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FEED AND TROPHIC MORPHOLOGY OF YELLOW HAKE *CYNOSCION ACOUPA* (LACÈPEDE, 1801) IN THE NORTHEAST BRAZIL

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ABSTRACT

The stomach contents analysis revealed 72.4% of the items as fishes, 4.56% as crustaceans, 23.0% of organic matter and 0.1% as seagrass. The item Teleostei was featured as essential in feeding followed by fish Ariidae Family and the crustaceans, especially Penaeidae. The morphology of the digestive tube is characterized by presented short and tubular esophagus, stomach cecal form "Y" may be divided into cardiac (greater proportion), fundic and pyloric regions. The sphincter pyloric marks the transition from the stomach to the intestine. The intestine presented coefficient of 0.87 showed medium intestine and rectum portion separated by an ileo-rectal valve.

Keywords: Stomach contents, diet, carnivorous, characteristics anatomic, digestive system.

INTRODUCTION

Several species of Teleost fish in Brazil are marketed under the trade name of Hake, most belonging to Order Perciform, Family Sciaenidae, especially of the genus Cynoscion (Matos e Lucena, 2006). The Yellow Hake (*C. acoupa*) is part of this family considered of great commercial importance (Menezes e Figueiredo, 1980) and environmentally friendly food chains, being considered prey to some marine mammals such as sea-lion in South America, seals and franciscana dolphin (*Pontoporia blainvillei*), and seabirds (Waessle, 2003).

Fishes of the Family Sciaenidae are among the most fish in the Brazilian continental shelf, mainly in southern and southeastern Brazil (Vazzoler *et al*., 1999) representing one of the main fishery resources of shallow waters in many tropical and temperate regions of the world (Nelson, 1994) and intense fishing activity target held by the commercial fleet in these regions (Braga, 1990). To determine the sustainable potential of a fishing resource is necessary a comprehensive study involving, among other things, fish feed characteristics is essential for a better understanding of other subjects such as nutrition, wildlife surveys, trophic ecology where equal attention is given to both the predator or the prey and also for energy transfer studies, both in the individual and the ecosystem (Zavala-Camin, 1996) and thus subsidize management plans aimed at the rational exploitation of fish stocks and other marine organisms. The present work presents new information about natural feeding data and morphological features of *C. acoupa* through the examination your gastric system.

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MATERIALS AND METHODS

Sample Collection

The specimens of *C. acoupa* were captured in the shallow continental shelf in Piaui coast, at medium depths of 10m (02º51'28'' S; 41º49'15''W), monthly from July 2013 to January 2014, by the artisanal fisheries. The fishing gear used was gill nets, anchored positioned in the background with mesh opening of ranging from 12-15 cm. After a realization biometrics we performed a longitudinal incision in the abdominal cavity for extracting for the digestive tract. The material was packed in individual plastic bags containing a paper label with the information of total length (cm), weight (g), Sex (Male/Female), date and place of collection and subsequently frozen.

Study of Diet and Morphology

The degree of repletion (DR) of the stomachs was verified by visually estimating, according Santos (1978) and the degree of digestion of the item proposed by Zavala-Camin (1996) adapted by Vaske-Jr. *et al*. (2003).

The stomachs content were examined under a stereomicroscope and food items were identified to the

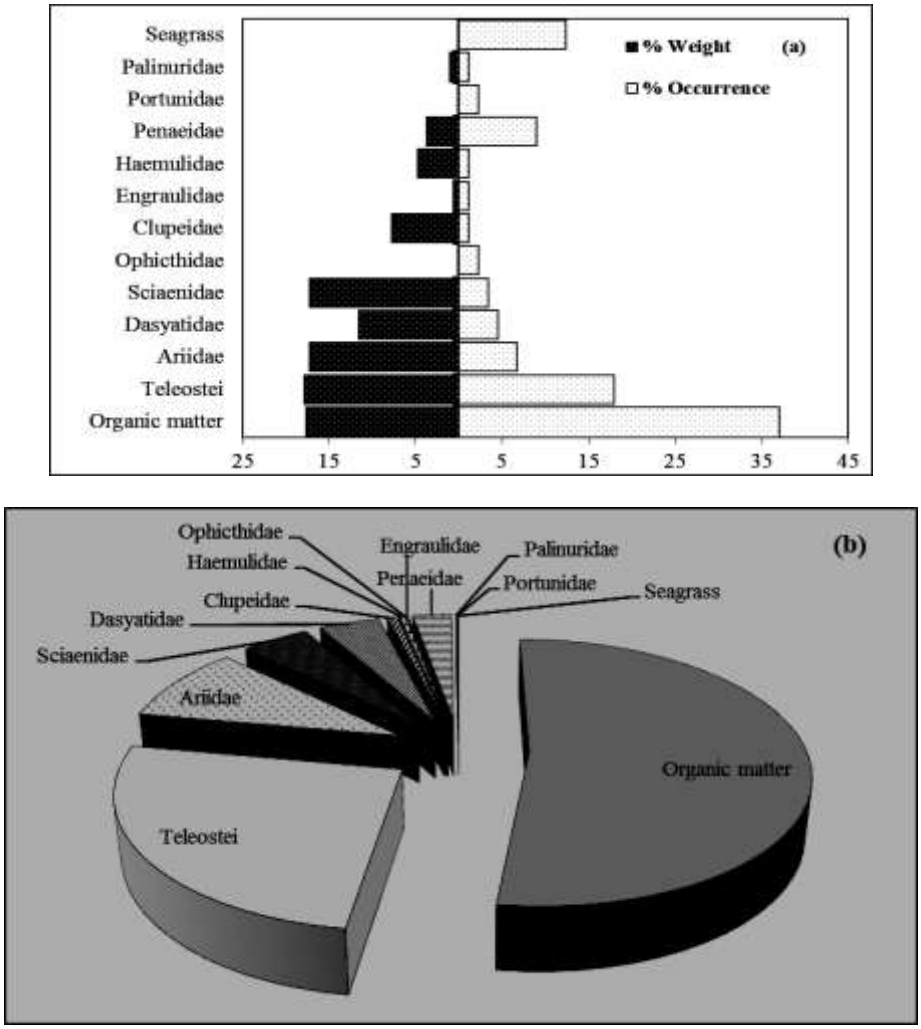

Fig. 1**. (a)** Participation in weight (% W) and Frequency of Occurrence (% FO) and **(b)** Food Index (% IAi) of food items found in the stomachs of *C. acoupa* captured in the Piaui coastline from July 2013 to January 2014.

lowest possible taxonomic level with the help of specialized literature, subsequently they were quantified and weighed (g) in digital scale with precision of 0.01g. During the counting of the items were considered only whole bodies or parts that clearly allowed the identification and quantification of the item.

Data analysis was across the frequency of occurrence according Hyslop (1980) and the gravimetric methods proposed by Hynes (1950). These data were combined in an alimentary index (IAi) proposed by Kawakami and Vazzoler (1980). Fifteen individuals of different sizes were taken at random for morphological characterization.

RESULTS AND DISCUSION

Overall Diet

The study was based on a lot of 83 specimens of *C. acoupa*, of these 53.9% were males and 46.1% females presenting overall length between 30 and 104 cm, with an average of 66 cm. Body weight ranged from 2.5 to 11.7 kg with an average of 6.4 kg. Among the stomachs analyzed seven were damaged, 30 were empty and 46 were considered for the analysis because it had some content.

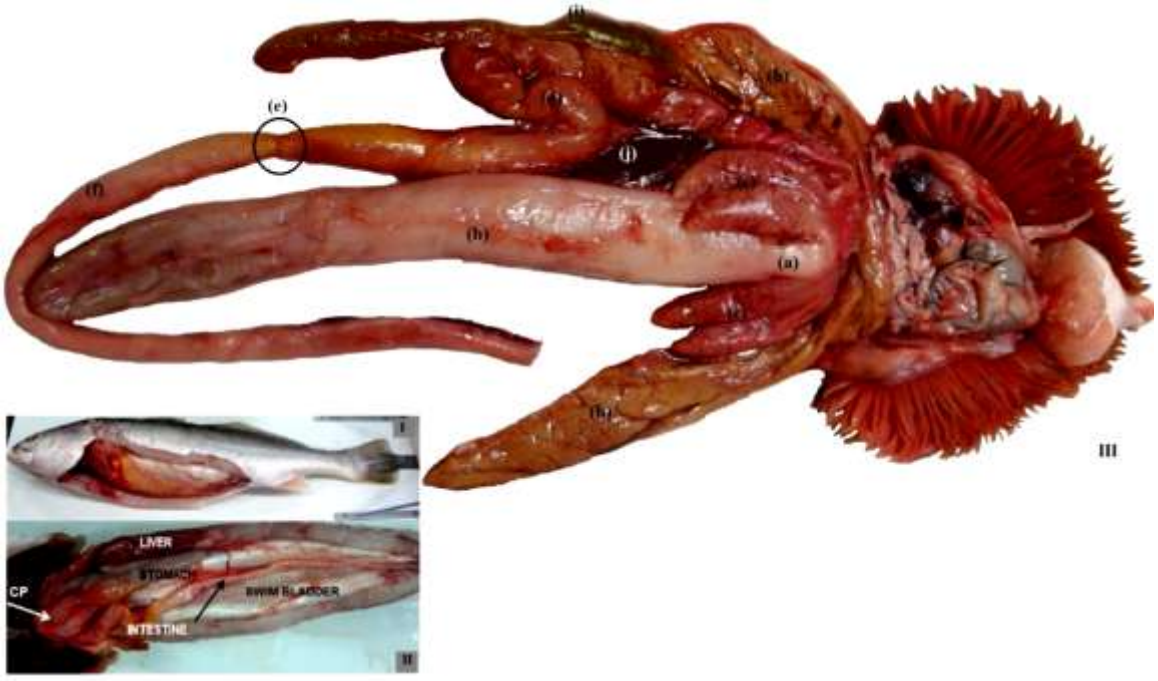

Fig. 2. **(I)** - Ventral view of the coelomic cavity *C. acoupa*, **(II)** Location stomach and swim bladder; **(III)** (a) esophagus; (b) stomach; (c) Pyloric caecum (CP); (d) intestine; (e) ileo-rectal valve; (f) Rectum; (h) Liver; (i) biliar vesicle; (j) Pancreas.

Table 1. Frequency of occurrence (FO) Volume (W) and feed index (IAi) of food items present in the stomachs of *C. acoupa* of Piaui coastline from July 2013 to January 2014.

Items	FO	%FO	W	%W	IAi
FISHES					
Dasyatidae	4	4.49	114.08	11.58	4.15
Teleostei	16	17.98	176.14	17.87	25.63
Ariidae	6	6.74	170.38	17.29	9.30
Sciaenidae	3	3.37	170.58	17.31	4.65
Ophicthidae	2	2.25	1.65	0.17	0.03
Clupeidae	1	1.12	76.80	7.79	0.70
Engraulidae	1	1.12	6.25	0.63	0.06
Haemulidae	1	1.12	46.77	4.75	0.43
CRUSTACEAN					
Penaeidae	8	8.99	36.36	3.69	2.65
Portunidae	2	2.25	1.35	0.14	0.02
Palinuridae	1	1.12	10.30	1.05	0.09
Organic matter (OM)	33	37.08	173.93	17.65	52.20
Seagrass	11	12.36	0.93	0.09	0.09
Total		100	985.52	100	100

The analysis on the degree of digestion indicated that most of the identified items found in the range III, followed by scale items II and to a lesser extent on the scale I, while the degree of repletion found in the stomachs with content revealed that 40.8% with 25% of the stomach occupied, 11 (14.5%) had between 25% and 75% of the occupied stomach, and only 4 (5.3%) degree of fullness 75-100%. The rest (39.5%), totaling 30 individuals presented degree of repletion 0, with empty stomach.

The food spectrum of *C. acoupa* presented an essentially carnivorous diet, with 4 food categories: Pisces, crustaceans (Decapod), OM (organic matter) and

seagrass. The obtained food items were represented by the following taxonomic groups: Teleostei, Ariidae, Sciaenidae, Ophicthidae, Clupeidae, Engraulidae, Haemulidae, Dasyatidae (Elasmobranchii), Penaeidae, Palinuridae, Portunidae, OM (organic matter) and seagrass (Table 1 and Fig. 1). In the fish category the families and species were identified: Ariidae (*Sciadeichthys luniscutis*), Sciaenidae (*Macrodon ancylodon*), Ophicthidae (*Ophichthus ophis*), Clupeidae (*Ophisthonema oglinum*), Haemulidae (*Genyatremus luteus*), Dasyatidae (*Dasyatis guttata* and *Dasyatis* spp.); while in the shellfish category occurred families and species: Palinuridae (*Panulirus laevicauda*), Portunidae (*Callinectes* spp.) and Penaeidae.

The largest proportion was in the category fish totaling 72.4% of the total weight of the items, the main were Teleostei (16.7%), and the Ariidae and Sciaenidae families, both with (16.2%) (Table 1 and Fig. 1a). Crustaceans showed 4.56% of highlighting the family Penaeidae (3.5%) (Table 1 and Fig. 1a). The plant represented solely by seagrass (0.1%) were considered incidental to present small proportion or weight (% W) (Table 1 and Fig. 1a).

The frequency of occurrence method (Table 1 and Fig. 1a) showed there was dominance of Teleostei (35.54%) and by family Penaeidae with (17.77%), followed by Family Ariidae (13.33%), Dasyatidae (8.89%), Sciaenidae (6.66%), Ophicthidae and *Callinectes* spp., both with 4.44% (Table 1 and Fig. 1a). Families Clupeidae, Engraulidae, Haemulidae and *Panulirus laevicauda* presented FO = 2.22% (Table 1 and Fig. 1a).

The Food Index express preferred food. The items essential were Teleostei (2722.76) followed by Family Ariidae with 734.99 (Table 1 and Fig. 1b). The taxonomic group of crustaceans with almost all belonging to the Family Penaeidae with 475.77, even though they have contributed significantly in the diet were classified as prey of secondary importance (Table 1 and Fig. 1b).

Trophic Morphology

The peritoneal cavity *C. acoupa* is relatively small (Fig. 2 I) as compared to the muscle mass of the fish. The digestive tract while extending along the cavity does not completely fill in due to the large volume occupied by the swim bladder and gonads that also extend throughout the peritoneum from the anterior third to the rectum (Fig. 2 II).

Most organs are in the anterior third of the celomatic cavity providing up sequentially the esophagus and stomach, pyloric caeca, liver and gallbladder, and in the middle portion occurs the intestine with shaped "N", and ends with the last intestinal segment that ends at the rectum and anus, located caudally (Fig. 2 III).

The esophagus is a relatively short, tubular and distensible with thick walls having folds 10 on average continuously to the pharynx and terminates at the cardiac region of the stomach, measuring approximately 3 cm in length.

The stomach is well developed with an average length of 17 cm; with linear format in "Y" shaped the cecal type presenting 3 well defined regions: cardiac (tube), fundic (shaped bag) and pyloric (tube). The cardiac and fundic regions are aligned in the same plane, responsible for food storage and in the stomach emptying, respectively, while the pyloric region is perpendicular to this plane, proportionately lower (Fig. 2 IIIb). The cardiac region is the largest portion of the stomach, accounting for about 60% of the total size (10.2 cm average), with large folds with average thickness of 3.6 mm in the longitudinal direction parallel, continuous folds with fundic or cecal region (thickness 1.8 mm), which represents 40% (6.5 cm) on average the total size of the stomach. The pyloric region is the minor, having an average length of 1.4 cm, with thin folds (1.7 mm thick) with a pyloric sphincter, which marks the transition from the stomach to the intestine.

The pyloric caeca are presented in the form of four small blind end tubes measuring on average 6.6 cm, project him from pyloric sphincter at the beginning of the midgut. The pattern of folds similar to the intestine, networked, with thickness 0.8 mm average (Fig. 2 IIIc). The intestine is relatively short, tubular shape, measuring 44.7 cm in total length, on average, formed by midgut and rectum, proportionally representing 60% (± 26.64 cm) and 40% (± 1.18 cm) of total length (Fig. 2 IIId). Among these there is the presence of a constriction characterized by a thickening of the muscle that forms the ileo-rectal valve enabling to make distinction between posterior intestine and rectum (Fig. 2 IIIe). Intestinal coefficient considered low with an average value of 0.87, indicating their carnivorous feeding habit.

The specimens examined in this study were derived from fishing and had sex ratio with a predominance of males (1.2 M: 1 F) and also observed that 63.6% of subjects were above the length of 1st maturity according to determining Chao (1978) which indicated that this maturity is achieved in individuals with 53 cm in total length. These characteristics are positive indications of the sustainability of the fishery yellow hake in Piaui coast.

It was possible to register a high incidence of empty stomachs (39.5%) among the samples used in this study. This feature can be associated to the characteristics of fishing gear used (network-in-waiting) as characteristics of the fishery. After being caught in the fishing gear, fish remain for a long period without food (Zavala-Camin, 1996), about 4 hours reported in this study. Fish caught

remain trapped on the network until they came on board and die quickly after capture, aspects that contribute to the advanced state of digestion of items observed in the stomachs. These observations are in line with Zavala-Camin settings (1996), where it comments that the fishing techniques with long periods of exposure influence in different ways in the obtained sample, including states, the de-expected net kill the fish quickly. However, when fishing a fish will postmortem digestion, while others will continue digesting alive and others will have to opportunity to continue to feed. Another contributing factor reported by fishermen is the fact regurgitation occur at the time of fishing, which claim that it is common to identify this process at the time of evisceration by the occurrence of prey in the mouth and esophagus yellow hake. According to Fonteles-Filho (2011), the fish may regurgitate stomach contents when hoisted aboard from great depths. The regurgitation process is described by Zavala-Camin (1996) as the partial or complete expulsion of stomach contents through the esophagus and is recognized by the occurrence of distended stomachs, empty or with little stomach contents. The incidence of empty stomachs is also a feature of carnivorous species (Gerking, 1994), as ingest trapped relatively large, high nutritional value and easily digestible, reducing the time to satiation (Hahn *et al*., 1999).

The plant food intake exclusively represented by seagrass in *C. acoupa* diet was considered accidental, because some aspects such as: the rapacious character of the species to snatch the prey ends up ingesting fragments of nearby vegetation and also the kind of behavior search for the next food in the background, due to its nekton-benthic habit, as it actively moves and lives most of the time in association with the substrate, dwelling sludge areas, sand or gravel, is coastal shallow water, brackish estuaries , estuarine lagoons and mouths of rivers, at depths ranging from 1-35 meters, and may also enter into the freshwater (Carvalho Filho, 1999). Finally, the species does not show anatomical adaptations required to use this feature (Zavala-Camin, 1996), evidenced by the fact that this item remain intact until the intestine.

In this analysis, the gravimetric method was used to measure the volume of food items to best suit the biological and anatomical characteristics of the species, the large size of the found items. The percentage of weight or volume has been considered by some authors as the most suitable approach to describe the importance of prey in the diet (Liao *et al*., 2001). The food index applied in this study proved to be appropriate in the context of the study and predator characteristics, combined with the objectives and work of the questions (Hahn and Delariva, 2003).

The power of Yellow hake (*C. acoupa*) was similar to hake-do-Piaui (*Plagioscion squamosissimus*) both of Sciaenidae, with a fish-based diet and shrimp (*Macrobrachium amazonicum*) (Santos *et al*., 2014) except for the presence of aquatic insects, absent in *C. acoupa*, concluding that it is a species of carnivorous feeding habits, prone to piscivory.

Several species of the Sciaenidae family were the subject of studies regarding its feed. Among them we can mention *Ctenosciaena gracilicirrhus*, *Macrodon ancylodon* and *Bairdiella ronchus*, whose studies showed no resemblance to the composition of the diet of *C. acoupa.* The species *C. gracilicirrhus* revealed broad food spectrum, comprising 15 food items, mainly consists of crustaceans (Gammaridae and Penaeidae) and Polychaete, other items were found fish scales, eggs and diatoms, foraminifera and bivalve (Cunningham, 1989). Studying the power *Macrodon ancylodon* verified as food items, crustaceans for young fish specimens to mature specimens (Juras and Yamaguti, 1985) although there is similarity between the items, you cannot relate to *C. acoupa* diet to maturation stages because they were not addressed their reproductive aspects in this study. Was registered in the diet of *B. ronchus* mainly crustacean decapod, and copepod and isopod, and other items were identified as fish, algae, higher plants, bivalves and gastropods (Vendel and Keys, 1998).

The species under study presents the carnivorous trend similar to other large species such as Common snook (*Centropomus undecimalis*) studied in the lagoon complex Mundaú in Alagoas (Teixeira, 1997) where it fed mainly on fish and secondarily crustaceans while the Golden (*Salminus brasiliensis*) fed into adulthood, preferably fish (Rodrigues and Menin, 2008).

Wootton (1990) emphasizes that fish are good samplers of the environment and their stomach contents reflect the availability of food. Thus, the species of carnivore habits reveal the fish fauna in the area and this top-down effect has been called trophic cascade (Carpenter and Kitchell, 1993). In this context, analyzing the *C. acoupa* of dietary components that inhabits the area of influence of the Parnaiba River estuary reveals the availability of prey in the area, at least related to fish fauna, as from the first ichthyofauna surveys conducted by Oliveira (1974), Families Scianidae and Ariidae are presented dominant with high numbers of species. Thus, the species appears as a balance of maintaining indicator of local fish populations and contributes to environmental health by their position in the food chain.

REFERENCES

Braga, FMS. 1990. Estudo da mortalidade de *Paralonchurus brasiliensis* (Teleostei, Sciaenidae) em área de pesca do camarão-sete-barbas (*Xiphopenaeus kroyeri).* Boletim do Instituto de Pesca. 17:27-35.

Carpenter, SR. and Kitchell, JF. 1993. The trophic cascade in lakes. Cambridge University Press, Cambridge. pp. 385.

Carvalho Filho, A. 1999. Peixes: costa brasileira. Editora Melro, São Paulo. pp. 320.

Chao, LN. 1978. Sciaenidae. In: FAO Species Identification Sheets for Fishery Purposes, West Atlantic (Fishing Area 31). Ed. Fischer, W. FAO, Rome. 4:94.

Cunningham, PTM. 1989. Observações sobre o espectro alimentar de *Ctenosciaena gracilicirrhus* (Metzelaar), Sciaenidae. Revista Brasileira de Biologia. 49(2):335-339.

Fonteles-Filho, AA. 2011. Oceanografia, biologia e dinâmica populacional dos recursos pesqueiros. Expressão Gráfica e Editora, Fortaleza. pp. 460.

Gerking, SD. 1994. Feeding ecology of fish. Academic press, San Diego, California. pp. 416.

Hahn, NS., Loureiro, VE. and Delariva, RL. 1999. Atividade alimentar da curvina *Plagioscion squamosissimus* (Heckel, 1840) (Perciformes, Sciaenidae) no rio Paraná. Acta Scientiuarum. 21:309-314.

Hahn, NS. and Delariva, L. 2003. Métodos para avaliação da alimentação natural de peixes: o que estamos usando? Interciencia 28:100-104.

Hynes, HBN. 1950. The food of freshwater sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in studies of the food of fishes. Journal Animal Ecology. 19:36-58.

Hyslop, EJ. 1980. Stomach contents analisys; a review of methods and their application. Journal of Fish Biology. 17:411-429.

Kawakami, E. and Vazzoler, G. 1980. Método gráfico e estimativa do índice alimentar aplicado no estudo de alimentação de peixes. Boletim do Instituto Oceanográfico. 29(2): 205-207.

Juras, AA. and Yamaguti, N. 1985. Food and feeding habitats of king weakfish, *Macrodon ancylodon* (Bloch and Schneider, 1801) caught in the southern coast of Brazil (Lat.29° to 32° S). Boletim do Instituto Oceanográfico. 33(2):149-157.

Liao, H., Pierce, CL. and Larscheid, JG. 2001. Empirical assessment of indices of prey importance in the diets of predacious fish. Transactions of the American Fisheries Society. 130:583-591.

Matos, IP. and Lucena, F. 2006. Descrição da pesca da pescada-amarela, *Cynoscion acoupa*, da costa do Pará**.** Arquivo de Ciências do Mar. 39:66-73.

Menezes, NA. and Figueiredo, JL. 1980. Manual de peixes marinhos do sudeste do Brasil. IV. Teleostei (III). Museu de Zoologia da USP, São Paulo. pp. 110.

Nelson, JS. 1994. Fishes of the World. John Wiley and Sons Inc., New York, USA. pp. 600.

Oliveira, AME. 1974. Ictiofauna das Águas estuarinas do Rio Parnaíba (Brasil). Arquivo de Ciências do Mar. 14:41-45.

Rodrigues, SSN. and Menin, E. 2008. Anatomia do tubo digestório de Leporinus macrocephalus (Characiformes, Anostomidae) em relação a seu habitar alimentar. Bioscience Journal. 24(3):86-95.

Santos, EP. 1978. Dinâmica de populações aplicada à pesca e a piscicultura. HUCITEC, EDUSP, São Paulo. pp. 129.

Santos, NCL. Medeiros, TN. Rocha, AAF. Dias, RM. and Severi, W. 2014. Uso de recursos alimentares por *Plagioscion squamosissimus* - piscívoro não-nativo no reservatório de sobradinho-Ba, Brasil. Boletim do Instituto de Pesca. 40:397-408.

Teixeira, RL. 1997. Distribuition and feeding habitats of the young common snnok, *Centropomus undecimalis* (Pisces: Centropomidae) in the shallow waters of a tropical Brazilian estuary. Boletim do Museu Biologia Mello Leitão. 6:35-46.

Vaske-Jr., T. Vooren, CM. and Lessa, RP. 2003. Feeding Strategy of Yellowfin Tuna (*Thunnus albacares*) and Wahoo (*Acanthocybium solandri*) in the Saint Peter and Saint Paul Archipelago, Brazil. Boletim do Instituto de Pesca. 29:173-181.

Vendel, AL. and Chaves, PTC. 1998. Alimentação de *Bairdiella ronchus* (Cuvier) (Perciforme, Sciaenidae) na Baía de Guanabara, Paraná, Brasil. Revista Brasileira de Zoologia. 15:297-305.

Vazzoler, AEM. Soares, LSH. and Cunningham, PM. 1999. Ictiofauna da Costa brasileira. In: Estudos ecológicos de comunidades de peixes tropicais. Ed. Lowe McConnell RC. Editora da Universidade de São Paulo, São Paulo, Brazil. 424-467.

Waessle, JA., Lasta, CA. and Favero, M. 2003. Otolith morphology and body size relationships for juvenile Sciaenidae in the Rio de la Plata estuary (35-36ºS). Scientia Marina. 67(2):233-240.

Zavala-Camin, LA. 1996**.** Introdução aos estudos sobre alimentação natural em peixes. NUPELIA, EDUEM, Maringá. pp.129.

Wootton, RJ. 1990. Ecology of Teleost Fishes. Chapman & Hall, London. pp. 404.

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