

FEEDING ECOLOGY AND MORPHOMETRY OF THE DIGESTIVE TRACT OF *Astronotus ocellatus* (CICHLIDAE) IN VÁRZEA ENVIRONMENTS OF THE MIDDLE SOLIMÕES REGION, CENTRAL AMAZON, BRAZIL.

ECOLOGIA ALIMENTAR E MORFOMETRIA DO TRATO DIGESTIVO DE *Astronotus ocellatus* (CICHLIDAE) EM AMBIENTES DE VÁRZEA DA REGIÃO DO MÉDIO SOLIMÕES, AMAZÔNIA CENTRAL, BRASIL.

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KEY WORDS:

Cichlidae;
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ABSTRACT

The diet of *Astronotus ocellatus* (Osteichthyes, Cichlidae) and the morphometry of its digestive tract were investigated at Mamirauá Sustainable Development Reserve (MSDR), Amazonas, Brazil, between February 2005 and January 2006. A total of 223 specimens were captured and from each of them the total and standard length, length of intestine, and length of abdominal cavity were determined. The intestinal coefficient and the celomatic coefficient were calculated. Contents from stomachs and intestines were analyzed in 182 specimens. Data gathered show *A. ocellatus* as a carnivorous species, and insects and fish proved to be the most important food items in its diet. It was detected a significant difference in the composition of diets between intestinal and stomach contents, suggesting the importance of separate analysis to better describe the use of food resources available for the fish species in this particular environment. During the year of study the diversity index of the diet was higher in the low water period.

PALAVRAS-CHAVE:

Cichlidae;
Morfometria;
Hábito alimentar;
Várzea;
Amazônia

RESUMO

A dieta de *Astronotus ocellatus* (Osteichthyes, Cichlidae) e a morfometria do seu trato digestório foram investigados na Reserva de Desenvolvimento Sustentável Mamirauá (RDSM), Amazonas, Brasil, entre fevereiro de 2005 e janeiro de 2006. Foram capturados 223 exemplares, e de cada espécime foi medido o comprimento total e padrão, o comprimento do intestino, e da cavidade celomática. Foram calculados os coeficientes intestinais e o celomático. Os conteúdos estomacal e intestinal foram analisados em 182 exemplares. A análise dos dados indicou que *A. ocellatus* é uma espécie carnívora, sendo insetos e peixes os itens mais importantes na sua dieta. Foi detectada uma diferença significativa na composição da dieta entre o conteúdo intestinal e o conteúdo estomacal, sugerindo que análises separadas possibilitem uma melhor descrição da utilização dos recursos alimentares disponíveis no ambiente por parte da espécie. Durante o ano do estudo a diversidade da dieta de *A. ocellatus* foi maior durante o período da seca.

INTRODUCTION

Astronotus ocellatus, (CUVIER, 1829), is a cichlid species of great economic importance in the Brazilian Amazon. Besides being a major food fish in the region (BATISTA; PETRERE JR., 2003; FERRAZ et al., 2012), this species is also valuable to the ornamental market, where it is known commercially as the Oscar (PRANG, 2007). Despite this importance, very little is known about the Oscar biology, which makes appropriate management of the species difficult.

This species has been very little studied in its natural environment (HERCOS et al., 2009). The Cichlid family is well represented in the Amazon basin, the Guyanas, northern Orinoco, southern Pará and rivers in Eastern Brazil (LOWE-McCONNELL, 1999). It has enormous ecological, genetic and evolutionary plasticity, as the result of various adaptations that it has developed over time (LOWE-McCONNELL, 1999) *Astronotus ocellatus* is widely distributed throughout the Amazon Basin, as opposed to *A. crassipinnis*, which has a more restricted distribution in the southwestern portion of the basin (KULLANDER, 2003). The association of *A. ocellatus* with shallow areas of up to 2m depth and with more complex environments such as aquatic macrophytes and submerged tree limbs has been described for Amaná, a blackwater lake in the Central Amazon (HERCOS et al., 2009). Reproduction in the species has so far been studied only in captivity (FONTENELE, 1983).

The family as a whole is very well adapted to Amazon conditions and has a great variety of feeding strategies (LOWE-MCCONNELL, 1999). The Oscar's diet has been evaluated together with that of other species found in the great assemblages

of floating grass species (MÉRONA, RANKIN-DEMÉRONA, 2004; REBELO et al., 2010). Because of the significant participation of animal and plant items in this diet, Mérone and Rankin-de-Mérone (2004) consider the species to be omnivorous. Rebelo and collaborators (2010) found a major coincidence between the items found in the diet of *A. crassipinnis* and the results of interviews that surveyed traditional knowledge about the species' feeding habits in areas of the Central Amazon. The number of animals analyzed in those studies was always quite reduced (05 in 2004 and 24 in 2010), which considerably limited the conclusions that could be drawn. A more detailed understanding of the diet of this species is one of the most important ways of understanding its complex interactions with its environment (ZAVALA-CAMIN, 1996).

Plasticity in the diet of fishes is probably not only submitted to obvious environmental variations, but also to pre-established limits in the form and structure of their digestive tubes (FUGI; HAHN, 1991). Several authors (ANGELESCU; GNERI, 1949; AGOSTINHO et al., 1993; FUGI et al., 2001) believe that the anatomic characteristics of the digestive apparatus in fishes are closely dependent on the nature of their foods, the characteristics of their habitat, their nutritional state and the development stage of individuals. Adaptations and morphological modifications caused by the action of environmental factors on an organism may be permanent in nature, produced in phylogenetic evolution, or of a temporary nature, produced during the ontogenetic development of an individual (MAKRAKIS et al., 2005). In this way, knowledge of the biology of the species and particularly its diet, the morphology of its digestive tract and other aspects of its feeding ecology, can

demonstrate the close interconnection of these factors with the environment, providing input for a better understanding of the ecosystems in which they live.

In this study our objective was to investigate the morphology of the digestive tract of *Astronotus ocellatus*, the Oscar, the composition of its diet and seasonal changes of the diet in the Central Amazon varzea habitat.

MATERIAL AND METHODS

The study was carried out in the Mamirauá Sustainable Development Reserve (RDSM), which is entirely made up of the varzea ecosystem and located in the central-western region of the state of Amazonas ($03^{\circ}08'S$, $64^{\circ}45'W$ and $2^{\circ}36'S$, $67^{\circ}13'W$). The area encompasses a large portion (1,124,000 hectares) of floodplain situated between the Japurá and Solimões rivers and the Auti-Paraná canal (VIANA, 2004; TÉRAN, 2005). This portion of Middle Solimões varzea in the Central Brazilian Amazon is characterized by a mosaic of different forest typologies (AYRES, 1993), interspersed by a large number of different water bodies (QUEIROZ, 2007), notably the lakes.

Aquatic environments in the RDSM are strongly seasonal and the water level varies annually by around 10.5 to 11 meters (RAMALHO et al., 2009). The lakes are normally abandoned canals or depressions in the floodplain where traditional fishing activities are carried out (FERRAZ et al., 2012). Classes of water bodies in the RDSM are determined especially by their morphology, type of bank and riparian forests, which will determine the type of invertebrate, aquatic macrophyte and fish communities that may be found in greater abundance in each typology (QUEIROZ, 2007).

The physical and chemical characteristics of the water in these places vary according to the great seasonality of the hydrological cycle. Some parameters present high stability, such as the pH values that range from 6.5 to 7.0, dissolved oxygen levels that rarely go beyond 10mg/l, and water temperature that varies from 29.2 to 33.6°C. However, most variables reflect the major change that occurs in water levels. Transparency can range from 0.56 to 1.20m, turbidity can range from 3.9 to 158.9, and electrical conductivity ranges from 61 to more than 300 $\mu S/cm$ (AFFONSO et al., 2011). A study analyzing hydrological cycles from more than 15 consecutive years in the RDSM (RAMALHO et al., 2009) determined the local pattern for variation in the water level, a determining factor for the entire production cycle in the varzea environment (JUNK, 1997). This cycle also defines hydrological phases or periods, which are based on the flooding pulse. For the RDSM those cycles are the periods of rising waters (December to April), high water (May to mid-July), falling water levels (end of July to beginning of September) and dry season or low water (September to November) (RAMALHO et al., 2009).

For this study monthly collections were done in seven varzea water bodies in the Mamirauá Reserve (Juruá Grande, Juruazinho, Pagão, Miratini, Pauzal, Paraná do Mamirauá and Paraná do Apara), during the period of February 2005 to January 2006. Collecting was grouped into the different phases of the flood pulse (rising water, high water, falling water and dry season as described above), but the collection effort during high water did not produce any individual of the species studied.

A total of 223 were captured with the use of a set of fishing gear, but fishing with hooks was the predominant method for collecting the fish in their preferred environments, floating grass and submerged tree limbs. Although there are doubts regarding the use of animals captured with active sampling gear using beat in terms of studying fish feeding habits (STONER, 2004), this was the only gear demonstrating the necessary efficiency for obtaining a significant number of animals. Still in the field, the specimens collected were fixed in an aqueous solution with 10% formaldehyde and later in the laboratory transferred to an aqueous 70% alcohol solution (where the witness specimens are kept).

Morphological analysis

For the morphological analysis 20 adult specimens of the species were utilized. But all individuals collected were weighed (total weight in grams) and measured (total length in centimeters). All of the animals considered to be adults according to the data available on length at first maturation (NAKATANI et. al., 2001) were analyzed, meaning that all belonged to the same ontogenetic stage. For each of the individuals the number of branchial clefts and position of the mouth were measured.

After a ventral incision, the digestive organs of each of those 20 fish were removed and measured. For the intestines, the intestinal length (CI), which extends from the pyloric valve to the rectum, was observed (in centimeters). Later, the intestinal quotient (QI) was calculated, expressed as the ratio between the intestinal length (CI) and the standard length of the body (CP). The average intestinal quotient (QIm) was obtained from the average of all the individual QIs calculated (ANGELESCU; GNERI, 1949; BARBIERI et. al., 1994):

$$QIm = \sum_i^n \left(\frac{Cl_i}{CP_i} \right) / n$$

Later on the length of the celomatic cavity was measured (CV), which extends from the transverse septum to the anus in a straight line (in centimeters). This measure was used to determine the Celomatic Coefficient (CC), which is the ratio between the length of the Celomatic Cavity (CV) and the standard length (CP). The average length of the celomatic cavity (CCm) was the average of the measures obtained from all of the animals studied (ANGELESCU; GNERI, 1949):

$$CCm = \sum_i^n \left(\frac{CV_i}{CP_i} \right) / n$$

Diet

In order to analyze the diet, the specimens were eviscerated and their digestive tracts were separated into a stomach and an intestinal portion. To keep ingestion of bait used in fish capture from interfering with the results, that portion of the contents was removed from the digestive tract as soon as it was separated. The remaining contents found in both the stomach and the intestines were observed under a stereomicroscope and identified down to the lowest taxonomic level possible, with help from the specialized literature (MUGNAI et al., 2009). After contents were identified the frequency of occurrence of the food items was calculated, as the percentage of stomach with contents representing each one of the food categories (HYSLOP, 1980), using the formula:

$$F = \frac{n_i}{n_t} \cdot 100 \text{ where,}$$

n_i is the number of individuals containing a given item i ,

n_t is the total number of items found in the stomachs with food.

Data on occurrence and percentage in weight (determined with a digital scale with a precision of 0.001g) were obtained for the items found in each individual. Occurrence and weight data were also used to calculate the frequency of occurrence (FO) and volumetric frequency (FV) (HYNES, 1950; HYSLOP, 1980). The association of these frequencies produced the food importance index (IAi) (KAWAKAMI ; VAZZOLER, 1980, BANNEMANN et al., 2006), whose values were expressed as a percentage:

$$IA_i = \frac{FoxFV}{\sum(FoxFV)} \cdot 100 \quad \text{where,}$$

IAi is the food index; FO is the frequency of occurrence and FV is the volumetric frequency.

Data analysis

The Shannon diversity index values were calculated for the food items in stomach and intestinal contents using the PAST software (version 1.68) (HAMMER et. al., 2001). Along with analysis of diversity in diet, parameters of frequency and dominance have often been used to enable a more complete knowledge of the differences between diets of different species, without the need for applying multivariate techniques (BANNEMANN et al., 2006; FERREIRA; CASATTI, 2007). In order to evaluate the use and appropriateness of including stomach and intestinal contents in the analysis, a paired t test was applied to determine if the diversity in diet was significantly greater between the intestinal and stomach contents, using the BioEstat 4.0 statistical program (AYRES et al., 2005) with a significance level ($\alpha=0.05$) for the Shannon diversity index values calculated using the food items. The similarity in diet between the different hydrological periods represented by the relative participation of diet items in each period was

calculated by means of a Cluster Analysis, utilizing the BioDiversity Pro program (McALEECE, 1997), which generates a similarity matrix with Bray Curtis Coefficient.

RESULTS

Morphological analysis

This species presents a high and laterally flattened body, with a terminal mouth that when open presents a slight protrability. The number of teeth in the upper jaw ranged from 24 to 35 no non-maxillary teeth were detected. The branchial clefts are numerous (ranging from 10 to 15) all located in the first branchial arc. The traces were thin and short, with a small spacing between them. The stomach is tubular-sacular, without muscular expansions or widening on the walls of the organ. Gastric caecae were not observed in any of the individuals analyzed. The intestines are not very coiled and present a U shaped form. Only one intestinal fold was observed, accompanying the same format.

The average for the intestinal coefficient value (QIm) was 1.067 and the average celomatic coefficient (CCm) was 2. 868 (Table 1).

Table 1 – Average values for total length (CT), standard length (CP); average intestinal coefficient (QIm); and average celomatic coefficient (CCm) for *Astronotus ocellatus* (n = 20) in the Mamirauá Reserve.

	CT	CP	QIm	CCm
Minimum	19.3	16.1	-	-
Maximum	26.6	21.3	-	-
Average	22.8	18.2	1. 067	2. 868
s.d.	2.01	1.55	0.07	0.29

Diet

The stomach food contents were analyzed for the species *A. ocellatus* distributed among 182 fish, while 41 specimens did not have any food contents.

In order to verify participation of the main items, food items from the contents were grouped into: Insecta, Crustacea, Mollusca, Fishes, Platyhelminthes, and Nemathelminthes, besides Plant Material, Unidentified Animal Material (NI), Unidentified Organic Material (NI) and Anura (Table 2).

While in the stomach contents one may observe that the items with the greatest food importance were Fish and Insecta, with IAi values of 81.08% and 11.6%, respectively, in the intestinal contents there was a notable presence of insects (IAi = 80.43%). Of the various orders present, the order Mantodea stood out, with an IAi value of 15.27%.

One may note a significant difference in the values of the Shannon Diversity Index for the diet of *A. ocellatus* among the food items found in the intestine and in the stomach ($p=0.001$) (Table 3).

The diet in the species being studied varied very little between the seasons or hydrological periods. With a constant predominance of insects, complemented by fish, mollusks or crustaceans during the different periods of the cycle (Figure 1), the characterization of the species as carnivorous, with an insectivorous-piscivorous tendency was once again confirmed.

A high similarity was observed between the diets of the animals during months in the falling water and dry season periods (84.3%), but during months in the other periods this similarity varied from 54.8 to 56.0%, with insects being the main items in the diet for all of the periods studied.

Table 2 – Frequency of occurrence (FO%), volumetric frequency (FV%) and food importance index (IAi%) of food items found in the digestive tracts of *Astronotus ocellatus*.

Food Items	Stomachs			Intestines		
	FO	FV	IAi	FO	FV	IAi
PLATYHELMINTHES	-	-	-	2.43	0.05	-
NEMATHELMINTHES	-	-	-	0.81	-	-
MOLLUSCA	1.85	0.03	-	15.44	5.66	1.52
INSECTA	31.48	15.20	11.59	81.30	56.89	80.43
Chironomidae	5.55	0.10	0.01	23.42	0.94	2.32
Coleoptera	5.55	9.09	1.19	16.21	1.24	2.12
Coleoptera (Larva)	-	-	-	1.80	0.28	0.05
Diptera	-	-	-	2.70	0.01	-
Ephemeroptera	-	-	-	3.60	0.29	0.11
Ephemeroptera (Larva)	-	-	-	0.90	0.02	-
Hemiptera	-	-	-	0.90	-	-
Heteroptera	-	-	-	1.80	0.02	-
Hymenoptera (Furmicaridae)	-	-	-	0.90	-	-
Orthoptera	5.55	0.59	0.007	-	-	-
Mantodea	-	-	-	1.80	80.77	15.27
Odonata	-	-	-	2.70	0.12	0.03
Insects (NI)	77.77	43.74	80.82	63.96	9.16	61.51
Insects (NI - Larva)	-	-	-	2.70	0.01	-
CRUSTACEA	1.85	0.11	-	2.43	2.84	0.12
Shrimp	5.55	0.39	0.05	1.80	0.54	0.10
Crustaceans (NI)	-	-	-	0.90	0.12	0.01
FISH	59.26	56.47	81.08	15.44	3.78	1.01
ANURA	1.85	3.50	0.15	0.81	0.28	-
ANIMAL MATERIAL (NI)	12.96	11.46	3.60	13.82	4.81	1.15
PLANT MATERIAL	11.11	13.20	3.55	38.21	23.45	15.58
Seeds	16.66	43.06	17.04	10.81	1.34	1.52
Plant remains	11.11	2.96	0.78	37.83	4.14	16.47
ORGANIC MATTER (NI)	-	-	-	4.06	2.19	0.15

Table 3 – Values of the Shannon Diversity Index (H') for food items in *Astronotus ocellatus* during the different periods of the flooding pulse (rising water, falling water and dry season).

Food contents		
Hydrological period	Stomach cont.	Intestinal cont.
Rising water	0.9503	1.561
Falling water	1.465	2.1
Dry season	1.535	2.208
Average	1.3168	1.9563
Standard deviation	0.3193	0.3466

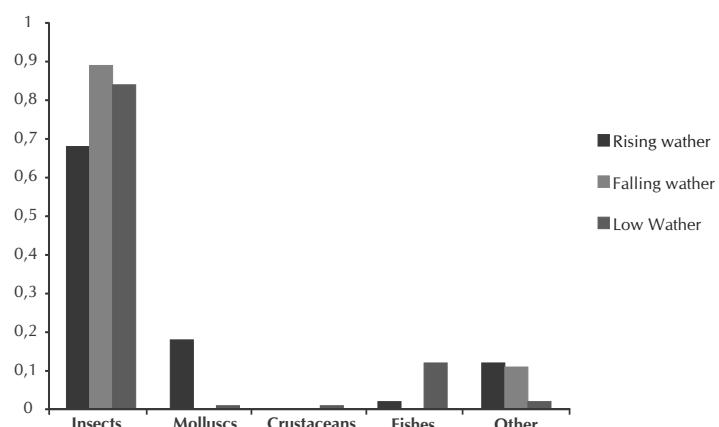


Figure 1 – Relative participation of the main classes of food items in the diet of *Astronotus ocellatus* in the different phases of the hydrological cycle in the Mamirauá Reserve.

DISCUSSION

Morphological analysis

The form and position of the mouth, dentition in the jaws and in the buccopharyngeal region, as well as the form of the branchial clefts are related to the feeding habits of the fish (WOOTTON, 1990; ZAVALA-CAMIN, 1996). The degree of protrability in the mouth is also an important factor in accessing food (MOTTA, 1984).

Fugi and collaborators (2001) have commented that the relation between the position and the form of the

teeth has been discussed by numerous authors and is considered to be an important adaptation resulting from evolutionary processes. Those authors emphasize the importance of palatine or pharyngeal teeth, which are responsible for macerating food, and their presence is associated with the absence of a clearly defined stomach. *Astronotus ocellatus* lacks non-maxillary teeth and has a clearly defined stomach.

According to Zavala-Camin (1996) the branchial clefts are modified for retaining, scraping and crushing food. There is also a relation between the morphology of the branchial clefts and the trophic status of the fish. It is generally assumed that the function of the branchial clefts is to act as a strainer to retain food particles in the water, so that there may be correlations between the number of clefts, the spacing between them, their length and the feeding habits of the fish. According to Zavala-Camin (1996), in carnivorous species in general the clefts are present only in the first branchial arc, as was the case with the species studied for this paper. Fugi and Hahn (1991) suggest that these structures also have the function of producing mucus and separating flocculent detritus by adhesion.

Moraes and collaborators (2004), studying the feeding and morphological relations in *Prochilodus lineatus*, verified that the stomach is of the fundic "U" type, with long cardiac and pyloric

regions and a short and round fundic region, quite different from the morphology found in *Astronotus ocellatus*. The muscle wall in the pyloric region is highly developed, acting as a gizzard in macerating the alimentary bolus. Similar results were found by Fugi and collaborators (2001) for the species *Prochilodus lineatus* and *Steindachnerina insculpta*. The authors affirm that this type of adaptation is related to an illiophagous feeding regime, in which the diet is based on items that are difficult to digest (organic mud and detritus). Moraes and Barbola (1995), studying the feeding habits and morphology of the digestive tube in *Hoplias malabaricus*, verified that this species has a siphon-type stomach that can be greatly distended and in which entire fish were found. This was also quite different from the stomachs observed in this study. The not very rigid or muscular structure and the sacular format, and the absence of gastric caecae suggest an adaptation for items in the diet that are small and not very rigid.

Some authors have demonstrated a relation between the feeding habits and intestinal length in Teleosts (VERIGINA, 1990; PERETTI, 2006; MORAES, et al., 1997; MORAES et al., 2004). Thus, the pattern of folding in the intestinal loops increases in complexity, going from an approximately rectilinear arrangement in carnivores to a highly coiled configuration, such as found in typical illiophagous species. Along this gradient, the average intestinal coefficient is also significantly increased.

There is generally an association between its length and the standard length of the body, which gives us the intestinal quotient calculation (ANGELESCU ; GNERI, 1949), whose values make it possible to infer to which trophic category the

fish belongs; that relation between the length of the intestine and that of the body can range from 0.2 to 2.5 for carnivores (as was the case with *Astronotus ocellatus* in the present study); 0.6 to 0.8 for omnivores and 0.8 to 15.0 for herbivores. According to Zavala-Camin (1996) there are several motives that can lead to differences in the intestinal quotient, even when one considers the same trophic category and that characteristic demonstrates how important knowledge of anatomy, because the appendices to the digestive tube perform part of the work for the main digestive organs.

Corroborating that view, in Moraes and Barbola (1995) and also in Moraes and collaborators (1997), differences in intestinal length as well as intestinal quotient were associated with feeding regimes. The QI values in association with food items consumed in this study corroborate those propositions are in agreement with the classification in Angelescu and Gneri, (1949) regarding carnivorous species.

As for analysis of food content, it was seen that *A. ocellatus* is a carnivorous species, with an insectivorous-piscivorous tendency. But the proportion of fish is small, when compared to the constant and intense proportion of insects in the diet. The stomachs are not muscular, but sacular and delicate, pointing to a greater importance for small items, such as insects. One should note the high number of empty stomachs, after subtracting the remains of the baits used for capturing the animals. The slight tendency towards piscivory observed in the diet may help to explain the high percentage of empty stomachs found in this study, given that foods such as fish are quickly digested.

Based on morphological characteristics such as the placement and shape of the eyes that define the

visual orientation of this species, Alcock (1975) described it as a mainly piscivorous predator, with large eyes and generally diurnal habits. Reis and collaborators (2010) described this same species as insectivorous, emphasizing that the results may have been influenced by the large number of juvenile individuals in their sample.

Andrian and collaborators (1994) note that in the aquatic communities found in the upper Paraná river floodplain, insects are the most important items in the diets. Among them, the largest contributors are Chironomidae and Ephemeroptera, which are part of the diet of many species of fish. In the present study, of the insects found in food contents, those in the order Chironomidae were the ones most frequently occurring, although the order Mantodea presented a higher IAi, due to its high volumetric representation in the intestines that were analyzed.

While studying the fauna in floating grasses in eleven varzea lakes in the Mamirauá Reserve throughout the Amazon hydrological cycle, Queiroz (2007) found a biological diversity of invertebrates, especially mollusks, crustaceans, arachnids and insects from different orders (Odonata, Coleoptera, Hemiptera, Lepidoptera, Diptera, Orthoptera, Trichoptera and Hymenoptera) such as those found as food items in the species here studied.

Allochthonous food items, mainly terrestrial insects, have been considered the most important components in the diet of cichlids and other carnivorous Amazon fishes (LOWE-McCONNELL, 1999), although other authors note the importance of autochthonous items as well, such as algae and aquatic insects (UIEDA; KIKUCHI, 1995). However, the food chain in creeks, lakes and flooded forests seems to be at least partially dependent upon

allochthonous contributions, given that aquatic insects depend upon organic matter that comes from riparian forests (WALKER , 1991).

It is important to emphasize that the high occurrence of allochthonous items in the animals recorded in the present study suggests exploitation of drifting or floating food resources, which requires foraging in the upper part of the water column, a fact that would explain the possible association with semi-pelagic habits. This has also been mentioned by Casatti and Castro (2006) for other species of fish with an allochthonous carnivorous diet.

Insectivorous fish include species that feed on both terrestrial and aquatic insects, and fragments of these animals are the most abundant and frequent in the studied diet, comprising the remains of semi-digested insects and exoskeletons of aquatic and terrestrial insects that could not be identified. The existence of fish adapted to catching this type of prey is mentioned in the literature, and is considered an advantage, since the remains maintain the nutritional value of the insect as a whole. Additionally, since they cannot defend themselves, they can be easily captured when drifting with the current (MELO et. al., 2004).

In the majority of the specimens analyzed the intestinal segment was found to be almost totally replete, forming a long food cord. According to Moraes and collaborators (1997), intestinal length is a variable that responds to subtle changes in feeding conditions. These authors note the dependence of intestinal length on the nutritional value of the food ingested. Fish that feed on items that resist digestion, such as detritus and the calcareous and chitinous exoskeletons of algae and arthropods, present a longer intestine and possibly a greater diversity of food items.

As described in the present study, the paired t test detected a significant difference in the composition of the diet between the intestinal and stomach contents for the Shannon diversity index of the food items. This fact highlights the importance of separately performing the analysis of contents, which will enable a better description of food resources available in the environment that are currently used by the species under analysis.

Other authors have already noted the importance of seasonal variation in the Amazon varzea for the distribution, behavior and diversity of the aquatic life forms inhabiting those environments, their habitats and microhabitats and the foods available in them for the fish community (CRAMPTON, 1999). This seasonality results in numerous notable changes in the availability of habitat and in the general physical conditions that influence the structure and composition of the communities associated with them (QUEIROZ, 2007).

Crampton (1999) observed that many of the fish that live in the flooded forest during high water periods are confined to submerged tree limb environments during the dry season. This microhabitat contains a fish community that makes use of a wide variation in spatial and food niches. Among them are niches allowing the use of allochthonous insects that persist during many periods of the hydrological cycle. Pereira (2010), studying the assemblage of cichlids in the RDSM, described a large number of species in the submerged limb microhabitat.

Studies related to diet, feeding habits and trophic morphology of the cichlid assemblage are underway in the RDSM, in environments similar to those analyzed in this analysis. Continuing

to obtain these data will certainly contribute towards increased knowledge regarding the morphological influence of the digestive tract on data regarding diet, providing new inputs for a better understanding of the varzea environments and of their most representative species.

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