**Article**

# Size-related and seasonal changes in the diet of the non-native *Cichla kelberi* Kullander & Ferreira, 2006 in a lowland reservoir in the southeastern Brazil

*Helaine Silva Mendonça[1,2]\*, Alexandre Clistenes Alcântara Santos[2], Mariana Marques Martins[1]*

*& Francisco Gerson Araújo[1]*

[1]*Universidade Federal Rural do Rio de Janeiro, Rodovia BR 465, Km 07, Campus Universitário, 23890-000, Seropédica, RJ, Brasil*
[2]*Universidade Estadual de Feira de Santana, Departamento de Ciências Biológicas, Av. Universitária s/n, Novo Horizonte, 44036-900, Feira de Santana, BA, Brasil*
*\*Corresponding author: Helaine Mendonça, e-mail: helainemendonca26@gmail.com*

***Abstract:*** We examined size-related and seasonal changes in the diet of the peacock bass *Cichla kelberi* in a tropical lowland reservoir in southeastern Brazil over three hydro-climatic seasons: summer (high rainfall and temperature), winter (low rainfall and temperature), and late spring (increasing rainfall and temperature) during two years (2006-2007). The tested hypothesis is that this non-native predator fish changes diet during the subadult and adult phases and among seasons to adapt in new colonized environment. Fishes of the families Clupeidae (*Platanichthys platana*), Characidae (*Astyanax* spp.) and Cichlidae (*Cichla kelberi*) were the most important food items, followed by insects of the order Odonata. Cannibalism was also recorded for the largest individuals. A significant size-related change in diet was found with the smallest individuals (Total Length, TL < 20 cm) preying mainly on fishes, whereas the larger individuals (TL > 30 cm) preyed mainly on Odonata. The niche breadth increased during growth, with the largest individuals having a diet more evenly distributed among the available resources. No significant seasonal differences in diet composition were found, but stomachs with higher degree of volume occupied by food were more frequent in late spring than in summer. Conversely, the highest niche breadth was found during the summer compared to the other seasons. Together, these observations suggest an efficient use of the available resources by this top predator in this new colonized system.
***Keywords:*** *Feeding ecology, freshwater fishes, non-native species, piscivory, impoundment.*

## Mudanças sazonais e relacionadas ao tamanho da dieta do não-nativo *Cichla kelberi* Kullander & Ferreira, 2006 em um reservatório de planície no sudeste do Brasil

***Resumo:*** Foram examinadas as mudanças sazonais na dieta e relacionadas ao tamanho para o tucunaré *Cichla kelberi* em um reservatório tropical de várzeas no Sudeste do Brasil em três ciclos hidrológicos: verão (elevadas precipitações e temperaturas), inverno (baixas precipitações e temperaturas), e final da primavera (aumentos das precipitações e temperaturas) durante dois anos (2006-2007). A hipótese testada é que este peixe predador não-nativo muda a dieta durante as fases adulta e subadulta e entre as estações do ano para se adaptar neste novo ambiente colonizado. Peixes das famílias Clupeidae (*Platanichthys platana*), (Characidae (*Astyanax* spp.) e Cichlidae (*Cichla kelberi*) foram os itens alimentares mais importantes, seguidos por insetos da ordem Odonata. O canibalismo também foi registrado para os maiores indivíduos. Mudanças significativas na dieta foram relacionadas ao tamanho, com os indivíduos menores (Comprimento Total, CT <20 cm) utilizando principalmente peixes, enquanto os indivíduos maiores (CT >20 cm) se alimentaram principalmente de Odonata. A amplitude de nicho aumentou ao longo do crescimento, com indivíduos de maior porte tendo dieta mais uniformemente distribuída entre os recursos disponíveis. Nenhuma diferença significativa na composição da dieta foi encontrada entre as estações do ano, mas estômagos com maiores volumes ocupados pelo alimento foram mais frequentes no fim da primavera e menos frequentes no verão. Por outro lado, a maior amplitude de nicho foi encontrada no verão comparada com as outras estações, o que indica o uso mais uniforme dos diversos recursos disponíveis. Juntas, estas observações sugerem uma utilização eficiente dos recursos disponíveis por esta espécie predadora de topo neste novo sistema colonizado.
***Palavras-chave:*** *Ecologia alimentar, peixes de água doce, espécies não nativas, piscívora, represamento.*

## Introduction

Many rivers in southeastern Brazil have undergone considerable changes due to the construction of dams. The artificial lakes fragment the lotic system, blocking routes for fish migration and forming systems with new environmental conditions (Agostinho et al. 2008). As a result, the natural structure of the fish assemblages changes in the new environment favoring the establishment of non-native fish species. The non-native species are, in many cases, more tolerant to the lentic conditions than the previously native lotic fish fauna (Hoeinghaus et al. 2009, Araújo et al. 2013).

Knowing the ecology of invasive species is crucial to help environmental managers in policies aiming the biodiversity conservation (Gozlan 2008). Trophic plasticity is a fundamental condition for species to adapt to a newly created lentic environment such as the reservoirs. Introduced species can affect the functioning of ecosystems by changing trophic relationships, besides presenting other deleterious effects (Adams 1991, Meffe et al. 1997, Marchetti 1999, Kati et al. 2015). These changes may have important economic and ecological consequences (Gomiero & Braga 2003, Fugi et al. 2008, Pelicice & Agostinho 2009). Native species may change their abundance due to competition with non-native species (Zaret & Paine 1973, Lodge 1993, Khan & Panikkar 2009, Kati et al. 2015). On the other hand, non-native species can alter the functioning of local ecosystems by intensifying predation pressure on native species, or by searching for other prey that are not used by native predators (Zavaleta et al. 2001, Laxson et al. 2003).

*Cichla* species have successfully invaded Neotropical reservoirs and this may seriously threaten native fish diversity due to their high predatory capacity (e.g., Santos et al. 2001, Latini & Petrere, 2004, Novaes et al. 2004, Fugi et al. 2008. Pinto-Coelho et al. 2008, Kolavensko et al. 2010, Menezes et al. 2012, Pelicice et al. 2015). Species of *Cichla* are able to change their diets according to resources availability, usually related to seasonal and ontogenetic variations (Gomiero et al. 2010). Seasonal changes in the fish diet associated to changes in water temperature and photoperiod also influence food availability (Zavala-Camin 1996). Moreover, in environments where species of *Cichla* have been introduced, high cannibalism rates can occur (Santos et al. 1994, Durães et al. 2000, Gomiero & Braga 2004b).

The peacock bass *Cichla kelberi* Kullander and Ferreira 2006 is native and endemic to the Araguaia and Tocantins Rivers basins (Kullander & Ferreira 2006) but has been introduced in several aquatic systems across the country. This species has been introduced in Brazilian reservoirs since the 1950s by hydroelectric companies and by amateur anglers and has colonized large areas of river basins (Oliveira et al. 1986). The wide distribution and high abundance of *C. kelberi* in Brazilian reservoirs suggests a high impact on the native fish communities and other aquatic organisms (Magalhães et al. 1996, Câmara et al. 2002, Chellapa et al. 2003, Gomiero & Braga 2003, Fugi et al. 2008, Santos et al. 2011, Pelicice et al. 2015). It is a top predator with piscivorous habits (Lowe McConnel 1969, Braga 1990, Arcifa & Meschiatti 1993, Jepsen et al. 1997, Novaes et al. 2004, Pelicice & Agostinho 2009, Montaña 2011), favored by its accurate visual capacity, preying largely on small fishes but occasionally consuming shrimps and other aquatic invertebrates when adults (Winemiller 2001, Kullander & Ferreira 2006, Santos et al. 2011). As most successful invaders, this species must be able to adapt to novel environmental conditions that include shifting feeding habits to explore the available resources. It is widely accepted that species of *Cichla* change diet during growth, with the juveniles feeding mainly on crustaceans and insects whereas the adults fed mainly on fishes (Gomiero & Braga 2004a, Novaes et al. 2004).

*Cichla kelberi* was introduced in the Juturnaíba Reservoir, a tropical impoundment in the north of Rio de Janeiro State, shortly after the reservoir construction, about three decades ago. This study aimed to assess dietary preference of *Cichla kelberi* and eventual changes among seasons and size-classes in the Juturnaíba Reservoir. Knowing the diet of *C. kelberi* from gut analyses, although may reflect more on prey availability than preference towards a particular prey species, is one of the first step to assess their success in the new colonized system. We hypothesized that there are size-related and seasonal changes in the diet of *Cichla kelberi* in the Juturnaíba Reservoir, which may be a mechanism that favor the use of available resources.

## Material and Methods

### 1. Studied area

The dam on the São João River that formed the Juturnaíba Reservoir (22º36'S, 42º16'W) is located at 65 km from the river headwaters and 38.5 km from its mouth in the Atlantic Ocean (Fig. 1). The reservoir has approximately 30.6 km$^2$ of water surface, a maximum depth of 9 meters and water volume of 100 million m$^3$ (Afonso & Cunha 1989). The reservoir has an average depth of 4 meters and is located in lowland areas of northeast floodplains of Rio de Janeiro State. We defined three instead of four seasons because changes in the major factors of temperature and rainfall reflect better three and not four seasonal periods: (i) summer, with the highest temperatures and rainfalls; (ii) winter, when environmental conditions are stable, characterized by the lowest temperature and rainfall; (iii) late spring, when the area experiences changes in environmental variables, with strong southwestern winds coinciding with increases in rainfall and temperature. Such seasons were already established in other studies (e.g. Azevedo et al. 2016) and the database supporting this pattern is available from the Instituto Nacional de Meteorologia (INMET), available at http://www.inmet.gov.br/html/clima.php#.
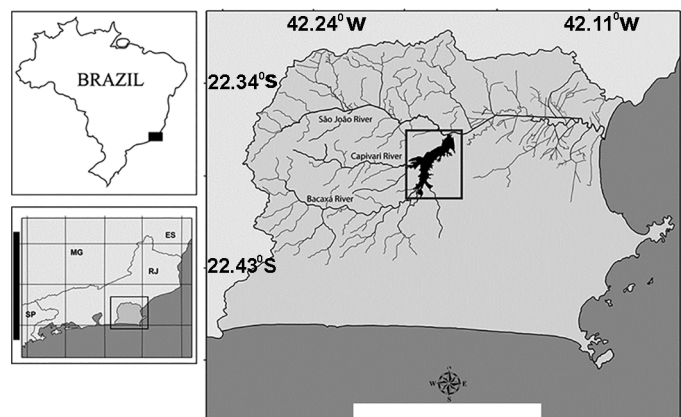


**Figure 1.** Map showing the study area, the Juturnaíba Reservoir and its drainage area, Rio de Janeiro, Brazil.

### 2. Sampling and data handling

Fishes were sampled in March (summer), August (winter) and December (late spring) during two years (2006 and 2007), covering two full hydro-climatic cycles. Information from each year were pooled by seasons, with years being used as replications of the seasons. At each season and each year, excursions were carried out at 7 sites randomly chosen covering most area of the reservoir, totaling 42 samples (7 sites × 3 seasons × 2 years). Seven gill nets (30 m long × 3 m high) of different mesh size (2-7 cm stretched mesh) at each sampling site were used. The nets were set up at sunrise and retrieved the following afternoon, remaining in operation for ca. 20 h. All fish were identified, measured for total length (TL, in centimeters) and weighed (in grams). The stomachs were removed and fixed in 10% formalin, and after 48 hours transferred to 70% ethanol.

For each individual, the degree of fullness in the stomach (SF) was measured and classified according to the following categories: SF-0 (empty stomach), SF-1 (< 30% of stomach volume occupied by food); SF-2 (between 30 and 70%); and SF-3 (above 70%).

The food items were identified under a stereomicroscope. Fish with empty stomachs or those with unidentifiable contents were excluded from the analyses. The volume of each identified food item was measured according to Albrecht & Caramaschi (2003). The volume and the frequency of occurrence of the food items were used to calculate the Alimentary Index (AI) proposed by Kawakami & Vazzoler (1980) according to the following equation: IAi = %Fi x %Vi / Σ (%Fi x %Vi), where: IAi = Index Feeding; %Fi = Frequency of occurrence of the item i in the diet (%); V = Volume of the item i in the diet (%).

### 3. Data analyses

The stomach contents of individuals were analyzed covering the three periods (March, August and December 2006 and 2007). To assess possible changes in diet with respect to size, fish were divided into three size classes that were assigned according to observed size ranges: Total Length (TL) TL1< 20 cm; TL2 = 20-30 cm; TL3 > 30.0 cm. Although these size classes do not encompass the juveniles (TL < 10 cm, according to Novaes et al. 2004) at smaller lengths, they included the subadult and adult, which are the focus of the present study.

The volume of the food items for each sample was square root transformed and converted into a triangular matrix of similarities among all samples, using the Bray–Curtis similarity measure (Schafer et al. 2002). The diet composition was compared among seasons (three seasons) and size class (three size classes) that were the fixed factors. We used ANOSIM procedure at a significance level of P < 0.05 to compare the diet composition among seasons and size classes. Theses analyses were performed with the PRIMER software package version 6.0+ PERMANOVA (Anderson et al. 2008). The volumetric data obtained for the food items were used to calculate the standardized Levin's index as a measure of the niche breadth for each season and size class.

### Results

A total of 125 specimens of *C. kelberi* were examined from which 98 had stomachs with identifiable food items and 27 were empty. A total of 34 individuals were examined in summer, 38 in winter and 26 in late spring. The specimens examined had sizes ranging from 9.7 to 48.1 cm

Total Length (TL), with 36 individuals in size class TL1 (< 20 cm TL), 45 individuals in size class TL2 (20-30 cm TL) and 17 individuals in size class TL3 (> 30 cm TL).

The diet consisted mainly of fishes and insects (Table 1). During the summer, the most important food items was fish remains (IAi =36.15%) and juveniles of *Cichla kelberi* (IAi =22.39%). During the winter, the most important food item was Odonata (IAi =52.15%) followed by characid fishes *Astyanax* spp. (IAi = 34.63%), whereas in the late spring, Odonata (IAi=55.86%), followed by fish remains (IAi=24.19%) and the clupeid *Platanichthys platana* (Regan, 1917) (IAi=18.18%) were the main food items (Table 1). The Cichlidae family was represented by *C. kelberi*, indicating cannibalism habit. No significant seasonal differences were found in the diet composition (R global= 0.022; P = 0.132) according to the ANOSIM test.

The frequency of stomachs with lower than 30% of fullness (SF-1) and with 30-70% of fullness (SF-2) was higher in late spring and lower in summer (Fig. 2). Conversely, the frequency of empty stomachs (SF-0) was higher in summer and lower in late spring. No seasonal differences were found in the frequency of stomachs with higher than 70% of fullness (SF-3).

The diet composition changed significantly (R global= 0.286; P = 0.03) among the three size classes according to the ANOSIM (Fig. 3). The smallest individuals (TL1) fed mainly on fish remains and fishes from the family Clupeidae, whereas the medium-sized individuals (TL2) fed preferably on fish remains and *Platanichthys platana*. The largest individuals (TL3) fed on Odonata and fishes from the Characidae family. Cannibalism was recorded mainly in the largest individuals that fed mainly on juveniles of *C. kelberi*.

Niche breadth was low, with comparatively higher values in summer (0.35) and lower in winter (0.21) and late spring (0.14). There was a trend of increasing niche breadth as fish grew, with lower values (0.12) in the sizes smaller than 20 cm (TL1), then increases to 0.21 in the 20-30 cm TL size class (TL2), reaching the highest value (0.24) at sizes larger than 30 cm (TL3).

### Discussion

The non-native *Cichla kelberi* seems to adapt its trophic niche to use a broad spectrum of the available resources in the Juturnaíba Reservoir. It is noticeable its opportunist carnivore strategy by using 16 different food item, usually in high volume and in low frequency. A generalist trait favors successful invasions (Ribeiro et al. 2007, Brandner et al. 2013) since it is less affected by shifting prey availability, whereas a specialist feeding strategy could result in fluctuating population abundance of the predator when preferred prey abundance varies (Volterra 1928).

Specialization in piscivory as the main feeding habit for species of *Cichla* is widely known (e.g., Santos et al. 2001, Rabelo et al. 2002, Gomiero & Braga 2004a, Novaes et al. 2004, Santos et al. 2004, Villares-Junior & Gomiero 2010, Pereira et al. 2015). However, some degree of trophic plasticity is also described for these species, which prey occasionally on shrimps and other aquatic invertebrates (Winemiller et al. 2001, Kullander & Ferreira 2006). Winemiller et al. (1997) found that Characiformes and Perciformes fishes are the major prey for species of *Cichla*, and food partitioning has been documented for *C. temensis*

**Table 1.** Diet composition (% of the Alimentary Index – IAi) of *Cichla kelberi* in the Juturnaíba Reservoir in the three seasons (summer, winter and late spring).

| Resources | Summer | Winter | Late Spring | Total |
|---|---|---|---|---|
| ANGIOSPERMA | | | | |
| Vegetal | 0.67 | 0.66 | 0.00 | 0.14 |
| MOLLUSCA | | | | |
| Bivalvia | 0.00 | 0.39 | 0.00 | 0.04 |
| ARTHROPODA | | | | |
| Crustacea | | | | |
| Decapoda | 0.00 | 0,85 | 0.28 | 0.28 |
| Ostracoda | 0.23 | 0.00 | 0.00 | 0.01 |
| Hexapoda | | | | |
| Ephemeroptera | 5.25 | 0,21 | 0.00 | 0,22 |
| Odonata | 4.99 | 52.15 | 55.86 | 68.07 |
| Diptera | 0.00 | 0.00 | 0.01 | 0.01 |
| Trichoptera | 0.12 | 0.02 | 0.00 | 0,01 |
| Hemynoptera | 15.98 | 0.00 | 0.00 | 0.31 |
| Hemiptera | 0.01 | 0.04 | 0.00 | 0.01 |
| Remains insecta | 0.02 | 0.10 | 0.00 | 0.02 |
| FISHES | | | | |
| Clupeidae | | | | |
| *Platanichthys platana* | | 1.55 | 18.18 | 6.72 |
| Characidae | | | | |
| *Astyanax* sp. | 8,45 | 34.63 | 1.49 | 8.03 |
| Auchnenipteridae | | | | |
| *Trachelyopterus striatulus* | 0.00 | 0.15 | 0.00 | 0.02 |
| Cichlidae | | | | |
| *Cichla kelberi* | 22.39 | 0.06 | 0.00 | 0.53 |
| Fish remains | 36.15 | 9.17 | 24.19 | 15.61 |
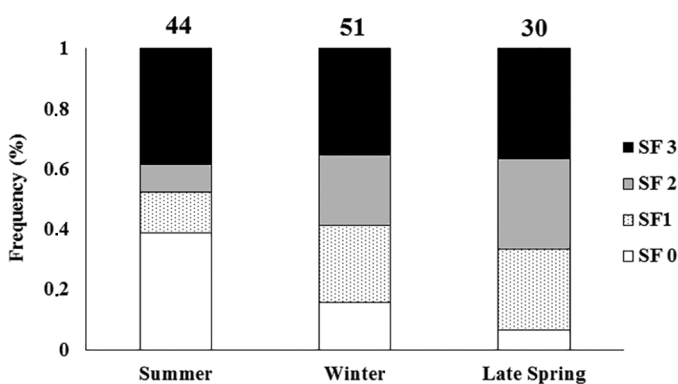


**Figure 2.** Frequency (%) of stomach of *Cichla kelberi* in the Juturnaiba Reservoir in different fulness degrees. SF-0, empty stomachs; SF-1, < 30% of the stomachs volume occupied by food; SF-2, 30-70%; SF-3, > 70%. Numbers of examined individuals also indicated.
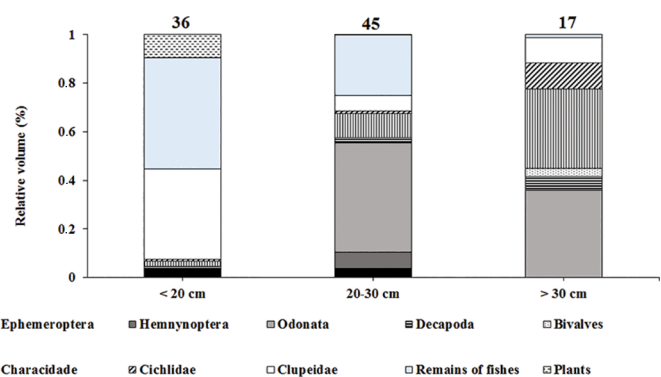


**Figure 3.** Main food items (% volume) by size classes of *Cichla kelberi* in the Juturnaíba Reservoir. Numbers of individuals examined also indicated.

and *C. intermedia* in the Cinaruco River, in Venezuela. In the Guri Reservoir, *C. temensis* feeds more on Characiforms and less on Cichlids than *C. orinocensis*. In the Tocantins River, the Tetragonopterinae subfamily was reported as the main prey for *Cichla kelberi* during the construction phase of a large reservoir (Serra da Mesa Reservoir), whereas the cichlids were the dominant prey during the operation phase (Novaes et al. 2004).

In its natural environment, the Tocantins-Araguaia watershed, *Cichla* kelberi preys mainly on small Tetragonopterinae, and to a lesser extent on shrimps and insects, besides practicing cannibalism (Novaes et al. 2004). When introduced in other reservoirs, this species prey on a variety of fish species that are available (Table 2), mainly small characiforms, siluriforms and cichlids, besides shrimps and insects (Santos et al. 2001, Gomieiro & Braga 2004a, Santos et al. 2004, Villares Junior & Gomiero 2010, Pereira et al. 2015). In the present study, this trend for using the available resources was confirmed, with *C. kelberi* preying mainly on characids, clupeids and cichlids. Additionally, a remarkable amount of insects of the order Odonata was also recorded in the stomachs examined.

Cannibalism is another aspect of the trophic behavior of *Cichla* species that is developed especially in invaded reservoirs. The high degree of cannibalism displayed by *C. kelberi* in the Corumbá (Fuji et al. 2008), Lajes (Santos et al. 2011) and Porto Primavera (Pereira et al. 2015) reservoirs highlights the aggressive behavior exhibited by this species. In the Lajes Reservoir, high cannibalism was recorded

accounting for 50% of the diet (Santos et al. 2011). We found that cannibalism is higher in larger individuals of *C. kelberi*, as also reported in other reservoirs (Gomiero & Braga 2004, Pereira et al. 2015). Cannibalism, although being recorded in the Juturnaíba Reservoir, does not seem to be the most important source of feeding for *C. kelberi*. During the summer, the spawning season increases the number of early juveniles, which are easily preyed by the adult individuals (Gomiero et al. 2009). In the present study, cannibalism was also more frequent in summer, when the fullness indexes were at the lowest levels.

A conspicuous change in the diet was found during the subadult and adult phase, with the smallest individuals preying on a limited number of resources, mainly fishes of the family Clupeidae, whereas the largest individuals increased their trophic breadth preying mainly on insect of the order Odonata and fishes of the family Characidae. During and after the parental care period, juveniles (< 10 cm TL) of *Cichla* spp feed themselves on zooplankton, such as cladocerans, copepods, and microcrustacea; above this length, the diet is based on crustaceans, insects, and small fishes, with fish being the preferential item for adults (Lowe-McConnell 1969, Santos et al. 1994, Jepsen et al. 1997, Winemiller 2001). We also found that the niche breadth increased with growth, because the largest adults (>20 cm TL) consumed in an even proportion more items compared with the subadults (<20 cm TL). This is the opposite to the pattern detected by Gomiero & Braga (2004a) for species of *Cichla* in the Volta Grande Reservoir, where the smallest individuals had the largest niche breadth, feeding mainly on

**Table 2.** Main food items in decreasing importance used by *C. kelberi* in different aquatic systems.

| Aquatic system | Origin | Main food items | References |
|---|---|---|---|
| Porto Primavera Reservoir (Southern Brazil), Paraná river basin | Non-native | Fishes (Anostomidae, Cheirodontidae, Curimatidae, Sternopygidae e Cichlidae) and Crustacea (Decapoda) | Pereira et al. 2015 |
| Lajes Reservoir (Southeastern Brazil) | Non-native | Fishes (Cichlidae - *Cichla kelberi*, *Crenicichla lacustris* and *Tilapia rendalli*, Characidae - *Astyanax* spp.; *Oligosarcus hepsetus*; Pimelodidae - *Pimelodella eigenmani* and *Rhamdia parahybae*) Insects (Odonata - nymphs and adults; Hemiptera); fish eggs; Crustacea (*Macrobrachium* sp.) and unidentifield fishes. | Santos et al. 2011 |
| Leme Lake (Southeastern Brazil) | Non-native | Fishes (Cichlidae - *Tilapia* sp., *C. kelberi* and *Geophagus brasiliensis*; Callichthyidae - *Hoplosternum litoralle*), Ophidia and unidentifield fishes | Villares Junior & Gomiero 2010 |
| Corumbá Reservoir, Rio Grande, Paraná river basin | Non-native | Fishes (*Galeocharax knerii*, *Cichlasoma paranaense*, *Astyanax altiparanae*, *Cichla kelberi* and *P. maculatus* | Fugi et al. 2008 |
| Lajes Reservoir (Southeastern Brazil) | Non-native | Fishes (Cichlidae - *Cichla monoculus*, *Crenicichla lacustris* and *Tilapia rendalli*, Characidae - *Astyanax* spp.; *Oligosarcus hepsetus*; Pimelodidae - *Pimelodella eigenmani* and *Rhamdia parahybae*) Insects (Odonata - nymphs and adults; Hemiptera); fish eggs; Crustacea (*Macrobrachium* sp.) and plants. | Santos et al. 2004 |
| Volta Grande Reservoir, (Southeastern Brazil), Paraná river basin | Non-native | Fishes (Cichlidae - *Cichla* sp., *Tilapia rendali* and Scianidae – *Plagioscion squamosissimus*, fishes remains and others species), Insects (Culicidae, Odonata) and Shrimp (Macrobrachium sp.) | Gomiero & Braga 2004a |
| Serra da Mesa Reservoir (Western Brazil), Tocantins river basin | Native | Fishes (Tetragonopterinae, unidentifield fishes and Cichlidae), Insects. | Novaes et al. 2004 |
| Lajes Reservoir (Southeastern Brazil) | Non-native | Fishes (Cichlidae, Characidae and Pimelodidae), Shrips (Macrobrachium sp.) & Insects Odonata. | Santos et al. 2001 |
| Juturnaíba Reservoir (Southeastern Brazil) | Non-native | Fishes (Characidae, Clupeidae and Cichlidae, unidentifield fishes), Insects (Odonata and Ephemeroptera) | This study |

juvenile fishes and insects whereas the largest individuals feed mainly on fishes. It seems that the opportunism is a more favorable strategy, rather than the specialism for *C. kelberi* in the Juturnaíba Reservoir, as this fish reaches larger size.

Seasonally, there was an inverse relationship between stomach fullness and the niche breadth for *C. kelberi* in the Juturnaíba Reservoir. In summer, it was detected the lowest stomach fullness and the highest niche breadth, whereas the opposite was recorded in late spring. The greater contribution of Odonata during the winter and late spring may have contributed for the high stomach fullness and low niche breadth in this period. Seasonal changes in feeding activity have been reported for this species in other reservoirs, as the case of the Volta Grande Reservoir (Gomiero & Braga 2004a) and the Leme Lake (Villares Junior & Gomiero 2010), which are likely to be associated to the dynamic in environmental conditions that affect seasonal resources availability. Villares-Junior & Gomiero (2010) reported that *C. kelberi* changes diet according to season, with low feeding activity during the winter when it feed on several fish species, increasing feeding activity during the spring, by preying mainly on *Tilapia* spp. and practicing cannibalism in summer/early autumn. In the present study, no significant seasonal differences were found in the diet composition of *C. kelberi.*

Piscivorous invaders change the diet composition in the new environment more than other trophic levels (Pereira et al. 2015), with direct effects on prey populations. In the case of *C. kelberi*, piscivory is the main feeding habit that have been recorded in several other studies (e.g., Santos et al. 2001, Rabelo et al. 2002, Gomiero & Braga 2004a, Novaes et al. 2004, Santos et al. 2004, Villares-Junior & Gomiero 2010, Pereira et al. 2015). It is expected that non-native species exploit the available resources in the new environment, and it was confirmed in this study, especially by the high consumption of Odonata and others invertebrates. We found that feeding plasticity is probably important to explain persistence of *C. kelberi* in reservoirs. Moreover, invasive species face new ecological interactions in the invaded environment and the success of an invasion might be affected by the biotic resistance presented by competitors and predators (Thompson et al. 2012).

The colonization and adaptation of *Cichla* spp. in altered environments such as reservoirs, is likely to result in decline of the original fish community. The presence of these highly adapted and quickly proliferating predators can cause serious losses to these communities by predation, competition, and cascade effects throughout the whole trophic chain. However, *Cichla* species attract recreational anglers, involving in this way the whole riverine community that depends on native fish species. The impact on the native ichthyofauna have been reported by several studies where there were introductions of species of *Cichla* (Pelicice & Agostinho 2009, Menezes et al. 2012, Orsi & Britton 2014). In the Juturnaíba Reservoir, *C. kelberi* seems to benefit from some native species (e.g., *Astyanax* spp. and *P. platana*). The opportunist feeding habit of *C. kelberi* enables to explore efficiently native species, thus facilitating its success to adapt and disperse in new colonized areas. A generalist feeding strategy, coupled with exceptionally high predatory ability may result in the proliferation of *C. kelberi* population.

## Author Contributions

Helaine da Silva Mendonça and Alexandre Clistenes de A. Santos: Substantial contribution in the concept and design of the study.

Helaine da Silva Mendonça and Alexandre Clistenes de A. Santos: Contribution to data collection.

Helaine da Silva Mendonça; Alexandre Clistenes A. Santos, Mariana Marques Martins e Francisco Gerson Araújo: Contribution to data analysis and interpretation.

Helaine da Silva Mendonça; Mariana Marques Martins and Francisco Gerson Araújo: Contribution to manuscript preparation.

Helaine da Silva Mendonça; Alexandre Clistenes de A. Santos and Francisco Gerson Araújo: Contribution to critical revision, adding intelectual content.

## Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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