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DIET OF *CHACEON RAMOSAE* (DECAPODA, BRACHYURA) ON THE SOUTHERN BRAZILIAN EXCLUSIVE ECONOMIC ZONE

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Among the great variety of species exploited in the Brazilian Exclusive Economic Zone (EEZ), the brachyuran decapods of the genus C*haceon* (Geryonidae) stand out for their high commercial value. There are two deep sea crab species inhabiting the southeastern and southern coastal waters of Brazil, *Chaceon ramosae* Manning, Tavares and Albuquerque, 1989 ("Royal Crab" or "Caranguejo Real") and *Chaceon notialis* Manning and Holthuis, 1989 ("Red Crab" or "Caranguejo Vermelho").

Crabs of the genus *Chaceon* are epibenthonic, inhabit muddy and muddy-sandy bottoms between 100 and 2800 m isobaths and are geographically widespread (DEFEO et al*.,* 1992; MANNING ; HOLTHUIS, 1989). There is evidence that the species *C. ramosae* is restricted to the southern coast off the state of Santa Catarina, Brasil (ATHIÊ ;ROSSI-WONGTSCHOWSKI, 2004).

The diet of adult geryonid crabs has been described by several authors (GRAY, 1970; GERRIOR, 1981; FARLOW, 1980); like many deep-sea organisms these animals present opportunistic feeding habits. Smaller crabs eat fish carcasses, dead squids, sponges, hydroids, gastropod, scaphopods and bivalve mollusks, small polychaete, crustaceans and probably tunicates (FARLOW, 1980). Bigger sized individuals feed upon the same benthic fauna and even on larger prey such as demersal fishes and squids.

Studies on the biology of geryonid crabs inhabiting Brazilian coastal waters are still few. The aim of the present study is to provide preliminary data on the composition of the diet of *Chaceon ramosae* living in the southern Brazilian EEZ.

The crabs were caught during samplings carried out for the REVIZEE Program (Living Resources in the Exclusive Economic Zone); it is important to note that the sampling occurred as part of a wider project and so collections were not directed specifically to the study of the diet, the specimens collected however have permitted a first assessment of the diet of the species.

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Specimens of *C. ramosae* were collected during expeditions of the research vessel "Soloncy Moura" (CEPSUL/IBAMA) at the coast of Santa Catarina, in the area located between the parallels 26°30'S - 27°30'S; 45°W – 47°30'W, between 100 and 600 m isobaths, using baited bottom traps (with fresh heads of *Katsuwonus pelamis* as bait), during September and October 2000.

A total of 66 specimens of *Chaceon ramosae* were analyzed. First, all the animals sampled were fixed with 10% buffered formaldehyde and then transferred to 70% alcohol. For each specimen cephalothorax length (CL) and cephalothorax width (CW) were measured in mm and body weight recorded in g using 0.01g precision scale. After biometry, the stomachs were extracted and weighed and their contents analyzed after the excess of liquids external to this organ had been wiped off with tissue paper. The fullness level (FL) of the stomachs, which indicates the volume of the contents as a proportion of the maximum volume of the stomach (ZAVALA-CAMIN, 1996), was recorded as a percentage using the following scale: FL= 0 (0% empty), FL= 1 (1% - 25% full), FL= 2 (26% - 75% full) and FL= 3 (76% - 100% full).

The identification of food items was made with the help of specialists from the Instituto Oceanográfico and the Museu de Zoologia, both from the Universidade de São Paulo, Brazil. Prey was identified either to species or to the lowest possible taxonomic level. Items that could not be identified were classified as Undetermined Organic Matter (UOM).

Considering that a whole prey is only rarely found, the number of ingested organisms cannot be taken to reconstitute the natural diet of brachyura (WILLIAMS, 1981). Because of the great number of items, the individual counting of which was impossible, it was decided not to analyze the numerical frequency of items. Thus, in the present study, the percentage frequency of occurrence (FO%) and percentage biomass abundance (M%) for each prey item and prey group were calculated in accordance with Hyslop's (1980) formula. From the percentage frequency of occurrence and percentage biomass abundance, the alimentary index (AI%) was calculated using the modified formula of Kawakami and Vazzoler (1989):

$$AI\% = \frac{\text{FO\% x M\%}}{\sum(\text{FO\% x M\%})} X100$$

Variations in diet composition in relation to different depth strata were analyzed by using the AI% data.

For the analyses of diet individuals were grouped by depth and three strata, 350 m, 450 m and 550 m, were considered. In order to establish alimentary affinities among animals of the different strata, cluster analysis was performed using the Percentage of Similarity Index and the UPGMA method of hierarchical agglomeration (SNEATH; SOKAL, 1973). Cluster analysis was performed with the use of MVSP Plus software (Multivariate Statistical Package 3.1). A data matrix was obtained using AI% values of items grouped in larger taxa, but this did not include the item UOM since this would not add any relevant information to the comparison of the diets.

The occurrence of *Chaceon ramosae* was confirmed at 60% of the 35 sampling stations; only the stations located on the 350 m, 450 m, and 550 m isobaths presenting catches. The cephalothorax width of individuals ranged from 92.80 mm to 187.00 mm giving a mean CW of 129.23 (± 19.11); cephalothorax length ranged from 81.70 mm to 160.00 mm, with a mean CL size of 111.63 (± 15.89); and body weight ranged from 184.50 g to 1613.30 g, with a mean weight of 564.57 (± 269.68) g.

Of 66 stomachs, 3% were empty (FL=0), 33% were almost empty (FL=1), 40% presented FL=2, and 24% were full (FL=3); of the stomachs containing some food, only 9.37% presented undigested contents, 49% had partially digested contents and 42% of them presented fully digested contents.

Forty-one items were identified in the diet of *C. ramosae*, including sediment and UOM. For items of minute size, recognizable crustaceans (with the exception of isopods) and synthetic material, only the frequency of occurrence was calculated. Excluding UOM and sediment, the items that predominated in terms of occurrence (FO%) were: Teleostei (63%), foraminifers (22.7%), unidentified crustaceans (9.0%), isopods (7.5%) and unidentified cephalopods (6.0%). Sediment was found in 45% of the foreguts and the high incidence of UOM (59.0%) demonstrates the large quantity of material that, due to the high degree of digestion and maceration, was unidentifiable (Table 1).

In terms of biomass (M%), the highest values were found for Teleostei, UOM, isopods, *Illex argentinus*, unidentified crustaceans and sediment. The values of the AI% confirm the importance of Teleostei, UOM, sediment, isopods and unidentified crustaceans (Table 1).

In view of the fact that all the *C. ramosae* individuals in this study were caught with fish-baited traps, it is possible that the value of the item teleostei has been overestimated and that this fact has therefore masked the true importance of other items. Thus, a second analysis was performed in which the item Teleostei was excluded. The analysis of AI% showed that UOM, sediment, isopods and unidentified crustaceans were the most important items (Table 1). In order to quantify how important other items would be, Teleostei, UOM and sediment were excluded in a third analysis, and in this case isopods, unidentified crustaceans and unidentified Teuthoidea predominated (Table 1).

Analyzing the diet in relation to depth, it was discovered that Teleostei, UOM and sediment were present in more than 30% of the foreguts collected on the three depth strata (Table 2). Using the matrix obtained from the AI% data (excluding UOM) for the cluster analysis it was detected that the diet of *C. ramosae* was very similar at all the three bathymetric strata analyzed. Two groups were formed on the basis of 88.2% similarity, that of 450 m and that of 350-550 m, the latter with 93.9% similarity (Fig.1).

The diet of *Chaceon ramosae* was diversified and very similar on all the three depth strata considered (350 m, 450 m and 550 m). Some ideas arise with regard to this dietary similarity; one is that prey composition on this bathymetric gradient does not vary sufficiently to lead to significant differences in the diet. A second one is that some geryonid crabs are known to be very mobile, as in the case of *Chaceon maritae* off the coast of Namibia, where according to Melville-Smith (1987 apud Hines, 1990), mature females cover distances of 0.46 km/day. In the light of such mobility, crabs could easily cover the distances between the strata analyzed within a few hours, so distances within a 200 m depth range would be too short to result in differences in diet. However, further studies are necessary to verify how far its diet may vary with depth.

The analysis of animals caught with traps using heads and pieces of fish as bait does not permit to quantify the real importance of Teleostei in the diet because the bait itself introduces an error. However, in another study with *Chaceon notialis* collected exclusively by bottom trawl (DOMINGOS et al., 2007) Teleostei occurred in 25% of the foreguts, demonstrating that fish is indeed an important resource for that species. Considering that both species presented similar items in their diets, possibly, Teleostei is equally important in the diet of *C. ramosae.*

Table 1. Frequency of occurrence (FO%), biomass abundance (M%) and alimentary index (AI%) of items found in foreguts of *Chaceon ramosae*.

AI%*: Alimentary Index calculated without teleostei
AI%**: Alimentary Index calculated without teleostei, UOM and sediment. N = 66

Items	FO%	M%	AI%	AI%*	AI%**
Osteichthyes					
Teleostei	63.6	55.8	68.0		
Mollusca					
Cephalopoda	6.1	0.7	0.1	0.3	4.4
Teuthoidea	4.5	1.7	0.1	0.5	8.0
Illex argentinus	1.5	4.9	0.1	0.4	7.7
Gastropoda	1.5	0.0	0.0	0.0	0.0
Crustacea	9.1	3.4	0.6	1.9	32.7
Brachyura					
Goneplacidae	6.1				
Leucosiidae	4.5				
Calappidae	1.5				
Thalassinidea	6.1				
Hippoidea	1.5				
Caridea	1.5				
Palinuridea	1.5				
Galatheidea					
Munida sp.	1.5				
Majidae	1.5				
Maxillopoda					
Thecostraca (Cirripedia)	1.5				
Peracarida					
Isopoda	7.6	5.9	0.9	2.7	47.2
Nematoda					
Leptosomatidae	1.5				
Annelida					
Polychaeta					
Aphrodita sp	1.5				
Echinodermata	1.5				
Ophiuroidea					
Foraminifera	22.7				
Globigerina bulloides	1.5				
Globigerinita uvula	1.5				
Globigerinoides conglobatus	6.1				
Globigerinoides ruber pink	1.5				
Globigerinoides ruber white	12.1				
Globigerinoides sacculifer	9.1				
Globocassidulina sp.	3.0				
Globorotalia menardi	16.7				
Globorotalia sp.	1.5				
Globorotalia truncatulinoides	3.0				
Neogloboquadrina durtertrei	1.5				
Neogloboquadrina sp.	1.5				
Ammonia rolshawseni	1.5				
Cibicidoides sp.	10.6				
Lenticulina sp.	1.5				
Planulina sp.	3.0				
Quinqueloculina horrida	3.0				
Quinqueloculina sp.	1.5				
Uvigerina sp.	3.0				
Undetermined Organic Matter (UOM)	59.1	24.1	27.2	85.1	
Sediment	45.5	3.4	2.9	9.2	
Synthetic material	1.5	0.1			
Total		100.0	100.0	100.0	100.0

Table 2. Frequency of occurrence (FO%), biomass abundance (M%) and alimentary index (AI%) of items found in foreguts of *Chaceon ramosae* at the three depth strata considered. UOM = undertemined organic matter.

	350 meters			450 meters			550 meters		
Items	FO%	M%	AI%	FO%	M%	AI%	FO%	M%	AI%
Teleostei	60.0	60.3	77.6	65.6	56.1	59.1	64.3	47.1	57.0
Cephalopoda	10.0	14.6	3.1	9.4	0.4	0.1	21.4	9.6	3.9
Crustacea	20.0	12.8	5.5	12.5	3.3	0.7	28.6	14.2	7.6
Nematoda	-	-	-	3.1	-	-	-	-	-
Polychaete	-	-	-	-	-	-	7.1	0.1	0.0
Foraminifera	30.0	-	-	12.5	-	-	42.9	-	-
UOM	55.0	9.0	10.6	65.6	35.6	37.5	57.1	27.3	29.4
Sediment	50.0	3.0	3.2	37.5	4.6	2.8	64.3	1.8	2.2
Synthetic material	5.0	0.4	-	-	-	-	-	-	-
Total	-	100.0	100.0	-	100.0	100.0	-	100.0	100.0
	N= 20			N=32			N=14		

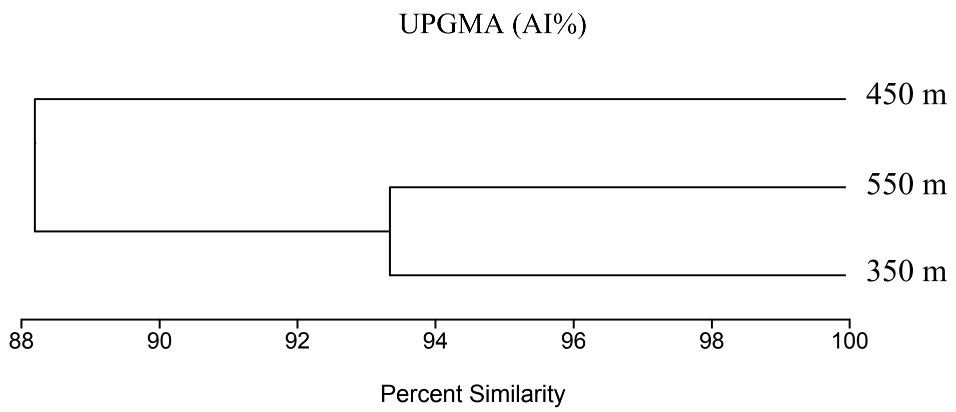

Fig. 1. Aggregation of foregut content samples, in accordance with the AI%, for *C. ramosae* individuals caught at different depth strata.

The presence of synthetic material, such as plastic and nylon, in the stomachs may indicate that these animals try to feed during the time they remain in the traps or are not selective consuming these items present on the substrate.

According to Cartes (1993), the presence of vertebras, otoliths and crystalline lenses of small fish in the foreguts of geryonids is an evidence of some degree of predatory activity. Similarly, the occurrence of these items and the occurrence of squid pens, suckers and crystalline lenses plus smaller crustaceans in foreguts of *C. ramosae* tend to reinforce the idea of active predation by this species.

Geryon longipes, another species of the Geryonidae family feeds upon a great variety of benthic invertebrates and is considered a scavenger, consuming mainly fish remains, for which the crab seeks actively (LAGARDÈRE, 1977 apud CARTES, 1993). In view of the fact that fishing that utilizes parts of fishes as bait is highly efficient we may affirm that necrophagy plays an important role in the diet of *Chaceon ramosae*.

Branco and Verani (1997) suggest that the ingestion of sand by *Callinectes danae* (Decapoda, Portunidae) occurs accidentally together with its prey; however, they also emphasize that it may be deliberate since the marine sediment is inhabited by a variety of microorganisms. Haefner (1990) considered sediment a source of carbonate and attests that it was the most frequent item in the diet of *Callinectes ornatus*. The present authors believe that the ingestion of sediment by *Chaceon ramosae* is both incidental and deliberate.

C. ramosae present the habits both of scavengers and of active feeding (i.e. predation). Thus, based on these analyses it is possible to affirm that this species is an opportunistic carnivore.

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