Decapod crustaceans from a marine tropical mangrove ecosystem on the Southern Western Atlantic, Brazil

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Abstract

The purpose of the present study was to investigate the biodiversity, relative abundance and frequency of decapod crustaceans in the marine mangrove ecosystem at Gaibu Beach, Pernambuco State, Brazil. A total of eight samples were taken: four in the rainy season (August 2010) and four in the dry season (February 2011), during spring low tides and according to the phases of the moon. In all, 352 decapods were sampled. These specimens belonged to 17 species, 14 genera and 13 families. *Pachygrapsus transversus* (Gibbes, 1850)*, P. gracilis* (Saussure, 1858)*, Panopeus americanus* Saussure, 1857 and *Uca (Leptuca) leptodactyla* Rathbun, 1898 were very frequent. The three latter species occurred in all samples. The most abundant species was *P. americanus.* The Shannon-Wiener index (H') showed that, in general, the diversity level was medium for all samples. However, the sample taken at the time of the new moon during the rainy season was classified as highly diverse. These results contribute to the knowledge of the decapod fauna inhabiting mangroves associated with fringe reefs.

Key words: Abundance, Decapoda, diversity, mangrove.

Introduction

The mangrove forest is a coastal ecosystem belonging to the transition zone between the land and the sea. It reflects strong tidal influence and is typical of tropical and subtropical regions (Schaeffer-Novelli, 1995). The mangrove ecosystem is considered one of the areas of the world with relatively high fertility, can provide valuable information about the dynamics of the littoral environment (Lacerda *et al.*, 2006), and is one of the most important coastal ecosystems. This high fertility results from the influence of many factors, including the abundance of primary producers, tidal action, high nutrient input, rapid cycling and uninterrupted annual production (Ottmann *et al.*, 1966).

In general, mangroves are associated with estuaries. However, certain estuaries do not support mangroves, a condition more common in temperate regions, as the Patos Lagoon, Rio Grande do Sul State, Brazil. Moreover, certain mangrove forests are not estuarine, as the Sueste mangroves of Fernando de Noronha Archipelago and those occurring along the shores of the Santa Cruz Channel, a U-shaped channel that separates Itamaracá Island from the continent, both of these sites located in Pernambuco State, Brazil (Coelho *et al.*, 2004). Gaibu Beach, also in Pernambuco, is one of the rare cases on the Brazilian coast

of mangroves occurring in association with a fringe reef. This site is an enclave protected by sandy reefs on the seashore, with *Laguncularia racemosa* C. F. Gaertn occurring as a dominant species. The area is under the influence of the Arrombado Stream (Rolim *et al*., 2002).

According to Aveline (1980), the invertebrate fauna of mangrove forests is composed primarily of decapod crustacean species. These organisms play a significant role in the dynamics of the mangroves. In addition to their role as important participants in the trophic web, certain crustaceans constantly excavate burrows in the mud to obtain shelter and to store food. By digging in the sediment, they transport organic matter from the underlying strata to the surface (Araújo and Maciel, 1977; Macintosh, 1988). The crustaceans also participate in the cycling of nutrients, controlling the remineralization of detritus in the forest (Robertson, 1991). The purpose of the present study was to investigate the biodiversity of decapod crustaceans inhabiting the marine mangrove at Gaibu Beach and to compare these findings with those of other studies in marine and estuarine areas.

Material and Methods

Study area

Gaibu Beach (Fig. 1) is located in the Municipality of Cabo de Santo Agostinho, southern Pernambuco, Brazil (8° 19' S and 34° 56' W). According to the Köppen (1936) classification, the climate type is As', i.e., a tropical humid climate with rainy winters and dry summers. The annual mean temperature is 25ºC. The beach can be considered intermediate in structure, showing an area of open sea and another area, larger and protected by two fringe reefs, in the infralittoral and intertidal. The mangrove is located in front of the intertidal fringe (CPRH, 1999).

Field procedures

Samples were taken during the spring low tide. Four samples were taken during the rainy season (August 2010) and four during the dry season (February 2011). The four samples during a given season were taken during different phases of the moon. As a result, a total of eight samples were performed: rainy period new moon (RPNM), rainy period waxing moon (RPWXM), rainy period full moon (RPFM), rainy period waning moon (RPWNM), dry period new moon (DPNM), dry period waxing moon (DPWXM), dry period full moon (DPFM) and dry period waning moon (DPWNM).

The individuals were randomly sampled by two collectors in the substratum (with a garden shovel), under rocks, in trees and in the water (with a dipnet), including every microhabitat within the mangrove. The specimens were fixed in 70% alcohol. The abiotic data collected during the sampling included air and water temperatures, measured *in situ* with a digital thermometer, and salinity and pH, determined from measurements of water samples in the laboratory.

Laboratory procedures

The pH was determined with a bench pH meter. The salinity was determined with the Mohr-Knudsen method (Strickland and Parsons, 1972).

The individuals in the sample were identified to the species level based on specialized literature, including Rathbun (1918; 1930), Chace (1972), Abele and Kim (1986), and Melo (1996; 1999).

Statistical analyses

The Student *t* test was applied to analyze the significance of the differences ($\alpha = 0.05$) in each abiotic factor between the dry and rainy periods (Zar, 1999). The relative abundance (RA) of each species was obtained from the equation $RA = n100/N$ (where n = the number

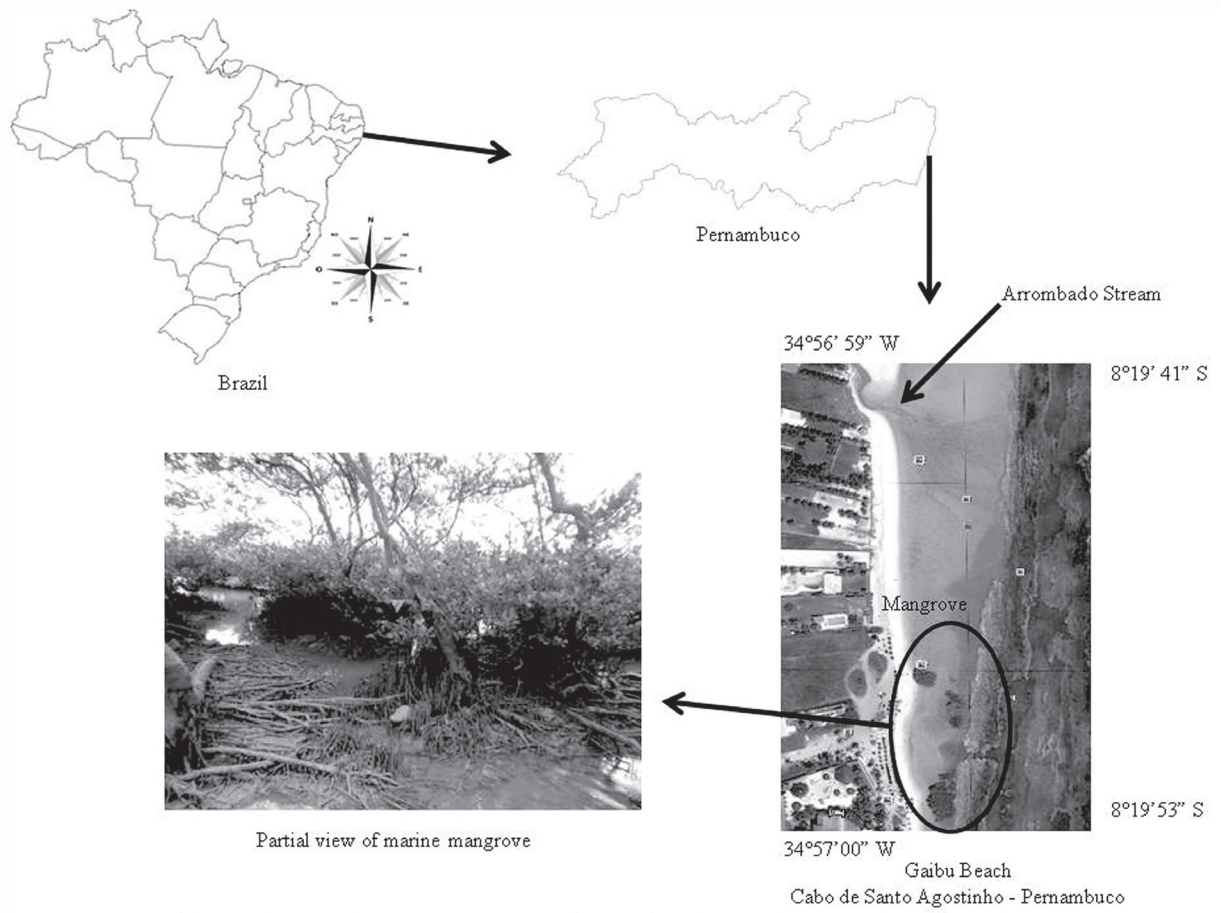

Figure 1. Map of the study area, the marine mangrove forest of Gaibu Beach, Pernambuco, Brazil.

of individuals of that species and N = the total number of individuals) and classified as dominant (≥ 70%), abundant (40 to 70%), less abundant (10 to 40%) and rare (≤ 10%).

The frequency of occurrence (FO) of each species was obtained from the equation $FO = a100/A$ (where a = number of samples containing the species and A = the total number of samples), with a posterior classification as very frequent (≥ 70%), frequent (40 to 70%), less frequent (10 to 40%) and sporadic (≤ 10%).

The following three ecological indexes were calculated: 1) Margalef (d), with values below 2.0 indicating areas of low diversity and values greater than 5.0 indicating areas of high diversity (Margalef, 1958); 2) Shannon-Wiener (H' $\log_2$), classified as very low (< 1 bit.ind^{-1}), low (1 to 2 bits.ind^{-1}), medium (2 to 3 bits.ind^{-1}), high (3 to 4 bits.ind^{-1}) and very high (> 4 bits.ind^{-1}) diversity (Shannon, 1948); and 3) Pielou (J'), with values above 0.5 considered equitable (Pielou, 1969).

Results

Water temperature varied between 26.0 and 32.6°C (29.7 ± 2.6°C) (Fig. 2A). The air temperature varied between 21.5 and 30.4°C (26.5 ± 3.1°C) (Fig. 2A). Significant differences were detected in the water (t = -5.69; p = 0.01) and air temperature (t = -3.02; p = 0.02) between the rainy and dry periods. Both temperatures were higher during the dry period.

Salinity oscillated between 16.15 and 32.62 (28.63 ± 5.30), but no significant difference was detected between the rainy and dry periods (t = 0.02; p = 0.44) (Fig. 2B). This pattern was also verified for the pH, which varied between 7.60 and 8.19 (7.88 ± 0.24)

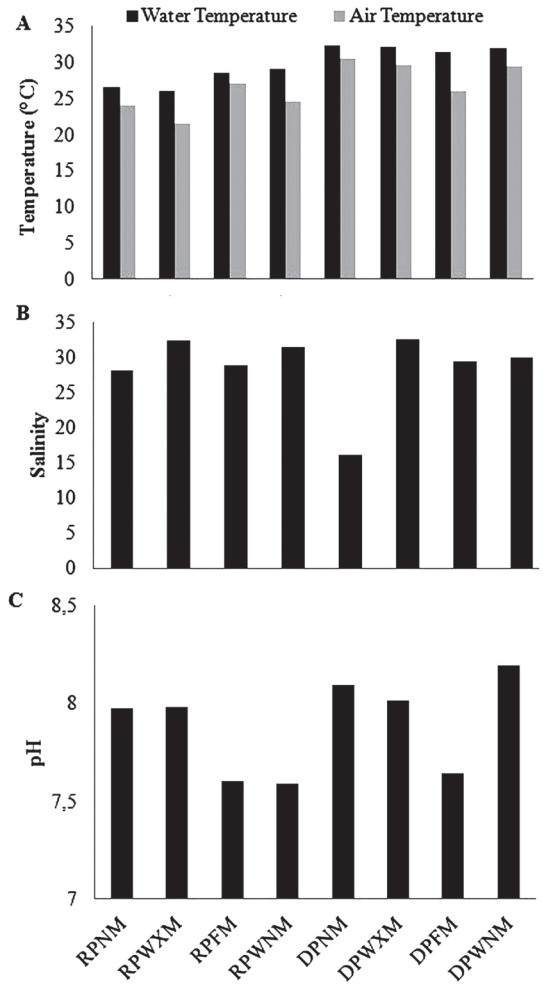

Figure 2. Values of (A) water and air temperatures, (B) salinity, (C) pH at the marine mangrove forest of Gaibu Beach, Pernambuco, Brazil.

(Fig. 2C) without any differences between the rainy and dry periods (t = -1.21; p = 0.27).

A total of 352 decapods was sampled, including 17 species, 14 genera and 13 families. The group with the highest number of species was the Infraorder Brachyura Linnaeus, 1758, with 10 species, followed by the Infraorder Anomura MacLeay, 1838 and Infraorder Caridea Dana, 1852b (3 species each) and the Infraorder Axiidea Huxley, 1879 (1 species) (Tab. 1).

Pachygrapsus transversus (Gibbes, 1850), *P. gracilis* (Saussure, 1858), *Panopeus americanus* Saussure, 1857 and *Uca (Leptuca) leptodactyla* Rathbun, 1898 occurred very frequently, especially the three latter species, which were recorded in all samples (Tab. 2).

Table 1. List of the species sampled in the marine mangrove forest of Gaibu Beach, Pernambuco, Brazil.

Infraorder Caridea Dana, 1852
Palaemonidae Rafinesque, 1815
Palaemon northropi (Rankin, 1898)
Alpheidae Rafinesque, 1815
Alpheus cf. *armillatus* H. Milne Edwards, 1837
Hippolytidae Spence Bate, 1888
Merguia rhizophorae (Rathbun, 1900)
Infraorder Axiidea Huxley, 1879
Upogebiidae Borradaile, 1903
Upogebia noronhensis Fausto-Filho, 1969
Infraorder Anomura MacLeay, 1838
Porcellanidae Haworth, 1825
Petrolisthes armatus (Gibbes, 1850)
Diogenidae Ortmann, 1892
Clibanarius antillensis Stimpson, 1859
Clibanarius sclopetarius (Herbst, 1796)
Infraorder Brachyura Linnaeus, 1758
Majidae Samouelle, 1819
Microphrys bicornutus (Latreille, 1825)
Portunidae Rafinesque, 1815
Callinectes exasperatus (Gerstaecker, 1856)
Callinectes marginatus (A. Milne-Edwards, 1861)
Panopeidae Ortmann, 1893
Eurytium limosum (Say, 1818)
Panopeus americanus Saussure, 1857
Xanthidae MacLeay, 1838
Cataleptodius floridanus (Gibbes, 1850)
Grapsidae MacLeay, 1838
Pachygrapsus gracilis (Saussure, 1858)
Pachygrapsus transversus (Gibbes, 1850)
Sesarmidae Dana,1851
Aratus pisonii (H. Milne Edwards, 1853)
Ocypodidae Rafinesque, 1815
Uca (Leptuca) leptodactyla Rathbun, 1898

Table 2. Frequency of occurrence (FO) and relative abundance (RA) of decapod crustacean species in the marine mangrove forest of Gaibu Beach, Pernambuco, Brazil.

Species	FO	Classification	RA	Classification
Alpheus cf. *armillatus*	37.5	less frequent	1.42	rare
Aratus pisonii	37.5	less frequent	0.85	rare
Callinectes exasperatus	12.5	less frequent	0.28	rare
Callinectes marginatus	37.5	less frequent	0.85	rare
Cataleptodius floridanus	50	frequent	0.27	rare
Clibanarius antillensis	12.5	less frequent	0.57	rare
Clibanarius sclopetarius	62.5	frequent	2.56	rare
Eurytium limosum	12.5	less frequent	0.28	rare
Merguia rhizophorae	25	less frequent	1.42	rare
Microphrys bicornutus	12.5	less frequent	0.28	rare
Pachygrapsus gracilis	100	very frequent	11.08	less abundant
Pachygrapsus transversus	75	very frequent	5.68	rare
Palaemon northropi	25	less frequent	4.55	rare
Panopeus americanus	100	very frequent	47.73	abundant
Petrolisthes armatus	12.5	less frequent	0.85	rare
Uca (Leptuca) leptodactyla	100	very frequent	19.03	less abundant
Upogebia noronhensis	12.5	less frequent	0.28	rare

In contrast, five species [*Callinectes exasperatus* (Gerstaecker, 1856), *Clibanarius antillensis* Stimpson, 1859, *Eurytium limosum* (Say, 1818), *Microphrys bicornutus* (Latreille, 1825) and *Upogebia noronhensis* Fausto-Filho, 1969] occurred only in one sample and were considered less frequent. The other species were considered frequent, and no species occurred sporadically.

Only one species (*P. americanus*) was relatively abundant (Tab. 2), whereas *U. (L.) leptodactyla* and *P. gracilis* were relatively less abundant. The other species were considered rare, and no species was dominant.

According to the Shannon-Wiener index (H'), the diversity was medium for all samples except for the RPNM sample, which was classified as high in diversity. The values of the Pielou index (J') were greater than 0.5 and equitable in all samples. The Margalef index (d) was lower for the RPWNM (2.17) and higher for the RPNM (3.65), indicating a medium-diversity area (Tab. 3).

Table 3. Ecological indices: monthly values of Margalef (d), Pielou (J') and Shannon-Wiener (H') indices obtained for the four phases of the moon during the rainy and dry periods in the marine mangrove forest of Gaibu Beach, Pernambuco, Brazil.

Period	Moon	d	J'	H'($\log_2$)
Rainy	New	3.654	0.921	3.301
	Waxing	2.274	0.920	2.582
	Full	2.963	0.895	2.836
	Waning	2.174	0.955	2.681
Dry	New	2.357	0.912	2.561
	Waxing	2.215	0.903	2.536
	Full	2.626	0.888	2.664
	Waning	2.970	0.890	2.821

Discussion

The water and air temperatures varied significantly between periods but showed only small oscillations among the samples. In the mangroves at Itamaracá Island, Pernambuco,

the temperatures similarly showed no substantial variation (Macedo *et al.*, 1973; Araújo *et al.*, 2012), a characteristic typical of tropical regions. At Enseada dos Corais Beach, located near the study area, the salinity was found to range between 9 and 36 (Florêncio, 2000), whereas the salinity at the mangrove of Gaibu Beach varied between 16.15 and 32.62, indicating a more saline and stable system. The samples obtained during the dry season showed a large decrease in salinity. According to SINDA (2012), an intense rainfall occurred on the day prior to this sample. The pH values were always alkaline, as previously observed by Araújo *et al.* (2012).

Several authors have previously investigated the diversity of decapods in estuarine mangroves. The species richness found at Gaibu Beach was lower than the richness previously found for these other localities (Tab. 4). This lower diversity may be linked to the location of this study in a non-estuarine area. This location could be unsuitable for many species typical of estuarine mangroves, as *Ucides cordatus* (Linnaeus, 1763), *Sesarma rectum* Randall, 1840 and *Goniopsis cruentata* (Latreille, 1803), adapted to the variations occurring in the estuarine environment, including salinity, turbidity, and the type of substrate. Note that each locality can present their peculiar microhabitats and the sampling efforts in each study may have been different, which may also account for the different diversity among estuaries.

The Ocypodidae Rafinesque, 1815 and Grapsidae MacLeay, 1838 are usually the most diverse decapod crustacean families in mangrove ecosystems (Coelho, 1966; Jones, 1984; Macintosh, 1988; von Prahl *et al.*, 1990; Cobo *et al.*, 1994; Oshiro *et al.*, 1998; Hartnoll *et al.*, 2002; Echeverría-Sáenz *et al.*, 2003). In the present study, the Ocypodidae were represented by a single species, *Uca (L.) leptodactyla.* Despite the annual oscillation in the temperature, this species was frequent and present in all samples. This finding shows that temperature is not a limiting factor for this eurythermic species. Similarly, Masunari (2006) observed this species in an area with a relatively broad range of temperature (13 to 35ºC). In addition, *U. (L.) leptodactyla* prefers high salinities (Crane, 1975; Barnwell, 1986; Thurman, 1998) and muddy sand substrata (Colpo and Negreiros-Fransozo, 2003; Benetti and Negreiros-Fransozo, 2004; Castiglioni and Negreiros-Fransozo, 2004), as observed in the present study, showing that the studied marine mangrove location has ideal characteristics as a habitat for this species. The family Grapsidae was represented by two very frequent but non-abundant species, *Pachygrapsus transversus* and *P. gracilis*. These species were rare and less abundant, respectively. Note that this mangrove forest is protected by a fringe reef and that this reef may provide a refuge for species that are difficult to sample, including those belonging to the genus *Pachygrapsus* Randall, 1840. For this reason, a more species-specific capture method should be applied to sample these crabs, as observed by Flores *et al.* (1998).

Panopeus americanus has normally been found in association with sandy-mud substrata (Masunari and Dubiaski-Silva, 1998), under stones, on muddy beaches and in mangroves (Melo, 1996), exactly the same habitats in which this species was found in this study. The finding that *P. americanus* was more abundant than the other species in the sample could be associated with the slow mobility of this species, which facilitated its capture.

In the samples, all the specimens of *Callinectes exasperatus* and *C. marginatus* (A. Milne-Edwards, 1861) (both members of the family Portunidae) were juveniles. For this reason, the marine mangrove ecosystem investigated in this study can be considered a nursery area for both species. Several papers have reported that juvenile *Callinectes* Stimpson, 1860 migrate to estuaries, where they find food and shelter from predation (Hines *et al.*, 1987; Guerin and Stickle, 1997; Araújo *et al.*, 2012). Although the Gaibu mangrove forest is not estuarine, it is protected by reefs. According to Melo (1996), *C. exasperatus* inhabits shallow waters from the intertidal to a depth of 8 m in the sea and in estuarine waters, near river mouths and in

mangroves. *Callinectes marginatus* inhabits sandy and muddy bottoms, the periphery of mangroves, brackish water, and, rarely, open sea, from the intertidal to a depth of 25 m. Due to these ecological preferences, the Gaibu mangrove forest is a suitable habitat for the development of the juveniles.

The value of H' during the RPNM was the only one similar to that previously observed in the mangroves of the Caribbean (H' $\log_2$= 3.525) (J'= 0.869) and of the Pacific coasts of Panama (H' $\log_2$= 3.704) (J'= 0.857) (Abele, 1974), whereas the other samples of the present study showed lower values. During the rainy period, phytoplankton production is less intense (Passavante and Feitosa, 2004). This decrease in production could result in a decrease in the availability of food to the decapods and could thus reduce their abundance. However, the days are significantly shorter during the winter in the temperate zones (Brosche and Sündermann, 1990), and slightly shorter in tropical ones. This difference associated with the absence of light on new moon nights, reduces the risk of predation. For this reason, this community may be affected more strongly by the action of predators (top-down control) than by the amount of food available (bottom-up control) (Uye and Liang, 1998). The results presented in this paper contribute to the knowledge of the decapod fauna inhabiting mangroves associated with fringe reefs, a rare and poorly studied habitat.

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