Diet of *Iheringichthys labrosus* (Siluriformes, Pimelodidae) in the Ibicuí River, Southern Brazil

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ABSTRACT. The diet of the benthic-feeding fish *Iheringichthys labrosus* (Lütken, 1874) was analyzed. Samples were taken bimonthly from December 1999 to January 2002, in three sites of the Ibicuí River, a tributary of Uruguay River basin (Rio Grande do Sul, Brazil). In each sampling point the specimens were collected in lentic and lotic environments. Gillnets and trammel nets were examined every 6 hours (6h, 12h, 18h and 24h). Diet description was based on the frequency of occurrence and the volume of each food item to obtain the Alimentary Index (IAi). The average stomach fullness was adopted to detect variations in the feeding activity according to the season, the circadian rhythm and the environment. Chironomids were the most important food item, followed by mollusks, and feeding activity was highest in summer, during daylight (6h and 12h), and in the lotic environment of the second sampling point.

KEY WORDS. Feeding activity, Chironomidae, Rio Grande do Sul.

RESUMO. Dieta de *Iheringichthys labrosus* (Siluriformes, Pimelodidae) no rio Ibicuí, Sul do Brasil. A biologia alimentar de *Iheringichthys labrosus* (Lütken, 1874) foi estudada através de exemplares coletados bimestralmente em três pontos do rio Ibicuí, um afluente da bacia do rio Uruguai, Rio Grande do Sul, Brasil, de dezembro de 1999 a janeiro de 2002. Em cada ponto foram amostrados ambientes lênticos e lóticos, sendo as redes de espera e feiticeiras revisadas a cada 6 horas (6, 12, 18 e 24hs). A descrição da dieta foi baseada na combinação da freqüência de ocorrência e volume de cada item alimentar para obtenção do índice de importância alimentar (IAi). Variações na tomada do alimento quanto à sazonalidade, ritmo circadiano e ambientes foram verificadas através do grau de repleção médio. Os Chironomidae constituíram a principal fonte alimentar da espécie, seguidos pelos moluscos. A maior atividade alimentar foi verificada no verão no período diurno (6 e 12h) no ambiente lótico do segundo ponto de coleta.

PALAVRAS-CHAVE. Atividade alimentar, Chironomidae, Rio Grande do Sul.

Studies on the feeding resources exploited by fishes are very important to the comprehension of their relations with the aquatic ecosystem and trophic position (WINDELL & BOWEN, 1978), and also to the knowledge on the feeding resources available in their environments (HAHN *et al.*, 1997). Additionally, the intensity of food intake can reflect the competition or resource partitioning among the components of the trophic levels (HAHN *et al.*, 1997).

In tropical regions, fish species exhibit great plasticity in their diet, due to the high food diversity available. However, the adaptability of fishes does not exceed the limits established by the morphologic structure of the digestive system of each species (FUGI & HAHN, 1991).

According to WELCOMME (1979) and WOOTTON (1990), the feeding activity of fishes can be altered by several environmental factors, such as differences in the hydrologic regime and luminosity throughout the day. Moreover, spatial and seasonal variations in the composition of the feeding items are known. Such changes are especially related with the quality and amount of food available in the habitat and with ontogenetic changes of the species (AGOSTINHO, JULIO-JR. *et al*., 1997).

Iheringichthys labrosus (Lütken, 1874) has a small and sub-inferior mouth, presenting adaptations for capturing food in bottom environments (NOMURA, 1984). The morphology of the digestive system and its structures, such as the wide space between the gill rakers and the short intestine, are also adapted to the feeding habit of the species (FUGI *et al*., 2001).

In the Paraná River basin, *I. labrosus* is one of the most important species of the ichthyofauna (AGOSTINHO, HAHN *et al*., 1997; BENEDITO-CECÍLIO & AGOSTINHO, 2000; BENNEMANN *et al*., 2000), and its feeding habits have been studied by many authors (FUGI *et al*., 1996; HAHN *et al*., 1997; BENNEMANN *et al*., 2000; ABES *et al*., 2001; FUGI *et al*., 2001). However, no study was conducted in the Uruguay River basin, where the species is very common (BERTOLETTI *et al*., 1989). In the Ibicuí River, for example, *I. labrosus* is the sixth species with higher relative biomass (E. Behr, pers. obs.)

This paper aims to describe the diet of *I. labrosus* in the Ibicuí River and its alterations related to seasonality, circadian rhythm and environments (lentic and lotic).

MATERIAL AND METHODS

The Ibicuí River is one of the main tributaries of the Uruguay River. According to RAMBO (1994), the river is shallow, showing a wide floodplain and several marginal marshes. The upper Ibicuí, formed by the Ibicuí-Mirim and Santa Maria rivers, presents a sandy substratum.

The sampling sites were chosen in the stretch between the municipalities of São Vicente do Sul and Itaqui. Site 1 is located downstream of the Santa Maria River confluence, between São Vicente do Sul and Cacequi (29º48'S; 54º58'W); Site 2 is located in the middle course of the Ibicuí River, between Manoel Viana and Alegrete (29º29'S; 55º45'W) and Site 3 is located upstream from the Ibirocai River confluence, between Itaqui and Alegrete (29º25'S; 56º37'W) (Fig. 1). In each site, the specimens were collected in lotic and lentic environments represented, respectively, by the axis of the river and by lakes or secondary channels that are connected with the river most part of the year.

The lentic environment of each site shows some particular characteristics. Site 1 is a very small stream with width ranging from 3 to 8m and very low water flow. During the floods, it feeds a lake, situated 40m far from the river. However, in the dry periods the lake vanishes and only the channel remains. Site 2 is represented by a lake, connected by a strait and short channel (2 to 3m width and around 8m length) to the river, with the margins shadowed by arboreus and shrubby vegetation. The lake is about 150m long and 70m wide, and during the dry periods it becomes isolated from the river. The lake of site 3 is large, being about 200m wide near the river. All sites present few aquatic macrophytes.

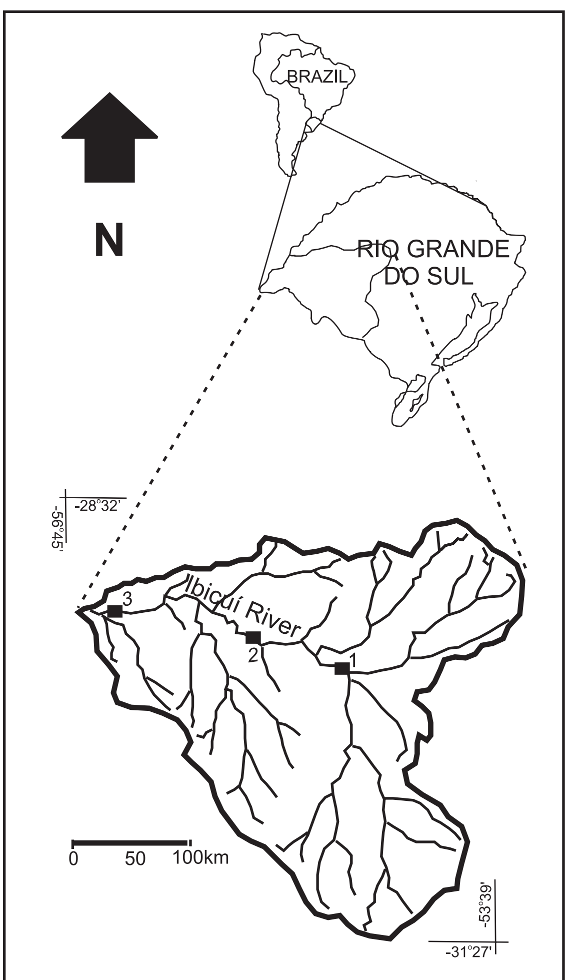

Fig. 1. Study area showing the sampling sites (1, site 1; 2, site 2; 3, site 3).

The specimens of *I. labrosus* were collected bimonthly from December 1999 to January 2002. In each sampling, gillnets of 10m (meshes 1.5, 2.0, 2.5, 3.0) and 20m (meshes 4.0, 5.0, 6.0, 8.0, 10.0), and trammel nets of 4.0/20.0; 5.0/20.0 and 6.0/20.0 (all mesh sizes in cm, measured between adjacent nodes) were employed. The gillnets were kept in the water for 24 hours and examined every 6 hours (6h, 12h, 18h and 24h).

The specimens were fixed in formaline 10% and preserved in alcohol 70% (Malabarba & Reis, 1987). The total weight and length and the standard length were measured. Stomachs were removed and stored in identified recipients. Stomach fullness was determined for each specimen according to the following categories: 0=completely empty, 1=partially empty (< 25%), 2=partially full (25% to 75%), and 3=completely full stomach (> 75%).

The volume of the small food items was obtained using a Petri dish with a graph paper attached outside of the inferior face. Two microscope glass slides were adhered inside the dish in order to obtain an angle of 90° and an area with uniform depth (1mm). Each alimentary item was classified according to their taxonomic group and they volume measured in the square area formed by the glass slides. It was assumed that $1mm^3$ is equal to 0.001 ml. The volume of the largest items was determined by water displacement method, using a graduated cylinder (Abes *et al*., 2001).

The organisms were identified under a stereoscopic microscope, at the lowest taxonomic level possible. The frequency of occurrence (%) and the volume of each food item found in the stomach contents were combined to obtain the Alimentary Index (IAi) (Kawakami & Vazzoler, 1980). The index values range from 0 to 100%.

Seasonal changes in the diet were analyzed by pooling the data according the seasons, which correspond in the south hemisphere to the following months: spring (October, November, December), summer (January, February, March), fall (April, May, June), and winter (July, August, September).

Spatial and temporal differences in capture of the species were analyzed using the Qui-square test (χ^2). Variations in the feeding activity related to the circadian rhythm, seasonality and environments were determined using the average stomach fullness (Santos, 1978), and their significance was tested by ANOVA ($P \leq 0.05$). The Tukey test was performed to compare the means values.

RESULTS

A total of 542 specimens of *I. labrosus* were collected. The total length of the fishes ranged from 10.5 to 33.4 cm and total weight from 7 to 320 g. For the diet study, 328 individuals were used.

The analysis of the feeding activity showed that 85.4% of the stomachs had some content. Regarding the stomach fullness, the level 2 (partially full) was more frequent, being assigned to 35.7% of the specimens examined. Diptera was the main food item (80.4%), according to the alimentary index, and was represented especially by Chironomidae (36.5%). Mollusca constituted the second group in importance (10.3%). Ephemeroptera (Baetidae, Leptohyphidae and Polymitarcyidae), and Trichoptera, (mainly Leptoceridae), were uncommon (2.7% and 2.5% respectively), as well as Nematoda (2.2%) and Crustacea (1.7%) (Fig. 2). Other organisms recorded in the diet of *I. labrosus* were very rare and represented less than 1% of the food items (Tab. I).

Small variations were detected in the frequency of the most important food items when the sites were analyzed separately. Diptera (Chironomidae) were dominant in all environments and seasons, always followed by mollusks, except in site 3, where Ephemeroptera and Trichoptera were the second most frequent food resource, respectively. However, higher magnitude differences can be observed when some factors are considered. In lotic environments, Trichoptera constituted the third item in importance (5.3%) but in lentic settings, crustaceans and Ephemeroptera represented, each one, 4.1% of the ingested food,

Table I. Food items ingested by *Iheringichthys labrosus* (Lütken, 1874) in the Ibicuí River, Southern Brazil, from December 1999 to January 2002 with the alimentary Index values (IAi) of the main groups at each station and environment.

	IAi (%)					
Food items	Seasons				Environments	
	Spring	Summer	Fall	Winter	Lentic	Lotic
Nematoda	2.76	0.22	3.91	6.37	3.98	1.02
Mollusca	17.26	7.85	15.89	10.32	7.69	12.8
Gastropoda						
Bivalvia						
Annelida	0.160	0.0002		0.11	0.15	
Oligochaeta						
Hirudinea						
Arachnida	0.034	0.0002	0.004	0.006	0.003	0.003
Araneae						
Acarina						
Crustacea	0.390	0.24	8.66	6.0	4.1	0.43
Cladocera						
Ostracoda						
Copepoda						
Isopoda						
Insecta (N.I.)	0.003	0.002		0.02	0.009	0.003
Odonata	0.003	0.12	0.81	0.01	0.16	0.04
Gomphidae						
Libellulidae						
Aeshenidae						
Ephemeroptera	0.280	4.28	8.25	1.13	4.1	1.48
Polymirtacyidae						
Baetidae						
Leptohyphidae						
Hemiptera	0.006	0.04	0.05		0.002	0.0001
Notonectidae						
Veliidae						
Trichoptera	0.850	6.09	0.57	0.1	0.46	5.33
Odontoceridae						
Leptoceridae						
Hydropsychidae						
Polycentropodidae						
Hydroptilidae						
Lepidoptera	0.02			0.01	0.01	
Diptera	78.19	81.15	61.85	75.65	79.24	78.88
Tipulidae						
Chironomidae						
Simuliidae						
Ceratopogonidae						
Chaoboridae						
Empididae						
Pupa						
Coleoptera	0.04	0.0004		0.27	0.09	0.01
Dytiscidae						
Hydrophilidae						
Hymenoptera	0.001				0.00007	
Chilopoda				0.002		0.0007

followed by Nematoda (3.9%). Concerning the seasons, Crustacea and Ephemeroptera were also important in the fall, Nematoda during the winter and spring, and Trichoptera, in the summer.

Most of *I. labrosus* individuals (57.6%) were collected in the river (χ^2 = 12.406; P<0.05), suggesting that the species could have preference for lotic environments. Highest numbers of specimens were obtained in site 1, where 41.3% of all fish captured (χ^2 = 15.69; P<0.05) were found, followed by sites 3 and 2, with 29.9% and 28.8%, respectively. The number of captured individuals was highest at 24 hours (N=182, 33.6%) and remained high at 6 hours (N=175, 32.3%), showing that the species is more easily found between the middle of the night and the sunrise (χ^2 = 62.66; P<0.05). *Iheringichthys labrosus* was also more frequent during the summer, when 44.21% (χ^2 = 83.88; P<0.05) of the specimens were collected.

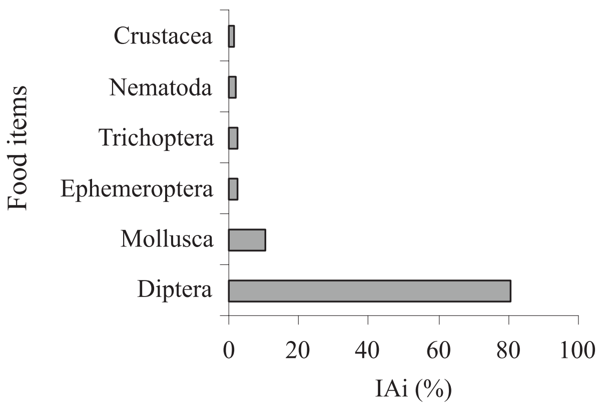

Fig. 2. Alimentary index (IAi) of the main items exploited by *Iheringichthys labrosus* (Lüetken, 1874) in the Ibicuí River, Southern Brazil, from December 1999 to January 2002.

Although more frequent in rivers, *I. labrosus* exhibited the highest average stomach fullness (1.86) in lentic environments. However, this result was not statistically significant (F=3.78; P>0.05), as well as the differences detected between the three sites (F=0.647; P>0.05). On the other hand, the highest feeding activity (F=4.14; P<0.05) was registered in the lotic environment of site 3.

The feeding activity of *I. labrosus* occurred during a long period. The highest number of completely full stomachs, which yielded an average stomach fullness of 2.16, was registered at 6h in the morning. The average stomach fullness was slightly lower (1.91) at 12h and drastically decreased (1.33) at 18h, when 18 empty stomachs were found. The same number of empty stomachs (N=18) was obtained at 24h. However, at this time, a considerable number of individuals presented partially full and completely full stomachs. In other words, the feeding activity of *I. labrosus* is highest during daylight.

Regarding the seasons, higher feeding activity was recorded in summer (F=3.89; P<0.05), when average stomach fullness was 1.88. The winter was the season with the highest percentage of empty stomachs, but during the spring lower levels (1.4) of feeding activity were observed (Fig. 3).

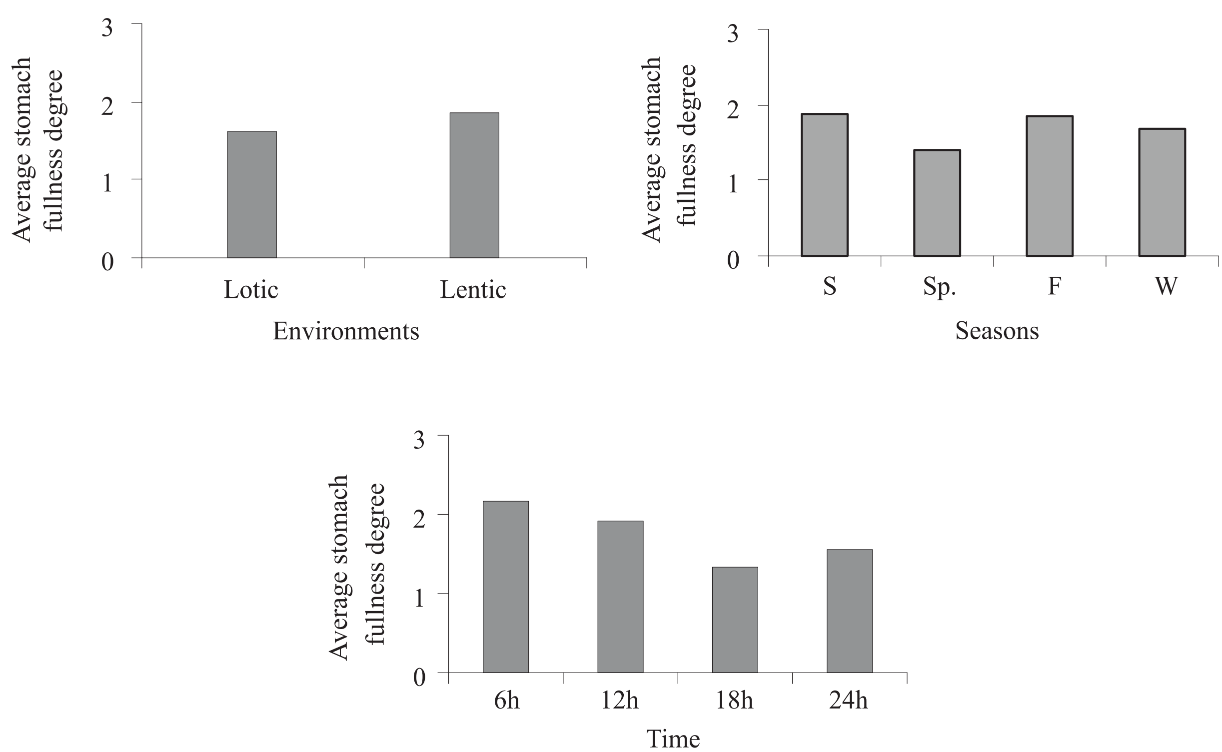

Fig. 3. Dial, seasonal and environmental variations in average stomach fullness degree of *Iheringichthys labrosus* (Lüetken, 1874) in the Ibicuí River, Southern Brazil, from December 1999 to January 2002 (S, Summer; Sp, Spring; F, Fall; W, Winter).

DISCUSSION

In the Ibicuí River, Chironomidae constituted the main food resource of *I. labrosus*, followed by Mollusca, Ephemeroptera, Trichoptera, Nematoda and Crustacea. Other organisms found in the stomach had very small feeding importance.

The Chironomidae exhibit a wide geographic distribution, and they are present in almost all aquatic habitats (MCCAFFERTY, 1981). For this reason, these insects are one of the most abundant food resources found by fishes (HAHN *et al*., 1997). Similarly, other juvenile insects can also be included in the main feeding resources utilized by ichthyofauna (ZAVALA-CAMIN, 1996). Rivers with sandy bottoms, as the Ibicuí River, are usually characterized by the presence of an abundant benthic fauna (HARTZ *et al*., 2000). Thus, the feeding habitat of the species is determined by an interaction between the morphology of their digestive system and the food availability in a particular habitat (FUGI & HAHN, 1991; BENNEMANN *et al*., 2000).

Although there is a consensus on the importance of Chironomidae in the diet of *I. labrosus*, the feeding spectrum observed during this study was different from the spectrum registered by FUGI *et al*. (1996) and ABES *et al*. (2001) in the Paraná River basin. In the former study, Nematoda and Crustacea were more important than Mollusca, Trichoptera and Ephemeroptera. In the latter, Trichoptera presented higher alimentary index values than mollusks in the diet of *I. labrosus*.

In the Tibagi River (state of Paraná), BENNEMANN *et al*. (2000) observed that Diptera and Ostracoda were important food items, corresponding 63% of the stomach content of the species. The results are slightly different from those obtained in the present study. In other words, the studies demonstrate that the diet of fishes are influenced mainly by the food availability and by the environmental changes that the populations and species of fishes are exposed (LOWE-MCCONNELL, 1999).

No significant variation was observed regarding the most important food items. Nevertheless, spatial and temporal fluctuations were registered for the secondary items. The spectrum and the feeding rhythm were probably influenced by particular characteristics of each habitat and their diversity and abundance of organisms, and certainly by the typical habitat and the life cycle of the preys (HAHN *et al*., 1997).

Iheringichthys labrosus seems to prefer lotic environments, but is able to explore different biotopes, capturing the available feeding resources. Although not statistically significant, the highest number of individuals with full stomachs (highest average stomach fullness) was recorded in lentic habitats (lakes), as previously observed by HAHN *et al*. (1997). According to BENNEMANN *et al*. (2000), there is less trophic specialization in rivers than lakes, due to the permanent resources availability along the year in the later, while in riverine settings the feeding items are affected by the seasons.

According to JUNK (1997), in floodplains, lakes constitute reservoirs of organisms and material carried from rivers, and differences in their production varies in accordance with the elements received. This dynamics is affected by characteristics such as morphology, size and position of the lakes, and also by the connectivity of the systems. All these factors eventually determine the composition of organisms present in the environments. In the present study, the abundance of *I. labrosus* in the site 1 reflect the differences existing in each environment. However, the highest feeding activity of the species in the lotic habitat of the site 1 is probably related to the expressive presence of vegetation on its margins, which constitutes an important alimentary resource for many aquatic invertebrates (RUSSO *et al*., 2002).

The percentage of captured specimens was highest at the first hours of the day (24h to 6h), differing from the results registered by BENNEMANN *et al*. (2000), which assigned highest percentages after midday (3h to 15h) and during the dusk (15h to 19h). Such differences of results could have been determined by the influence of the food availability in the environments on the daily rhythms of feeding activity of fishes (BARTHEM, 1987).

HAHN *et al*. (1997) suggested that fishes that adopt a visual method of capturing organisms exhibit high feeding activity during the daylight. In this study, the peak of feeding activity occurred between 6 and 12 hours, confirming the influence of the luminosity. However, at 24 hours, the highest number of full stomachs was recorded, showing that the circadian rhythm of the invertebrate preys, which are generally active during the night (SCRIMGEOUR & WINTERBOURN, 1987), is also an important factor on the species diet.

DEVINCENZI & TEAGUE (1942) observed that in Uruguay River, *I. labrosus* is more frequent in summer. During this season, they did not register increase in the frequency of full and partially full stomachs. On the other hand, in this study the highest average of stomach fullness was recorded in summer. This result suggests that the intensity of the feeding activity could be positively affected by the reproductive period of the species, which occurs from October to November (DEVINCENZI & TEAGUE, 1942). Similar results were found by VIANA *et al*. (2006), which observed that the fluctuations in the feeding of the Pimelodidae, *Pimelodella* **cf.** *gracilis*, was influenced by the reproductive cycle. According to these authors, before the reproductive period, all the energy obtained through feeding was employed in the growing of the gonads. Hence an increase of the feeding activity should be expected after this period, in order to compensate the energy then spent.

In the Ibicuí River, Chironomids constituted the main food item of *I. labrosus* in all environments and periods analyzed, followed by mollusks. However, the species showed some temporal and spatial variations to the other food items. Significant differences in the alimentary rhythm concerning seasons, circadian rhythm and environments (lentic, lotic), were detected, but *I. labrosus* shows high adaptability to the different environments of the river. Future studies should be conducted in order to analyze the relations of the diet of the species with the alimentary resources available in the Ibicuí River.

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