, the specimens were recorded in a salt marsh area.

The presence of two ovigerous females among the collected specimens suggests also the presence of an established, though small, population. This is in accordance with data found in the literature, which indicate a reproductive period comprised between mid-April and October in the natural range (Omori and Chida 1988).

The introduction of alien species is a major concern worldwide, with a frequent occurrence of biological invasions affecting estuarine ecosystems (Rikke et al. 2008). Regarding this species, some authors (Sitts and Knight 1979; Siegfried 1982) found that *P. macrodactylus* could have been considered a threat for native shrimps in California, such as *Crangon franciscorum*. Along European coasts, and also within the Venice lagoon, *P. macrodactylus* could compete for food resources and spatial niche with other caridean shrimp, such as *P. elegans, P. adspersus* and *C. crangon* (Ashelby et al. 2004). However, some authors (Micu and Niţă 2009) highlighted that the high abundance of trophic resources typical of estuarine habitats, added to the nocturnal and cryptic behaviour of this species, may prevent wide niche overlap with other caridean decapods. Another threat, however, may come in the form of transmission of pathogen agents, such as fungi (Gil-Turnes et al. 1989), to native species.

Even if recorded with a low abundance at present, it is recommended that the presence of *P. macrodactylus* and its eventual expansion within the lagoon waters will be monitored in the next few years, through directed monitoring programmes as well as in the artisanal fishery catches.

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