FEEDING OF INTRODUCED SPECIES OF *Cichla* (PERCIFORMES, CICHLIDAE) IN VOLTA GRANDE RESERVOIR, RIVER GRANDE (MG/SP)

GOMIERO, L. M. and BRAGA, F. M. S.

Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, UNESP, C.P. 199, CEP 13506-900, Av. 24-A, n. 1515, Rio Claro, São Paulo, Brazil

Correspondence to: Leandro M. Gomiero, Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, UNESP, C.P. 199, CEP 13506-900, Av. 24-A, n. 1515, Rio Claro, São Paulo, Brazil, e-mail: leanmg@rc.unesp.br

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ABSTRACT

Both species studied, *Cichla* cf. *ocellaris* and *Cichla monoculus*, fed mainly on fish, the first on *Cichla* spp., *Plagioscion squamosissimus*, and *Tilapia rendalli*, and the second, *Cichla monoculus,* on *Cichla* spp. Both diets indicated a strong correlation among the food items. Remarkable ontogenetic change was noted in both species diet: the young fed on crustaceans and insects while the adults fed mainly on fishes. The species studied, which are highly adapted to a brief life span, cause serious damage to the fish communities by predation, competition, and cascade effects throughout the whole trophic chain.

Key words: feeding, *Cichla,* tucunaré, reservoir, introduction, Rio Grande.

RESUMO

Alimentação de espécies introduzidas de *Cichla* (Perciformes, Cichlidae) no reservatório de Volta Grande, Rio Grande (MG/SP)

A alimentação de *Cichla* cf. *ocellaris* e *Cichla monoculus* consistiu principalmente de peixes. *Cichla* cf. *ocellaris* alimentou-se de *Cichla* spp. (tucunaré), *Plagioscion squamosissimus* (corvina) e *Tilapia rendalli* (tilápia), enquanto *Cichla monoculus* alimentou-se de *Cichla* spp. As duas dietas foram analisadas e mostraram correlação entre os itens alimentares, ou seja, as dietas são iguais. Houve notória mudança ontogenética na dieta das duas espécies, sendo que os jovens se alimentaram com crustáceos e insetos e os adultos, principalmente com peixes. A introdução desses predadores altamente adaptados e de rápida proliferação causa sérios danos a essas comunidades ícticas pela predação, pela competição e pelos efeitos em cascata na cadeia trófica.

Palavras-chave: alimentação, *Cichla,* tucunaré, reservatório, introdução, Rio Grande.

INTRODUCTION

Dam construction determines the course of river sectioning, in which running waters start to accumulate, resulting in lentic water masses. Obstactles to normal river flow. Intercalation of lentic environments along fluvial paths causes a fundamental transformation in hydrographic basins by changing hydrography, water quality, sedimentation, and aquatic life (Paiva, 1983).

Gallery forest is destroyed by overflow and many resources used by the fish communities become scarce, with alterations in occupation and growth occurring in species of aquatic plants (Castro & Arcifa, 1987).

Dams obstruct upstream migration of lotic fishes in addition to degrading habitats (Lowe-McConnell, 1990).

The Volta Grande Reservoir, located in a tropical area (48°25'-47°35'W, 19°57'-20°10'S), resulted from damming of the Rio Grande river approximately 25 years ago to produce electric energy. The result was a flooded area of 221.7 km^2 with a volume of 2,268 km^3 (Braga & Gomiero, 1997).

The reservoir has a great abundance of the tucunares *Cichla* cf. *ocellaris* and *Cichla monoculus* (Bloch & Schneider, 1801), fishes originally from the Amazon basin and having varied coloration and characteristic caudal occelus. Mandible protrusion, typical of this genus, ensures greater success in capturing prey with comparatively little energy expenditure (Motta, 1984).

The practice of introducing new species into recently created sites is common for a variety of reasons: recreational fishing, economic value increase, control of previously introduced species that have become undesirable, sentimental reasons, or for no reason at all (McDowall, 1968). Direct interactions between native and exotic species result from competition, predation, and parasitism (Vitousek *et al*., 1987). Many declines in fish population stem from overfishing, environmental changes, and introduction of species (Lowe-McConnell, 1990).

A successful species introduction may trigger extinctions and initiate a cascade effect in the whole community (Pimm, 1987). The most primitive forms become extinct when they lack a refuge to survive in places where more evolved species are established (McDowall, 1968).

Once established, a species is very difficult to eradicate and future effects of its continuation are unpredictable (Lowe-McConnell, 1990).

The tucunaré is a predator, mainly of small fishes (Zaret & Paine, 1973; Braga, 1990; Novoa, 1996; Jepsen *et al*., 1997; Winemiller *et al*., 1997), normally capturing prey with up to one third of its own length (Lowe-McConnell, 1975, 1999; Machado-Allison, 1990; Gil *et al*., 1996). According to its abundance, it causes modifications in autochthonous fishes populations (Godinho & Formagio, 1992; Fonteles-Filho & Alves, 1995; Pompeu & Godinho, 2001).

The tucunaré is a typical piscivorous fish, with direct impact observable in secondary consumer populations. Indirectly, other trophic levels are affected: the fishes fed upon by the predator and, in turn, ichthyophagous birds, insects, and the zooplankton (Zaret & Paine, 1973). Regardless of these consequences, great support exists in some sectors of a given community for introducing the tucunaré because of its huge potential in recreational fishing (Machado-Allison, 1971; Novoa *et al*., 1990; Larrazábal, 1996; Shafland, 1996).

In Florida, the tucunaré (*Cichla* sp.) was introduced, but not until intensive research was done to verify the probable effects of colonization. With respect to species introductions in general, Courtenay & Robins (1973) pointed out that in unaltered environments, competition from native species may exclude exotic fishes, which depends on many factors including the number of specimens introduced, their adaptations, and adaptability. In some cases, extinction of native species may occur, but this biomass loss is compensated for by exotic species population growth.

Shafland (1996) overviewed the tucunaré introduction in Florida and found that the species adapted well, becoming very abundant and acquiring great socioeconomic value in fishing. However, the introduction of this species must be regarded cautiously, and caution should be exercised in new introductions.

The objective of this work is to characterize the feeding of both tucunare species (*Cichla* cf. *ocellaris* and *Cichla monoculus*) introduced in Volta Grande reservoir.

MATERIAL AND METHODS

Collections were made in April and June 1997 and monthly from September 1997 to August 1998, using two kinds of fishing equipment: gill nets with meshes of 2, 3, 4, 5, and 6 cm (between adjacent knots); and fishing rods with natural and artificial bait. Each gill net set was 150 m in length and 1.5 m in height, totaling 750 m.

For every specimen of each species, data were taken: total weight (TW) in grams, total length (TL) in centimeters, repletion degree of the stomach (RD), fat degree in the visceral cavity, and sex.

Three categories, according to a previously established scale, indicated the repletion degree: 1 = empty stomach, 2 = half-full stomach, and 3 = full stomach (Braga, 1990).

The stomachs with category 3 RD were withdrawn from the visceral cavity, weighted, and fixed in formalin 5%. After some days in formalin, the stomach content was transferred to alcohol diluted at 70% (Zavala-Camin, 1996). For stomach content analysis, 76 stomachs of *Cichla* cf. *ocellaris* and 18 of *Cichla monoculus* were used. Alimentary item identification occurred to the lowest taxonomic level reached. In addition, whenever possible the following were determined: number, weight, and length of each alimentary item. Preys found were analyzed using the following indexes (Matallanas, 1980, 1982a, b; Braga & Braga, 1987):

- Numeric Index (Ni): relation in percentage between the number of preys from a taxonomic group and the total number of preys;
- Frequency Index (Fi): relation in percentage between the number of stomachs with preys from a determined taxonomic group and the total number of stomachs with food;
- Frequency in weight (Wi): relation between the weight of the preys from a taxonomic group and the tot al weight of all preys.

Through the (Ni) and (Wi) data the alimentary coefficient (Q) was obtained by the formula: $Q = Ni \cdot Wi$. This coefficient is classified in three categories: Q more than 200 (preferential prey), Q between 20 and 200 (secondary prey), and less than 20 (occasional prey) (Matallanas, 1981).

To analyze the alimentary items found, the alimentary preference degree (APD), was used following Braga (1999) in accordance with the formula: $APD = Si/N$, where Si is the sum of the values related to abundance of the food item (i) in the stomachs and N, the total number of the stomachs analyzed. The estimated value for the alimentary preference degree (APD) for each item is indicated by:

- $APD = 4$: the chosen item has absolute preference;
- $3 \leq APD < 4$: the chosen item has high preference degree;
- $2 \leq APD < 3$: the chosen item is preferential, otherwise different items are ingested, in which case;
- $1 \leq APD < 2$: the chosen item is secondary;
- $0 < APD < 1$: the chosen item is occasional.

Feeding variation related to the length was analyzed, and fishes were separated in length classes. The average number of preys (aN) and their average weight (aW) were calculated for each class.

Seasonal alimentary variation during the collection period was also analyzed.

Spearman's rank correlation was used to test homogeneity between alimentary diets of *Cichla* cf. *ocellaris* and *Cichla monoculus* (Fritz, 1974).

RESULTS

The stomach repletion distribution demonstrated that in both species level 1 predominated, with the exception of the October collection that revealed level 2 for *Cichla* cf. *ocellaris* (Figs. 1 and 2).

The feeding of both species consisted mainly of fishes (Table 1), represented mainly by *Cichla* sp., *Plagioscion squamosissimus*, and *Tilapia rendalli* for *Cichla* cf. *ocellaris*, and *Cichla* sp. for *Cichla monoculus*.

The feeding coefficient analysis (Q) revealed that for *Cichla* cf. *ocellaris* the item *Cichla* sp. was preferential and the items *Plagioscion squamosissimus* and *Tilapia rendalli* were secondary, the others being occasional. Similarly, for *Cichla monoculus* the item *Cichla* sp. was preferential, and only *Tilapia rendalli* was secondary; the other items were occasional (Figs. 3 and 4).

The average number (aN) and average weight (aW) of the preys ingested by both species revealed that for *Cichla* cf. *ocellaris,* the average number is high in the small classes. On the other hand, the average weight of prey is the opposite, with higher values in the bigger length classes. In *Cichla monoculus* the number and weight averages increase in the higher classes (Figs. 5 and 6).

According to the alimentary preference degree (APD) of *Cichla* cf. *ocellaris*, the item *Cichla* sp. is secondary, reaching a value equal to 1.63, with all the others being occasional. For *Cichla monoculus* this item is preferential, having a value equal to 2, with all others being occasional.

Both diets were analyzed according to Spearman's rank correlation, which revealed that the diets are similar ($p < 0.05$).

DISCUSSION

The low quantity of replete stomachs sampled was expected, as they are of carnivorous species, as noted by Braga (1998).

The feeding of both species demonstrated that piscivorous behavior was the rule, although crustaceans and insects were also included; little diversity of alimentary items was found. A study carried out in Volta Grande reservoir also showed a low number of preyed-upon species (Braga & Gomiero, 1997). The feeding spectra for the *Cichla* genus is based mainly on fishes, however such other items as aquatic insects and crustaceans may occur secondarily or frequently be ingested by young specimens. According to Zaret & Rand (1971), low food abundance means more competition among the fishes.

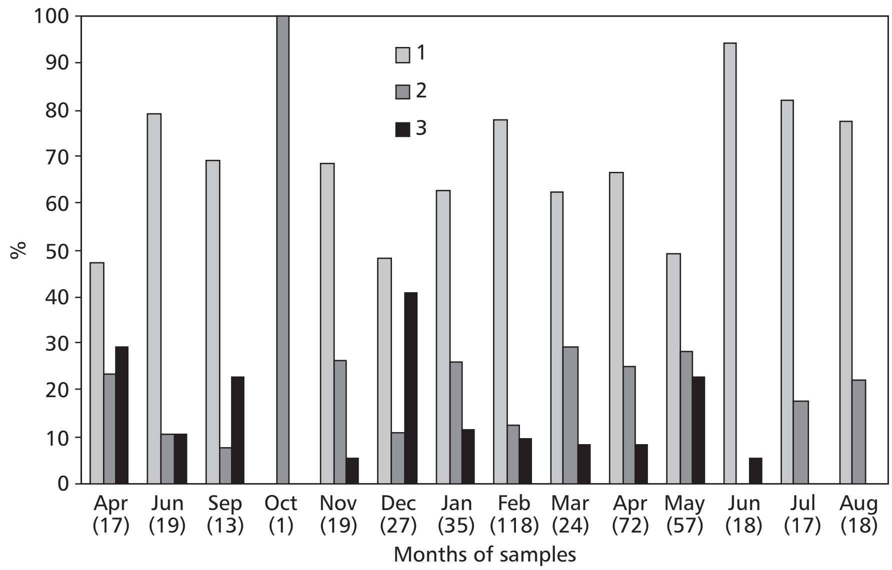

Fig. 1 — Frequency percentage of stomach repletion degrees of *Cichla* cf. *ocellaris* in the collections of April 1997 to August 1998.

TABLE 1
Alimentary items used by *Cichla* cf. *ocellaris* and *Cichla monoculus* introduced in Volta Grande Reservoir.

Number	Alimentary items	Popular names
1	*Cichla* sp. (Bloch & Schneider, 1801)	Tucunaré
2	*Plagioscion squamosissimus* (Heckel, 1840)	Corvina
3	*Tilapia rendalli* (Boulenger, 1897)	Tilápia
4	*Apareiodon piracicabae* (Eigenmann & Ogle, 1907)	Canivete
5	*Crenicichla lacustris* (Castelnau, 1855)	Joaninha
6	*Cichlasoma fascetum* (Regan, 1905)	Acará
7	*Myleus tiete* (Eigenmann & Norris, 1900)	Pacu
8	*Salminus* sp. (Spix & Agassiz, 1829)	
9	Siluriformes	
10	Culicidae larvae	
11	Odonata nimphs	
12	*Macrobrachium* sp. (Wiegmann, 1836)	
13	Algae	
14	Fish remains	

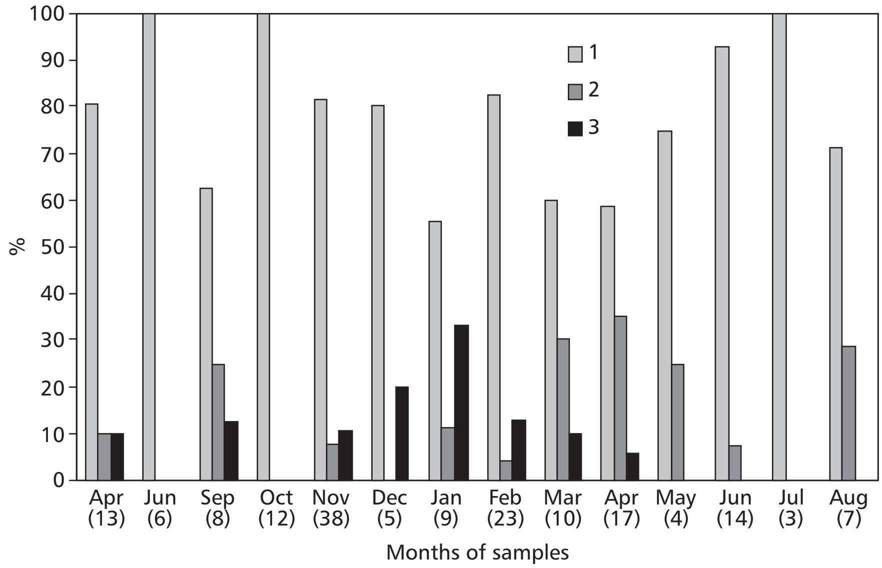

Fig. 2 — Frequency percentage of stomach repletion degrees of *Cichla monoculus* in the collections of April 1997 to August 1998.

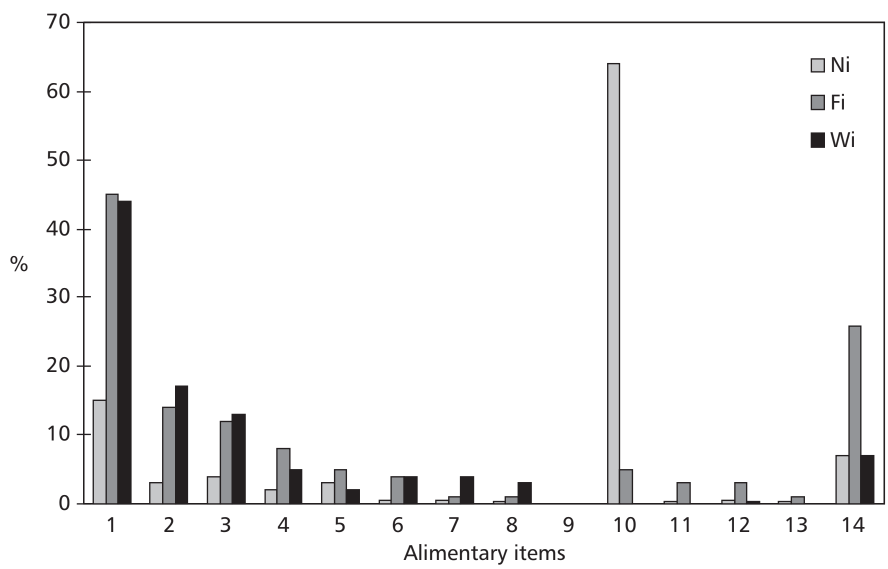

Fig. 3 — Numeric index (Ni), frequency index (Fi), and weight percentage (Wi) of the alimentary items found in *Cichla* cf. *ocellaris* stomachs.

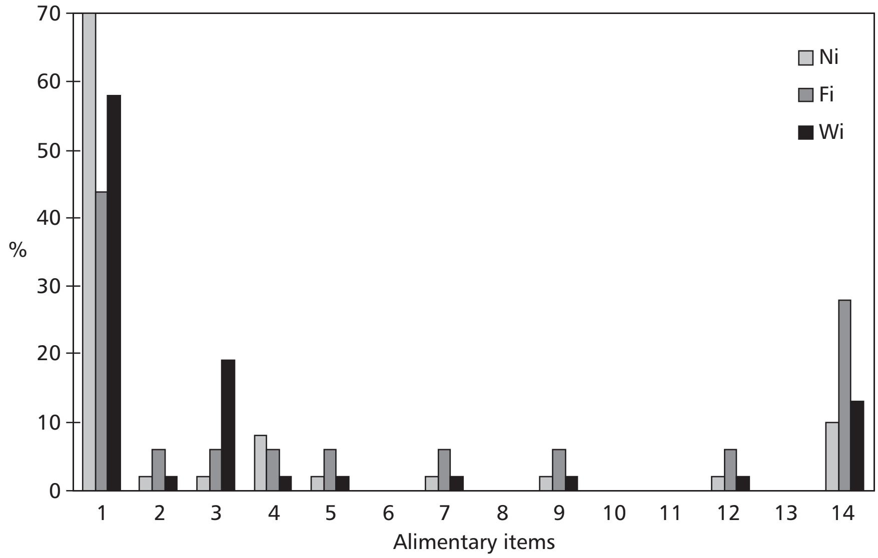

Fig. 4 — Numeric index (Ni), frequency index (Fi), and weight percentage (Wi) of the alimentary items found in *Cichla monoculus* stomachs.

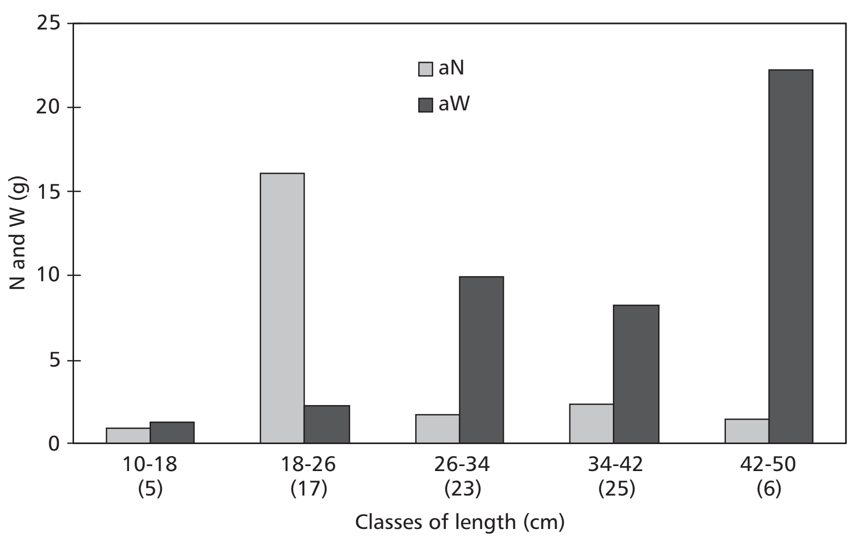

Fig. 5 — Average number and weight of the preys found in the stomachs of *Cichla* cf. *ocellaris* analyzed by length classes.

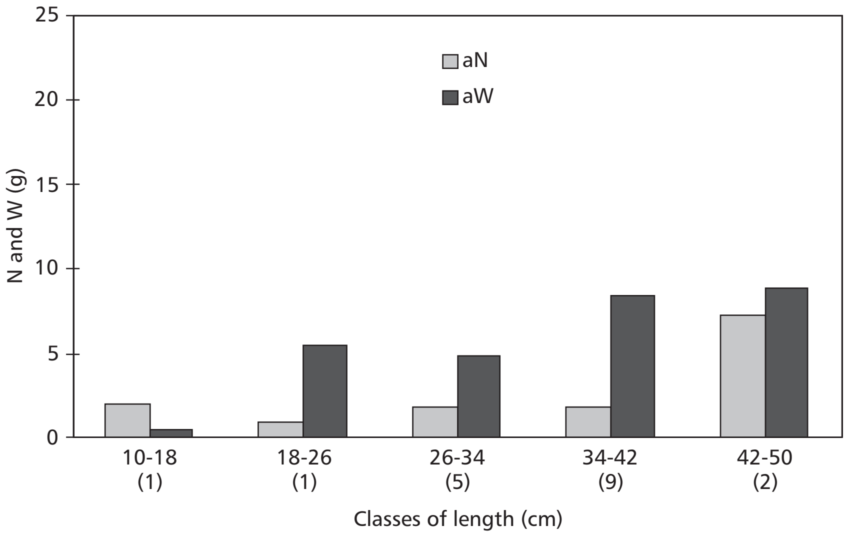

Fig. 6 — Average number and weight of the preys found in the stomachs of *Cichla monoculus* analyzed by length classes.

The average number of preys was higher in the small length classes of *Cichla* cf. *ocellaris* due to a great Culicidae larvae occurrence, although this item contributed very little in weight.

Tucunarés capture their prey by chasing, and act like selective agents in removing young preys (Helfman, 1986).

According to Lowe-McConnell (1975), this genus is specialized in fish eating, with little dietary difference throughout the year. Arcifa & Meschiatti (1993) also concluded that *Cichla ocellaris* is piscivorous, mainly finding in their stomachs *Cichla* (48-57 mm total length) juveniles. In tucunarés of less than 86 mm TL, their findings principally showed aquatic insects and, in lesser proportions, zooplankton and fishes.

Many predator species are characterized by ontogenetic changes in diet related to changes in: morphologic characteristics, predatory behavior, habitat selection, and prey availability (Schmitt & Holbrook, 1984). During and after the parental care period, tucunaré juveniles (until 80 mm) feed themselves on zooplankton, rather than cladocerans, copepods, and microcrustacea. Above this length, the diet is based on crustaceans, insects, and small fishes, with fish the preferential item in adults (Lowe-McConnell, 1969, 1999; Zaret, 1980; Santos *et al*., 1994; Jepsen *et al*., 1997; Winemiller, 2001).

Futuyma (1992) showed that the predators in varying degrees focus their food search efforts on the most common kinds of prey, even shifting to places where a particular kind of food is concentrated. By acting as if they were equipped with a search image, predators both increase the effectiveness of the search and decrease impact on uncommon kinds of prey.

The fishes consumed by tucunaré vary according to the environment, with the greatest predation incidence among the most abundant species. Fish of their own genus, forage fishes (Characiformes), and bentonics (pimelodids and ciclids) are frequent alimentary items (Novoa *et al*., 1990; Santos *et al*., 1994; Gil *et al*., 1996; Novoa, 1996; Jepsen *et al*., 1997; Williams *et al*., 1998; Lowe-McConnell, 1999). Ogari (1985) studied the prey-predator relation in Lake Victoria, with emphasis on Nile perch (*Lates niloticus* Linnaeus, 1758). After stabilization, this predatory species presented a high cannibalism degree and considerably reduced the endemic species stock.

After introduction into the most varied environments of species from the genus *Cichla*, a drastic alteration was observed in the fish community. The small-fish population began decreasing due to tucunaré predation, which can ultimately bring about alterations at all trophic levels (Arcifa & Meschiatti, 1993; Santos *et al*., 1994; Santos & Formagio, 2000). When the tucunaré is introduced into favorable conditions, what may result is the extinction of some autochthonous species through predation (Zaret & Paine, 1973; Godinho & Formagio, 1992; Molina *et al*., 1996). On the other hand, this threat may be offset by dietary flexibility of endemic tropical piscivores (competitors of the introduced piscivores), which in these environments may be contributing to assure population maintenance (Pompeu & Godinho, 2001).

According to Godinho *et al.* (1994), the richness of species in lakes following tucunaré and piranha introduction declined almost 50% in relation to what it had been and was smaller than that found on lakes without introductions. The number of captured fishes was not significantly different between the two groups of lakes, but the biomass was higher in lakes with introductions. These lakes also differ from the lake group without introductions, in which small fishes were abundant.

Tucunarés do not cause overbalance in their natural environment owing to the adaptations of countless species of prey to predatory pressure and to the great number of competing piscivorous species. According to Lowe-McConnell (1999), great predator diversity maintains high prey-species diversity by allowing coexistence, thus keeping the predator number lower than it would otherwise be if these species were competing with one another for food or space.

The introduction of *Cichla* mainly occurs in altered environments, where the community of fishes is already in decline. The presence of these highly adapted and quickly proliferating predators causes serious damage to these communities by predation, competition, and cascade effects throughout the whole trophic chain. However, tucunarés attract recreational fishermen, involving in this way the whole riverine community that depends on native fish species. This factor explains recent introductions in these altered environments.

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