

Natural Diet of Three Species of Shrimp in a Tropical Coastal Lagoon

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ABSTRACT

The gut content of 495 specimens of *Farfantepenaeus brasiliensis*, 131 of *F. paulensis* (Penaeidae) and 102 of *Macrobrachium acanthurus* (Palaemonidae) were analyzed to establish the composition of their diets. *F. brasiliensis* had as the most important feeding items in its diet larvae of Chironomidae, Polychaeta and *Heleobia australis* (Mollusca). For *F. paulensis*, the most important items were the same as for *F. brasiliensis*, but the order of importance of *H. australis* and Polychaeta was inverted. *M. acanthurus* had detritus as the most important item, followed by Chironomidae larvae, Odonata nymphs, and fragments of the macroalgae *Chara*. The results showed that the three species were omnivorous, with a varied diet including both components of macrofauna of benthos and associated to the macroalgae *Chara* and plant fragments and detritus.

Key words: Coastal lagoon, feeding, *Farfantepenaeus brasiliensis*, *Farfantepenaeus paulensis*, *Macrobrachium acanthurus*, Feeding Index

INTRODUCTION

The coastal lagoons of tropical regions are traditional fisheries, which have been used as a source of feeding resources by many cities, although in the last decades the human activities have become more common, with serious damage for the natural systems (Branco et al., 1997). Despite being important sites for traditional subsistence fishing, few information on the biology and ecology of the main organisms used as a fishing resource are available. Shrimps are an important resource in coastal lagoons, since they use these systems for their development (D'Incao, 1991; Albertoni, 1998a). Three species were observed at Imboassica lagoon: *Farfantepenaeus*

brasiliensis Latreille, 1917; *F. paulensis* Pérez-Farfante, 1967 (Penaeidae) and *Macrobrachium acanthurus* Wiegmann, 1836 (Palaemonidae) (Albertoni, 1998b). The possibility of rational usage of this resource demands knowledge of several ecological aspects of the different species, considering that this system is subjected to many impacts of anthropic origin, having a potential to alter the composition of communities and their conditions of growth and survival (Frota and Caramaschi, 1998; Albertoni et al., 1999; Palma-Silva et al., 2000). The knowledge of the diet of a species in nature is important for the establishment of its nutritional needs and of its interactions with other organisms. Therefore, studies of gut content aim to identify and quantify

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the food resource that are more intensively used by a species, providing information on the food that is preferred over others available in the environment (Williams, 1981; Tararam et al., 1993). Aiming to evaluate the trophic relationships of these three species of Decapoda at Imboassica lagoon, the study of gut content was performed, analyzing the frequency of occurrence of the dietary items and applying Feeding Index.

STUDY AREA

Imboassica lagoon is located on the northern coast of the State of Rio de Janeiro, Brazil (22° 50' S; 44° 42' W) in the urban zone of Macaé Municipality. The regional climate is subhumid, with a maximum mean temperature of 29.9° C in February (summer) and a minimum mean temperature of 25.4° C in July (winter). Annual precipitation varies between 800 mm and 120 mm (Radambrasil, 1983). Its present area is 3.26 Km², medium depth of 1.1 m (Panosso et al., 1998) and is separated from the sea by a sand barrier about 50 m wide. The surroundings are partially occupied by residential areas and, sometimes, during the rainy season, inundation of these areas occurs (Branco et al., 1997). An artificial opening (by human action) of the sand barrier then causes a drastic drop in the water level and sea water entrance and these modifications cause substantial change in the biotic communities. When the lagoon communicates with the ocean, many organisms of marine origins enter, such as the shrimp species *Farfantepenaeus brasiliensis* and *F. paulensis* (Penaeidae), and others of continental origin, like *Macrobrachium acanthurus* (Palaemonidae), uses the mesohaline waters for hatching (Albertoni et al., 1999).

MATERIAL AND METHODS

The species analyzed were *Farfantepenaeus brasiliensis* Latreille, 1817, *F. paulensis* Pérez-Farfante, 1967 and *Macrobrachium acanthurus* Wiegmann, 1836, sampled at Imboassica lagoon, from Aug/95 to Sep/97. The samplings took place at night, one hour after sunset, in three areas in the lagoon: a- near the sandbar, b- central area and c- near the mouth of a sewage discharge channel,

with dragnets, throwing net, and waiting net. The sampled animals were immediately preserved in ice, and their guts were withdrawn with dorsal cuts in the cephalotorax and preserved in ethanol 70% for later analysis. At the laboratory, the gut content was dumped on a counting chamber, and the items were separated, identified to the smaller taxonomic unit possible, and the volume occupied by each item was estimated through the points method. The frequency of occurrence of each item for each species was estimated and the comparison among the frequencies of occurrence obtained for the three species was made through the Friedman nonparametric test. The empty guts were not considered in the estimates of frequency of dietary items, only in the estimates of repletion.

The contribution of each item for the total volume of the stomach was quantitatively estimated through the Points Method for each species (Hynes, 1950; Windell, 1971; Hyslop, 1980; Williams, 1981), using a base 2 logarithmic scale. The estimate of the percentage of filled space in the gut was made according to the total volume of each stomach, and categorized as follows:

0 = empty
 0.1 to 4 = <25%
 from 4.1 to 16 = between 25 and 50%
 from 16.1 to 24 = between 50 and 75%
 > 24.1 to 32 = 75 to 100%

Through these relationships, the gut repletion degree was established, according to the total number of analyzed guts and to the number of empty guts:

$$Rd = (\text{No. Guts in the "i" category} / \text{Total guts}) \times 100$$

Through the estimates of volume and frequency of occurrence of preys the Feeding Index was established, as proposed by Kawakami and Vazzoler (1980). Parallelograms of the importance of the groups of dietary items were constructed with the obtained data. According to these authors, a figure with a combination of the volume percentage in the x- axis and frequency of occurrence percentage in the y- axis represents the relative importance of the food items:

$$FI_i = F_i \times V_i / \sum(F_i \times V_i),$$

where:

F_i = frequency of occurrence (percentage) of "i" item

V_i = volume (percentage) of "i" item

RESULTS

A great amount of the gut content of the three species was fragmented. Therefore, the

categorization of the dietary items was made for items with hard parts (carapaces, exoskeletons and shells), and other organisms with quick digestion and without hard parts were categorized as detritus. Twenty five dietary items were categorized for *Farfantepenaeus brasiliensis*, 17 for *F. paulensis*, and 20 for *Macrobrachium acanthurus*.

Table 1 - Frequency of occurrence and volume (percentage) of the dietary items, number of analyzed and empty guts, and number of guts where the item was founded.

	ITEMS	<i>Farfantepenaeus brasiliensis</i>			<i>Farfantepenaeus paulensis</i>			<i>Macrobrachium acanthurus</i>		
		N° guts	Occur(%)	Vol.(%)	N° guts	Occur(%)	Vol. (%)	N°guts	Occur(%)	Vol. (%)
INSECTA	Chironomidae	290	58.58	34.21	89	67.94	48.98	24	23.53	7.10
	Odonata	93	18.79	5.00	17	12.98	2.97	33	32.35	6.35
	Coleoptera	0	0	0	0	0	0	2	1.96	0.16
MOLLUSCA	<i>Heleobia australis</i>	253	51.11	13.33	88	67.17	18.97	30	29.41	4.55
	Bivalvia	5	1.01	0.13	0	0	0	0	0	0
	Planorbidea	0	0	0	0	0	0	1	0.98	0.04
CRUSTACEA	Tanaidacea	48	9.69	1.67	6	4.58	1.38	0	0	0
	Ostracoda	25	5.05	0.67	22	16.79	1.93	6	5.88	0.67
	Isopoda	14	2.82	0.49	6	4.58	0.34	0	0	0
	Amphipoda	32	6.46	10.2	1	0.76	0.27	0	0	0
	Cladocera	4	0.80	0.09	0	0	0	1	0.98	0.04
	Copepoda	2	0.40	0.02	0	0	0	0	0	0
	Cirripedia (larvae)	0	0	0	0	0	0	4	3.92	1.57
ANELLIDA	Polychaeta	334	67.47	36.37	48	36.64	17.97	20	19.61	9.80
	Oligochaeta	1	0.20	0.01	0	0	0	0	0	0
ALGAE	Filamentous algae	49	9.89	1.50	8	6.11	1.90	13	12.74	3.76
	Chara (frag.)	5	1.01	0.24	0	0	0	0	0	0
	Chara (Oogonium)	4	0.801	0.18	5	3.82	1.52	32	31.37	9.41
PISCES	Fish (scale)	8	1.61	0.28	0	0	0	26	25.49	6.20
	Fish (bone)	0	0	0	0	0	0	2	1.96	0.20
OTHERS	Detritus	60	12.12	3.17	12	9.16	1.41	80	78.43	46.58
	Foraminifera	3	0.60	0.06	0	0	0	0	0	0
	Insecta (frag.)	7	1.41	0.24	0	0	0	4	3.92	0.78
	Crustacea (frag.)	4	0.801	0.06	1	0.76	0.14	7	6.86	0.51
	Sand	2	0.40	0.04	1	0.76	0.07	14	13.72	0.67
	Hydracarina	1	0.20	0.02	1	0.76	0.07	0	0	0
	Thorn	19	3.83	0.36	3	2.29	0.14	2	1.96	0.12
	Schell (frag.)	6	1.21	0.06	0	0	0	17	16.67	1.45
	Unknown	28	5.65	0.78	5	3.81	5.18	2	1.96	0.08
	Rotifera	0	0	0	4	3.05	1.38	0	0	0

The results of the frequency of occurrence of the dietary items found for the three species (Table 1) showed that for the Penaeidae species, the dominant dietary items were Polychaeta, *Heleobia australis* and Chironomidae.

In the gut content of *M. acanthurus*, the dominant item was detritus, found in 78% of the examined guts. No significant statistical differences were found (Friedman, $p > 0.05$) between the frequencies of occurrence of dietary items among the three species, but it was observed that the species of Penaeidae had similar occurrences for most items, while in *M. acanthurus*, detritus and algae reached the highest occurrences. The relative volume of the dietary items found in the gut content of the three species is presented in Table 1. *F. brasiliensis* had as the items that contributed the most to the total volume Polychaeta (36.4%), Chironomidae (34.2%) and *Heleobia australis* (13.3%). *F. paulensis* had a higher relative volume of Chironomidae (48.9%), followed by *H. australis* (18.9%) and Polychaeta (17.9%). *M. acanthurus* had detritus (46.6%) as the most volumous item, followed by Polychaeta (9.8%) and *Chara oogonium* (9.4%). The relative composition of the food found in the guts, as the frequency of occurrence and as percentage of

points showed a correlation between the results obtained by the two methodologies (Spearman; $p < 0.001$). The food capture is made with the chelae, and they usually can ingest large prey by manipulation prior to ingestion. Therefore, most of the gut content was composed by broken fragments, and the identification was possible only by the analysis of the hard parts of the preys. The values of r_s were considered as extremely significant, pointing at a good fit between the ranks of relative importance (*F. brasiliensis*, $r_s = 0.986$; *F. paulensis* $r_s = 0.988$ and *M. acanthurus* $r_s = 0.967$). The three analyzed species had a low occurrence of empty stomachs. A total of 534 stomachs of *F. brasiliensis* were found, of which 39 (7.3%) were empty; 143 stomachs of *F. paulensis*, with 12 (8.4%) empty, and 105 of *M. acanthurus*, with 3 (2.8%) empty. Most stomachs had indices of repletion above 50%. The calculations of the Feeding Index (FI) (Table 2) and its representation as parallelograms (Figure 1) presented the relative importance of each dietary item and showed that for the species of Penaeidae, Insecta was the dominant item, with an FI of 47.5% and 66.2% for *F. brasiliensis* and *F. paulensis*, respectively. For *M. acanthurus* the highest FI was found for the detritus, with 63.9%.

Table 2 - Feeding index for the three species (in percentage)

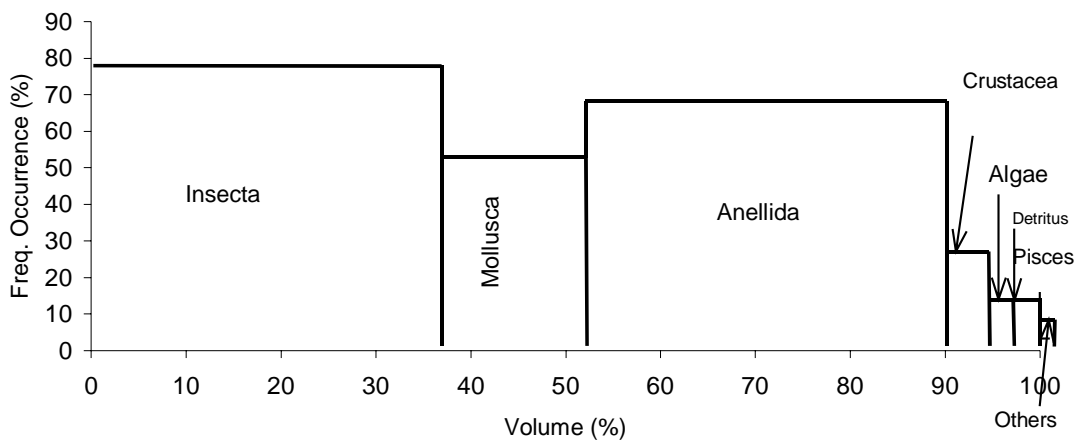
Items	<i>F. brasiliensis</i>	<i>F. paulensis</i>	<i>M. acanthurus</i>
Insecta	47.55	66.20	13.77
Mollusca	10.99	20.07	2.43
Anellida	38.59	10.37	3.36
Crustacea	1.54	2.49	0.42
Algae	0.35	0.53	10.17
Pisces	0.01	0.0	3.07
Detritus	0.60	0.20	63.92
Others	0.36	0.12	2.84

DISCUSSION

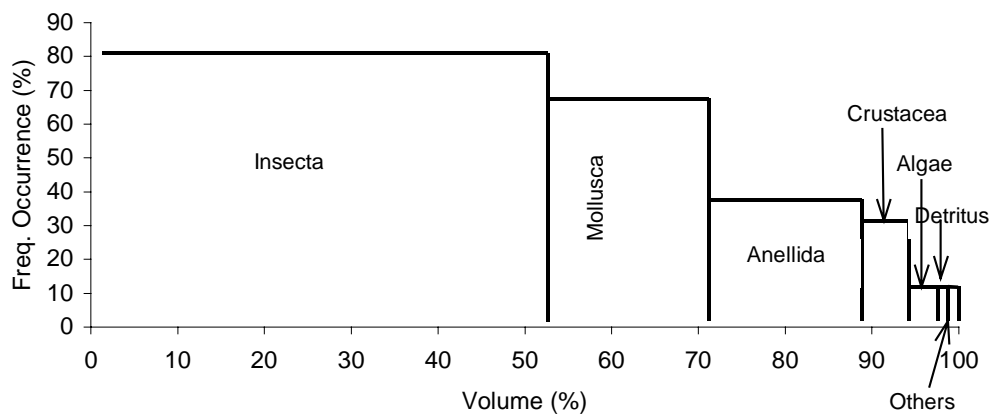
Studies on the feeding role of species are important tools for the evaluation of the structure and functioning of ecosystems (Krebs, 1989). Decapods crustaceans are usually opportunistic omnivores, taking their food from the bottom of their habitats or from the fauna associated to submersed and shore vegetation in the water bodies (Williams, 1981). Decapoda have been recognized as important

predators in tropical coastal environments by several authors (Marte, 1980; Nelson, 1981; Leber, 1985; Preston et al., 1992; Heales, 1996, among others). They are important predators in habitats with aquatic macrophytes, and shrimps have a great proportion of the epifauna, such as small crustaceans, mollusks and polychaetes, in their diet (Leber, 1985). Apparently there are no established methodologies for the quantitative description of macroscopic items in the gut content in crustaceans.

Farfantepenaeus brasiliensis



Farfantepenaeus paulensis



Macrobrachium acanthurus

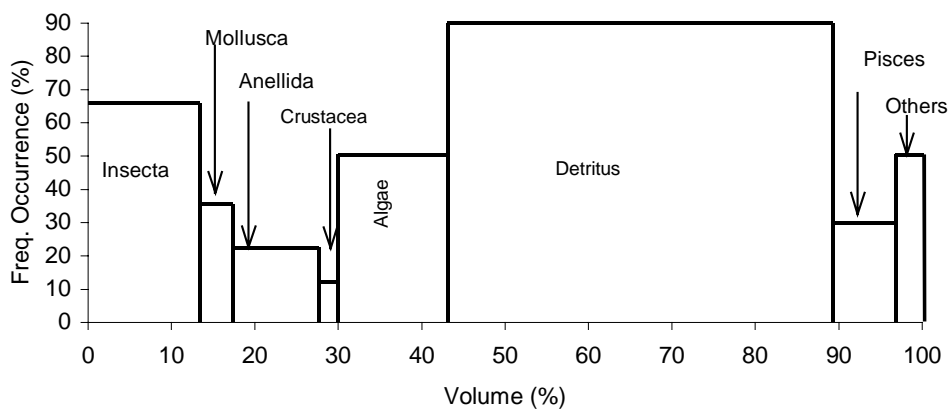


Figure 1 - Parallelograms of feeding index

Especially regarding the feeding habits of Decapoda crustaceans, several authors used the method of the frequency of occurrence of dietary items, due to the fragmentation of the preys found in the gut (Edwards, 1978; Chong and Sasekumar, 1981; Su et al., 1990; Tararam et al., 1993; Cartes, 1995; among others).

Some analyzed the frequency of occurrence and the number of certain items (Cartes, 1995), and the diet through the volume occupied by the dietary items (Williams, 1981; Wear and Haddon, 1987). The "Points method", reviewed by Hynes (1950), was used in several studies of natural diets, especially in fishes, and was to be satisfactory in the analysis of the diet of Decapoda crustaceans (Williams, 1981, Marte, 1980; Guerao, 1995; Branco and Verani, 1997). Hynes (1950) and Hyslop (1980) described the method as satisfactory in the analysis of the dietary spectrum, and compared it with the methods used by other authors, such as number of organisms, volume, and weight and they found no higher differences than those between samples.

The percentage of occurrence is a measurement of the regularity of one item in the diet of a sampled population. Our study showed an agreement between the percentage of points and the frequency of occurrence of items, indicating that the items more frequently ingested were also those found in higher amounts. Similar result was found by Guerao (1995) who, analyzing the diet of *Palaemon xiphias*, also found a good agreement between the two measurements. Although some authors classified the Penaeidae as detritivores (Dall, 1968), it was shown that their diet had a higher diversity of feeding items. Diversified diets, with several elements of the benthic community, have been observed by many authors (Edwards; 1978; Marte, 1980; Chong and Sazekumar; 1981; Tararam et al.; 1993 and Cartes; 1995). Some authors have shown that species of Palaemonidae also had a diet composed by several items, although the detritus was usually an important and quite common component (Howard, 1984; Collins and Paggi, 1998). In our study, *M. acanthurus* also showed omnivore characteristics, but the most common item was detritus. Another common item was oogonium of *Chara*, a macroalgae that occupied most of the benthic region of Imboassica lagoon and which harbored a rich periphytic community with associated

macrofauna (Albertoni et al., 2001). The presence of high amounts of detritus, both in frequency and in relative volume, suggested that *M. acanthurus* could feed on dead material, but also that the manipulation before ingestion could be important, easing the digestion of many items by the separation of its harder parts. We observed this behavior in laboratory, with the manipulation of the food and fragmentation of small pieces of fish, Chironomidae larvae and other insects associated to aquatic macrophytes were ingested without fragmentation. Due to the diversified diet found both for Penaeidae and Palaemonidae, many studies were developed aiming to clarify the role of these consumers in the regulation of the meso and macrofauna of aquatic environments. *Penaeus duorarum* had a negative effect on most groups, with a particularly strong effect on the group of small crustaceans and polychaetes (Nelson, 1981). According to Nelson and Capone (1990), through laboratory and field experiments, *P. duorarum* resulted in a significant reduction in the abundance of polychaetes of many species associated to the aquatic macrophyte *Halodule wrightii* in a coastal lagoon at Florida. The Decapoda crustaceans had a great influence on the predation of habitats with plants and rival fishes in their potential for disturbing the structure of the communities in these habitats (Leber, 1985; Posey and Hynes; 1991). In experiments with several species, including *Macrobrachium*, Rosemond et al. (1998) observed the influence of macroconsumers on small invertebrates, concluding that its omnivory could result in disturbance on several trophic levels in tropical environments. Likewise, Bell and Coull (1978) showed the same effect for *Palaemonetes pugio*, proving that it controlled populations and communities of the meiofauna of marine and coastal environments. Therefore, the results of dietary items occurrence in the three studied species presented a similarity to other studies with related species, with similar diets at the level of great taxonomic groups, showing its omnivory. Although no specific experiments on predation and selectivity were executed, the available data suggested that both the Penaeidae and *M. acanthurus* were important predators on the community of meso and macrofauna at Imboassica lagoon. The night feeding of these species was reported by several authors (Lewis et al.; 1966;

Hill and Wassenberg, 1987; Wassenberg and Hill, 1987; Primavera and Leбата, 1995; Collins and Paggi, 1998; Rosemond et al., 1998, among others). Through the obtained results, a low index of empty or partially empty stomachs was detected and the majority of stomachs were with over 50% of their total volume filled, ensuring the validity of the estimates of frequency of occurrence and volume of dietary items. Kawakami and Vazzoler (1980) proposed an index that evaluated the importance of the dietary items for a given species, using the proportions of frequency of occurrence and volume of each dietary item. This index, called Feeding Index (FI), has been used by some authors (Andrian and Barbieri, 1996; Branco et al., 1997; Reis, 1997; Branco and Verani, 1997), and allows for a finer distinction of the relative importance of each item, whatever its condition regarding the frequency of occurrence and volume. The feeding indices clearly determine the actual importance of each item in the diet, and are an important aid to the understanding of the interaction of the feeding processes among different species in the same area (Kawakami and Vazzoler, 1980). The FI results for the three studied species showed that for the species of Penaeidae, the insects, especially larvae of chironomids, constituted the most important item, and *M. acanthurus* had detritus as the main component of its diet, with insects as the second most important item. It is believed that the obtained estimates are valid for the analysis of trophic relations of the studied species in the environment, due to the great difficulty in observing their feeding behavior "in situ". The results for the diet analysis of *F. brasiliensis*, *F. paulensis* and *M. acanthurus* allowed the description of these species role in the trophic relations at Imboassica lagoon, acting as important predators of elements of the benthic fauna and of the fauna associated to aquatic macrophytes. Future research, focusing on quantitative evaluation of the predation pressure of these species on the zoobenthic communities in this lagoon, would allow a real evaluation of their trophic role, both as predators and as preys for fish and avian species, a role in which no study was executed yet. By a preliminary evaluation of the density of the benthic fauna and communities associated to the macroalgae *Chara*, coupled with the growing indices, especially of Penaeidae

species (Albertoni, 1999), it could be inferred that Imboassica lagoon was a nonlimiting environment regarding feeding resources. This fact may stimulate the elaboration of management plans for this ecosystem, including the development of programs of extensive culture of some species (Albertoni, 1998a).

CONCLUSIONS

The techniques used for the evaluation of the natural diet of *M. acanthurus*, *F. brasiliensis* and *F. paulensis* were considered satisfactory, and the Points method, although providing a subjective estimate of the volume of dietary items, was an appropriate technique for quantitative estimates of the gut content in Penaeidae and Palaemonidae in Imboassica lagoon. The evaluation of the frequency of occurrence of the diverse dietary items allowed the conclusion that the three studied species were important predators of benthic macrofauna and of the fauna associated to aquatic macrophytes in Imboassica, having as the main dietary items the mollusk *Heleobia australis*, larvae of Chironomidae, Polychaeta and detritus. The Feeding Index (FI) was showed to be efficient in the quantitative determination of the diet of the studied species, with the highest values being found for the items Insecta, Polychaeta and Mollusca in the evaluation of the species of Penaeidae. When *M. acanthurus* was studied, detritus and insects had the highest values. The evaluation of the diet of shrimps provides support for the elaboration of management plans for Imboassica lagoon, including projects for farms, since this environment provides abundant food resources.

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RESUMO

O conteúdo estomacal de 495 espécimens de *Farfantepenaeus brasiliensis*, 131 de *F. paulensis* (Penaeidae) e 102 de *Macrobrachium acanthurus*

(Palaemonidae) foi analisado para estabelecer a composição de suas dietas. As espécies foram coletadas em uma lagoa costeira ao norte do Estado do Rio de Janeiro (lagoa Imboassica), entre agosto de 1995 a setembro de 1997, os estômagos retirados dos animais e conservados em álcool 70%. Foram estimados a frequência de ocorrência dos itens alimentares, seu volume relativo através do método de pontos, e o Índice Alimentar. *F. brasiliensis* apresentou como itens mais importantes em sua dieta larvas de Chironomidae, Polychaeta e *Heleobia australis* (Mollusca). Para *F. paulensis*, os itens mais importantes foram os mesmos de *F. brasiliensis*, porém invertendo-se a ordem de importância de *H. australis* e Polychaeta. *M. acanthurus* apresentou o item detrito como mais importante, seguido de Chironomidae (larvas), Odonata (ninfas), e fragmentos da macroalga *Chara*. Os resultados mostram que as três espécies são omnívoras, com uma dieta alimentar variada que inclui tanto componentes da macrofauna bêntica e associados a macroalga *Chara*, como fragmentos vegetais e detritos.

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