# DIET AND FEEDING ACTIVITY OF *Pimelodus maculatus* (OSTEICHTHYES, PIMELODIDAE) IN THE PIRACICABA RIVER (STATE OF SÃO PAULO, BRAZIL) – THE EFFECT OF SEASONALITY*

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**ABSTRACT**

The study describes the effect of seasonality on the diet and feeding activity of *Pimelodus maculatus* in the Piracicaba River (State of São Paulo, Brazil). The stomach contents of individuals caught along the four seasons of the year (n=241) were analyzed and the Stomach Fullness Index of each specimen was calculated. The results indicate that *P. maculatus* is an omnivorous and opportunist species, which consumes mainly aquatic insects during the whole year. However, it presents seasonal diet shifts, due to the oscillation of the secondary items importance, which is probably the result of the distinct availabilities of food along the seasons. Moreover, its highest feeding activity occurs during the autumn and the lowest one in the coldest months, i. e., in winter.

**Key words:** fish; *P. maculatus*; freshwater; seasonal effect; stomach contents; Stomach Fullness Index

## DIETA E ATIVIDADE ALIMENTAR DE *Pimelodus maculatus* (OSTEICHTHYES, PIMELODIDAE) NO RIO PIRACICABA (ESTADO DE SÃO PAULO, BRASIL) – O EFEITO DA SAZONALIDADE

**RESUMO**

O trabalho descreve o efeito da sazonalidade sobre a dieta e a atividade alimentar de *Pimelodus maculatus* no Rio Piracicaba (Estado de São Paulo, Brasil). Para tanto, analisou-se o conteúdo estomacal de indivíduos capturados ao longo das quatro estações do ano (n=241), e calculou-se o Índice de Repleção Estomacal desses exemplares. Os resultados indicam que *P. maculatus* é uma espécie onívora e oportunista, consumindo, principalmente, insetos aquáticos durante o ano todo. Contudo, a espécie apresenta mudanças sazonais em sua dieta, devido às oscilações da importância dos itens secundários, oscilações essas resultantes, provavelmente, da disponibilidade diferenciada de alimentos ao longo das estações. Além disso, a maior atividade alimentar da espécie ocorre durante o outono, e a menor, nos meses mais frios, isto é, no inverno.

**Palavras-chave:** peixe; *P. maculatus*; água doce; efeito sazonal; conteúdo estomacal; Índice de Repleção Estomacal

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## INTRODUCTION

The studies on natural feeding of fish permit to identify the trophic relationships present in aquatic ecosystems (ZAVALA-CAMIN, 1996; HAHN *et al.*, 1997), besides to produce a valuable knowledge for the development of artificial foods used in the pisciculture (CASTAGNOLLI, 1979).

It is important, furthermore, to emphasize that the effect of seasonality should always be considered in such studies, because the temporal changes of biotic and abiotic factors alter the structure of the food web along the year and, as a consequence, the fish often shows seasonal diet shifts (LOWE-McCONNELL, 1987; WOOTTON, 1992; ABELHA *et al.*, 2001).

One of the most abundant species in Paraná River Basin (South America) is *Pimelodus maculatus* Lacépède (Siluriformes, Pimelodidae), an important component of the fish fauna, both in streams (LOLIS and ANDRIAN, 1996; LOBÓN-CERVIÁ and BENNEMANN, 2000) and in lentic waters (BRAGA and GOMIERO, 1997; ALVES *et al.*, 1998). The species shows a remarkable trophic plasticity, including algae and other plant items, porypherans, mollusks, worms, arthropods and fishes in its trophic spectrum (BASILE-MARTINS *et al.*, 1986; LOLIS and ANDRIAN, 1996; BRAGA, 2000; LOBÓN-CERVIÁ and BENNEMANN, 2000).

The only study about seasonal diet shifts of *P. maculatus* in the Piracicaba River (BASILE-MARTINS *et al.*, 1986) states that the species feeds mainly on plants and insects during the year, with minor variations when secondary items are considered by their occurrence and relative abundance. However, those authors analyzed the data of the four seasons through two groups only, a fact that may hide the possible differences between autumn and winter (grouped as cold season) and between spring and summer (named warm season).

Based on this background, the purpose of this study is to analyze, along the four seasons of the year, the effect of seasonality on the diet and feeding activity of *Pimelodus maculatus*.

## MATERIAL AND METHODS

The effect of seasonality on the natural diet and feeding activity of *Pimelodus maculatus* in the Piracicaba River, inside the urban limits of Piracicaba City (22°42′ S; 47°38′ W) in the State of São Paulo, Brazil (Figure 1) was studied. In that place, the marginal vegetation has been deeply depleted and replaced by buildings and grassy plants. Besides such impact, one may say that, nowadays, the waters of the Piracicaba River are not drinkable and, in consequence, people uses the water of another river.

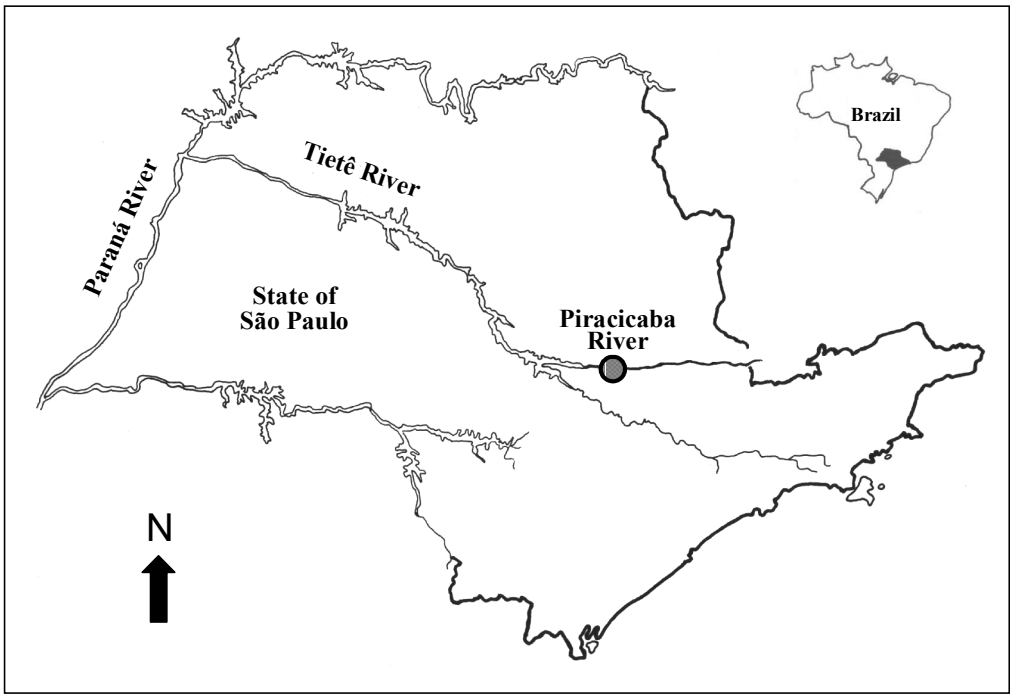


**Figure 1.** Map of the State of São Paulo (Brazil). The black circle shows the sampling site in the Piracicaba River.

In the sampling site, 241 individuals of *P. maculatus* (16.3–27.0 cm Standard Length) were collected with the aid of cast nets (1.0 cm, 2.0 cm and 3.0 cm between knots), from March 1998 to February 1999. In order to minimize possible errors due to punctual samplings, two collections were made in each season (Table 1).

**Table 1.** Date of collections and number of individuals caught in each one, during the four seasons of the year

| *Season* | *Date of collection (number of individuals)* |
|---|---|
| Autumn | Mar. 25 (30) and May 16 (31) |
| Winter | July 16 (30) and Aug. 10 (30) |
| Spring | Oct. 15 (30) and Dec. 09 (30) |
| Summer | Jan. 21 (30) and Feb. 10 (30) |

In the laboratory, the total weight ($W_T$, in grams, to the nearest 0.5 g) and the stomach contents weight ($W_S$, in grams, to the nearest 0.01 g) were taken from each specimen. Such data were used to calculate the Stomach Fullness Index ($I_{SF}$), an indicator of feeding activity of the individuals, defined by the ratio between $W_S$ and $W_T$ (modified from HYSLOP, 1980). The values of $I_{SF}$ in the distinct seasons were compared with each other using the Kruskal-Wallis test complemented by the *a posteriori* test, described by ZAR (1999), with significance level of 0.05.

Stomachs containing food (n=231) were inspected with the use of a stereomicroscope, and the food items were quantified according to the method proposed by LIMA-JUNIOR and GOITEIN (2001). This method allows the calculation of the Importance Index (AI) of each food category, using data from frequency of occurrence and abundance of those food items. The calculation of AI was made for each season and the statistic comparison of the results followed the method proposed by FRITZ (1974), by which the food items are ranked in each sample and compared using the Spearman rank correlation coefficients, with significance level of 0.05.

Although *P. maculatus* shows some ontogenetic variations in its diet (LIMA-JUNIOR and GOITEIN, 2003), the seasonal data were not disturbed by this fact, because the means of Standard Length did not show significant differences among the seasons (ANOVA, p = 0.1104).

**RESULTS**

Aquatic insects – mainly Chironomidae larvae and pupae and Coleoptera larvae – represented the main food item of *P. maculatus* from the Piracicaba River, independently of seasonal effects (Figure 2). However, it was also evidenced that the species shows an omnivorous and opportunist diet, as many other organisms were present in the stomach of the individuals, such as terrestrial insects (Diptera, Coleoptera and Hymenoptera), mollusks (Bivalvia and Gastropoda), annelids (Hirudinea), fishes (mainly Parodontidae and Synbranchidae) and plants (leaves and seeds).

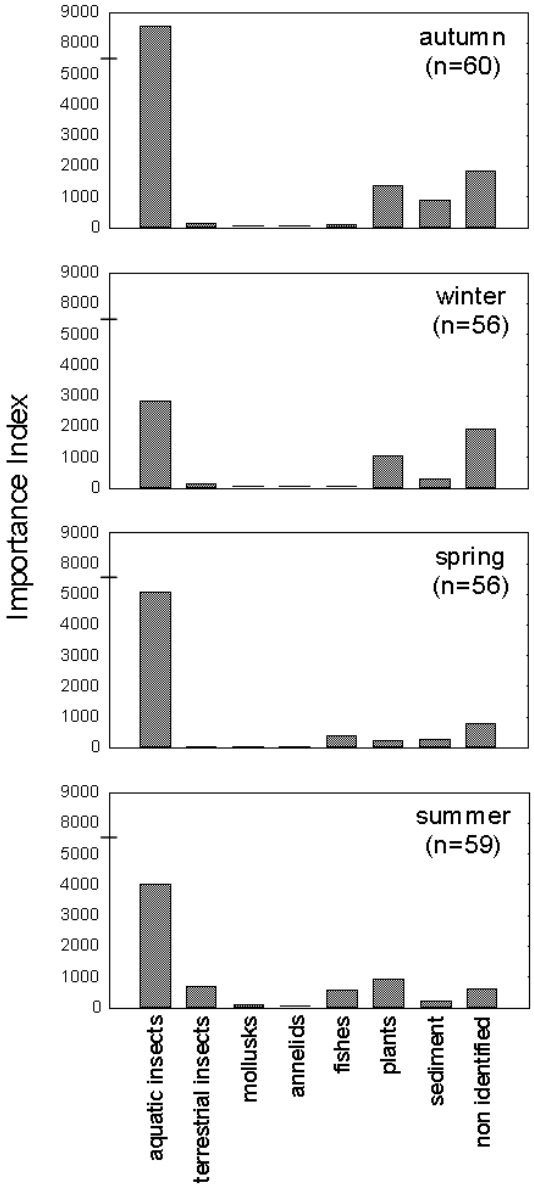


**Figure 2.** Importance Index of the food items consumed by *P. maculatus* in each season, in the Piracicaba River

Concerning the seasonal shifts of the diet, it was observed that the food items consumed by the species, mainly the secondary ones, show a distinct importance ranking during spring, when compared to the results recorded during the winter and summer (Figure 2; Table 2).

**Table 2.** Statistical comparison (Spearman rank correlation) among the seasons according to the ranking of the food items consumed by *P. maculatus,* in the Piracicaba River - The significant correlations are highlighted in bold ($p < 0.05$).

| SEASON | Autumn | Winter | Spring |
|---|---|---|---|
| Winter | **0.9285** | | |
| Spring | **0.8333** | 0.6190 | |
| Summer | **0.8333** | **0.7142** | 0.6428 |

The Stomach Fullness Index did not show significant differences when the winter, spring and summer data were compared, but it was statistically higher in autumn, when compared to all other seasons (Figure 3), indicating an increased feeding activity during the autumn.

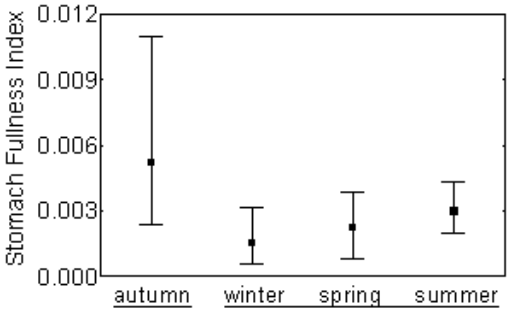


**Figure 3.** Median and quartile range (25-75%) of the Stomach Fullness Index of *P. maculatus*, in the Piracicaba River - The line at the bottom links the seasons whose data have no significant differences ($p > 0.05$, Kruskal-Wallis test).

## DISCUSSION

Similar to the results obtained in this study, in which *P. maculatus* shows its highest feeding activity during the autumn, BENNEMANN *et al.* (1996) observed, in the Tibagi River (Brazil), that this species feeds more intensely between the end of the summer and the beginning of the autumn, that is, in March.

Considering that in *P. maculatus* the visceral fat is consumed during the process of its gonad development (DORIA and ANDRIAN, 1997), that its spawning occurs in the summer (BASILE-MARTINS *et al.*, 1975; LIMA-JUNIOR, 2000), and that its lowest condition indexes are observed just after the spawning season (LIMA-JUNIOR and GOITEIN, unpublished data), one may infer that *P. maculatus* shows its highest feeding activity during the autumn, as a reflex of the recovery strategy due to the physiological process of gonad maturation, which attains its apex in the summer.

Though no significant difference in food items ranking has been observed when the autumn and winter data were compared, the clear drop in importance of the main food item (aquatic insects), added to significant smaller Stomach Fullness Indexes observed in the winter, show a decrease of feeding activity at the transition between the two seasons. In agreement to this consideration, MARQUES *et al.* (1992), WOOTTON (1992) and JOBLING (1994) state that, for fish, the food ingestion rate is directly proportional to the environment temperature. Despite the fact that such statement differs from the conclusions of BASILE-MARTINS *et al.* (1986), who observed the highest feeding activity of *P. maculatus* just during the cold season, it is important to emphasize that in such study the data referent to the autumn and the winter were grouped and analyzed under the name "cold season". Thus, it is worthy to consider the possibility of an important contribution of the autumn data, which made it difficult to perceive the real differences between these two seasons.

The noticeable increase of the Importance Index of "aquatic insects", observed at the transition between the winter and spring, indicates that individuals caught during that last season showed a higher feeding activity than the individuals collected in the winter. But, on the other hand, the Stomach Fullness Index, calculated from the data obtained in those seasons, was statistically the same. It is possible, however, that such fact has been influenced by the high importance of the "non identified" item in the winter collection. So, the mass of this item may have compensated the smaller quantities of aquatic insects, and the proportional mass of the stomach contents was practically the same in the winter and spring. However, this does not mean that the feeding activity of the individuals was the same in these two seasons.

Such conclusions are reinforced by MARQUES *et al.* (1992), who studied another pimelodid (*Pseudoplatystoma corruscans*) and observed that the time during which the food stays inside the stomach is inversely proportional to the temperature. When one considers that the presence of "non identified"

material into the fish stomach may be the result of the long duration of the activity of digestive enzymes, it is possible to infer that the lower rate of gastric evacuation may have been the cause of the higher amount of that item in the stomach of the fish caught in the winter.

The comparison of the diet of the individuals collected during the winter and spring indicates also the existence of differences in the food items ranking between those two seasons, though "aquatic insects" is the principal food item in both samples. This difference has been mainly influenced by the increase of the Importance Index of "fishes", whose ranking position changed from the eighth position, in the winter, to the third one, in the spring. Such a fact may be the reflex of a higher availability of fish as prey during the spring, since the increase of the fish activity is related to the elevation of the temperature (WOOTTON, 1992). BASILE-MARTINS *et al.* (1986) also verified that *P. maculatus* eats more fish during the warmer months, in comparison to what is observed in the cold months. Anyway, the authors do not discuss about the probable causes of that fact.

The Stomach Fullness Index did not show significant differences between the spring and the summer samples, which permits to conclude that the feeding activity of the individuals was similar during these two seasons. However, differences in the food items ranking were observed as a consequence of a visible increase of the Importance Index of the item "terrestrial insects", whose ranking position changed from the sixth position to the third one in the last sample. Such result was possibly related to the heavier rainfalls observed during the summer (ESALQ, 2002), when the rain water carries allochthonous materials inside the river. Data from LOLIS and ANDRIAN (1996) also show that the importance of allochthonous materials to the diet of *P. maculatus* is increased during the flood period.

As a conclusion, one may say that, in the Piracicaba River, *P. maculatus* consumes mainly aquatic insects during the whole year, presenting also seasonal diet shifts when the secondary items ranking is considered. Besides that, the highest feeding activity of the species occurs during the autumn, and the lowest one in the coldest months, i.e., during the winter.

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