

Rapid Communication

First record of non-indigenous *Paracaprella pusilla* Mayer, 1890 (Crustacea: Amphipoda) in the Northern Tropical East Pacific

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Abstract

Despite the large number of biological invasion studies, little is known about non-indigenous caprellids in the eastern Pacific. This study represents the first record of *Paracaprella pusilla* Mayer, 1890, an invasive species, in the northern tropical east Pacific (NTEP) region. Caprellids were collected from June 2013 to March 2014 on fouling substrates (mainly macroalgae, sponge, and bryozoans) associated with artificial structures at four sites from the Mexican Pacific. Marinas, sheltered waters, and aquaculture farms appeared to function as caprellid nurseries and may act as distribution points to other localities. *P. pusilla* inhabited a wide range of artificial structures, which appears to increase their survival success and may facilitate their dispersal to new locations in the eastern Pacific Ocean.

Key words: bioinvasions, artificial structures, Mexican Pacific, Caprellidae

Introduction

In the last decade, anthropogenic activities have promoted and accelerated the dispersal of many species, which has led to increasing numbers of invasion records worldwide (Álvarez-León and Gutiérrez-Bonilla 2007; Ruiz et al. 2009; Blackburn et al. 2011). Successful establishment of non-indigenous species may result in the competition for food and habitat with species already present and may also result in a predator-prey interaction (Mack et al. 2000). Consequently, establishment of non-native species poses a threat to native and naturalized species, and can affect (effects can be positive or negative) community composition and ecosystem structure and functioning (Needless and Wendt 2012).

Crustaceans are one of the most invasive taxa, often employing with passive dispersal, in the Pacific region (Montelli and Lewis 2008; Coles et al. 1999; Zabin et al. 2014; Kiessling et al. 2015). On the Mexican Pacific coast, 39 exotic species of crustacean (including: 21 peracarids, one

mysid, two tanaids, six isopods, and 12 amphipods) have been reported to be associated with fouling communities. However, there is limited information on non-indigenous caprellid amphipods (Rodríguez-Almaraz and García-Madriral 2014).

The non-indigenous caprellid *Paracaprella pusilla* Mayer, 1890 is reported from many marinas on the Atlantic and Mediterranean coasts, and it is well established in many areas outside of its native range (Ros and Guerra-García 2012; Winfield and Ortíz 2013). *Paracaprella pusilla* was first described from the Atlantic Ocean at Rio de Janeiro, Brazil, which makes this the type locality (Mayer, 1890). In the Pacific Ocean, *P. pusilla* has been recorded in Australia and Hawaii (Edmondson and Mansfield 1948; Montelli and Lewis 2008). It was suspected that the species had invaded the Pacific coast of the Americas (Guerra-García and Thiel 2001; Astudillo et al. 2009), but this was only confirmed in 2004 at the entrance of the Panama Canal (Ros et al. 2014). To date, this caprellid amphipod has not been detected in north eastern tropical Pacific (NETP)

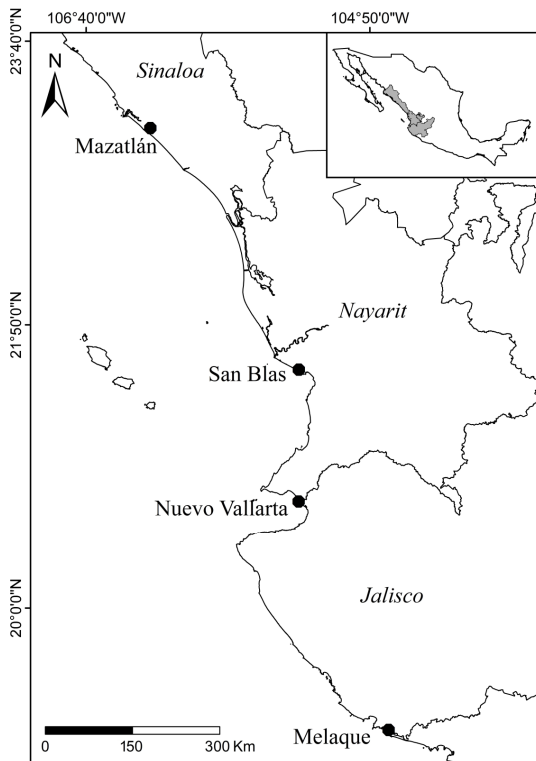


Figure 1. Map of the study area. Filled symbols represent locations where specimens of *Paracaprella pusilla* were collected.

region. This study is the first record of the caprellid *P. pusilla* from the NETP and includes notes on their geographic distribution in sheltered waters and marinas on the Pacific coast of Mexico.

Materials and methods

Various substrates associated with fouling communities were sampled between June 2013 and March 2014 (Table 1). Marinas (including docks, pilings, ropes, buoys, and vessels) were sampled at three localities on the Central Mexican Pacific coast (Figure 1): Mazatlán, Sinaloa; San Blas, Nayarit; and Nuevo Vallarta, Nayarit. We also sampled boxes from an oyster *Crassostrea gigas* (Thunberg 1793) farm in Melaque, Jalisco. Samples of encrusting organisms were collected from artificial structures by hand-scraping the substrate at haphazardly chosen locations on the structure (<1m depth). The scraped materials consisted of: macroalgae (*Enteromorpha* sp. and *Cladophora* sp.); sponges (*Halichondria* sp.); and bryozoans (*Bugula* sp. and *Zoobotryon* sp.).

This material was examined under a Stemi DV4 Carl Zeiss microscope and all caprellids were removed and preserved in 70% ethanol.

Caprellid amphipods were identified as *Paracaprella pusilla* Mayer, 1890 based on morphological descriptions of McCain (1968) and Ros et al. (2013a). The criteria used for determining the sex and age of the specimens were: females with the presence of fully developed brood pouches; males by the absence of the brood pouches and the presence of a large acute projection on the antero-ventral margin of pereonite 2. Specimens lacking these characteristics were classified as juveniles. The maximum body size (mean \pm SD) was measured from the dorsal surface of the rostrum to the base of pereonite 7. Digital images of each specimen were documented with a Canon SX20 IS digital camera and analyzed using the software ImageJ 1.4 (<http://rsb.info.nih.gov/ij/>). To compare average body size between study locations, the data were first grouped as females, males, and juveniles for each location and analyzed using separate non-parametric analysis of variance (Kruskal-Wallis) tests. Differences between means were detected *a posteriori* using Dunn's pairwise multiple comparisons procedures. Statistical analyses were performed using SigmaPlot 11.0 (Systat Software, Inc., San Jose, California, USA) using $\alpha = 0.05$.

Results

The diagnostic characteristics used to identify *P. pusilla* were: head without projection; smooth body with a large anterolateral projection of pereonite 2 (Figure 2a-b); the presence of a small dorsal tubercle on pereonite 2 (Figure 2b); peduncle of antenna 1 setose and usually longer than antenna 2; antenna 2 without swimming setae but densely setose; propodus of gnathopod 1 with one proximal grasping spine; basis of gnathopod 2 with a proximal knob and propodus with trapezoidal projection on the inner margin (Figure 2c); gills and lateral pleura in pereonites 3–4 (pleura in pereonite 3 more developed) (Figure 2d); pereopods 3–4, 2 segmented; propodus of pereonites 5–7 with a pair of grasping spines and several knobs which increase in size proximally; females with a pair of brood pouch on pereonites 3–4 (Figure 2a) (Mayer 1903; McCain 1968; Cain 1978).

We collected 313 *Paracaprella pusilla* specimens that were associated with three substrates: macroalgae, sponges, and bryozoans (Table 1). There were 50 males, 17 ovigerous females, 71 non-ovigerous

Figure 2. *Paracaprella pusilla* Mayer, 1890 from the Northeast Pacific. **a)** Lateral view of an adult male and female. **b)** Pereonite 2. **c)** Gnathopod 2. **d)** Pereonite 3 and 4. Black arrows represent the principal morphological characteristics. Photographs by Lucy C. Alarcón-Ortega.



Table 1. Study sites, geographic coordinates, record of surveys and substrata type collected (Sp= sponge, Al= algae, Br= bryozoan).

Location	Coordinates		Record data	Substrata collected
Mazatlán marina	23°10'51.76" N	106°25'14.52" W	4 December 2013	Al
San Blas marina	21°32'38.72" N	105°17'32.70" W	16 October 2013	Al, Sp
			21 November 2013	Br, Al, Sp
Nuevo Vallarta marina	20°41'31.83" N	105°17'36.07" W	3 June 2013	Br
			21 July 2013	Br
Melaque oyster farm	19°13'04.61" N	104°42'43.92" W	26 March 2014	Al

females, and 175 juveniles (Table 2). The mean body size of males differed significantly between locations (Kruskal-Wallis, $H_{3,50}=89.545$, $p<0.001$) where *P. pusilla* males from Melaque were twice as long as those of all other study locations (Dunn's test $p<0.05$). The mean length of females also differed between locations (Kruskal-Wallis, $H_{3,88} = 22.174$, $p \leq 0.001$) with specimens from San Blas and Nuevo Vallarta being smaller than those collected at the other sit (Dunn's test $p<0.05$). Juveniles also showed significant between-site differences (Kruskal-Wallis, $H_{2,175} = 14.441$, $p \leq 0.001$) as San Blas organisms were smaller than those collected from Melaque and Nuevo Vallarta (Dunn's test $p<0.05$).

Discussion

The presence of *Paracaprella pusilla* on the northern Mexican Pacific coast represents the first record for the NETP region. This species was found living on fouling communities associated

with estuarine environments and artificial substrates in marinas, similar to reports elsewhere (Bhave and Deshmukh 2009; Ros and Guerra-García 2012; Ros et al. 2013a; Ros et al. 2014). So far, *P. pusilla* appears to be limited to modified ecosystems such as marinas and harbors and has not yet been detected in natural habitats along the Mexican Pacific coast (Sánchez-Moyano et al. 2014).

Paracaprella pusilla is unselective with respect to fouling substrate occupied as it is found on sponges, algae, and bryozoans (McCain 1968; Díaz et al. 2005; Guerra-García et al. 2010; this study). The general morphology of *P. pusilla* is well suited to clinging to fibrous substrates (Caine 1978; Takeuchi and Hirano 1995), including fouling organisms on artificial floating objects, which facilitates their dispersal via drifting. This ability to cling is a common feature of invasive caprellid species (Ros and Guerra-García 2012; Ros et al. 2013a; Woods et al. 2014; Kiessling et al. 2015) and allows the species to cope with effects of waves and currents on floating marine

Table 2. Body measurements of different life stages (♀= females) of *Paracaprella pusilla* in different locations of the Northern Tropical Pacific. (*) Statistical difference ($p < 0.05$).

Sex/age	Locality	Mean±SD	Length (mm)	
			Max	Min
Ovigerous ♀	Mazatlán marina	4.82	-	-
	San Blas marina*	3.99 ± 0.66	5.72	3.38
	Nuevo Vallarta marina*	-	-	-
	Melaque oyster farm	4.94 ± 0.20	5.23	4.65
Non-ovigerous ♀	Mazatlán marina	-	-	-
	San Blas marina*	3.12 ± 0.53	5.03	3.38
	Nuevo Vallarta marina*	3.63 ± 0.54	5.16	3.07
	Melaque oyster farm	4.74	-	-
Males	Mazatlán marina	4.13	-	-
	San Blas marina	4.37 ± 0.97	7.27	3.01
	Nuevo Vallarta marina	4.72 ± 0.58	5.62	3.99
	Melaque oyster farm*	8.92 ± 1.39	10.66	5.79
Juvenile	Mazatlán marina	-	-	-
	San Blas marina*	2.34 ± 0.67	3.89	0.55
	Nuevo Vallarta marina	2.78 ± 1.00	3.57	1.53
	Melaque oyster farm	2.50 ± 1.00	3.54	1.1

structures (Thiel et al. 2003). Along with other caprellid invasive species, *P. pusilla* is adapted to inhabit different substrates, which increases their chance of survival when colonizing new localities.

The *P. pusilla* occupying aquaculture oyster boxes were larger than those collected recreational marinas and harbors. The difference in size is likely related to favorable conditions in oyster boxes where caprellids are protected from extreme hydrodynamic conditions, and there often is high food availability associated with those aquaculture areas (Caine 1989; Cook 2007). An alternative explanation is the difference in sampling dates. Unlike samples collected in harbours and marinas, the oyster boxes were sampled during March, which is during the December to May period of high productivity driven by seasonal upwellings and the presence of the California current in the area (Pennington et al. 2006; Kessler 2006). Therefore, the caprellids during this period may grow to larger sizes due the abundant availability of food resources. These two hypotheses are not mutually exclusive.

The presence of mature males, ovigerous females, and juveniles at all sampling locations indicates *P. pusilla* is fully established on the Mexican Pacific coast. Protected ecosystems provide a suitable habitat and food sources for non-native caprellids, which allows their successful recruitment and growth (Cook et al. 2007; Ros et al. 2013b).

Hence, marinas and sheltered waters are most likely caprellid nurseries and, in the context of the present study, may act as distributional points leading to colonization of additional areas in the NETP and beyond.

The vector of introduction of *P. pusilla* into the study area is unknown. It is suspected that this occurred through a combination of ballast water, attachment to hulls of vessels (Ros and Guerra-García 2012; Ros et al. 2013a), and dispersal on floating materials (Astudillo et al. 2009). These same vectors may allow small amphipods such as caprellids to successfully colonize new areas. Therefore, it is our recommendation to continue to systematically study the potential dispersal routes and the population densities in different localities to help track the potential spread of *P. pusilla* in the Pacific Ocean.

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