

SHORT NOTE

**Abundance of *Petrolisthes armatus* (Crustacea: Porcellanidae)
on a tropical estuarine intertidal rocky beach,
Gulf of Nicoya estuary, Costa Rica**

Edgardo Díaz-Ferguson¹ and José A. Vargas-Zamora²

¹Programa de Posgrado en Biología, Sistema de Estudios de Posgrado, Universidad de Costa Rica, 2060 San José, Costa Rica.

²Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica, 2060 San José, Costa Rica. Fax (506) 2073280. E-mail: javargas@cariari.ucr.ac.cr

(Recibed 30-V-2001. Corrected 28-VIII-2001. Accepted 02-XI-2001)

Abstract: Population of the porcellanid crab *Petrolisthes armatus* was studied on a rocky intertidal beach located at the Punta Morales peninsula in the mid upper Gulf of Nicoya estuary, Pacific coast of Costa Rica, from December 1997 to November 1998 (14 dates). Horizontal plankton tows (280 micron mesh net) were also made to verify the presence of *P. armatus* larvae. Crabs were collected every 3 m along three 18 m long transects, at two sites on the beach, by placing a bottomless bucket fringed with canvas to prevent the organisms from escaping under the rim. A total of 15 382 *P. armatus* were collected. Only 146 (0.95%) crabs had a carapace length longer than 10 mm, and 8 995 (58.5%) were in the size range of 2 to 4.5 mm. The remaining crabs 6 241 (40.5%) were in the size range of 4.6 to 10 mm. Male and female *P. armatus* were represented by 2 777 and 3 518 individuals respectively, with a sex ratio of 1:1.26. Ovigerous females were found at all dates and included 2 937 individuals (83 % of females). Plankton tows yielded only 73 larvae of *P. armatus* (Zoea 1), with a density of 1.2 larvae/m³. No statistically significant seasonal trends in the population of this species were detected. *P. armatus* appears to reproduce continuously the year around in Punta Morales, and some peaks of abundance were present during the dry and rainy seasons. These trends are similar to trends reported for other crustacean species in the Gulf of Nicoya.

Key words: Crustacea, Porcellanidae, *Petrolisthes*, rocky intertidal, Gulf of Nicoya, Costa Rica.

The Gulf of Nicoya is an estuary on the Pacific coast of Costa Rica (10°N – 85°W), extending about 100 km from the Tempisque river to the 500 m isobath. A dry season (December-April) and a rainy season (May-November) exert a significant impact on its water characteristics (Epifanio *et al.* 1983, Voorhis *et al.* 1983). Mean tidal range is 3 m. The estuary is the most important fishing ground of Costa Rica and two of the main Pacific ports are located within it. An ongoing research programme to conduct a long-term multidis-

ciplinary evaluation of the Gulf was established at CIMAR in 1979, and more than 110 scientific papers have been published, making the Gulf one of the better known tropical embayments worldwide (Vargas 1995). The study of benthic crustacean populations, with emphasis on the portunid blue crab *Callinectes arcuatus*, received special attention under the programme and reports on its larvae, lunar rhythms, dispersal, seasonality, and feeding habits are available (Dittel *et al.* 1985, Dittel 1993). The Punta Morales peninsula, located in the mid

upper Gulf (10°03'N – 84°57'W), has been the site for several studies on the intertidal ecology of invertebrates in general (Vargas 1987, 1996, Dittmann and Vargas 2001), and on crustaceans in particular (Perry 1988, Vargas 1989, Dittel and Epifanio 1990, Wehrtmann and Dittel 1990). However, no studies have been conducted in Punta Morales on the populations of rocky intertidal crabs. The porcellanid crab *Petrolisthes armatus* (Gibbes 1850) has a wide geographical distribution including the Pacific coast of Central America and is often found in high number under rocks at low tide (Haig 1960). This species is euryhaline and the adults are filter feeders (Gore and Abele 1976). Other information available on *P. armatus* includes reports on its larval morphology (Gore 1972), the timing of its larval release (Christy 1986), and the presence of its larvae associated with a limpet (Campos-González and Macías-Chávez 1987). The only published study of adult population dynamics has been conducted in Brazil by Oliveira and Masunari (1995), but no information is available for the Panamic Province. The Gulf of Nicoya is the habitat for 14 species of *Petrolisthes* crabs, with *P. armatus* being reported more frequently for the mid and upper Gulf (Moran and Dittel 1993). Thus, the objective of this study is to describe the population oscillations of *P. armatus* at the Punta Morales peninsula in the upper Gulf of Nicoya estuary, Costa Rica.

Samples were collected at near monthly intervals (14 dates) from December 1997 through November 1998 at two rocky (sandstone, with abundant rock fragments of sizes ranging from boulders to about 0.5 m diameter) intertidal locations on the southern shore of this peninsula. The rocky areas were separated 500 m from each other (see Vargas 1989 for a map of the site). Samples were collected at low tide at each location along three transects, two of them placed between the highest and lowest extent of the tides, and one in the middle. The transects were 18 m long, laid about 10 m from each other, and six samples were collected every 3 m with a bottomless bucket (0.13 m²) fringed with canvas to prevent crabs from scaping under the rim. The rocks inside the area sampled by the bucket were lifted and crabs handpicked.

These rocks were later placed in another container filled with water to allow the remaining crabs to leave the crevices and fall to the bottom of the container. All crabs were placed in labelled plastic bags and brought to the laboratory where the contents of each bag were stored in glass jars and fixed with 10% buffered formalin in sea water. After 24 hours the samples were transferred to 70% ethylic alcohol. All *P. armatus* crabs were identified using the description provided by Haig (1960). Three size categories were defined based on carapace length: 2 mm to 4.5 mm, 4.6 mm to 10 mm, and larger than 10 mm. Male and female crabs were identified only from individuals of carapace length greater than 4.5 mm, based on the features also described in Haig (1960). During October-November of 1997 (rainy season), December (1997) and February-March 1998, (dry season), two horizontal plankton tows were also taken per site at high tide at the surface and near the bottom, with a 280 micron mesh net (0.5 m mouth diameter) and equipped with a flow meter. Salinity was measured with an optical refractometer. Water temperature and dissolved oxygen concentrations were measured with a polarographic sensor.

Salinity ranged from 15 to 30 during the rainy season, and from 20 to 33 during the dry season. Water temperature oscillated between 25°C and 32°C, with an average of 29°C. Dissolved oxygen ranged from 4 ppm to 8 ppm. These values are typical of the Gulf of Nicoya estuary and the Punta Morales region (Epifanio *et al.* 1983, Voorhis *et al.* 1983, Vargas 1987).

A total of 15 382 *P. armatus* crabs were collected during this study, with a mean of 180 ± 152 individuals per date. Only 146 (0.95%) individuals had a carapace length greater than 10 mm. A total of 8 995 crabs (58.5 %) were in the size range of 2 mm to 4.5 mm, and 6 241 individuals (40.5 %) were in the size class of 4.6 mm to 10 mm. The female crabs were represented by 3 518 individuals, and the males by 2 777, with an average sex ratio of 1: 1.26. The ovigerous females were represented by 2 937 individuals (83 %). Due to damage during collection and preservation it was not possible to identify the sex of 92 of the crabs in the 4.6 to 10 mm range. The plankton tows yielded

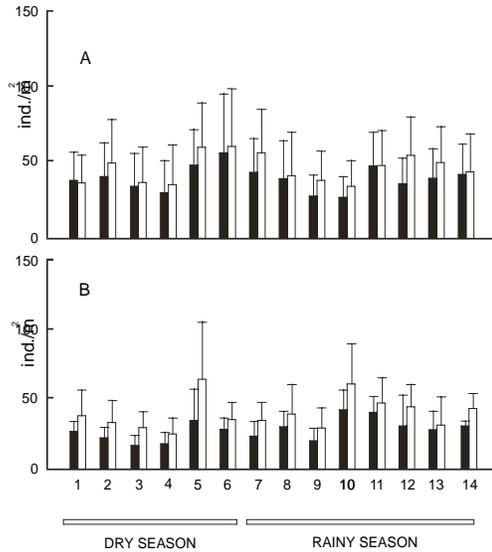


Fig. 1. Density (Mean number of $\text{ind}/\text{m}^2 \pm \text{SD}$) of the crab *Petrolisthes armatus* at two (A, B) sites on the rocky intertidal beach at the Punta Morales peninsula, Gulf of Nicoya estuary, Costa Rica. Date 1 is December 1997. Date 14 is November 1998. First bar: male crabs. Second bar: female crabs.

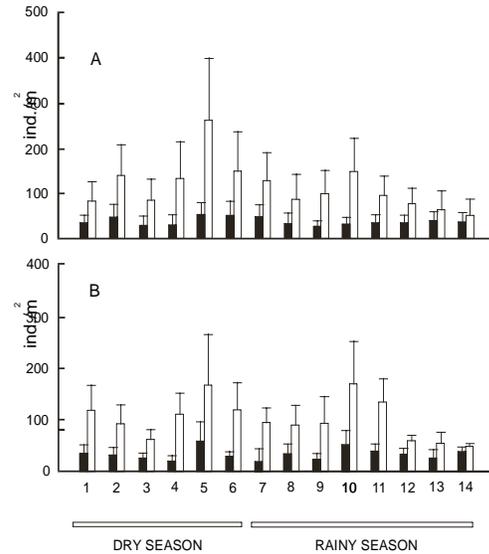


Fig. 2. Density (Mean number of $\text{ind}/\text{m}^2 \pm \text{SD}$) of the crab *Petrolisthes armatus* at two (A, B) sites on the rocky intertidal beach at the Punta Morales peninsula, Gulf of Nicoya estuary, Costa Rica. Date 1 is December 1997, Date 14 is November 1998. First bar: ovigerous females. Second bar: crabs in the size range of 2.0 to 4.5 mm.

6 014 crab larvae (mean: 95 larvae/ m^3), of which only 73 (1.21 %) belonged to *P. armatus* and all were Zoea I (mean: 1.2 larvae/ m^3). The density (ind/m^2) of male and female crabs found at the two rocky intertidal beaches over the sampling period is illustrated in Fig. 1. Mean male and female crab density were 33 ± 27 and 42 ± 35 ind/m^2 , respectively. There were no significant differences (*t* test, $p < 0.05$) in mean density between the two beaches nor between dry and rainy seasons. The density of ovigerous females and crabs smaller than 4.5 mm carapace length over the sampling period is illustrated in Fig. 2. There were also no significant differences (*t* test, $p < 0.05$) in the number of ovigerous females between dates or seasons.

The only study available on the population structure of *P. armatus* was conducted by Oliveira and Masunari (1995) on a rocky beach in Brazil (25°S - 48°W). The subtropical conditions of this beach make comparisons difficult. For instance, minimum and maximum water temperature were 16°C and 28°C respectively, and salinity oscillated from 6 to 31.5. However, the density of *P. armatus* ranged from

15 to 305 ind/m^2 , with a peak in January. This density was considered the highest among the porcelain crabs populations known from the literature. In our study, the maximum density was near 100 ind/m^2 (Figs. 1 and 2). Oliveira and Masunari (1995) concluded that *P. armatus* has continuous reproduction at their site, with at least two peaks of abundance during the year.

The studies conducted by Vargas (1987, 1989, 1996) in the region of Punta Morales have pointed out that seasonal (dry vs rainy) population patterns in the benthos are only part of a wider catalogue of possible oscillations, as some species of polychaete worms and crustaceans appear to have cycles with periods longer than a year. In this study, seasonal differences, as well as differences between sites (Figs. 1 and 2) in the number of juveniles and adults of *P. armatus* were statistically non-significant, although peaks of abundance were present during both seasons and appeared with different intensity at both sites studied. Thus, the identification of any repeatable pattern on the population of *P. armatus* will await future long-term studies, like the one conducted on *Coricuma nicoyensis* by Vargas (1989). This cumacean,

which inhabits the muddy-sand flats adjacent to the two rocky sites sampled for *P. armatus*, appears to breed the year around in the Gulf of Nicoya, but with peaks of reproductive activity being more frequent during the dry season. These patterns were also found during the second and third year of observations, but varied in timing and intensity (Vargas 1989). The presence of ovigerous *P. armatus* females and crabs smaller than 4.5 mm during this study, supports the idea that this crustacean also has continuous reproduction in the Gulf of Nicoya estuary, with at least two peaks during the year (Figs.1 and 2). These results are similar to those of Oliveira and Masunari (1995).

The mean density of *P. armatus* larvae ($1.2/m^3$) found in this study is similar to that reported for *Petrolisthes* spp larvae (5.5 to 9.9 larvae $/m^3$) by Dittel and Epifanio (1990) in a study conducted on a tidal creek on the northern shore of the Punta Morales peninsula. Moreover, they found that spawning occurred year-round but individual taxa showed distinct seasonality, and the Zoea I were the most abundant stage for all taxa, as in this study. Post-planktonic stages of *P. armatus* have been recorded as commensals of the limpet *Crucibulum spinosum* in the Gulf of California. This relationship is for shelter and seems to diminish the predation pressure at high tide on the later stages of development. It also reduces the risk of desiccation at low tide (Campos-González and Macías-Chávez 1987). The presence of several species of calyptreids in the Punta Morales region (Vargas 1987) may explain, in part, the lack of later stages of development of *P. armatus* in the plankton tows.

ACKNOWLEDGEMENTS

This study was part of the first chapter of a M.Sc.Thesis presented by the senior author at the University of Costa Rica. We thank the Organization of American States for providing support to the senior author to conduct graduate studies and research in Costa Rica. We thank Ana Dittel and Rita Vargas for their help with the ecology and identification of *P. armatus*, and three anonymous reviewers for comments on the manuscript.

RESUMEN

Se estudió, de diciembre de 1997 a noviembre de 1998 (14 fechas), la población del cangrejo porcelánido *Petrolisthes armatus* en dos sitios en una playa rocosa de entre mareas en el Golfo de Nicoya, costa pacífica de Costa Rica. Se hizo arrastres horizontales, en marea alta, con una red de plancton (280 micrómetros de malla) para verificar la presencia de sus larvas. Los cangrejos fueron recolectados cada 3 m a lo largo de tres transectos de 18 m de longitud en cada sitio. Se utilizó un recipiente sin fondo pero con un borde de tela adherido para evitar el escape de los organismos. Se recolectó un total de 15 382 *P. armatus*. Los machos incluyeron 2 777 individuos y 3 518 las hembras, para una relación entre sexos de 1: 1.26. Se encontró hembras ovígeras en todas las fechas y éstas estuvieron representadas por 2 937 cangrejos (83% del total). Los arrastres de plancton capturaron 73 larvas de *P. armatus* (Zoea I), con una densidad promedio de 1.2 larvas/ m^3 . No se encontró diferencias estadísticamente significativas entre las abundancias presentes durante las estaciones seca y lluviosa típicas del Golfo de Nicoya. *P. armatus* se reproduce aparentemente durante todo el año en el Golfo. Sin embargo, hubo presencia de máximos de abundancia en ambas estaciones, lo que hace las oscilaciones poblaciones de esta especie similares a las presentadas por otros crustáceos en el Golfo de Nicoya.

REFERENCES

- Christy, J. 1986. Timing of larval release by intertidal crabs on a exposed shore. Bull. Mar. Sci. 39: 176- 191.
- Campos-González, E. & L.J. Macías-Chávez. 1987. Fases posplanktonicas de *Petrolisthes armatus* (Gibbes) (Decapoda, Porcellanidae) comensales con la lapa *Crucibulum* (*Crucibulum*) *spinosum* (Sowerby) (Gastropoda, Calyptreidae) en el Alto Golfo de California, Mexico. Rev. Biol. Trop. 35: 214-244.
- Dittel, A., C.E. Epifanio & J.B. Chavarría. 1985. Population biology of the portunid crab *Callinectes arcuatus* Ordway in the Gulf of Nicoya, Costa Rica; Central America. Est. Coastal. Shelf. Sci. 20: 593-602.
- Dittel, A.I. & C.E. Epifanio. 1990. Seasonal and tidal abundance of crab larvae in a tropical mangrove system, Gulf of Nicoya, Costa Rica. Mar. Ecol. Prog. Ser. 65: 25-34.

- Dittel, A. 1993. Cambios en los hábitos alimentarios de *Callinectes arcuatus* (Crustacea: Decapoda) en el Golfo de Nicoya, Costa Rica. *Rev. Biol. Trop.* 41: 639-646.
- Dittmann, S. & J.A. Vargas. 2001. Tropical tidal flat benthos compared between Australia and Central America, p 275-293. *In*: K. Reise (ed). *Ecological Comparisons of Sedimentary Shores*. Ecological Studies 151. Springer, Berlin.
- Epifanio, C.E., D. Maurer & A.I. Dittel. 1983. Seasonal changes in nutrients and dissolved oxygen in the Gulf of Nicoya, a tropical estuary on the Pacific coast of Central America. *Hydrobiologia* 101: 231-238.
- Gore, R. 1972. *Petrolisthes armatus* (Gibbes, 1850): the development under laboratory conditions of larvae from a Pacific specimen (Decapoda: Porcellanidae). *Crustaceana* 22: 68-83.
- Gore, R. & L. Abele. 1976. Shallow water Porcelain crabs from the Pacific coast of Panama and adjacent Caribbean waters (Crustacea: Anomura: Porcellanidae). *Smithson. Contrib. Zool.* 237: 1 – 30.
- Haig, J. 1960. The Porcellanidae (Crustacea: Anomura) of the Eastern Pacific. *Allan Hancock Pacific Expeditions* 24: 1– 440.
- Moran, D. & A.I. Dittel. 1993. Anomuran and Brachyuran crabs of Costa Rica: annotated list of species. *Rev. Biol. Trop.* 41: 599-617.
- Oliveira, E. & S. Masunari. 1995. Estrutura populacional de *Petrolisthes armatus* (Gibbes) (Decapoda, Anomura, Porcellanidae) da Ilha do Farol, Matinhos, Parana, Brazil. *Revta. bras. Zool.* 12: 355 – 371.
- Perry, D. 1988. Effects of associated fauna on growth and productivity in the red mangrove. *Ecology* 69: 1064-1075.
- Vargas, J.A. 1987. The benthic community of an intertidal mud flat in the Gulf of Nicoya, Costa Rica. Description of the community. *Rev. Biol. Trop.* 35: 229-316.
- Vargas, J.A. 1989. Seasonal abundance of *Coricuma nicoyensis* Watling and Breedy (Crustacea, Cumacea), on an intertidal mud flat in the Gulf of Nicoya, Costa Rica. *Rev. Biol. Trop.* 37: 207-211.
- Vargas, J. A. 1995. The Gulf of Nicoya estuary, Costa Rica: Past, present, and future cooperative research. *Helgoländer Meeresunters* 49: 821-828.
- Vargas, J.A. 1996. Ecological dynamics of a tropical intertidal mudflat community. p. 355-371. *In* Nordstrom, K.F. and C.T. Roman (eds.). *Estuarine Shores: Evolution, Environments and Human Alterations*. Wiley, London.
- Voorhis, A., C.E. Epifanio, D. Maurer, A.I. Dittel & J.A. Vargas. 1983. The estuarine character of the Gulf of Nicoya, an embayment on the Pacific coast of Central America. *Hydrobiologia* 99: 225-237.
- Wehrtmann, I. & A. I. Dittel. 1990. Utilization of floating mangrove leaves as a transport mechanism of estuarine organisms, with emphasis on decapod Crustacea. *Mar. Ecol. Prog. Ser.* 60: 67-73.