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Impact assessment of the introduction of *Cichla kelberi* in a large Neotropical reservoir and its lateral lagoons (Upper Paraná River Basin, Brazil)

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(With 6 figures)

Abstract

This study aimed to understand how the introduction of *Cichla kelberi* in Rosana Reservoir (Paranapanema River) affected the native ichthyofauna. Data on the structure of the small fish fauna assemblage were obtained before and after the introduction of this carnivorous species. Samplings were carried out in February and September of 2004, previously to the register of *Cichla kelberi* in the reservoir, and after its introduction, November of 2004, January, March, May and August of 2005, February and June of 2006, February and July of 2007, February and October of 2008 and February of 2009. A total of 4,693 fish, belonging to 43 different species was sampled between 2004 and 2009. The order Characiformes was the most abundant, followed by Perciformes and Siluriformes. Comparative analyses, before and after the introduction, could not demonstrate significant changes in composition, richness, abundance, biomass, mean length and diversity of fish. Aquatic insects were the main feeding item of *C. kelberi*, followed by tetragonopterinae fish. Cannibalism was recorded during the whole study period. The results showed that *Cichla* cannot deeply affect the ichthyofauna assemblages of a large Neotropical reservoir, at least in a short or medium term period after its introduction. The results also allowed concluding that the introduction of *C. kelberi* in the reservoir is in the phase 3. In this phase, the specie can survive and reproduce in the new environment; however it is not totally established and disseminated. The reasons for the fact that *Cichla* is still not dominant in Rosana Reservoir could be related to feeding competition, high rate of cannibalism and the presence of large amount of aquatic macrophytes (refuge zones). In spite of the results, the continuous monitoring of the role of non-native species on the local fish fauna is absolutely necessary because the impacts caused by colonization of this undesirable species can be magnified by complex processes, usually correlated with other environmental disturb, especially the negative effects of damming.

Keywords: Paranapanema River, Rosana reservoir, non-native fish, biodiversity, ecological impact.

Avaliação do impacto da introdução da *Cichla kelberi* em um reservatório Neotropical de grande porte e suas lagoas laterais (Bacia do Alto Paraná, Brasil)

Resumo

O objetivo deste estudo foi entender como a introdução da *Cichla kelberi* no reservatório de Rosana (rio Paranapanema) afeta as assembléias de peixes. Dados da estrutura da ictiofauna de pequeno porte foram obtidos antes e após a introdução dessa espécie carnívora. As coletas foram realizadas em fevereiro e setembro de 2004, quando *Cichla kelberi*, ainda não havia sido registrado no reservatório, e após sua presença, em novembro de 2004, janeiro, março, maio e agosto de 2005, fevereiro e junho de 2006, fevereiro e julho de 2007, fevereiro e outubro de 2008 e fevereiro de 2009. Um total de 4693 peixes, pertencentes a 43 espécies foi amostrado entre 2004 e 2009. A Ordem Characiformes foi a mais abundante, seguida por Perciformes e Siluriformes. Análises comparativas, antes e depois da introdução, não demonstraram mudanças significativas na composição, riqueza, abundância, biomassa, comprimento médio e diversidade dos peixes. Insetos aquáticos constituíram no principal item da alimentação de *Cichla kelberi*, seguido por peixes tetragonopterídeos. Canibalismo foi registrado durante todo o período de estudo. Os resultados mostraram que *Cichla* não afeta substancialmente a ictiofauna dos reservatórios neotropicais, pelo menos no curto e médio prazo após sua introdução. Os resultados também permitiram concluir que a introdução de *Cichla kelberi* se encontra na fase 3. Nessa fase, a espécie pode sobreviver e reproduzir no novo ambiente, contudo ela não está totalmente estabelecida e disseminada. As razões que explicam a ausência de dominância de *Cichla* no reservatório de Rosana podem estar relacionadas à competição alimentar, a alta taxa de canibalismo e grande quantidade de macrófitas aquáticas (zonas de refúgio). Apesar dos resultados, o monitoramento contínuo do papel das espécies não nativas sobre a ictiofauna local é de extrema importância, pelo fato de que os impactos causados por essas espécies podem ser amplificados, geralmente correlacionados com outros distúrbios ambientais, principalmente efeitos negativos do barramento.

Palavras-chave: Rio Paranapanema, reservatório de Rosana, peixes não nativos, biodiversidade, impacto ecológico.

1. Introduction

River regulation represents one of the major impacts on fish fauna and can drastically change the species composition and abundance. Some species cannot survive to the newly created environment while others can become excessively abundant (Ahearn et al., 2005; Agostinho et al., 2008).

Another serious damage for the ichthyofauna is the introduction of non-native species. The introduction of non-native fish species can cause the decline or even the extinction of native fish populations, the biotic homogenization - the replacement of endemic native species by widespread distributed exotic species (Gido and Brown, 1999; Olden and Poff, 2004; Marchetti et al., 2006; McKinney, 2006; Smith, 2006; Light and Marchetti, 2007).

Biotic invasion, as a consequence of human activities, is an over century phenomenon (Simberloff, 2003). Since the Roman Empire, introduction of fish into alien environments have been mediated by boat displacement, importation of aquarium fish, aquaculture activities based on exotic species, releases for biological control, releases for fisheries improvement, construction of inter-catchment canals for water transportation, pipes and tunnels (Ruesink, 2005; Brasher et al., 2006; Jeschke and Strayer, 2006; Stohlgren et al., 2006). Exotic fishes are positively associated with man-made reservoirs, generally due to stocking for sport fishing and inundation of natural barriers, such large waterfalls (Pringle et al., 2000; Leprieur et al., 2006). Above dam populations of exotics usually have higher abundance than the ones living below dam (Holmquist et al., 1998).

In the last years the introduction of the Amazonian peacock-bass species (*Cichla* spp.) in Neotropical reservoirs has been considered as a major problem (Kullander and Ferreira, 2006). *Cichla* is an exceptionally voracious predator and studies showed that its introduction may seriously threat the native fish, compromising the assemblage diversity or even causing the complete regional extinction of several species (Zaret and Paine, 1973; Godinho et al., 1994; Santos et al., 1994; Latini and Petrere Junior, 2004; Pelicice and Agostinho, 2009).

Nevertheless, quantitative analysis of the dispersion and establishment of non-native fish in a wide spatial and temporal scale is still rare. The complete understanding of the process is crucial for prediction, and maybe the avoidance, of further expansion of invasive species and biotic homogenization in aquatic ecosystems (Han et al., 2008).

The proposal of the present study is to evaluate the potential negative impact of the introduction of *Cichla kelberi* Spix and Agassiz, 1831 in Rosana Reservoir, Paranapanema River. The aim is to understand how *Cichla* affects the small size ichthyofauna, comparing the assemblage structure before and after (in a relatively long term) the introduction.

Additional information on the small size fish assemblage distribution and ecological attributes and limnological characteristic of the study environment is provided by Ferrareze and Nogueira (2011) and Ferrareze et al. (2014), respectively.

2. Material and Methods

2.1. Study area

The study area is located in the upstream (tail) zone of Rosana Reservoir, approximately 80 km above dam (Figure 1), which is located at 22° 36’ S and 52° 52’ W. The reservoir is the last one, from a series of eleven along the Paranapanema River (SP/PR, Brazil), with a surface area of 276 km^2 (watershed of 11,000 km^2), water retention time of 21 days (annual mean values), shallow (maximum of 26 m close to the dam) and oligo-mesotrophic (Nogueira et al., 2006).

The climate is subtropical humid (average temperature of 21 °C) with two pronounced seasons, a dry weather predominates from April to August (autumn/winter), and the rains are concentrated in late spring and summer (from November to March) (Ferrareze et al., 2014).

2.2. Samplings and laboratory analyses

The samplings were carried out in February and September of 2004, previously to the register of *Cichla kelberi* in the Rosana Reservoir (Casatti et al., 2003; Pelicice et al., 2005), and in November of 2004 (register of the first occurrence of this species) (Pelicice and Agostinho, 2009), January, March, May and August of 2005, February and June of 2006, February and July of 2007, February and October of 2008 and February of 2009.

The study was carried out in 4 lagoons and one sampling station in Paranapanema River (PR), close to the river bank (Figure 1; Table 1). Two kinds of lagoons were assessed: 3 natural lagoons and one originated by the flood of mining digging (FPA). The natural lagoons (FPB and FPD) are located inside the State Park of Morro do Diabo, while the last one (FPC) is located in an area influenced by human activities (agriculture and cattle breeding). The dominant macrophytes of each lagoon, in terms of stand area, were registered (Table 1). Identification of these plants was performed at the genus level, with help of taxonomists of Botany Department from Biosciences Institute of State University of São Paulo, UNESP, Campus of Botucatu.

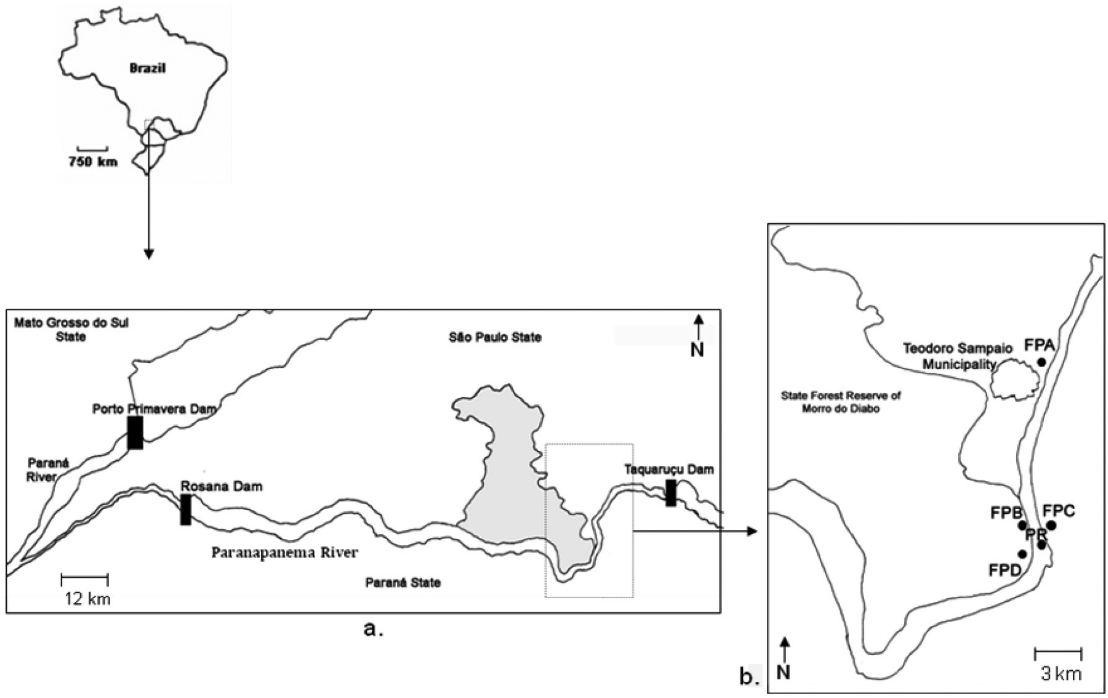

Figure 1. Study area in the region of the confluence of Paraná and Paranapanema Rivers showing the positioning of Rosana, Taquaruçu and Porto Primavera dams and the State Park of "Morro do Diabo" (gray area) (a). On the right (detail) the location of the sampling stations and the municipality of Teodoro Sampaio (b).

Table 1. Denomination of the sampling stations, geographical positioning, lagoons surface area, and main aquatic macrophytes found in each sampling site.

Sampling station	Geographical coordinates	Area (km^2)	Dominant macrophytes
Lateral lagoon A (FPA)	22° 34' 03.3"S / 52° 09' 11.4"W	0.110	*Typha, Eichhornia, Brachiaria, Pontederia* and *Salvinia*
Lateral lagoon B (FPB)	22° 36' 56.5"S / 52° 09' 47.3"W	0.024	*Eichhornia, Brachiaria, Pontederia, Salvinia, Pistia, Egeria* and *Nymphaea*
Lateral lagoon C (FPC)	22° 37' 28,9"S / 52° 09' 21.1"W	0.721	*Eichhornia, Brachiaria, Pontederia, Salvinia* and *Egeria*
Paranapanema River Bank (PR)	22° 37' 51.6"S / 52° 09' 30.5"W	-	*Tipha, Eichhornia, Brachiaria, Pontederia, Salvinia* and *Pistia*
Lateral lagoon D (FPD)	22° 38' 22.0"S / 52° 09' 29.0"W	0.063	*Eichhornia, Brachiaria, Pontederia, Salvinia, Pistia* and *Nymphaea*

Small fish were sampled with a net of $7.5m^2$ (1.5×5m; 0.3 cm of mesh size). In each point/period five manual throws were performed towards to the aquatic macrophyte stands and in the limnetic zone.

In the laboratory, the organisms were transferred to ethanol 70% for permanent storage. Voucher specimens are deposited in the Freshwater Fish Collection of the Department of Zoology, UNESP/Botucatu.

The biometry of the collected organisms was obtained through measurements of weigh (biomass in g; 0.01g accuracy) and length (caliper, 0.1 mm) – standard (except for Gymnotiformes and Synbranchiformes) and total.

For taxonomical identification of the fish species it was used specialized literature (Britsk, 1972; Britsk et al., 1986, 1999; Reis et al., 2003; Nelson, 2006; Graça and Pavanelli, 2007) and the scientific collections of the UNESP/São José do Rio Preto) and University of São Paulo Museum of Zoology (MZUSP) were also consulted.

Numerical richness, abundance and biomass were calculated for the communities, while the Index of Importance (Nataragam and Jhingian, 1961, apud Beaumord and Petrere Junior, 1994) was calculated for each species. The Shannon index was calculated to estimate the fish assemblage diversity of each lagoon for the distinct sampling periods. This index is widely used in analyses of communities structure (Magurran, 2004).

In order to describe the feeding preference of *C. kelberi*, its diet was determined through stomach content analysis.

The items were identified under a stereoscopic microscope and microscope, trying to attain the most detailed taxonomic level.

The mean values of the community variables were calculated to synthesize the information and facilitate the identification of patterns. The data were grouped by sampling year. The representativeness of the means was assumed based on the normal data distribution (Shapiro-Wilk's W test) (Underwood, 1997; Statsoft, 2001), after previously standardization (Log_x+1).

Finally, a one-way ANOVA test was performed to detect differences among periods. When differences were detected, the Tukey test was applied to determine the level of significance (Underwood, 1997). It was considered significant difference values of $p < 0.05$ (Underwood, 1997), which were mentioned in the results. The analyses were performed using StatisticaTM 6.0 software (Statsoft, 2001).

3. Results

A total of 4,693 fish, belonging to 43 species was sampled between 2004 and 2009 (Table 2). The assemblages were primarily composed by small-size species, due to the chosen methodology. The order Characiformes was the most abundant, totalizing 95.4% of the individuals, followed by Perciformes, 2.5%, and Siluriformes, 1.2%. Other orders represented only 0.9% of the individuals.

In terms of Species Importance, the main species was *Hemigrammus marginatus* Ellis, 1911, which represented about 37% of the total captures. Other abundant species were *Hyphessobrycon eques* (Steindachner, 1882), *Bryconamericus stramineus* Eigenmann, 1908 and *Serrapinnus notomelas* (Eigenmann, 1915) for Characiformes; *Crenicichla britskii* Kullander, 1982 for Perciformes; *Hypostomus ancistroides* (Ihering, 1911) for Siluriformes and *Gymnotus sylvius* Albert & Fernandes-Matioli, 1999 for Gymnotiformes.

A total of 899 individuals (21 species) were captured in the period that preceded the introduction of *C. kelberi* (before), while 3,994 individuals (43 species) were caught in all subsequent periods. Thirty-seven individuals of *C. kelberi* were captured along the study.

There were no differences between the fish richness if compared the periods before and after the introduction ($p=0.86$; Figure 2). The fish richness during the year of 2008 showed a remarkable decreasing ($p=0.03$). However, this fact is probably not related to the *Cichla* introduction, because the number of caught individuals of this species during the mentioned period was low.

There were no difference between the fish abundance before and after the introduction ($p=0.55$; Figure 3). It was verified a decrease in the fish abundance when there was an increase in the *Cichla* abundance. Posterior to the reduction of *Cichla*, the assemblage abundance was reestablished. The species *H. marginatus*, *H. eques* and *C. britskii* exhibited higher decrease in abundance when the number of *Cichla* specimens was elevated. Other observed particularity is that most *Cichla* individuals were sampled in the lateral lagoon with higher fish abundance (FPA).

The same pattern was observed in terms of fish biomass. During the increase of *Cichla* population, the fish biomass decreased; but the weight just reestablished when *Cichla* abundance reduced. There was no significantly difference between the fish biomass before and after the introduction ($p=0.677$; Figure 4).

The introduction of *Cichla* did not interfere in the mean length of fish ($p=0.83$; Table 2). The sampled species

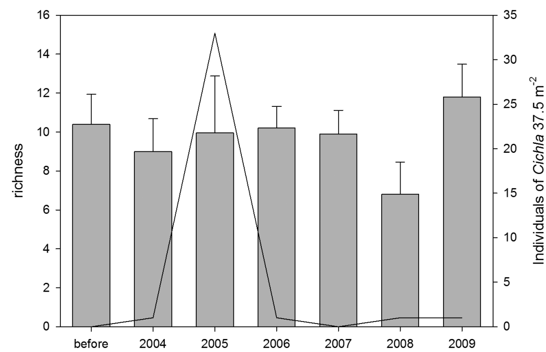

Figure 2. Mean value (and standard deviation) of species richness at the different sampling periods (gray bars) and density of *Cichla* (continuous line) (37.5 m^2 of net = sampling effort).

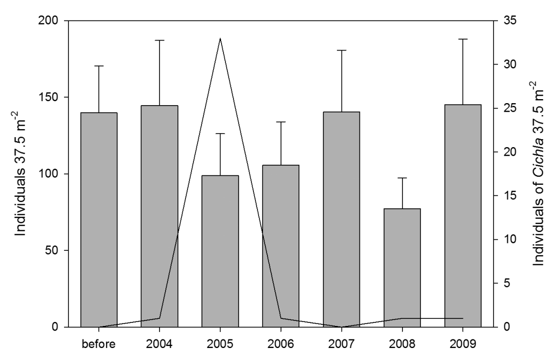

Figure 3. Mean value (and standard deviation) of absolute abundance of the ichthyofauna at the different sampling periods (gray bars) and density of *Cichla* (continuous line) (37.5 m^2 of net = sampling effort).

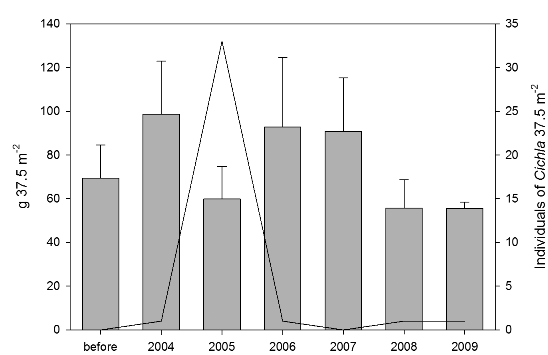

Figure 4. Mean value (and standard deviation) of biomass of the ichthyofauna at the different sampling periods (gray bars) and density of *Cichla* (continuous line) (37.5 m^2 of net = sampling effort).

Table 2. List of taxa identified in Rosana Reservoir during the study and the mean length (L) of the specimens, before and after the introduction of *Cichla kelberi*.

Taxon		L before	L after
Order Characiformes	**Family**		
Astyanax altiparanae Garutti and Britski, 2000	Characidae	25	25.6
Acestrorhynchus lacustris (Lütken, 1875)	Acestrorhynchidae	-	16
Apareiodon piracicabae (Eigenmann, 1907)	Parodontidae	21	16.7
Aphyocharax anisitsi Eigenmann and Kennedy, 1903	Characidae	18	18.2
Bryconamericus stramineus Eigenmann, 1908	Characidae	23	22.1
Cyphocharax modestus (Fernández-Yépez, 1948)	Curimatidae	20	15.4
Galeocharax knerii (Steindachner, 1875)	Characidae	-	31
Hemigrammus marginatus Ellis, 1911	Characidae	18	17.8
Hoplias malabaricus (Bloch, 1794)	Erythrinidae	74	73
Hyphessobrycon eques (Steindachner, 1882)	Characidae	17	16.5
Leporinus friderici (Bloch, 1794)	Anostomidae	32	32.8
Leporinus octofasciatus Steindachner, 1915	Anostomidae	-	20
Leporinus striatus Kner, 1858	Anostomidae	30	29.5
Metynnis lippincottianus (Cope, 1870)	Characidae	14	14.3
Moenkhausia intermedia Eigenmann, 1908	Characidae	16	16.3
Myleus tiete (Eigenmann and Norris, 1900)	Characidae	-	16
Oligosarcus pintoi Amaral Campos, 1945	Characidae	-	22
Roeboides descalvadensis Fowler, 1932	Characidae	28	28.5
Schizodon nasutus Kner, 1858	Anostomidae	28	28.7
Serrapinnus notomelas (Eigenmann, 1915)	Characidae	19	19
Serrasalmus maculatus Kner, 1858	Characidae	16	15.9
Serrasalmus marginatus Valenciennes, 1836	Characidae	-	22
Steindachnerina brevipinna (Eigenmann and Eigenmann, 1889)	Curimatidae	-	30
Order Gymnotiformes			
Eigenmannia trilineata López and Castello, 1966	Sternopygidae	-	47
Eigenmannia virescens (Valenciennes, 1842)	Sternopygidae	-	100
Gymnotus sylvius Albert & Fernandes-Matioli, 1999	Gymnotidae	47	48.6
Rhamphichthys hahni (Meinken, 1937)	Rhamphichthyidae	-	28
Order Siluriformes			
Hypostomus ancistroides (Ihering, 1911)	Loricariidae	19	20.3
Hypostomus sp. 1	Loricariidae	-	15
Hypostomus sp. 2	Loricariidae	-	28
Loricariichthys platymetopon Isbrücker and Nijssen, 1979	Loricariidae	-	24
Trachelyopterus galeatus (Linnaeus, 1766)	Auchenipteridae	-	61
Pimelodus maculatus Lacepède, 1803	Pimelodidae	-	28
Rhamdia quelen (Quoy and Gaimard, 1824)	Heptapteridae	-	38
Order Perciformes			
Cichla kelberi Spix and Agassiz, 1831	Cichlidae	-	32
Cichlasoma paranaense Kullander, 1983	Cichlidae	29	27.3
Crenicichla britskii Kullander, 1982	Cichlidae	25	24.6
Crenicichla haroldoi Luengo and Britski, 1974	Cichlidae	-	19
*Crenicichla jaguarensis*Haseman, 1911	Cichlidae	-	28
Satanoperca pappaterra (Heckel, 1840)	Cichlidae	17	18.5
Order Synbranchiformes			
Synbranchus marmoratus Bloch, 1795	Synbranchidae	-	130
Order Cyprinidontiformes			
Phalloceros harpagus Lucinda, 2008	Poeciliidae	-	35
Order Rajiformes			
Potamotrygon motoro (Müller and Henle, 1841)	Potamotrygonidae	*	*

*Missing data.

showed similar size before and after the introduction, even during the period when *Cichla* abundance was high.

The fish assemblage composition did not change after *Cichla* introduction. There was the predominance of Characiformes, followed by Perciformes and Siluriformes in all periods. Characiformes is more abundant in the lagoons, while Perciformes, Siluriformes and Gymnotiformes are more important in the river channel. The unique difference was seen when the *Cichla* abundance raised, the predominance of Characiformes was lower, due to the decrease of *H. marginatus*. The Siluriformes was the order that increased most after the introduction, but this is probably associated with the higher number samplings, as no species of this order was predominant after the introduction. The relative abundance among the taxonomic orders is presented in Figure 5, for the whole sampling period.

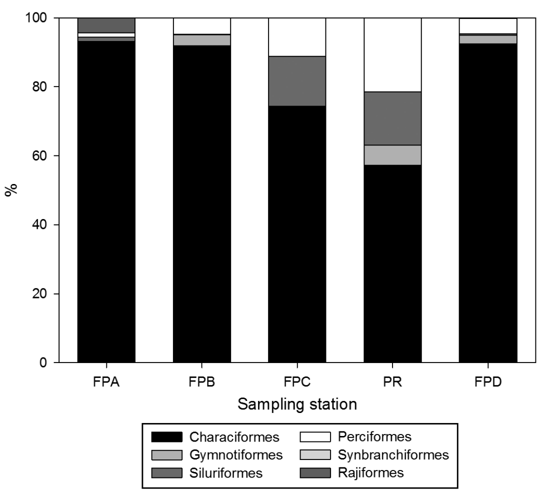

Figure 5. Relative abundance of the ichthyofauna at the different sampling stations considering the whole sampling period. PR = Paranapanema River; FPA = lagoon originated by the flood of mining digging; FPB and FPD = natural lagoons located inside a preservation area; FPC = lagoon under influence of agriculture and cattle breeding.

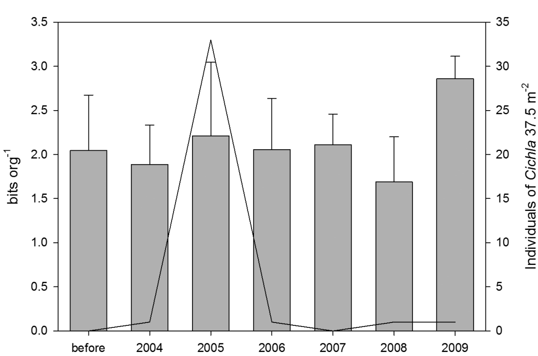

Figure 6. Shannon diversity index (H') of the ichthyofauna at the different sampling periods (gray bars) and density of *Cichla* (continuous line) (37.5 m^2 of net = sampling effort).

The fish diversity was higher before the introduction of *Cichla* (p=0.04; Figure 6). The number of the predominant species (*H. marginatus*, *H. eques* and *C. britskii*) decreased, what allowed other species of minor importance to increase in abundance, such as *Cyphocharax modestus* (Fernández-Yépez, 1948), *Roeboides descalvadensis* Fowler, 1932 and *Aphyocharax anisitisi* Eigenmann and Kennedy, 1903.

Finally, aquatic insects were the main feeding item of *C. kelberi*, followed by fish of the sub-family Tetragonopterinae. Cannibalism was recorded during the whole study period. Detailed analyses of the assemblages fish diet is provided by Ferrareze et al. (2015).

4. Discussion

The probability of a given species to become a well succeeded invader is generally low, even rare. When the event is rare, the prediction of the facts becomes hard, because it depends not only on the prediction accuracy, but also on the frequency that the event occurs (Colautti and MacIsaac, 2004; Brasher et al., 2006).

When a species is introduced in a region, only a certain number of individuals will survive and most of them will fail to succeed. Thus, the damage of non native species can just be evaluated after the real introduction, because no one can be completely sure if the establishment of it will occur (Colautti and MacIsaac, 2004; Jeschke and Strayer, 2006).

In the Rosana Reservoir case, the results showed that *C. kelberi* seems not to have had a significant effect on the ichthyofauna, as predicted by Pelicice and Agostinho et al. (2008).

Our results did not show statistically differences in the ichthyofauna structure after the introduction of *C. kelberi* in the reservoir. The diversity values even improved, after the introduction. This fact happened due to the decrease of the number of the most abundant species, diminishing the competition and allowing the increase of the abundance of some species with minor importance as *C. modestus*, *R. descalvadensis* and *A. anisitisi*. However, some tendencies of disturb could be observed, indicating that this species can interfere in the local ichthyofauna. According to McKinney (2006), when a high number of predators found an opportunity to spread, they can produce pronounced changes on the local fish community, and this possibility cannot be neglected.

Firstly, it is interesting to note that a high number of *Cichla* was found in the lagoon with the higher abundance of small size fish. Second, when the *Cichla* abundance was high, the abundance of the main species and the fish biomass decreased, corroborating with the initial study of the species impact in the Rosana Reservoir (Pelicice and Agostinho, 2009).

The results allowed to conclude that the introduction of *Cichla kelberi* in the reservoir is in the phase 3 (*sensu* Colautti and MacIsaac, 2004). In this phase, the specie can survive and reproduce in the new environment; however it is not established, disseminated and dominant. So, probably *Cichla* is still not well established in the reservoir, and the initial introduction effects were buffered by the plasticity of the fish along the time (Ruesink, 2005).

It is difficult to point out the reasons to explain why *Cichla* is not properly established, but it could be related with the feeding competition, high rate of cannibalism and the extensive presence of aquatic macrophytes in the reservoir.

Juveniles of *Cichla kelberi*, as several other Neotropical fish species, uses the aquatic insects as the main feeding item and some of this species are highly specialized to capture their prey, such as *Gymnotus* and *Crenicichla*. Another fact is that the Tetragonipterinae, used by *Cichla*, are also an important feeding item of *Serrasalmus maculatus* Kner, 1858 and *Hoplias malabaricus* (Bloch, 1794) (Ferrareze et al., 2015).

The feeding competition can reduce the prey availability and raise the cannibalism (Novaes et al., 2004). The cannibalism also can reduce the chances of surviving of a non native fish in a new environment. The drastic reduction of the introduced population, reduce the genetic and morphologic variability, as well as the reproduction success (Wootton, 1990; Santos et al., 2001).

Other important fact preventing *Cichla* to become dominant in the reservoir is the presence of macrophytes, as previously mentioned. The plant structures offer an ideal environment for refuge and shelter for prey, mainly for small sized fish, what makes harder their capture by predators (Rozas and Odum, 1988; Schriver et al., 1995; Ferrareze and Nogueira, 2011).

Therefore, the results showed that *Cichla* didn't impair the whole ichthyofauna assemblages of a Neotropical reservoir and changed the fish assemblage structure immediately after its introduction (Ferrareze and Nogueira, 2011). But, the real problems about the introduction only will be determined, when the process reaches the next steps (4 and 5). When the species will reach these steps cannot be determined (Colautti and MacIsaac, 2004).

The decrease in the ichthyofauna attributes verified during the year of 2008, such as low richness, abundance, biomass and diversity is probably resulted of the irregular climate verified in that year. There were strong rains in the wet period (from January to March) and a long dry season in the winter/spring of 2008 (no published data). These changes reflected on the ichthyofauna, promoting the decrease of the ecological attributes, as verified in other studies (Gafny et al., 2000; Barrella and Petrere Junior 2003).

Despite of the inconclusive results to support the hypothesis that *Cichla kelberi* has caused a significant negative impact on the ichthyofauna of Rosana Reservoir, the role of non native species in the local fish fauna should be a major concern of aquatic ecology scientists and environmental managers. The continuous monitoring of non-native species is imperative, because in several cases, the introduction reach the final phase, promoting drastic changes in the local ichthyofauna (Zaret and Paine, 1973; Kaufman, 1992; Macchi et al., 1999). Additionally, it must be considered that the impacts caused by colonization of this undesirable species can be magnified by complex processes, usually correlated with other environmental disturb (Byers, 2002; Shea and Chesson, 2002), especially the negative effects of damming (Agostinho et al., 2007). Nevertheless, the assumptions cannot be totally pessimist, as the system has a natural resiliency that can minimize disturbances (Odum, 2004).

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