Seasonal and ontogenetic variations in the diet of *Cichla kelberi* Kullander and Ferreira, 2006 introduced in an artificial lake in southeastern Brazil

Gomiero, LM., Villares Junior, GA. and Naous, F.*

Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista – UNESP, Av. 24-A, 1515, CP 199, CEP 13506-900, Rio Claro, SP, Brazil

*e-mail: leanmg@rc.unesp.br

Received November 10, 2009 – Accepted March 8, 2010 – Distributed November 30, 2010

(With 3 figures)

Abstract

The diet of *Cichla kelberi* introduced in an artificial lake in Leme-SP was predominantly composed of common fish species (*Oreochromis niloticus* and *C. kelberi*). In the spring and summer, the most consumed item was *O. niloticus*. However, cannibalism was very common for this species. The high frequencies of *O. niloticus* and *C. kelberi* reveal that this species is adapted to a seasonal cycle, feeding on the most common prey in each period of the year, with a reduction of foraging activity during the winter. The diets were different among the immature and mature individuals suggesting that there are ontogenetic differences, mainly related to prey type, such as: Ephemeroptera consumed by the immature peacock bass and fish by the mature ones, besides the size of the prey.

Keywords: introduction of species, peacock bass, *Cichla kelberi*.

Variações sazonais e ontogenéticas na dieta de *Cichla kelberi* Kullander e Ferreira, 2006 introduzidos em um lago artificial no sudeste do Brasil

Resumo

A dieta de *Cichla kelberi* introduzido em um lago artificial em Leme-SP foi composta predominantemente pelas espécies de peixes mais comuns nesse lago (*Oreochromis niloticus* e o próprio *C. kelberi*). Na primavera e no verão, o item mais consumido foi *O. niloticus*. Porém, o canibalismo foi muito comum para esta espécie. As altas frequências de *O. niloticus* e de *C. kelberi* revelam que a espécie apresenta um ciclo sazonal, se alimentando das presas mais comuns em cada período do ano, com uma redução da sua atividade alimentar durante o inverno. As dietas foram diferentes entre os exemplares imaturos e maduros, sugerindo que existem diferenças ontogenéticas, principalmente relacionadas ao tipo de presa, como: Ephemeroptera, consumidos pelos tucunarés imaturos e peixes, pelos maduros, além do tamanho das presas.

Palavras-chave: introdução de espécies, tucunarés, *Cichla kelberi*.

1. Introduction

The genus *Cichla* is comprised of 24 species (Kullander and Ferreira, 2006). These fish are introduced into lakes and rivers in several parts of the world to increase aquatic fauna (Shafland, 1996), fish production (Novoa, 1996), and for the biological control of other species, such as the piranha and the pirambeba (Agostinho and Julio Jr., 1996). The yellow peacock bass (*Cichla kelberi* Kullander and Ferreira, 2006) is among the fish species used for fish culture and introduction in new reservoirs (stocking), private lakes and other water courses (Fontenele and Peixoto, 1979, Oliveira et al., 1986), due to its high tolerance of lower temperatures, as experienced in the winter of the Brazilian southeast (Kullander and Ferreira, 2006). These introductions are accomplished without previous study regarding the damage that this exotic and voracious species can cause in a new environment. An example is the Gatún lake, in Panama, where the introduction of *Cichla ocellaris* Bloch and Schneider (1801) was followed by an intense modification in the community's composition and in the structure of the aquatic food web (Zaret and Paine, 1973). Similar consequences also occurred in Las Majaguas (Winemiller, 1989), and in the Gurí reservoir (Novoa et al., 1989), besides other reservoirs in Venezuela. In these cases, the peacock bass becomes a veritable pest, difficult to eradicate and control.

The yellow peacock bass (*Cichla kelberi*) originates from the Araguaia-Tocantins basin. It is an exclusively carnivorous fish, with ontogenetic variation in diet; the

young consume crustaceans and insects, and the adults consume mainly fish, cannibalism being frequent in areas where this species was introduced (Gomiero and Braga, 2004a). Its rapid proliferation, voracious predatory habits and high adaptability makes *C. kelberi* cause serious damages to fish communities, because of the increase of competition and effects in cascade in the trophic chain (Gomiero and Braga, 2004b).

The study of diet allows for the interpretation of the trophic relationships that certain species present in aquatic ecosystems (Hahn et al., 1997). Currently, there is growing interest in the studies concerning the feeding strategies of fish. For that reason, the study of the trophic ecology of a carnivorous species frequently used for the settlement of lentic habitats, such as the peacock bass, is an important tool for management and future decisions.

Ontogeny, analysing the several sizes of fish, can have some relationship with the food type consumed and/or even with the form of food ingestion. Feeding is also associated with the reproductive state of the fish. Therefore, these factors could be different for juveniles in relation to adults (Gomiero et al., 2009).

The present study aimed at analysing the feeding of the yellow peacock bass, *Cichla kelberi*, out of its natural environment, evidencing the main alimentary items, besides the variations that can occur in agreement with its ontogeny and seasonality.

2. Material and Methods

The lake is located in a tropical area (47° 18' W, 22° 13' S) in the town of Leme, in the state of São Paulo. The lake was built over 50 years ago and has about 2.5 km of shoreline, a length of 860 m between the two most distant points, and 83 m between the two closest points, with a flooded area of about 360,000 m^2. The depth of the lake is quite variable (1-9 m). The vegetation is sparse with grass or bushes, and a few tall trees. Part of the lake (~15%) is bordered by *Typha* sp. and another part (20%) is formed by reforested forest. The shorelines are shallow, varying from a few centimetres to 1 m, although at some points the depth at the lake edges exceeds 3 m. The climate is typical of tropical regions, with an average annual temperature of 21°C and average annual rainfall of 1400 mm. There are two typical seasonal periods: the hot and rainy period, which begins in October and lasts until April, and a colder one, the dry season, from May to September.

A total of 12 monthly samples were made from April 2006 to March 2007. Each collection period lasted eight hours. The collections were carried out throughout the lake by three people using fishing poles and artificial bait (bait casting).

Total length of individual fish was measured in mm, mass was measured in grams, repletion degree of the stomach and fat degree in the visceral cavity were registered. Three categories were used, according to a previously established scale, indicating as much the repletion of the stomachs as the degrees of accumulated fat: 1) empty, 2) half-full, and 3) full (Braga, 1990). The frequencies of the repletion degree of the stomach and of the fat degree in the visceral cavity were used to characterise the periods of high intensity food of *Cichla kelberi*. The data comparisons of numeric distributions of repletion degree and of accumulated fat were done with the use of the Kruskal-Wallis test (5%) with analysis *a posteriori* of Dunn for the cases with significant differences.

The differentiation between adults and juveniles was made according to Gomiero et al. (2009), considering the maturation stage, juveniles (immature and in maturation) and adults (mature and spent).

Food items were identified using a stereomicroscope up to the lowest taxonomic level. Besides the identification, the number, the weight and the length of each alimentary item were determined.

The preys were analysed using the following frequencies (Braga, FMS. and Braga, MAAS., 1987): frequency in number (Ni) as the proportion of prey numbers of one taxonomic group as a percentage of the total prey number; frequency index (Fi) as the proportion of the number of stomachs with preys of a determined taxonomic group as a percentage of the total number of stomachs with food; and frequency in weight (Pi) as the proportion of prey weight by taxonomic group as a percentage of the total weight of preys.

With the use of the values of frequency in number (Ni), frequency index (Fi) and frequency in weight (Pi) the index of relative importance was obtained IRI = Fi (Ni + Pi) to show the importance of each taxonomic group in the feeding habit of *Cichla kelberi* (Hyslop, 1980). This analysis was accomplished for the adults (> 290 mm) and for the juveniles (< 290 mm), as verified in Gomiero et al. (2009).

Comparisons of the seasonal feeding variations were made by Spearman rank correlations coefficient-rs.

3. Results

A total of 544 individuals of *Cichla kelberi* were captured and analysed out of which 324 were immature and 220 were adults.

Higher frequencies of individuals with full stomachs were observed in the summer that was characterised as the period of greatest feeding activity. On the other hand, in the winter, only empty stomachs or stomachs with little content were found (Figure 1). There were significant differences ($p < 0.05$) in the distribution of the degrees of stomach repletion among all of the seasons.

As for the frequencies of the degrees of stomach repletion, the fat degree in the visceral cavity was not uniform during the seasons. However, between the autumn/winter (lower temperatures) and spring/summer (higher temperatures), there were no significant differences in the frequencies of the degree of accumulated fat (Figure 2). Nevertheless, the main difference was the occurrence of individuals who presented degree of accumulated fat 1 in the summer.

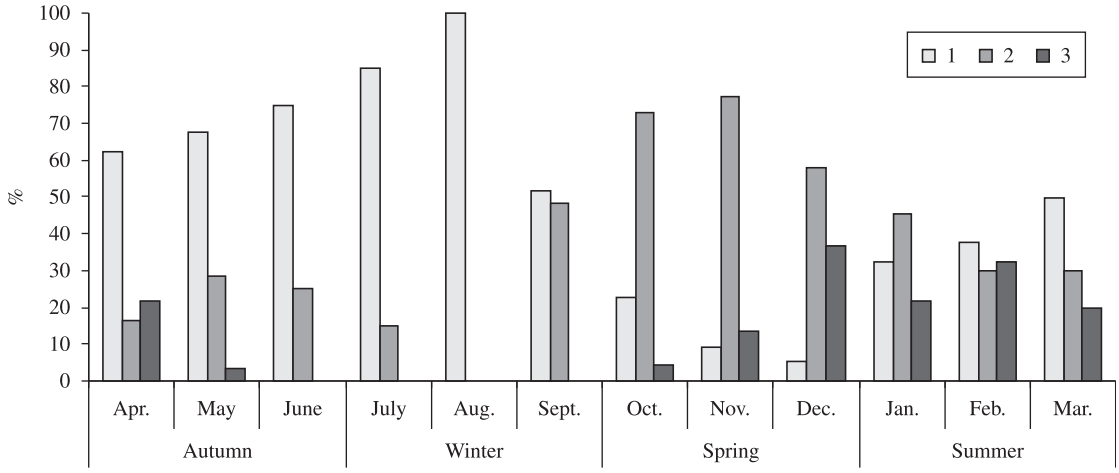

Figure 1. Relative frequencies of the repletion degree of the stomach (1 - empty, 2 - partly full, 3 - full) of *Cichla kelberi* per collection period.

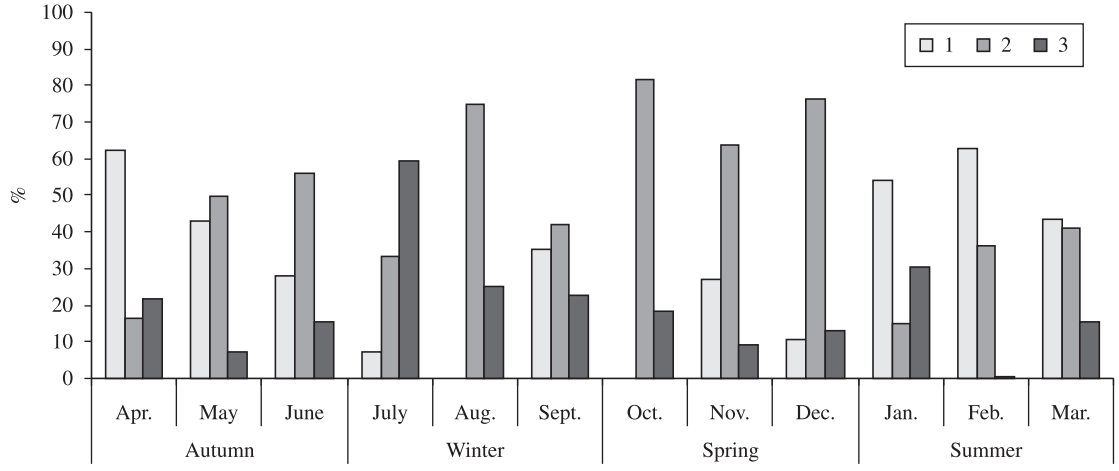

Figure 2. Relative frequencies of the fat degree in the visceral cavity (1 - empty, 2 - partly full, 3 - full) of *Cichla kelberi* per collection period.

In this artificial lake, the feeding of *Cichla kelberi* consisted predominantly of fish (*Oreochromis niloticus* (Linnaeus, 1758), *Cichla kelberi*, *Geophagus brasiliensis* Quoy and Gaimard, 1824, *Hoplosternum littorale* Hancock, 1828, Siluriforms), besides Ephemeroptera, Ophidia, remains of non-identified fish and remains of non-identified insects. The adults fed on fish and in one case Ophidia occurred, while the juveniles ingested Ephemeroptera, remains of insects and smaller fish.

With the Index of Relative Importance (IRI), the great representativeness of the items *Cichla kelberi* and *Oreochromis niloticus* in the diet of the adult and young peacock-bass was verified. The item Ephemeroptera presented high numeric frequency and low frequency in weight in the juvenile diet of *Cichla kelberi* (Figure 3).

According to the Spearman rank correlations coefficient-rs, the diets were different among the seasons ($p < 0.05$). The season with the largest difference was winter, because in this season only the item uncertain fish (fish remains) was found.

4. Discussion

The repletion degree is a complement and secondary determination of the characteristics of the stomach content, concerning a comparison of the effect of seasonality. Jobling (1993) states that with the increase in temperature, there is a tendency for an increase in the rate of ingestion due to a more accelerated digestion. On the other hand, in low temperatures, some fish reduce alimentary activity due to a slower digestion (Zavala-Camin, 1996).

In the lake of Leme-SP there was peacock bass prevalence with food in their stomachs, although a great part of those stomachs had a little amount of food and/or high digestion degree, contradicting Barbieri et al. (1992) and Esteves and Pinto Lobo (2001) who mention that a low number of

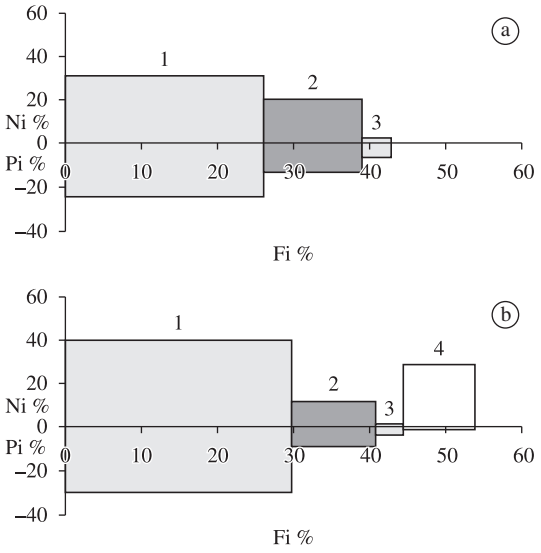

Figure 3. Graphic representation of the index of relative importance (IRI) of the more important food items of *Cichla kelberi* (a - adults > 290 mm and b - juveniles < 290 mm), being: 1) *Oreochromis niloticus*, 2) *Cichla kelberi*, 3) *Geophagus brasiliensis*, and 4) Ephemeropter. Ni% = relationship in percentage between the total number of items and the total number of prey, Pi% = total weight of the item in the total weight of found foods, and Fi% = number of stomachs in which the item occurred in relation to the total number of stomachs.

stomachs containing food among the piscivory fish of the dam of the Lobo-SP reservoir in river Mogi-Guaçu-SP is more common. However, a substantial amount of replete stomachs analysed in the lake of Leme-SP occurred in accordance with the results obtained for two peacock bass species in a reservoir (Volta Grande MG-SP) (Gomiero and Braga, 2004b). This characteristic can be typical of *Cichla* evidencing the great voracity of this fish.

With the analysis of accumulated fat degree in the visceral cavity, it was verified that the smaller individuals (immature) did not present accumulated fat. Gomiero et al. (2009) and Junk (1985) reported that this can be an indication that fat accumulation (reserve) must be more related to reproductive aspects or the larger size of individuals (adults). The fat accumulation in the visceral cavity of immatures was low, since in this phase of life, all the available energy is allocated to growth and/or to gonadal maturation (Vazzoler, 1996).

According to Lowe-McConnell (1975), *Cichla* is specialised in eating fish, with few differences in the year. In the Gurí lake (Venezuela), Gil et al. (1996) identified only eleven alimentary items for *Cichla temensis* Humboldt and Valenciennes (1821) and six for *Cichla orinocensis* Humboldt (1821). The peacock bass of the lake in Leme (SP) presented 9 alimentary items, fish being the most frequent one. Gomiero and Braga (2004b) in the reservoir of Volta Grande (MG) observed that the diets of *Cichla ocellaris* (= *Cichla piquiti* Kullander and Ferreira, 2006) and *Cichla monoculus* Spix and Agassiz (1831) (= *Cichla kelberi*) were predominantly fish, the occurrence of cannibalism being common, as was found in the present study.

The index of relative importance (IRI) considers the number, the weight and the frequency of each item giving a better description of the diet of a species. The IRI shown by the adults indicated the great importance of the items *Cichla kelberi* and *Oreochromis niloticus*, as well as the values of the IRI of the juveniles. However, for the young ones, the importance of Ephemeroptera was also verified.

Cannibalism in young individuals of predator fish regulates the amount of juveniles, and it occurs mainly where the concentration of predators is high and with intense competition for prey (Chevalier, 1973). Futuyma (1992) related that predators focus their efforts of food search in a disproportional degree on the more common types of prey, moving to places where a peculiar type of food is concentrated or forming a search image that qualifies to find the food reducing the impact on the less common prey. In *Cichla orinocensis*, Novoa (1996) observed that piscivory was dominant with a rate of cannibalism of 12%. Zaret (1980) comments that cannibalism in *Cichla* can be avoided due to a series of conditions: territoriality of the couple in the reproductive period, juvenile of a same area are descendants of a single couple, great amount of preys and shelters. As in the reservoir of Volta Grande (SP/MG) (Gomiero and Braga, 2004a), the lake of Leme (SP) makes the survival of a great amount of individuals of *C. kelberi* possible, characterising a large population, and in this setting, cannibalism happens due to the lack of other predators, of natural shelters and of the shortage of alternative prey during most of the year, being, therefore, a natural control mechanism of this population.

Exotic species, such as *Oreochromis niloticus* that were also introduced, are very abundant in the lake at Leme (SP), and due to transparency of the water, it was possible to observe that this species spawned mainly in the spring, before the peacock bass (Gomiero et al., 2009), so that it could be an adaptation of typical synchrony reproduction of fish predators. The reproductive period of the species of piscivory fish is regulated by the reproductive cycle of the other species with different alimentary habits (Vazzoler, 1996). That reproductive synchrony can be understood as an adaptation of the peacock bass to guarantee a reliable food source for the young individuals, as well as to obtain reserves of energy for reproduction, coinciding with seasonal fat accumulation in the visceral cavity.

In the winter, most of the stomachs presented little content and the item fish appeared with great prominence. That fact is due to a long interval between ingestions, and due to the lower temperatures, leading the stomach contents to be, almost always, in a final stage of digestion (Zavala-Camin, 1996).

In the summer, the high digestion velocity was already expected, as well as for the end of the spring and beginning of autumn, when the highest temperatures occurred, confirming

the description of Jobling (1993). These seasons had a strong influence on the values obtained for the numeric frequency (FN%) of the alimentary items. In several stomachs, juvenile *Oreochromis niloticus* in great number (up to 50) were found, suggesting substantial availability of those preys and corroborating the reproductive synchrony between the peacock bass and tilapias.

The high frequencies of the alimentary items *Oreochromis niloticus* and *C. kelberi* in the respective seasons reveal that this species is adapted to a seasonal cycle, feeding of the most common preys in each period of the year, with a reduction of alimentary activity during the winter. The diets were different between the young and adult fish (piscivory-insectivory and mainly piscivory, respectively) indicating that there is a shared ontogeny of resources for the species, mainly for the size of prey and their availability.

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