Estuarine carcinofauna (Decapoda) of Rio Grande do Norte, Brazil

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Abstract

A study of two estuaries (Potengi and Macau) of the State of Rio Grande do Norte, Brazil, yielded 69 species of decapods (Crustacea), 48 from Potengi and 52 from Macau. Hypersaline conditions prevail in the estuary close to Macau while the estuary of Potengi is heavily polluted. The carcinofauna was collected from littoral and sublittoral regions. While the littoral region was sampled manually, a shore seine and two different types of dredges were used for sampling the sublittoral region. Among the species collected there are two recently described (*Hexapanopeus manningi* Sankarankutty and Ferreira and *Podochela meloi* Sankarankutty, Ferreira and Cunha) and 4 new records for the region: *Processa hemphilli* Manning and Chace, *Sesarma curacaoense* De Man, *Panopeus mirafloresensis* Abele and Kim and *Charybdis hellerii* (A. Milne Edwards). The estuary near Macau has a more diverse carcinofauna due to the diversity of its habitats, showing that geomorphology plays an important role in the diversity of the carcinofauna of the estuaries. The similarity found between the littoral brachyuran species of different mangroves shows that irrespective of the tree species the littoral carcinofauna forms a regular assemblage.

Key words: Biodiversity, Carcinofauna, Estuaries, Rio Grande do Norte, Brazil

Introduction

The estuaries and the mangrove forests form an important community. Along the coast of Brazil approximately 1,012,376 hectares of coastal area are covered with mangroves (Lacerda, 1993). Increasing human activities detrimental to the well-being of this community demand effective measures to preserve its biodiversity on a global basis.

Among the macrobenthos, the decapods represent a major component in terms of the number of species as well as biomass of this community (Macintosh,1988). Many brachyurans play an important role in the production and recycling of detritus.

The estuaries near Macau are in reality incursions of the sea with no freshwater discharge and they are under the influence of "salinas" operating in the region. Only two species of mangroves trees, *Rhizophora mangle* (Linnaeus) and *Avicennia schaueriana* (Stapf. and Leech.), exist there.

The estuary of Potengi, on the other hand, is a true estuary with freshwater discharge from two rivers, River Potengi and River Jundiaí. However, industrial and domestic pollution has caused pronounced environmental changes (Nobrega, 1982). The plants *R. mangle, Laguncularia racemosa* (Gaertn.) and *A. schaueriana* (the latter named being very sparse) are encountered along the margins of the river.

A taxonomic survey of the species of Decapoda of the mangroves constitutes an important step to the understanding of the biodiversity of the community. Several studies have so far been conducted in the estuaries of the Northeast of Brazil (Coelho, 1966; Coelho *et al.*, 1970; Coelho, 1971; Coelho and Ramos, 1972; Fausto-Filho, 1978, 1979; Fausto-Filho and Moura, 1986; Coelho *et al.*, 1986; Sankarankutty *et al.*, 1991; Mochel, 1995; Coelho and Ramos-Porto, 1995 a, b; Ferreira and Sankarankutty, 1997; Ferreira, 1998; Sankarankutty *et al.*, 1999; Sankarankutty and Ferreira, 2000; Ferreira *et al.*, 2001; Sankarankutty and Ferreira, 2001; Sankarankutty *et al.*, 2001.)

The present survey is an attempt to study the carcinofauna of two estuarine systems and to compare their faunistic components in relation to certain environmental characteristics like salinity, pollution and geomorphology of the substratum.

Material and Methods

The areas of study are located close to the township of Natal (Fig. 1) and Macau (Fig. 2).

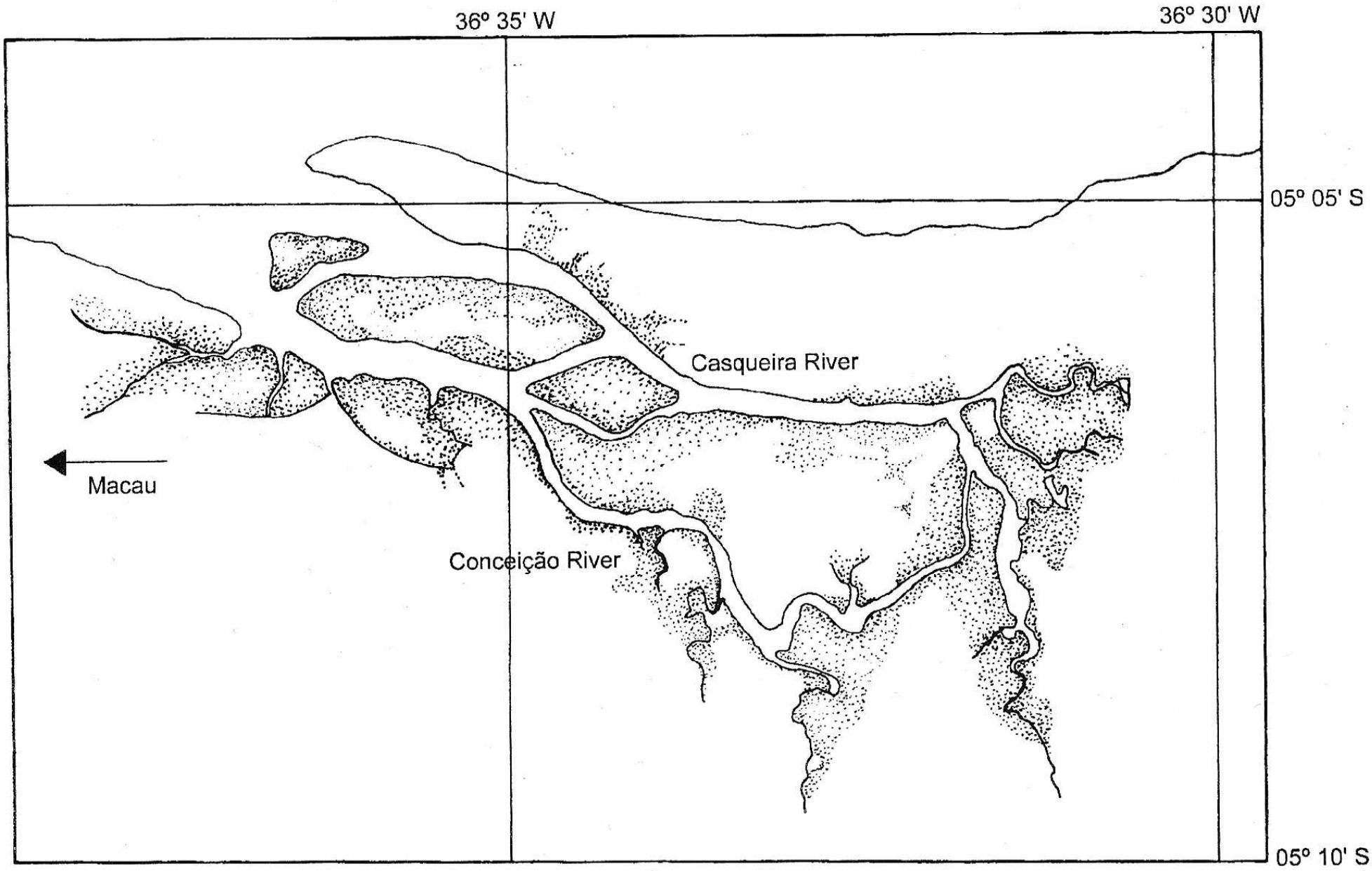

Figure 1: Map of the estuary of Casqueira and Conceição Rivers with mangrove areas (stippled) indicated.

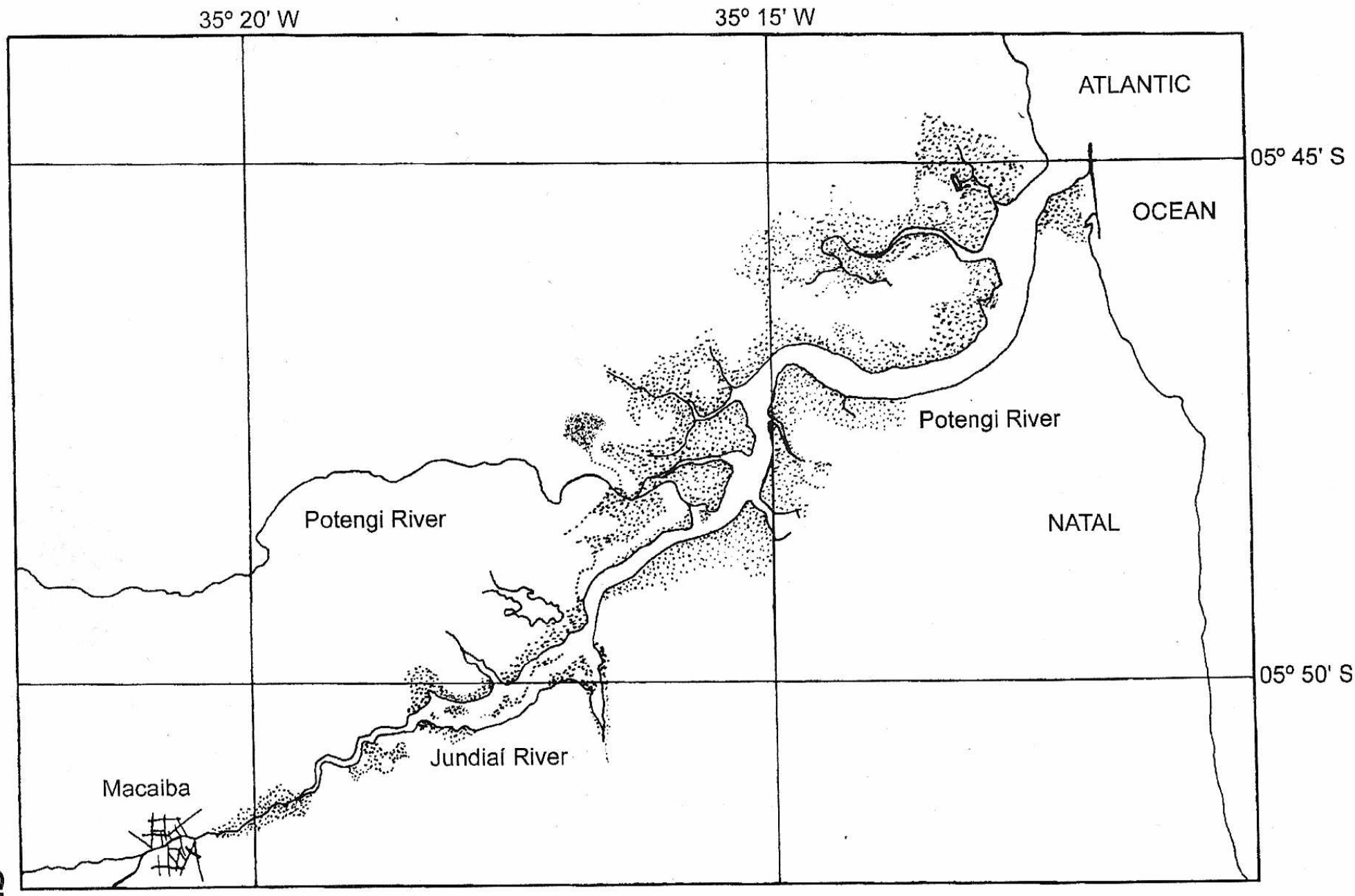

Figure 2: Map of the estuary of Potengi River with mangrove areas (stippled) indicated.

The sampling in the region of Macau was carried out between 1996 e 1998, and in Potengi between 1996 and 2000 covering all types of habitats from intertidal to sublittoral regions of the estuaries. Four collecting gears were used to sample from the sublittoral region: an Ockelman dredge, a common dredge

with a mouth dimension of 50 cm x 15 cm having a mesh size of 0.8 cm, a beach seine of 9.5 metre length having a mesh size of 1.2 cm and a cast net. The dredges were operated from a boat parallel to the beach, each sampling lasting about 5 minutes. Operated by two people, the beach seine sampled for approximately 50 meters each time. Sampling of intertidal fauna was done manually. Though most of the sampling was done during the day, some nocturnal sampling was also done in the region of Macau.

The following factors were considered in this study: salinity, pollution and geomorphology of the substratum.

The identification of the species was accomplished utilizing the studies of Rathbun (1918, 1925, 1930), Crane (1975), Williams (1984), Perez-Farfante (1988), Abele and Kim (1989), Abele (1992) and Melo (1996, 1999).

Results and Discussion

A total of 70 species of decapods belonging to 19 families were collected from the twoestuaries (Tables I and III), 52 species from Macau and 49 species from Potengi. While the sublittoral region provided 45 species, the total number of species from the littoral region numbered only 25. While the sublittoral region of Macau is richer compared to that of Potengi (33 and 26 respectively), Potengi has more species in the littoral region (23 : 19). Only 14 of the sublittoral (31%) and 17 (68%) of littoral inhabitants are common to both estuaries.

Among the species collected, *Hexapanopeus manningi* (Sankarankutty and Ferreira, 2000) and *Podochela meloi* (Sankarankutty *et al.,* 2001) are recently described.

Other notable findings during this study are those species which are reported for the first time from this regions viz. *Panopeus mirafloresensis* Abele and Kim (Ferreira and Sankarankutty, 1997), *Callinectes maracaiboensis* Taissoun (Sankarankutty *et al.*, 1999) and *Charybdis helleri* (A. Milne Edwards) (Ferreira *et al.*, 2001),. Also *Sesarma curacaoense* De Man and *Processa hemphilli* Manning and Chace (unpublished data).

A case of dimorphism among the males of *Zaops ostreum* (Say, 1817), so far localized in the Macau region (Sankarankutty and Ferreira, 2001), is another interesting phenomenon observed. The planktonic shrimp, *Lucifer faxoni* Borradaile, is present in both estuaries.

Eight species common to both systems were collected in littoral and sublittoral substrata: *Alpheus heterochaelis* Say, *Clibanarius antillensis* Stimpson, *Clibanarius vittatus* (Bosc), *Clibanarius sclopetarius* (Herbst), *Petrochirus diogenes* (Linnaeus), *Pagurus criniticornis* (Dana), *Hexapanopeus schmitti* Rathbun, 1930 and *Pinnixa sayana* Stimpson (Table I).

Table III represents the littoral decapods of both estuaries.

The muddy substratum close and among the tree roots is traversed by systems of anastomosing tunnels inhabited by different species of crabs living closely. These communal tunnels, crossed by burrows of *Uca thayeri* Rathbun, 1900 and *Uca cumulanta* Crane, 1943 (Ocypodidae) stay open by the constant use of individuals of different sizes of *S. curacaoense*, *Pachygrapsus gracilis* (Saussure, 1858) (Grapsidae), *Eurytium limosum* (Say, 1818), *Panopeus lacustris* Desbonne, 1867 (Xanthidae), and young crabs of *Aratus pisonii* (H. Milne Edwards, 1837) and *Goniopsis cruentata* (Latreille, 1803) (Grapsidae). Apparently young Grapsids seem to take advantage of these burrows, rather than construct them.

The estuary near Macau is characterized by hypersaline condition most of the year with insignificant domestic pollution but under the influence of "salinas", while the estuary of Potengi is subjected to variable salinity and heavy domestic and industrial pollution.

While it is possible to assume that the species inhabiting the estuary of Macau are essentially those adapted to hypersaline conditions with the exception of a few polyhaline species (*Callinectes danae* Smith, 1869, *Farfantepenaeus brasiliensis*), the species occurring in Potengi estuary are polyhaline and even freshwater species (*Macrobrachium* spp.). However, while sublittoral species common in both of the estuaries have their distribution restricted to the mouth of the Potengi estuary (*A. heterochaelis*, *C. sclopetarius, C. vittatus,*

P. criniticornis, Callinectes larvatus, H. schmitti, and *H. manningi*), given satisfactory bottom conditions they may be encountered in the inner part of the estuary of Macau due to the fairly uniform salinity conditions. The littoral inhabitants of the mangroves exist in any location independently of the tree species, but differences exist in relation to density and size of certain species.

The substratum of the Potengi estuary is predominantly muddy except at the mouth of the estuary where small patches of sandy or shell bottoms exist. On the other hand, a similar variety of bottoms exist in Macau but the broken-shells / coral bottom is far more extensive.

The diversity of the carcinofauna is primarily a function of the diversity of the geomorphology of the substratum (Abele, 1976; Tavares and Albuquerque, 1989). The sublittoral region with a sandy substratum containing a mixture of broken shells and pieces of corals, observed only in Macau, has the largest diversity of decapod fauna (29 species) while a low number of species (6) occurred in the muddy substratum. The reduced number of decapods on bottoms of mud with algae in Macau may be attributed to the limited area of this substrate. Of the thirteen species founded in the sandy bottoms of Potengi river, seven of them were found in the sandy with broken shells and corals bottom of Macau, and five were not collected from this estuary (Table II). The existence of rocky intertidal substratum only in Potengi has its associated species as well such as *Cataleptodius floridanus* (Gibbes, 1850) and *Eriphia gonagra* (Fabricius, 1781).

Three species, *F. brasiliensis, C. vittatus* and *C. danae* were found in every kind of bottom in both estuaries. *Zaops ostreum*, associated with *Crassostrea rhizophorae*, was observed only in the Macau region attached to the mangroves (Sankarankutty and Ferreira, 2001).

When comparing the species of Brachyura associated with the mangroves of this region, 11 are also known from Jamaica (Warner, 1969) and Panama (Abele, 1976) (Table IV) with the same species inhabiting similar communal habitats, reflecting the evolution under similar selective regimes of these communities (Abele, *op. cit.*).

Similarity of the littoral crab species irrespective of the tree diversity is a noteworthy feature (Table IV). If the community richness is a measure of the niches available in the habitat (McNaughton and Wolf, 1970; Abele, 1976), the availability of more tree species and hence new exploitable sites, might accommodate more species of crabs. It was observed that some more abundant ones such as *U. cumulanta* and *U. maracoani* (Ocypodidae) having no strict substrate preferences as traditionally described by several authors (Ferreira, 1998) colonize an ample niche. Similarly the more mobile *G. cruentata* (Grapsidae) also occupies a wide spatial area of the substrate and roots. Hence, using a great portion of the spatial dimension these crabs seem to restrict the insertion of new ones. The existence of dominant species more abundant and with ample niches (exploiting a larger proportion of one or more dimensions of their niche) and others less abundant crowded in peripheral portions of the dimensions is a characteristic found in many communities (McNaughton and Wolf, *op.cit.*).

Although many of these littoral Brachyura species are exclusive of mangroves like *G. cruentata, A. pisonii, S. curacaoense* and the *Uca* spp, others like *E. limosum* (which live in salt marshes too) and *P. gracilis* extend its niches beyond the mangroves. The resulting assemblage, however, is a constant community.

In the communal habitats the existence of several species in a relatively small space may be attributed to reduced competition, due to the superabundance of resources. But maybe these species have been dislocated to a crowded existence due to the abundance of the surface dominant species.

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Table I: List of sublittoral decapods of Macau and Potengi.

Species	Macau				Potengi			
	(1)	(2)	(3)	(5)	(2)	(3)	(4)	(5)
Farfantepenaeus brasiliensis (Latreille)	*	*	*		*	*	*	
Litopenaeus schmitti (Burkenroad)							*	
Xiphopenaeus kroyeri (Heller)							*	
Sicyonia laevigata Stimpson	*							
S. typica (Boeck)	*							
Macrobrachium acanthurus (Wiegmann)								*
M. amazonicum (Heller)							*	
M. olfersii (Wiegmann)								*
Periclimenes americanus (Kingsley)		*						
Alpheus heterochaelis Say ⌘	*	*	*			*		
Alpheus normanni Kingsley	*							
Ogyrides alphaerostris (Kingsley)		*						
Latreutes parvulus (Stimpson)	*							
Processa hemphilli Manning and Chace	*	*						
Panulirus argus (Latreille)	*	*						
Dardanus venosus (H. Milne Edwards)	*				*			
Clibanarius antillensis Stimpson ⌘	*	*				*		
C. sclopetarius (Herbst) ⌘	*	*	*		*	*		
C. vittatus (Bosc) ⌘	*	*	*		*	*	*	
Petrochirus diogenes (Linnaeus) ⌘				*			*	
Pagurus criniticornis (Dana) ⌘	*				*	*	*	
Minyoceros angustus (Dana)	*							
Porcellana brasiliensis (Haig)	*							
Calappa ocellata Holthuis								*
Metoporhaphis calcarata (Say)	*							
Podochela meloi Sankarankutty, Ferreira and Cunha	*							
Pelia rotunda A. Milne Edwards	*							
Notolopas brasiliensis Miers	*				*		*	
Microphrys bicornutus (Latreille)					*			
Callinectes bocourti A. Milne Edwards						*		
C. danae Smith	*	*	*		*	*	*	
C. exasperatus (Gerstaecker)	*					*		
C. larvatus Ordway	*	*	*				*	
C. maracaiboensis Taissoun					*			
C. ornatus Ordway							*	
Arenaeus cribrarius (Lamarck)							*	
Charybdis hellerii A. Milne Edwards	*							

Cont. Tabe I

Cronius tumidulus (Stimpson)	*					
Pilumnus reticulatus Stimpson	*					
Panopeus mirafloresensis Abele and Kim		*				
Hexapanopeus manningi Sankarakutty and Ferreira	*	*			*	
H. paulensis Rathbun	*					
H. schmitti Rathbun ⌘	*			*	*	*
Pinnixa chaetopterana Stimpson	*					
Pinnixa sayana Stimpson ⌘					*	

1- Sandy w/ broken shells and coral pieces; 2- Muddy w/ broken shells; 3- Muddy w/ algae; 4- Sandy; 5- No data.
* = presence; ⌘= also collected from intertidal region.

Table II: Number of sublittoral decapods of Macau and Potengi related to the morphology of the substratum.

Type of substratum	Number of species	
	Macau region	Potengi
Sandy / broken shells and coral pieces	29	--
Muddy / broken shells	13	10
Muddy (w / algae)	6	12
Sandy	--	13
Without data	1	3

-- = no data

Table III: List of intertidal decapods of Macau and Potengi.

Species	Macau	Potengi
Alpheus bouvieri A. Milne Edwards	--	*
A. armillatus H. Milne Edwards	--	*
Merguia rhizophorae Rathbun	*	--
Upogebia omissa Gomes Corrêa	--	*
Petrolisthes armatus (Gibbes)	*	*
Panopeus americanus Saussure	--	*
P. lacustris Desbonne	*	*
Menippe nodifrons Stimpson	*	*
Eurytium limosum (Say)	*	*
Eriphia gonagra (Fabricius)	--	*
Cataleptodius floridanus (Gibbes)	--	*
aops ostreum (Say)	*	--
Pachygrapsus gracilis (Saussure)	*	*
P. transversus (Gibbes)	*	*
Goniopsis cruentata (Latreille)	*	*
Aratus pisonii (H. Milne Edwards)	*	*
Sesarma curacaoense De Man	*	*

Cont. Tabe III

S. rectum Randall	*	*
Uca cumulanta Crane	*	*
U. leptodactyla Rathbun	*	*
U. maracoani (Latreille)	*	*
U. rapax (Smith)	*	*
U. thayeri Rathbun	*	*
Ucides cordatus (Linnaeus)	*	*
Cardisoma guanhumi Latreille	*	*

* = presence, -- = no data

Table IV: Littoral Brachyura found in mangroves of Macau, Potengi, Port Royal (Jamaica) and Panamá, including the tree species in each area.

	Macau	Potengi	Jamaica	Panama
Species	♣ ♥	♣ ♦	♣ ♦ ♠	♣
Panopeus lacustris Desbonne	*	*	(*)	(*)
P. americanus Saussure	--	*	--	--
Eurytium limosum (Say)	*	*	*	*
Zaops ostreum (Say)	*	--	--	--
Pachygrapsus gracilis (Saussure)	*	*	*	*
P. transversus	*	*	--	--
Goniopsis cruentata (Latreille)	*	*	*	*
Aratus pisonii (Milne Edwards)	*	*	*	*
Sesarma rectum Randall	*	*	(*)	(*)
S. curacaoense De Man	*	*	*	*
Uca leptodactyla Rathbun	*	*	*	--
U. cumulanta Crane	*	*	--	*
U. thayeri Rathbun	*	*	*	*
U. rapax (Smith)	*	*	*	*
U. maracoani (Latreille)	*	*	--	(*)
Ucides cordatus (Linnaeus)	*	*	*	*
Cardisoma guanhumi Latreille	*	*	*	*

* =presence; (*) = species of same genera occupying the same niche; —= no data
♣ = *Rhizophora mangle*; ♦ = *Laguncularia racemosa*; ♥ = *Avicennia schaueriana*; ♠ = *Avicennia nitida.*

References

Abele, L. G. 1976. Comparative Species Composition and Relative Abundance of Decapod Crustaceans in Marine Habitats of Panamá. Marine Biology, 38: 263-278.

Abele, L. G. 1992. A review of the Grapsid Crab Genus *Sesarma* (Crustacea: Decapoda: Grapsidae) in America, with the Description of a New Genus. Smithsonian Contributions to Zoology, 527.

Abele, L. G. and Kim, W. 1989. The Decapod Crustaceans of the Panama Canal. Smithsonian Contributions to Zoology, 482p.

Coelho, P. A. 1966. Os Crustáceos Decapodos de alguns manguezais pernambucanos. Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco, 7(80): 71-99.

Coelho, P. A. 1971. A distribuição dos Crustáceos Decápodes reptantes do Norte do Brasil. Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco, 9(11): 223-238.

Coelho, P. A. and Ramos, M A. 1972. A constituição e a distribuição da fauna de Decápodos do litoral leste da America do Sul entre as latitudes de 5° N e 39° S. Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco, 13: 133-236.

Coelho, P. A. and Ramos-Porto, M. 1995a. Distribuição ecológica dos Crustáceos Decápodos marinhos do Nordeste do Brasil. Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco, 23: 113-127.

Coelho, P. A. and Ramos-Porto, M. 1995b. Crustáceos da região de Tamandaré, Estado de Pernambuco, Brasil. Boletim Técnico-Científico do CEPENE, 3(1): 57-80.

Coelho, P. A.; Koening, M. L. and Ramos, M. A. 1970. A macrofauna béntica dos estuários de Pernambuco e da Paraíba. *In*: IV Congresso Latinoamericano de Zoologia, 1968, Caracas. Actas. Caracas: Francisco Leccia, 2: 497-528.

Coelho, P. A.; Ramos-Porto, M. and Calado, T. C. S. 1986. Litoral de Rio Grande do Norte: Decapoda. Separata Cadernos Omega, Série Ciência Aquática, (2): 79-105.

Crane, J. 1975. Fiddler crabs of the world. Ocypodidae: genus *Uca*. Princeton University Press, xxiv, 736 p.

Fausto-Filho, J. 1978. Crustáceos Estomatópodos e Decápodos dos sustratos de lama do Nordeste Brasileiro. Arquivos de Ciências do Mar, 18(1/2): 63-71.

Fausto-Filho, J. 1979. Crustáceos Estomatópodos e Decápodos dos sustratos de areia do Nordeste Brasileiro. Arquivos de Ciências do Mar, 19(1/2): 45-56.

Fausto-Filho, J. and Moura, A. L. L. 1986. Bioecologia dos Crustáceos ocipodídeos do gênero *Uca* Leach, do estuário do rio Cocó, no município de Fortaleza, Ceará, Brasil. Ciência e Agronomia, 17(1): 1-12.

Ferreira, A. C. 1998. Composição de Crustacea (Decapoda) dos manguezais do Município de Macau / RN. 104 p. Master Science Dissertation. Departamento de Limnologia e Oceanografia, Universidade Federal do Rio Grande do Norte (UFRN).

Ferreira, A. C. and Sankarankutty, C. 1997. Extension of the range of distribution of *Panopeus mirafloresensis* Abele and Kim (Crustacea: Decapoda: Xanthidae). Nauplius, 5(2): 155-157.

Ferreira, A. C.; Sankarankutty, C.; Cunha, I. M. C. and Duarte, F. T. 2000. Yet another record of *Charybdis hellerii* (A. Milne Edwards, 1867) from the Northeast of Brazil. Revista Brasileira de Zoologia, 18(1): 357-358, 2001.

Lacerda, L. D. (Coord.). 1993. Mangrove Ecosystems of Latin America and the Caribbean: a Summary. Conservation and sustainable utilization of mangrove forests in Latin America and Africa regions, 1: 1-42.

Macintosh, D. J. 1988. The ecology and physiology of decapods of mangrove swamps. Symposyum of Zoological Society of London, 59: 315-341.

McNaughton, S. J. and Wolf, L. L. 1970. Dominance and the niche in ecological systems. Science, 167(3915): 131-139.

Melo, G. A. S. 1996. Manual de identificação dos Brachyura (caranguejos e siris) do litoral brasileiro. São Paulo: FAPESP, 604 p.

Melo, G. A. S. 1999. Manual de identificação dos Crustacea Decapoda do litoral brasileiro: Anomura, Thalassinidea, Palinuridea, Astacidea. São Paulo: FAPESP, 551 p.

Mochel, F. R. 1995. Endofauna do manguezal. São Luis: EDUFMA, 121 p.

Nobrega, M. D. 1982. Indicadores de poluição no estuário do Potengi e em águas de esgotos em Natal/ RN. São Paulo, 80 p. Master Science Dissertation - Universidade de São Paulo.

Perez Farfante, I. 1988. Illustrated Key to Penaeoid Shrimps of Commerce in the Americas. NOAA Technical Report NMFS, 64: 1-32.

Rathbun, M. J. 1918. The Grapsid crabs of America. Bulletin of the United States National Museum, 97. 1-461.

Rathbun, M. J. 1925. The spider crabs of America. Bulletin of the United States National Museum, 129. 1-613.

Rathbun, M. J. 1930. The Cancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae and Xanthidae. Bulletin of the United States National Museum, 152. 1-609.

Sankarankutty, C. and Ferreira, A. C. 2000. *Hexapanopeus manningi*, a new Xanthid crab (Crustacea; Decapoda: Xanthidae) from Brazil. Revista Brasileira de Zoologia, 17(3): 645-649, 2000.

Sankarankutty, C.; Ferreira, A. C. and Cunha, I. M. C. 2001. On a new species of spider crab (Crustacea; Brachyura; Majidae) from the Northeast of Brazil. Revista Brasileira de Zoologia, 18(2): 551-556, 2001.

Sankarankutty, C. and Ferreira, A. C. 2001. Dimorfism in males of *Zaops ostreum* (Say, 1817) (Crustacea: Decapoda: Pinnotheridae). Revista Brasileira de Zoologia, 18(4): 1343-1344, 2001.

Sankarankutty, C; Freire, A. G. and Santiago, L. G. 1991. On the taxonomy and distribution of *Callinectes*

Stimpson (Crustacea, Decapoda, Portunidae) in Rio Grande do Norte. Revista Brasileira de Zoologia, 8(1,2,3,4): 17-22.

Sankarankutty, C.; Ferreira, A. C.; Pinto, C. S. C.; Barca, F. E. N. V. and Alencar, M. A. 1999. *Callinectes maracaiboensis* Taissoun (Crustacea, Decapoda, Portunidae), a species common but so far unrecorded in the Northeast of Brazil. Revista Brasileira de Zoologia, 16(1): 145-150.

Tavares, M. S. and Albuquerque, E. F. 1989. Levantamento taxonômico preliminar dos Brachyura (Crustacea: Decapoda) da lagoa de Itaipú, Rio de Janeiro, Brasil. Atlântica, 11(1): 101-108.

Warner, G. F. 1969. The occurrence and distribution of crabs in a Jamaican mangrove swamp. Journal of Animal Ecology, 38: 379-389.

Williams, A. B. 1984. Shrimps, lobsters and crabs of the Atlantic coast of the Eastern United States, Maine to Florida. Washington: Smithsonian Institution Press, 550 p.

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Nauplius