STOMACH CONTENTS OF THE CARIBBEAN SHARPNOSE SHARK *RHIZOPRIONODON POROSUS* (POEY 1861) (ELASMOBRANCHII: CARCHARHINIDAE) FROM THE COAST OF PARAÍBA, BRAZIL

CONTEÚDOS ESTOMACAIS DO CAÇÃO RABO-SECO *RHIZOPRIONODON POROSUS* (POEY 1861) (ELASMOBRANCHII: CARCHARHINIDAE) DA COSTA DA PARAÍBA, BRASIL

CONTENIDO ESTOMACAL DEL TIBURÓN BOCA ZAPATO *RHIZOPRIONODON POROSUS* (POEY 1861) (ELASMOBRANCHII: CARCHARHINIDAE) DE LA COSTA DE PARAÍBA, BRASIL

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Resumo

O hábito alimentar de *Rhizoprionodon porosus* foi determinada pela análise dos conteúdos estomacais dos animais capturados pela frota artesanal. As presas foram identificadas até o menor nível taxonômico possível e classificadas com o auxílio do Índice de Importância Relativa (IRI). Um total de 76 indivíduos foram analisados, com a predominância de jovens. Vinte e cinco estômagos estavam vazios, 14 contendo somente massa amorfa e o restante dos estômagos (37) tinha no mínimo uma presa em processo de digestão. O item predominante foi teleósteo, presente em todos os estômagos com conteúdo (83,8%), seguidos de crustáceos (18,9%) e moluscos (13.5%), totalizando 11 grupos taxonômicos identificados: peixes (Clupeidae, Engraulidae, Holocentridae, Ophichtidae, Pomacentridae e Pleuronectoidei), crustáceos (Isopoda, Stomatopoda e Penaeidae) e moluscos (Octopodidae e Loliginidae). Não foram identificadas diferenças significativas nos itens alimentares entre machos e fêmeas ou entre jovens e adultos. O Índice de Importância Relativa indicou que *Rhizoprionodon porosus* tem hábito piscívoro (95,5%), consumindo uma variedade de peixes, porém, complementando sua dieta com crustáceos e moluscos. Resultados similares tem sido encontrados para outras espécies de *Rhizoprionodon* e, provavelmente, isso está relacionado com sua seletividade por peixes e sua respectiva abundância nas áreas em que esses cações foram capturados.

Palavras-chave: dieta; elasmobrânquios; hábitos alimentares; piscívoros.

Resumen

Los hábitos alimenticios de *Rhizoprionodon porosus* se determinó mediante el análisis del contenido del estómago de los animales capturados. Las presas fueron identificadas al nivel taxonómico más bajo posible y clasificado con el Índice de

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Importancia Relativa (IRI). Se analizaron un total de 76 individuos, con predominio de jóvenes. Veinticinco estómagos estaban vacíos, 14 contenían solo masa amorfa y los estómagos restantes (37) tenían al menos una presa en digestión. El ítem predominante fueron los peces teleósteos, presentes en todos los estómagos con contenido (83.8%), seguidos por los crustáceos (18.9%) y los moluscos (13.5%), con un total de 11 grupos taxonómicos identificados: peces (Clupeidae, Engraulidae, Holocentridae, Ophichtidae, Pomacentridae y Pleuronectoidei), crustáceos (Isopoda, Stomatopoda y Penaeidae) y moluscos (Octopodidae y Loliginidae). No fueron encontrados diferencias significativas en los alimentos entre hombres y mujeres o entre jóvenes y adultos. El Índice de Importancia Relativa indicó que *Rhizoprionodon porosus* tiene un hábito piscívoro (95.5%), que consume una variedad de peces, pero que complementa su dieta con crustáceos y moluscos. Se han encontrado resultados similares para otras especies de *Rhizoprionodon* y probablemente esto está relacionado con su selectividad para los peces y su respectiva abundancia en las áreas en que se capturaron estos peces.

Palavras-clave: dieta; elasmobranquios; hábitos alimenticios; piscívoros.

Abstract

Feeding habits of *Rhizoprionodon porosus* were assessed by the analysis of stomach contents of individuals captured by artisanal fisheries. Prey items were identified to the lowest possible taxonomic level and classified according to the Index of Relative Importance (IRI). A total of 76 individuals were analyzed with a predominance of juveniles. Twenty-five stomachs were empty, fourteen contained only amorphous masses, and the remaining (37) had at least one partially digested prey. The predominant items were teleost fishes, present in 40 stomachs (83.8%), followed by crustaceans (18.9%) and mollusks (13.5%), totaling 11 identified taxonomic groups: Clupeidae, Engraulidae, Holocentridae, Ophichtidae, Pomacentridae and Pleuronectoidei (teleost fish); Isopoda, Stomatopoda and Penaeidae (crustaceans), and Octopodidae and Loliginidae (mollusks). No significant differences in food items were found between males and females or between juveniles and adults. The Index of Relative Importance indicated that *Rhizoprionodon porosus* has piscivorous habits (95.5%), consuming a variety of fish but complementing its diet with crustaceans and mollusks. Similar results have been reported for other *Rhizoprionodon* species, and this is probably related to their selectivity for fish and to the abundance of this type of prey in the areas where these sharks were taken.

Keywords: diet; elasmobranchs; feeding habits; piscivorous.

INTRODUCTION

Elasmobranchs occur in many aquatic ecosystems and comprise a dominant group of aquatic predators that feed on a high variety of prey categories (Cortés 1999). Information on their diets and feeding strategies is relevant to understand their

natural history as well as trophic level relationships in their aquatic environment (Wetherbee et al. 2012).

There are about 89 living species of sharks along the Brazilian coast (Rosa and Gadig 2014). Diet and feeding habits of coastal shark species are well documented due to their abundance and to their important role in traditional coastal fishing in Brazil (e.g. Lessa and Almeida 1997, 1998; Silva and Almeida 2001; Motta et al. 2009; Bornatowski et al. 2012).

Rhizoprionodon Whitley 1929 occurs in tropical and subtropical waters, comprising seven species of small-sized sharks (Compagno 2005). Studies on the diet of this shark group were carried out with six valid species and indicate that fish is a predominant item in its diet. In Brazilian waters, two species are commonly captured by artisanal fishery: *R. lalandii* and *R. porosus* (Figueiredo 1977). *Rhizoprionodon porosus* has been frequently captured by artisanal fisheries in Northern coast of Brazil. Although this species is not considered the main target of local fishery activity, and often being rated as bycatch, *R. porosus* has been found in local fish markets and obtained at low cost. Despite the diet and feeding habits of *Rhizoprionodon* sharks have been well documented, studies of the prey composition in species of Brazilian coast were carried out especially for *R. lalandii*. Even with information presented by Fermin and Bashirulah (1984) and Dallos et al. (2012) for *R. porosus*, investigation for Brazilian population of this species was limited to the northeastern coast (Maranhão State) and indicated that this species feeds mainly on fish and crustaceans, with little participation of cephalopods (Loliginidae) (Silva and Almeida 2001). As such, the current work examined stomach contents of *Rhizoprionodon porosus* from the Paraíba coast, comparing its diet to other investigations of this genus.

MATERIALS AND METHODS

The study was conducted from April/2002 to November/2003. The specimens were caught in the main fishery points along the coasts of Paraíba State, Brazil (Figure 1), during the daylight and using gillnets, as result of the artisanal fishery bycatch. Total length (TL, in cm), weight (in grams) and sex were recorded.

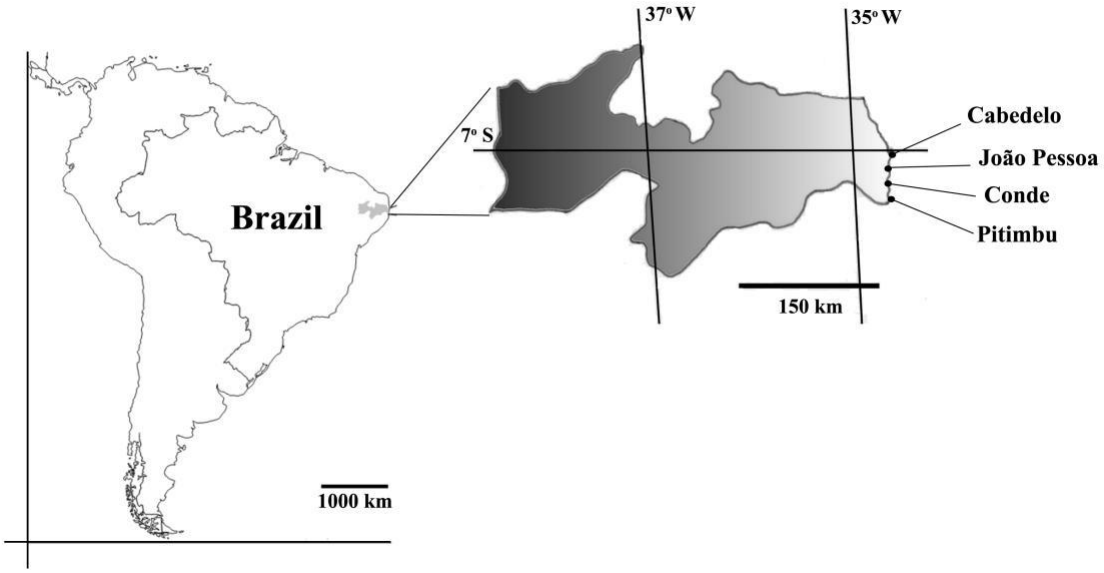

Figure 1. Sampling sites (Cabedelo, João Pessoa, Conde and Pitimbu counties) of *Rhizoprionodon porosus* off the coast of Paraíba State, Brazil.

Stomachs were removed and preserved in 10% buffered formalin solution and transferred to 75% ethanol. Stomach contents were sorted and weighted, and prey items were identified to the lowest taxonomic level, with the assistance of specialists for each taxonomic category or grouped as "unidentified in advanced states of digestion" (amorphous substances). For teleosts, items were also compared with specimens catalogued in the Fish Collection of the Universidade Federal da Paraíba (UFPB). Stomachs with thinner and more distended walls were categorized as "regurgitated", in comparison to empty stomachs (Simpfendorfer 1998).

Percentages of weight (%W), numbers (%N) and frequencies of occurrence (%FO) (Hyslop 1980) were calculated and these three measures used to construct the Index of Relative Importance (IRI) (Pinkas et al. 1971): IRI = (%W + %N) X %FO. The IRI values were transformed into percentages (%IRI, c.f. Cortés 1997) to facilitate comparisons among studies. Empty stomachs and those containing only amorphous substances were not considered in the IRI calculations.

RESULTS

Seventy-six specimens of *Rhizoprionodon porosus* were analyzed, with a predominance of juveniles (N = 54). Total lengths and weight varied from 31.2 to 81.5 cm and 95.8 to 2232.0 g for males (N=57), and from 33.5 to 91.5 cm and 114.0 to 3886.0 g for females (N=19).

At least one prey item had been found in thirty-seven stomachs (48.68%), while 25 (32.89%) were empty (two of them were inverted and three showed evidence of regurgitation), and the remaining stomachs (18.42%) contained amorphous

substances. Twenty-nine of the stomachs with prey items were from males and eight were from females.

A total of eleven different taxonomic prey groups were identified (mostly in Family level), distributed among three prey categories: mollusks, crustaceans and teleost fish (Table I). The %IRI showed teleosts were the dominant prey items in the diet of *R. porosus* (95.54%) with specimens from six families; clupeid fish were the most representative (29.41%). Crustaceans and mollusks were rare items, having %IRI values of 2.40 and 2.06, respectively. The three-dimensional graphical representation of the diet of *R. porosus* indicated a dominance of fish, with the rare participation of crustaceans and mollusks (Figure 2). The Table 2 presents a data survey of feeding habits and diet of *Rhizoprionodon* species.

Table I. Diet composition of *Rhizoprionodon porosus* from the coast of Paraíba State, Brazil, expressed in percentages of number (%N), weight (%W), and frequency of occurrence (%FO), as well as the Index of Relative Importance (%IRI).

Items	%N	%W	%O	%IRI
FISHES	75.2	85.1	83.8	95.5
Clupeidae	17.0	53.3	21.6	
Engraulidae	3.8	3.4	5.4	
Holocentridae	1.9	3.1	2.7	
Ophichtidae	1.9	2.8	2.7	
Pleuronectoidei	1.9	7.4	2.7	
Pomacentridae	1.9	2.4	2.7	
Unidentified	47.1	12.7	54.0	
CRUSTACEANS	13.2	4.7	18.9	2.4
Isopoda	1.9	<0.1	2.7	
Penaeidae	9.4	4.5	13.5	
Stomatopoda	1.9	<0.1	2.7	
MOLLUSKS	11.3	10.2	13.5	2.1
Loliginidae	5.7	1.3	5.4	
Octopodidae	3.8	7.8	5.4	
Unidentified	1.9	1.1	2.7	

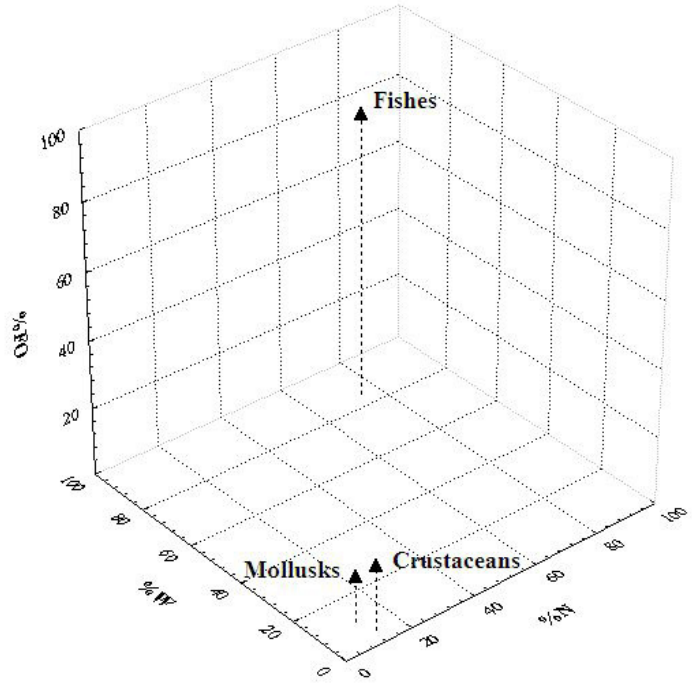

Figure 2. Three-dimensional graphic representation of the diet of *Rhizoprionodon porosus*, using percentages of weight (%W), number (%N) and frequency of occurrence (%F.O.).

Table II. Previous studies of the dietary composition of *Rhizoprionodon* species, showing the primary category followed by the less important prey in %IRI or other data analysis methods. Cep = Cephalopods, specifically; Cru=Crustaceans; Mol=Mollusks; Tel=Teleosts. Data Sources: 1. Ba et al. (2013); 2. Lima et al. (2000); 3. Salini et al. (2003); 4. Bornatowski et al. (2012); 5. Dallos et al. (2012); 6. Márquez-Farias et al. (2005); 7. Silva and Almeida (2001); 8. Fermin and Bashirulah (1984); 9. Stevens and McLoughlin (1991); 10. Simpfendorfer (1998); 11. Harrington et al. (2016); 12. Gelsleichter et al. (1999); 13. Drymon et al. (2012); 14. Bethea et al. (2006); 15. Hoffmayer and Parsons (2003).

Species	Method	Primary prey	Less important prey	References
R. acutus	%IRI; %O	Tel	Cep; Cru	1; 2
	%W	Tel	Cru; Cep	3
R. lalandii	%O; %IRI	Tel	Cep; Cru	2; 4
	%IRI	Tel	Cru	5
R. longurio	%IRI	Tel	Cep; Cru	6
R. porosus	%IRI	Tel	Cru; Cep	7
	%N; %W	Cru	Mol	8
	%IRI	Tel	Cru	5
R. taylori	%O	Tel	Cru; Cep	9; 10
R. terraenovae	%IRI	Tel	Cru; Cep	11; 12
	%IRI	Tel	Cru	13; 14; 15

DISCUSSION

The high %IRI value for fish items in the stomachs of *Rhizoprionodon porosus* indicated a relatively homogeneous diet of this prey type. This species has a piscivorous habit, consuming a variety of fish (six identified families). However, Silva and Almeida (2001) reported that crustaceans and mollusks are also important prey items for *R. porosus* along the northern coast of Brazil (Maranhão State) and that the species seems to have generalist habits.

Investigations of the diets of *Rhizoprionodon* species have shown teleosts as primary prey category, although crustaceans also had a significant participation for some species. Overall, crustaceans (mostly shrimps) and cephalopods have less importance on the feeding of *Rhizoprionodon*.

The consumption of clupeid fishes is probably related to the abundance of this group in the foraging area of *Rhizoprionodon*, the pelagic-neritic zone, where there is a high availability of this fish group (Lima et al. 2000; Silva and Almeida 2001; Bornatowski et al. 2012).

Overall, previous studies on the feeding of *Rhizoprionodon* have shown that they feed according to the prey availability in their habitat. Nevertheless, there is some selectivity especially for clupeid and sciaenid fish and, in case of crustaceans and mollusks, for penaeid and loliginid species (Simpfendorfer 1998; Hoffmayer and Parsons 2003; Bornatowski et al. 2012). All these preys are commonly found in demersal and pelagic zones, evidencing that *Rhizoprionodon* species actively forage in the water column. Although these relationships with diet were not carried out in the current investigation, they might occur in Paraiba coast, considering the diverse habitat for *Rhizopriondon porosus*.

Reinforcing previous works on the diet of *Rhizoprionodon*, the high number of empty stomachs, including two specimens with regurgitation evidences, suggests that the use of gillnets is not adequate for the purpose of investigating the diet and feeding habits (Simpfendorfer 1998; Bornatowski et al. 2012). The long period of entanglement in gillnets prolongs digestive activities of the stomachs, results in capture stress and consequently in empty stomachs or contents in advanced state of digestion (Wetherbee et al. 1990). Observation of the regurgitation was described for *R. taylori* (Simpfendorfer 1998), when the signs are clear to identify.

The diets and feeding habits of *Rhizoprionodon* sharks have been widely investigated and these analyses indicate that similar prey categories are consumed by all shark species of this genus. In an extensive investigation of the standardization of trophic levels in sharks carried out by Cortés (1999), five *Rhizoprionodon* species were considerate to belong to higher trophic levels (between 3.8 and 4.2), and fed mainly on fish (but with a significance participation of crustaceans in the diets of some species).

CONCLUSION

It is clear that *Rhizoprionodon porosus* has piscivorous habits along the Paraíba State coast in Brazil. Finally, the standardization of data analyses has contributed to the comparisons of the results of most of previous investigations, and all of them have demonstrated the predominance of fish in the diets of *Rhizoprionodon* species, despite slight differences in methodologies.

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