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Density of the Porcelain Crab *Petrolisthes teres* Melin (Anomura: Porcellanidae) in the Intertidal Zone of Cocoy Beach, Tiniguiban, Puerto Princesa City, Palawan, Philippines

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ABSTRACT

The present study aimed to assess the monthly density of *P. teres* in intertidal pebble/cobble substrate. The study was conducted from June to November 2004. Density of porcelain crabs was assessed in six stations that were equally distributed over the intertidal area of Cocoy Beach, Puerto Princesa City. In each station two quadrats ($0.25m^2$) were selected and sampled monthly. Environmental parameters such as water temperature, salinity, substrate temperature and rainfall were also assessed on a monthly basis.

The pebble substrate of Cocoy Beach constitutes an important habitat for *P. teres*. A total of 10,096 individuals were collected with monthly mean density of 369.7, 475.3, 557.7, 631.0, 661.0, 707.6 and 615.2ind./m^2 in June, July, August, September, October and November, respectively, and an overall mean density of 559.4ind./m^2. Density in June was significantly lower than the other months. It is assumed, that *P. teres* occurs in lower densities in summer compared to the rainy season. Among the stations the highest overall mean density (772.4ind./m^2) was encountered in station IV, followed by stations V, III, II and I. Densities were significantly lower in stations I and II compared to the other stations. The significantly higher density of *P. teres* in stations III-VI in comparison to I and II is assumed to be related to the fact that station I and II are more disturb since they are within a passage for gleaners and boats. Differences in density among stations might also be substrate related.

Monthly water temperature and salinity were within the normal range for the geographic location and season. It is recommended to extend the study to include the dry season.

Keywords: Petrolisthes teres, porcelain crabs, density, Palawan

INTRODUCTION

Porcelain crabs are globally distributed in temperate and tropical marine habitats and are one of the most diverse families of near-shore decapod crustaceans (Haig 1960). They are filter-feeding organisms (Trager and Genin

1993) that often occur in large numbers (Ruppert and Barnes 1994). Many species live in close association with other invertebrates such as corals or algae (Haig 1960), sponges (Morton 1988), sea pens (Jones 1959, Morton 1988, Sankarankutty 1961), sea anemones (Gordon 1960), hermit crabs (Parente and Hendrickx 1999) and sea urchins (Schoppe 1994). Other inhabits intertidal habitats where they are for example associated with rocky or stony beaches (Wear 1964, Jensen and Armstrong 1999), sand reefs built by polychaete worms (Micheletti-Flores and Negreiros-Fransozo 1999) or with mangrove roots (Haig 1988, Dolorosa in prep.).

The genus *Petrolisthes* is the largest in the family Porcellanidae and contains approximately 90 species (Osawa 1995). *Petrolisthes* Melin that is known from the Bonin Islands in Japan, Australia and Singapore (Johnson 1970) has only recently been encountered in the Philippines (Dolorosa in prep). It is an intertidal species commonly encountered in silted areas. In Palawan, it is abundant in decaying mangrove trunks of the genus *Rhizophora* were it occurs in densities of up to 18ind./liter (Dolorosa in prep.). Recent observations revealed that it also occurs in association with coral rubble, pebble and cobble in Cocoy Beach, Puerto Princesa City, Palawan (Dolorosa in prep). Such substrata are known to offer protection to rupestrine species and they appear to be nursery habitats (Linnane *et al.* 2003). The present study therefore aimed to assess the density of *P. teres* in this kind of substrate and to compare results among months and among stations. The results constitute baseline data for a long-term monitoring of density, and eventual changes of which might be related to climate change as suggested by Stillman (2003). Porcelain crabs have proven to be an excellent study system for examination of physiological adaptation to temperature (Stillman 2002).

METHODOLOGY

The study was conducted along the intertidal area of Cocoy Beach, Purok Sandiwa, Tiniguiban, Puerto Princesa City, Palawan at 9°45.991' N latitude and 118°43.550' E longitude (Figure 1). The substrate is dominated by stony pebbles (4-64mm) that are mixed with oyster shells and cobble (64-256mm). During low tide, this area is exposed and easily accessible. Landward, mangroves (*Sonneratia alba* and *Rhizophora stylosa*) fringe the intertidal. Part of the area is commonly frequented by gleaners and fishermen.

Fieldwork was conducted during the rainy season of 2004 from June to November. The area was divided into six equal parts that were considered sampling stations. In each station, two 50 x 50cm quadrats (replicates) were sampled per month. Sampling was conducted during low tide. Stony substrate within the quadrat was removed one by one down to about 10cm. Each stone was searched for porcelain crabs. The finer substrate within the quadrat was sieved (0.5mm mesh grid) and searched for additional porcelain crabs. Porcelain crabs were preserved in 95% denatured alcohol, vials labeled and brought to the laboratory of WPU for identification and counting. Density data (mean±SD) were analyzed per station and per month. Results are provided per quadrat ($0.25m^2$) and

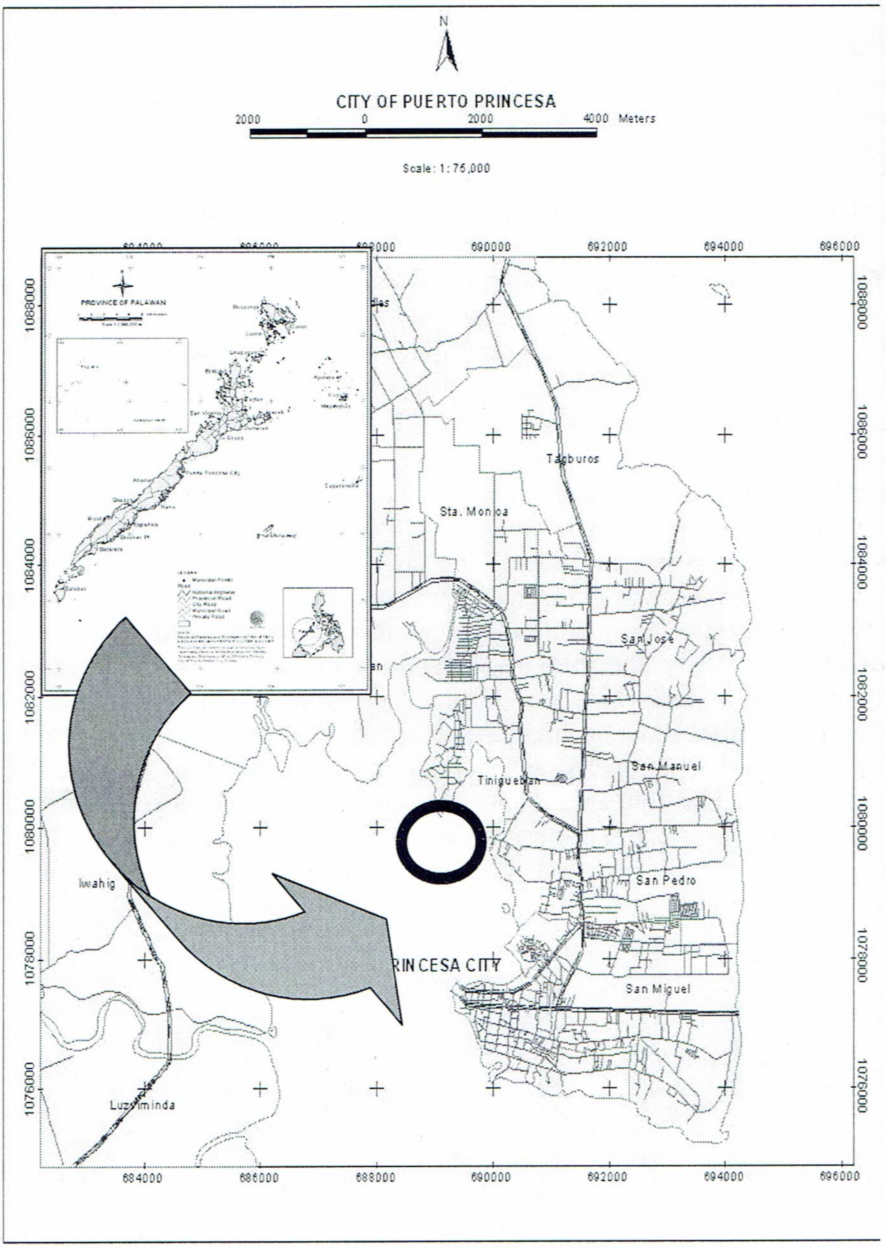

Figure 1. Map of Puerto Princesa City, Palawan wherein the location of Cocoy Beach is indicated.

per m^2 and were compared using ANOVA. For comparative purposes, the overall mean density was also expressed per liter (1000cm^3).

Data on total monthly rainfall were obtained from the PAG-ASA weather station in Puerto Princesa City. Water temperature and salinity were assessed during high tide. This was done thrice a month, each with triplicate readings. The maximum substrate temperature during the months of September to November was determined.

RESULTS AND DISCUSSION

During the six months of the survey a total of 10,069 *Petrolisthes teres* Melin were collected. The genus *Petrolisthes* is the largest in the family Porcellanidae and contains approximately 90 species (Osawa 1995). *P. teres* that is known from Japan, Australia and Singapore (Johnson 1970) has only recently been encountered in the Philippines where Dolorosa (in prep.) found it in decaying mangrove trunks of the genus *Rhizophora* in Puerto Bay, Palawan. The present study is the first published record of the species from intertidal pebble substrate.

The lowest temperature and highest rainfall during the six months occurred in August and lowest salinity occurred in June (Figure 2). Temperature, salinity and rainfall were within the normal range for the geographic location and season. Substrate temperature maxima during low tide emersion ranged from 29-36.0°C. The highest value was obtained in September in accordance with low rainfall and high water temperature. It is expected that substrate temperature is significantly higher during summer months when it might as well reach the maximum thermal tolerance limits of *P. teres*. Stillmann and Somero (2000 as cited by Stillmann 2002) determined for 20 *Petrolisthes* species the temperature at which 50% mortality occurred. They found out that LT_{50} ranged form 30-40^{0}C for tropical species.

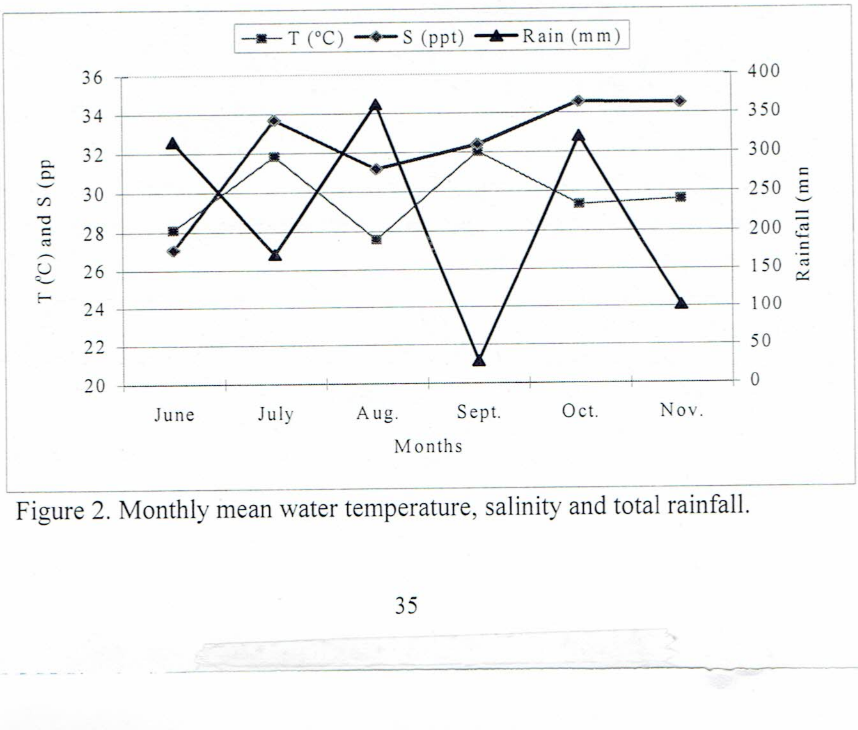

Figure 2. Monthly mean water temperature, salinity and total rainfall.

The monthly mean density of *P. teres* per quadrat of $0.25m^2$ was highest in October, followed by September, November, August, July and June with a mean density of 176.9, 157.8, 153.8, 139.4, 118.8 and 92.4ind./$0.25m^2$, respectively (Table 1). ANOVA revealed a significant difference ($p<0.05$) between density in June and the densities encountered during all other months. The limited number of months sampled, all of which were during the rainy season, does not provide an explanation for the significantly lower density in June. It is though assumed that the June density is a result of the previous summer months (Jan-May). Considering that in summer temperature is much higher, especially the temperature of the substrate, it could well be probable that this would cause lower density of *P. teres*, at least in the upper intertidal that is exposed for several hours to the heat of the day. With the onset of the rainy season in June, populations recovered and gradually increased until October after which density decreased again. This is especially visible if graphically expressed (Figure 3). For easy comparison density is here shown as the number of individuals per square meter. The overall mean density for all months was 559.4ind./m^2.

Table 2. Minimum, maximum and mean (±SD) density of *P. teres* per month.

Month	Mean density (ind./$0.25m^2$)
June	55.0-111.5 (92.4±35.8)[a]
July	67.5-200.0 (118.8±58.6)[b]
August	33.0-290.5 (139.4±100.3)[b]
September	70.0-279.5 (157.8±85.4)[b]
October	60.0-229.5 (176.9±72.9)[b]
November	77.5-217.5 (153.8±50.5)[b]
Overall mean	139.9±30.3

Note: monthly mean densities with same letter superscripts are not significantly different

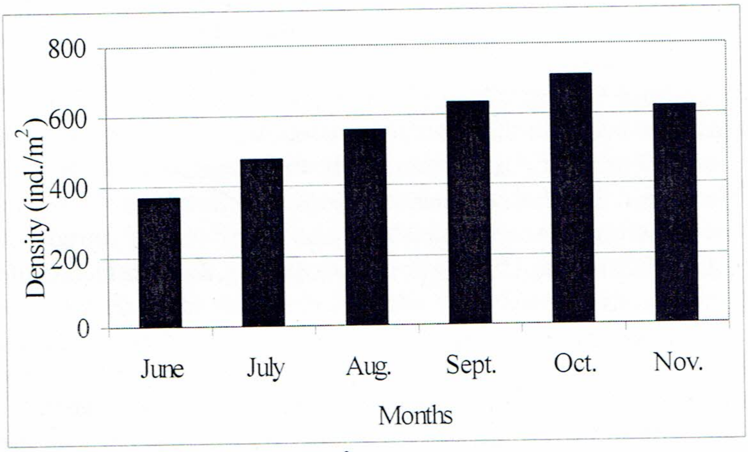

Figure 3. Mean density (ind./m^2) of *P. teres* per month.

The findings of Dolorosa (in prep) who studied *P. teres* over a one-year period in a mangrove ecosystem in Sta. Monica, support the above hypothesis. Dolorosa found low abundance of the species from February to June and high abundance from July to January. Peak abundance was encountered in August. The assumption of lower densities in summer is also supported by findings of Micheletti-Flores and Negreiros-Fransozo (1999) who studied porcelain crab density in Brazil. They found higher densities of the species during winter and lower densities during months that were about 5^0C warmer. Another possible explanation for significantly higher densities during the rainy season might be recruitment related. In a study on the population dynamics of *P. longicornis* in Europe by Robinson and Tully (2002a as cited by Linnane *et al*. 2003) the highest density was encountered at a time of the year when samples were dominated by newly settled animals. For *P. teres* from Cocoy Beach no final conclusion on this can be drawn since the animals were not measured nor sorted into size classes, it was though observed, that ovigerous females were abundant in August and newly settled crabs outnumbered adults in September and October. Here again, the comparison with the findings of Dolorosa (in prep) can shed more light. He found considerably more juveniles in August and September. This supports the assumption that higher density in September and October is recruitment related.

Among the stations, the highest mean density was encountered in station IV, followed by stations V, III, VI, II and I (Table 2). ANOVA revealed a significant difference ($p<0.01$) in density among stations. Further testing of differences revealed that the densities encountered in the different quadrats of stations I and II were significantly different from those encountered in the quadrats of all other stations. The conversion into density per square meter revealed a minimum density of 261.2ind./m^2, a maximum density of 772.4ind./m^2 (Figure 4) and an overall mean density of 559.4ind./m^2 (=5.59ind./l). Though relatively high density values are lower than the known density of the same species in a neighboring mangrove habitat. Here, the species ranged in density over a one-year period from 2.60-51.55ind./l with a overall mean density of 18ind./l (Dolorosa in prep.). The comparison with other species under the genus *Petrolisthes* that occur in similar substrata shows that high density is common. The maximum density of *P. cinctipes* has been estimated at nearly 4,000ind./m^2 in beds of the mussel *Mytilus californianus* in the northeastern Pacific (Jensen 1990 as cited in Jensen and Armstrong 1991) and at 950ind./m^2 in cobble fields and mussel beds in California, USA to British Colombia, Canada (Donahue 2004).

It is believed that the high density of *P. teres* in Cocoy Beach is related to the substrate type whereas substrata with pebble dimension (4-64mm) of stony or shell nature offer the highest number of hiding spaces. Such substrata are known to offer protection to rupestrine species and they appear to be nursery habitats (Linnane *et al.* 2003). Studies of Samuelsen (1970) who assessed the density of the porcelain crab *Pisidia longicornis* on different bottom types over a period of 18 months in Norway support the assumption. He found the abundance of the crab

Table 2. Minimum, maximum and mean (±SD) density of *P. teres* per station.

Station	Density (ind./0.25m^2)
I	27-118 (65.3±23.3)^a
II	41-135 (92.3±30.9)^a
III	57-274 (158.6±75.7)^b
IV	45-324 (193.1±78.4)^b
V	78-292 (184.6±69.0)^b
VI	70-222 (145.3±50.7)^b

Note: mean densities with same letter superscripts are not significantly different

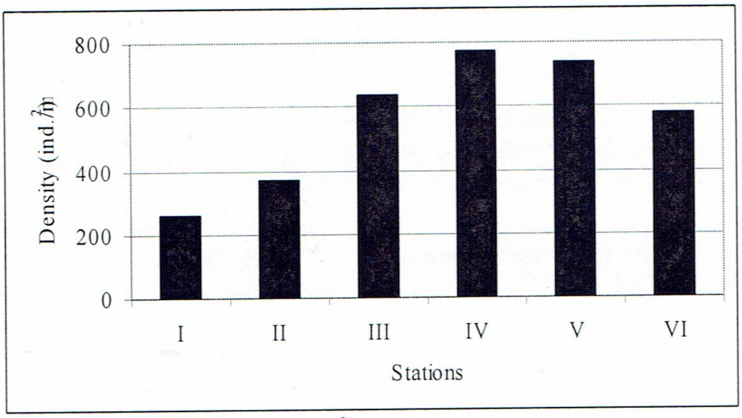

Figure 4. Mean density (ind./m^2) of *P. teres* per station.

positively correlated with the amount of coarse substrate. The highest density of the species was encountered in substrate composed of empty shells (>16mm), shell gravel (2-16mm) and pebbles (16-64mm).

The fact that such high densities of a species have been overlooked in the past gives reason to believe that intensive studies of such habitats would bring even more amazing facts to light. It is recommended to continue the study on *P. teres* for a one-year period and thereafter monitor the density on a regular basis. Of especially interest is the comparison of density data during summer months (January to May) with those during rainy months (June to December). It is recommended that such study should include the assessment of the maximum time the habitat is exposed during low tide, and the maximum substrate temperature during low tide. It is further recommended to assess the nature of the substrate of each station in detail. Finally, a continuation of the study should include the sizes and development stages of individuals in order to identify periods of high recruitment.

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