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RESEARCH ARTICLE OPEN ACCESS

FEEDING ASPECTS OF *NOTARIUS GRANDICASSIS* (SILURIFORMES: ARIIDAE) CAUGHT BY ARTISANAL FISHERIES ON THE EASTERN AMAZON COAST, STATE OF MARANHÃO, BRAZIL

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ABSTRACT

The analysis of stomach contents is one of the few methods that provide information on food ecology and the trophic spectrum of fishes in their natural habitat. The aim of the present study was to investigate the food spectrum of *Notarius grandicassis* caught by the fishing fleet operating in estuaries in the state of Maranhão (Eastern Amazon). Biological material was obtained from artisanal fisheries in the study area. Sampling was conducted between April 2012 and August 2013 using driftnets with stretch mesh sizes from 40 to 120 mm. Stomach content analysis enabled the identification of a diet consisting of six categories of food items: Crustacea Decapoda, Crustacea Isopoda, Crustacea Cumacea, Mollusca Bivalvia, fishes and plant material. The analysis indicates a tendency toward greater feeding activity in the rainy season. Ontogenetic changes in the consumption of species were also observed, with a predominance of crustaceans and fishes among larger individuals and Crustacea Cumacea, Crustacea Isopoda and plant material exclusively consumed by smaller individuals. The Feeding activity results found in this study can contribute to fishing strategies and the management of this potentially exploitable economic resource.

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INTRODUCTION

Studies on the feeding activity of species provide basic biological knowledge and enable inferences regarding population dynamics, contributing to the understanding of the partition of resources, habitat preferences, prey selection, predation, evolution, competition and the transference of energy within and between ecosystems (Wootton, 1992; Lima and Behr, 2010).

Studies involving the analysis of stomach contents are among the few resources that provide information on feeding ecology and the trophic spectrum of fishes in their natural habitat (Palmeira and Monteiro-Neto, 2010). Quantitative information on the diet of aquatic organisms is essential to the development of models that consider trophic interactions and the flow of nutrients in aquatic systems. This is one of the basic requirements for a detailed examination of the relations between fishes and their habitats (Fatema *et al*., 2013; Campos *et al*., 2015).

Neotropical fishes generally exhibit trophic plasticity, varying their diet in accordance with space, season and ontogeny (Abelha *et al*., 2001; Castro *et al*., 2018). Fishes use quite diverse food items that differ in type (animal, plant or detritus/sediment) and origin (autochthonous or allochthonous). The availability of these items in aquatic environments is also variable (Bennemann *et al*., 2005). This variation is influenced by characteristics of the water body and surrounding area and can occur seasonally and/or spatially as a function of the longitudinal gradient of the watercourse (Gomiero and Braga, 2005; Castro *et al*., 2018). The Amazon coast is one of the main aquatic systems in Brazil. The eastern portion of the Amazon coast involves the Maranhão Inlets, where the family Ariidae constitutes one of the most abundant fishing resources (Silva *et al*., 2018). This group of catfishes occurs in coastal tropical and subtropical areas in marine, estuarine and freshwater environments and is generally abundant in shallow coastal waters with a muddy bottom, using these areas for feeding, reproduction and shelter (Araújo, 1988; Andreata *et al*., 1989; Gurgel *et al*., 2000).

One of the main representatives of the family Ariidae exploited on the Amazon coast is the Thomas sea catfish, *Notariusgrandicassis* (Valenciennes, 1840), which of considerable importance to fishing activities, especially artisanal fisheries. Several studies have addressed the importance of catfish as fishing resources along the entire coast of Brazil due to their economic value and use as subsistence for the human population (Barbieri, 1992; Amezcua and Muro-Torres, 2012; Hernández-Morales *et al*., 2018; Zavala-Leal *et al*., 2019). However, publications on the feeding habits of *N. grandicassis* are scarce (Mendes and Barthen, 2010). Studies that address feeding aspects are essential to the monitoring and management of species, offering data that can assist in fishery management measures and the maintenance of the exploitation of the stock at sustainable levels. Studies on variations among size classes per sex associated with the food supply of marine fishes have been conducted throughout the world to broaden knowledge on trophic dynamics and the feeding strategies of species, offering a more complete understanding of the functional role of these species within an ecosystem (Oliveira *et al*., 2012; Fontelles-Filho, 2011). Therefore, the aim of the present study was to investigate the feeding spectrum of *N. grandicassis* caught by the fishing fleet operating in the Maranhão Inlets (Eastern Amazon), assuming the hypothesis that the feeding strategy of this species is associated with at least one of the following factors: seasonal dynamics, ontogenetic factors or the supply of available items.

MATERIAL AND METHODS

The study area was the Maranhão Inlets, which is one of the most extensive areas of mangrove in Brazil and is part of the Eastern Amazon (latitude: 1º02' to 2º27'S; longitude: 46º02' to 43º38'W). The study areas covers a region that spans from Tubarão Bay to Gurupi Bay and is often used by artisanal fisheries (Cantanhêde *et al*., 2007) (Figure 1). According to the Köeppen classification, the climate of the region is Aw, characterized as wet tropical, with rainfall concentrated in summer and a dry season in winter (Dubreuil *et al*., 2017). Due to the proximity to the equator, the annual temperature range varies little (Torres and Machado, 2008) and two distinct seasonal periods are defined based on precipitation: a rainy season (January to June) and a dry season (July to December) (Azevedo and Cutrim, 2007). Mean annual precipitation is 1896 mm (INMET, 2019). The study area is characterized by a coastal region dominated by numerous inlets with a large number of islands, peninsulas, bays, creeks and tidal channels with clay and mud, which favor the development of mangroves (El-Robrini *et al*., 2006; Rebelo-Mochel and Ponzoni, 2007). The high concentration of nutrients and other favorable environmental conditions, such a variable thermal and salinity gradients, and the exceptional sheltering characteristics that offer support to the reproduction and initial feeding of marine and estuarine species make this region one of the main focuses of attention in terms of environmental conservation and the maintenance of its biodiversity (Lefèvre *et al*., 2017).

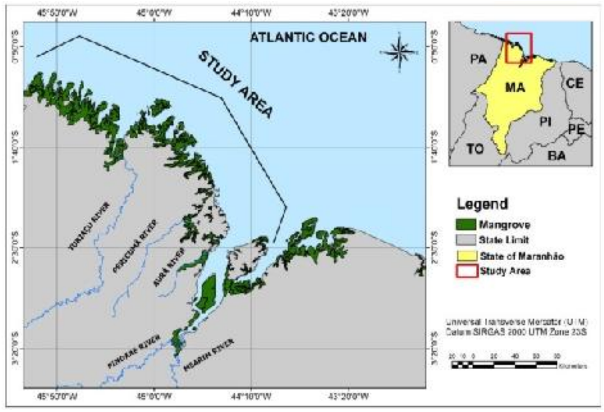

Figure 1. Area of capture of *Notariusgrandicassis* (Valenciennes, 1840), Maranhão Inlets, Brazil

Biological material was obtained from artisanal fisheries operating in the study area. Landings were monitored from April 2012 to August 2013 to encompass the environmental and climatic variability of the region. The individuals were caught with using driftnets with stretch mesh sizes from 40 to 120 mm during six-hour periods. The individuals were placed in coolers and conserved on ice until arrival at the Ichthyology Lab of the Federal University of Maranhão. At the lab, the species were identified based on Marceniuk (2005) and the following measurements were made on each individual: total length (L_t) in centimeters, total weight (W_t) in grams, stomach weight (W_s) in grams, fullness stage and characterization of sex based on the macroscopic analysis of the gonads (Vazzoler, 1996). The stomachs were removed by an abdominal incision from the base of the anal fin to the anterior region of the body and stored in 10% formol. Prior to analysis, the stomachs were washed and transferred to 70% alcohol. The stomach of each individual was weighed full and empty. The extracted contents were placed in Petri dishes for identification and weighing of the food items. The volume (ml) of each item was determined based on the displacement of liquid following immersion in a graduated test tube (Hyslop, 1980; Capitoli, 1992). Voucher material was deposited at the Ichthyology Collection of the Department of Biology of the Federal University of Maranhão, Brazil (CPUFMA 122823 to 132828). The definition of class intervals followed the recommendation in which the range of the length groups for a length frequency histogram generally depends on the maximum and minimum length of the fish and the number of individuals measured (Zale *et al*., 2012). The feeding habits of *N. grandicassis* were analyzed based on frequency of occurrence and volumetric measures (Hyslop, 1980) for the subsequent determination of the Index of Alimentary Importance (IA_i) (Kawakami and Vazzoler, 1980).

Frequency of occurrence (Fi): determines the number of stomachs in which a given prey item was found using the following equation:

$\%F = \frac{(n \times 1\ \ )}{N}$,in which:

Fi = frequency of occurrence of item *i* in diet of species;
ni = number of times food item *i* is repeated in stomachs;
N = total number of items in stomachs analyzed.

Volumetric frequency:

$\%F = \frac{(V \times 1\ \ )}{V}$,in which:

Fv = volumetric frequency of item *i* in diet of species;
Vi = volume of each food item *i*;
V = total volume of items in stomachs analyzed.

Index of alimentary importance (IAi): method proposed by Kawakami &Vazzoler (1980) using frequency of occurrence and volumetric frequency of each food item represented in percentage.

$\% I_i = \frac{F \times V}{\sum(F \times V)} \times 100$,in which:

IAi = Index of Alimentary Importance (ranges from 0 to 100);
Fi= frequency of occurrence of each food item *i*;
Vi = volume of each food item *i*.

From the frequency distribution by total length class, three size groups were defined to determine possible ontogenetic changes in feeding habits within the size range of the individuals collected: Class I (< 40.3 cm), Class II (> 40.3 cm and < 57.5 cm) and Class III (> 57.5). Principal component analysis (PCA) was performed to determine possible associations between size class and food items using a variance-covariance matrix and absolute frequency data of the items. LOG (X+1) transformation was employed for all data prior to the multivariate analysis (Castro *et al*., 2018).

The same ordination analysis was performed to detect possible seasonal changes in the consumption pattern of the food items for *N. grandicassis*. Analysis of similarity (ANOSIM) was used to determine the occurrence of trophic ontogeny for *N. grandicassis* (Clarke, 1993) in the Maranhão Inlets. Similarity percentage (SIMPER) analysis was performed to identify food items that contributed to the formation of the groups in the ordination analysis and identify the importance of each item in the group formed through the product between dissimilarity and the standard deviation (CLARKE, 1993). All analyses were processed using the PAST statistical program, version 3.14 (Hammer, 2001).

RESULTS

Four hundred thirty-four specimens of *N. grandicassis*were analyzed: 80 males and 354 females. Total length ranged from 28.6 to 59.5 cm for males and 27.4 to 69 cm for females. Total weight of the individuals caught was 102,953.38 g for males and 239,183.84 g for females. The frequency distribution per total length class interval indicated a predominance of females in all defined class intervals, with the exception of the 31.7 to 36.0 cm interval. The modal length class for all data pooled by sex ranged from 44.6 to 48.9 cm. Only females were recorded at a total length of 61.8 cm and larger (Figure 2).

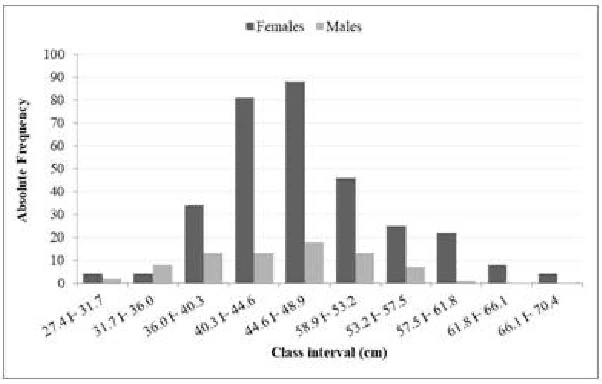

Figure 2. Frequency distribution by total length (cm) class interval for *N. grandicassis*males and females caught in Maranhão Inlets, Brazil

The stomach content analysis revealed a total of 678 food items. However, 271 were characterized as digested matter or matter in an advanced stage of digestion, which impeded precise identification. The identification of the remaining contents enabled the determination of a diet consisting of six categories of food items: CrustaceaDecapoda, Crustacea Isopoda, CrustaceaCumacea, Mollusca Bivalvia, fishes and plant material. Decapods were composed of the shrimp *Litopenaeus schmitti* (Burkenroad, 1936), crabs of the genus *Uca*, crabs of the genus *Callinectes* and hermit crabs of the family Diogenidae (Figure 3).

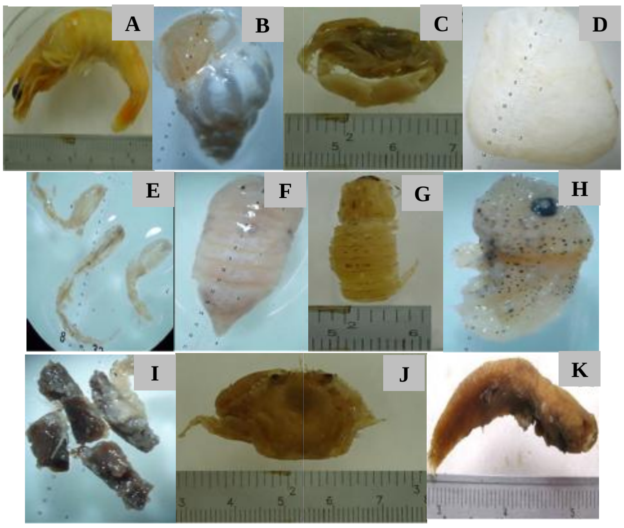

Figure 3. Main items in stomachs of *N. grandicassis*: A – shrimp – (Crustacea Decapoda); B – hermit crab (Crustacea Decapoda) ; C – crab (Crustacea Decapoda); D – shell (Mollusca Bivalvia); E – Crustacea Cumacea; F and G – Crustacea isopoda; H – fish larva; I – plant material; J – crab (Crustacea Decapoda); K – fish

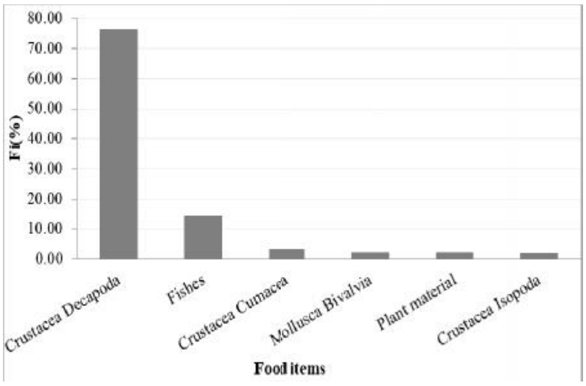

Figure 4. Dietary composition of *N. grandicassissis* caught in Maranhão Inlets, Brazil

The frequency of occurrence (Fi) of the food items indicated the dominance of CrustaceaDecapoda (76%), followed by fishes (14%). All other contents had frequencies lower than 4% (Figure 4). The frequency of occurrence of the food items was also evaluated by collection month. CrustaceaDecapoda dominated throughout the sampling period. Although at a smaller proportion, fishes were also found throughout all collection months, whereas CrustaceaCumacea was recorded in Abril, May, September and November 2012. Plant material was identified in May, November and December 2012. Mollusca Bivalvia was identified in May and September 2012. Crustacea Isopoda was recorded in May and June 2012 (Figure 5A). The largest diversity was found in May 2012 and the lowest was found in July 2013, when the sampling of items was dominated by CrustaceaDecapoda as well as a small record of fishes.

The frequency of occurrence of the food items per length class revealed the main components consumed throughout the ontogenetic development of the species. CrustaceaDecapoda (shrimps and crabs) contributed to the diet of all classes (Figure 5B), suggesting that this is an essential element to the food supply of the species. Only crustaceans and plant material were found for the smallest class, whereas the diet of largest classes comprised fishes, shrimps and crabs. The most important food items for *N. grandicassis*in the Eastern Amazon (coast of the state of Maranhão) based on volumetric frequency (Fv) were CrustaceaDecapoda (57.4%) and fishes (41.1%); all other items had Fv lower than 10%. The evaluation by sampling month also indicated the preference for CrustaceaDecapoda (shrimps and crabs) and fishes, as these contents were recorded throughout the entire sampling period.

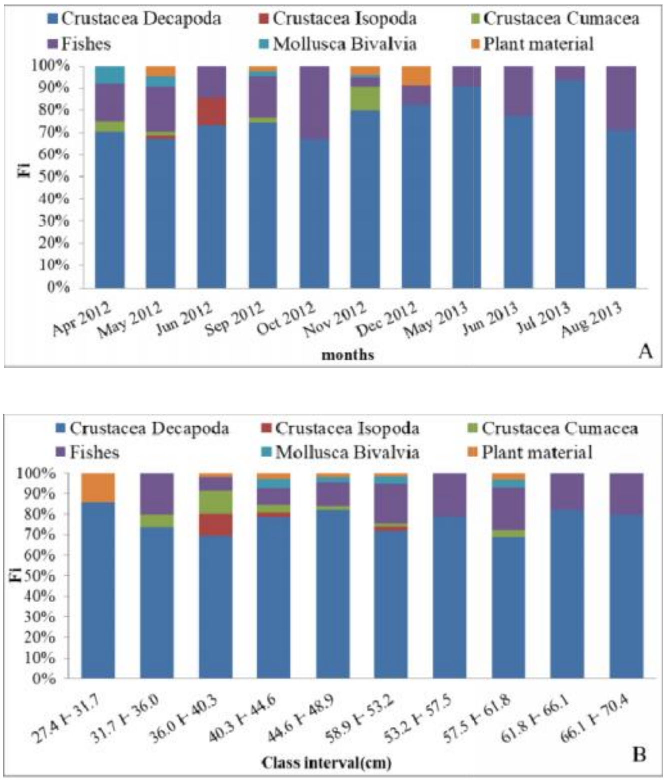

Figure 5. Frequency of occurrence of food items per sampling month (A) and length class (B) in stomachs of *N. grandicassis*caught in Maranhão Inlets, Brazil

The highest percentages for volumetric frequency were found in April 2012 (18.9%) and September 2012 (15.05%), whereas the lowest were recorded in June 2013 (1.02%) and July 2013 (1.39%). The percentage composition of the diet of *N. grandicassis* based on the Index of Alimentary Importance (IAi) revealed a feeding spectrum concentrated on shrimps and crabs (CrustaceaDecapoda) (86.08%), followed by fishes (13.75%). The other contents had IAi values lower than 1% (Table 1).

Axes 1 and 2 of the principal component analysis (PCA) between the sampling months and number of food items corresponded to 77.1% of the total variance in the data; Axis 1 accounted for 55.7% and Axis 2 accounted for 21.4%. The results reveal that *N. grandicassis* in the Maranhão Inlets has a tendency toward greater feeding activity in the rainy season regarding all food items (Figure 6A). The individual representation of the weight of each specimen also indicated a tendency for individuals with greater weight to occur in the rainy season (Figure 6B), confirming the results of the ordination analysis.

The PCA applied to the size of the individuals in association with the food items revealed a significant change in the food spectrum throughout the ontogenetic development of the species. The first two axes of the component accounted for 77.4% of the total variance in the data. CrustaceaDecapoda and fishes were negatively correlated with Component 1 and were associated with Class 3, which corresponds to larger individuals (greater than 57.5 cm). Plant material exhibited a strong positive correlation with Component I, indicating its association with Class 1, which corresponds to individuals smaller than 40.3cm. Crustacea Isopoda, CrustaceaCumacea and Mollusca Bivalvia were positively correlated with Component 2 and associated with Classes 2 (individuals with lengths between 40.3 and 57.5cm) and Class 1 (Figure 7). The analysis of similarity (ANOSIM) revealed significant differences among the three size classes ($p < 0.05$; $R = 0.27$), complementing the results of the SIMPER analysis. Fishes and CrustaceaCumacea contributed most to the dissimilarity between Classes 1 and 2, with a greater consumption of fishes, on average, in Class 2 and CrustaceaCumacea in Class 1.

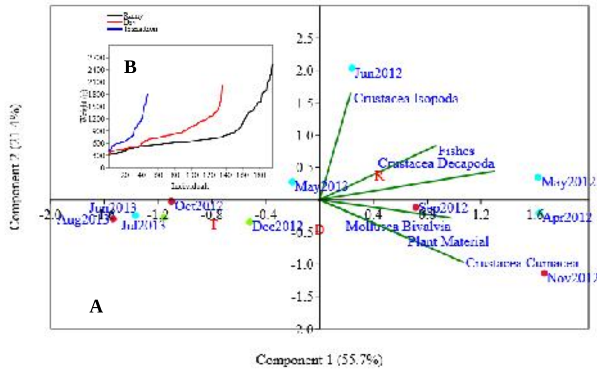

Figure 6. (A) Principal component analysis associating sampling months and food item; (B) Representation of weight (g) for each *N. grandicassis* individual occurring in Maranhão Inlets, Brazil; R – Rainy group, month represented by blue dot; D – Dry group, months represented by red dot; T – Transition group, months represented by green dot

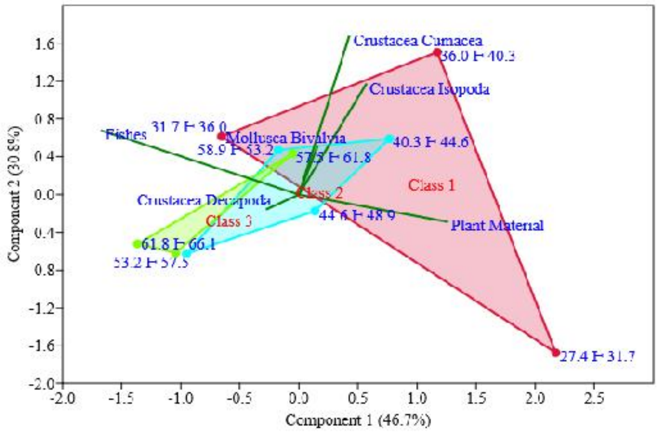

Figure 7. Principal component analysis associating length classes of individuals and food items of *N. grandicassis*in Maranhão Inlets, Brazil. Red point – smaller individuals belonging to Class 1; Blue point – intermediate individuals belonging to Class 2; Green point – larger individuals belonging to Class 3

The dissimilarity between Classes 1 and 3 was evident by the greater consumption of CrustaceaDecapoda and fishes by larger individuals. The other items were found in higher quantities in smaller individuals (Class 1). The same dissimilarity pattern was found between Classes 2 and 3 (Table 2).

DISCUSSION

The results of the present study reveal the dominance of CrustaceaDecapoda (shrimps and crabs) and fishes in the majority of individuals of the species *N. grandicassis* occurring in the Maranhão Inlets of the Eastern Amazon. Studies conducted in Brazil on the feeding habits of species of the family Ariidae have demonstrated the predominance of carnivorous behavior in this group (Huerta and Craig, 1980; Pedra *et al*., 2006; Mendes and Barthem, 2010; Ribeiro *et al*., 2012). Studying *Bagre marinus* (Mitchill, 1815), which is also from this family, in the Colombian Caribbean, Hernández-Morales *et al*. (2018) found a diet composed mainly of fishes and, to a lesser degree, crustaceans. This inversion in the food preference in the comparison of the Colombian coast and the coast of the Eastern Amazon in Brazil may be attributed to the intrinsic characteristics of each species as well as the dense mangrove forest in the present study area, which favors greater productivity, resulting in an increase in the occurrence of crustaceans, fishes, mollusks, etc.

Table 1. Percentage values of volumetric frequency (%Fv) and Index of Alimentary Importance (%*IAi*) for food items in stomachs of *N. grandicassis* caught in Maranhão Inlets, Brazil

Months	Food Items											
	CrustaceaDecapoda		Crustacea Isopoda		CrustaceaCumacea		Fishes		Mollusca Bivalvia		Plant material	
	Fv(%)	IAi(%)	Fv(%)	IAi(%)	Fv(%)	IAi(%)	Fv(%)	IAi(%)	Fv(%)	IAi(%)	Fv(%)	IAi(%)
Apr 12	15.45	27.56	0.00	0.00	0.05	0.01	3.31	1.44	0.09	0.02	0.00	0.00
May 12	1.81	3.08	0.72	0.03	0.02	0.00	10.32	5.32	0.07	0.01	0.05	0.01
Jun 12	7.12	11.57	0.13	0.03	0.00	0.00	6.29	2.00	0.00	0.00	0.00	0.00
Sep 12	3.93	4.99	0.00	0.00	0.04	0.00	11.05	3.50	0.02	0.00	0.02	0.00
Oct 12	3.16	1.00	0.00	0.00	0.00	0.00	5.99	0.95	0.00	0.00	0.00	0.00
Nov 12	7.42	17.36	0.00	0.00	0.18	0.06	0.34	0.04	0.09	0.00	0.05	0.01
Dec 12	3.43	2.59	0.00	0.00	0.00	0.00	0.72	0.06	0.00	0.00	0.04	0.00
May 13	10.08	16.39	0.00	0.00	0.00	0.00	2.45	0.39	0.00	0.00	0.00	0.00
Jun 13	0.91	0.25	0.00	0.00	0.00	0.00	0.11	0.01	0.00	0.00	0.00	0.00
Jul 13	1.36	0.75	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Aug 13	2.68	0.53	0.00	0.00	0.00	0.00	0.48	0.04	0.00	0.00	0.00	0.00
Total	57.36	86.08	0.84	0.06	0.29	0.07	41.09	13.75	0.27	0.03	0.16	0.02

Table 2. Percentage of similarity (SIMPER) analysis for food items found in *N. grandicassis*as a function of size class Class 1: < 40.3 cm; Class 2: > 40.3 < 57.5 cm; Class 3: > 57.5 cm

Class 1 x Class 2					
Food items	**Dissimilarity**	**Contrib. %**	**% Accum.**	**Mean Class 1**	**Mean Class 2**
Fishes	5.21	32.80	32.80	5.43	8.96
Crustacea Cumacea	2.67	16.81	49.61	3.50	1.14
Crustacea Decapoda	2.50	15.75	65.37	43.10	45.40
Plant material	2.32	14.60	79.97	2.80	0.99
Crustacea Isopoda	1.97	12.42	92.38	2.11	0.56
Mollusca Bivalvia	1.21	7.62	100.00	0.00	1.41
Class 1 x Class 3					
Food items	**Dissimilarity**	**Contrib. %**	**% Accum.**	**Mean Class 1**	**Mean Class 3**
CrustaceaDecapoda	13.14	48.13	48.13	43.10	62.20
Fishes	7.55	27.64	75.77	5.43	15.80
CrustaceaCumacea	2.34	8.56	84.32	3.50	0.78
Plant material	2.12	7.75	92.07	2.80	0.78
Crustacea Isopoda	1.54	5.63	97.71	2.11	0.00
Mollusca Bivalvia	0.63	2.29	100.00	0.00	0.78
Class 2 x Class 3					
Food items	**Dissimilarity**	**Contrib. %**	**% Accum.**	**Mean Class 2**	**Mean Class 3**
CrustaceaDecapoda	11.32	59.27	59.27	45.40	62.20
Fishes	4.81	25.19	84.46	8.96	15.80
Mollusca Bivalvia	0.90	4.72	89.18	1.41	0.78
CrustaceaCumacea	0.85	4.45	93.63	1.14	0.78
Plant material	0.81	4.27	97.90	0.99	0.78
Crustacea Isopoda	0.40	2.10	100.00	0.56	0.00

On the other hand, the mangrove roots, the density of which is the highest in the country (Rebelo-Mochel and Ponzoni, 2007), provide a refuge for small fishes, hindering their capture by predators. Diet depends on the intrinsic variables of each species, such as oral anatomy, nutritional requirements and detection/capturing capacity, but can also vary within the same stage of life depending on the local availability of food items (Chaves *et al*., 2008). Thus, the considerable availability of preferred food items in the mangrove forests on the coast of the state of Maranhão, the mouth shape and rigid tooth plates in *N. grandicassis*, with mentumbarbels and strong jaws, attest to the capacity of this species to seek food items near the sediment and make use of hard material, such as the carapace of crustaceans. The importance of crustaceans to the diet of catfishes of the family Ariidae has previously been reported by Barthem (1985) on the coast of the state of Pará and Ribeiro *et al*. (2012) on Caranguejos Island in the Gulf of Maranhão. Hernández-Morales *et al*. (2018) highlights the importance of the availability of habitats for the dominant preys in different ichthyofauna groups. This is confirmed in studies on feeding habits, which can contribute to conservation measures targeting key species from the standpoint of biodiversity, food sources and fishing activities. The analysis of the volumetric frequency revealed the same feeding preference pattern as that found through the frequency of occurrence analysis, although with a much higher percentage of fishes, making the difference between the consumption of decapod crustaceans and fishes less distinct. This is explained by the tendency for fish fauna to be larger in both size and biomass in comparison to crustaceans, leading to fewer individuals in the stomachs analyzed. The analysis of the Index of Alimentary Importance confirmed the preference for CrustaceaDecapoda (shrimps and crabs), (IAi = 86.08%), followed by fishes (13.75%). The low incidence of other items, such as CrustaceaCumacea, Crustacea Isopoda and plant material (IAi values lower than 1%), may be associated with the mesh size of the fishing gear, as there were no individuals smaller than 27.0 cm, which is a reflection of the artisanal fishing that occurs on the coast of the state of Maranhão. Arenas-Uribe (2019) state that the maintenance of individuals in fishing nets for long periods of time should be avoided to ensure that fishes do not regurgitate their food, which affects the empty stomach coefficient as well as the identification of prey items. However, we had no control over this in the present study, as the samples came from artisanal fishing activities, for which the period of net deployment and harvest is relatively long, hindering the identification of food items and leading to a large amount of digested material. An analysis of the diet of catfish of the family Ariidae in the Amazon estuary revealed that five species fed mainly on crustaceans *Amphiarius phrygiatus*

(Valenciennes, 1840), *Aspistor quadriscutis* (Valenciennes, 1840), *Sciades proops* (Valenciennes, 1840), *Amphiarius rugispinis* (Valenciennes, 1840) and *N. grandicassis* and only two fed mainly on fishes *Sciades couma* (Valenciennes, 1840) and *Sciades parkeri* (Traill, 1832) (Mendes and Barthen, 2010). Among the species that fed mainly on crustaceans, the authors stated that only *A. phrygiatus* preferably consumed isopods. The others, including *N. grandicassis*, were characterized by a diet comprised particularly of decapods. The present results are in line with findings described for other estuaries of the Amazon region, which indicates the sharing of resources by a large part of representatives of the family Ariidae that occur in these environments. It is therefore imperative to establish conservation strategies for the habitats to maintain the adequate offer of resources for this family, which is always among the most abundant on the Amazon coast (Silva *et al*., 2018; Le Joncour *et al*., 2020) and has considerable importance to fisheries.

The multivariate analysis revealed a tendency toward greater feeding activity in the rainy season, as also demonstrated by the biomass curve for each individual considering the two seasonal periods. Moreover, trophic ontogeny was found, with a predominance of crustaceans and fishes in larger length classes and items such as CrustaceaCumacea, Crustacea Isopoda and plant material exclusive to smaller length classes. The ontogenetic shift in the diet and the temporal variation in food items has also been reported for *Sciades herzbergii* (Valenciennes, 1840) in Amazon estuaries (Giarrizzo and Saint-Paul, 2008) and *Cathorops aguadulce* (Meek, 1904) in estuaries of the Gulf of Mexico (Reyes-Ramírez *et al*., 2017). Ribeiro *et al*. (2012) reported greater feeding diversity in the rainy season for *S. herzbergii*, which also belongs to the family Ariidae, caught on Caranguejos Island in the Gulf of Maranhão. A similar pattern was found in the present investigation; although the diversity of the food items for *N. grandicassis* was not calculated, higher frequencies of all items were associated with months of greater rainfall.

Regarding trophic ontogeny, Fugi *et al*. (2001) and Galarowicz *et al*. (2006) report that morphological changes during ontogenetic development are important adaptations that enable a species to exploit new habitats to capture larger preys and/or consume more energy resources. Winemiller (1989) postulates that changes in feeding habits in different stages of the lifecycle may reduce intraspecific and interspecific overlap in the use of food resources.

This aspect is important for *N. grandicassis*, as having a more generalist nature in the consumption of food items, particularly in the early phases of the lifecycle, is a more effective survival strategy for juveniles, especially considering the well-known trophic overlap found in the family Ariidae for the Amazon coast and regions of the Caribbean. The aspects of the diet of *N. grandicassis* demonstrate the considerable adaptation of the species to the Maranhão Inlets of the Eastern Amazon and the food items stand out for having an autochthonous origin. Based on the categories established by Elliott *et al*. (2007), *N. grandicassis* can be classified as zoobentivorous, with specialized feeding on decapod crustaceans, such as shrimp (*L. schmitti*), crabs (*Callinectes* sp. and *Uca* sp.) and, to a lesser degree, fishes.

CONCLUSION

The estuarine systems of the Eastern Amazon, such as the Maranhão Inlets, maintain a population of *N. grandicassis* that uses this area for feeding and growth, with a diet predominated by shrimps, crabs and, to a lesser degree, fishes. However, the occurrence of other food items, such as CrustaceaCumacea, Crustacea Isopoda and plant material, is seen in smaller individuals, indicating trophic ontogeny. Seasonal variations exerted an influence on the trophic pattern of the species, with greater feeding activity in the rainy season. The considerable availability of resources in estuarine habitats on the coast of the state of Maranhão is another factor that exerts an influence on the eating behavior of *N. grandicassis*. The food items found, all of which are of an autochthonous origin, indicate the good adaptation of the species to the study area, but also demonstrate its considerable dependence on the resources of the environment investigated, underscoring the need for protection measures to ensure the maintenance of these resources for the regional fish fauna and, consequently, for fishing activities. The present findings on the eating activity pattern of *N. grandicassis* can contribute to fishing strategies as well as the management of this potentially exploitable economic resource.

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