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Effects of impoundment on the body condition of fish in the Manso reservoir, Mato Grosso State, Brazil

Efeitos do represamento sobre a condição nutricional de peixes no reservatório de Manso, Mato Grosso, Brasil

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Abstract: Aim: This study evaluated the body condition de *Acestrorhynchus pantaneiro, Auchenipterus osteomystax, Pimelodus maculatus, Psectrogaster curviventris* and *Schizodon borellii* in the Manso reservoir, Mato Grosso State, Brazil, during the first years after its formation (years I, II, III and IV). We hypothesized that sudden environmental changes alter differently the body condition, according to the time (sampling years) and sex of individuals. Also, we checked the influence of the amount of food ingested and the reproductive status on nutritional status of the species. **Methods:** The body condition (*Kn*), the feeding activity (SRI) and reproductive (GSI) were calculated only for adults. The difference between the sampling years and sexes (used as factors) was assessed using the nonparametric Kruskal-Wallis test. Temporal influence was tested by Spearman correlation and the interaction between both factors by PERMANOVA. **Results:** The values of the *Kn* showed two groups: group 1: species whose body condition decreased in the year II, with a posterior increase (*A. pantaneiro*, *P. curviventris* and *S. borelli*), considered sensitive to the reservoir filling; group 2: species whose body condition increased in the year II (*A. osteomystax* and *P. maculatus*), indicating a more rapid adaptation to new environmental conditions. Still, all parameters investigated were somehow affected by the dam, mainly the body condition and gonadosomatic index for several species. On the other hand, the least affected factor was the feeding activity. **Conclusions**: The results did not evidence a same pattern of either increase or decrease of body condition for all species examined, since everything indicates that responses are species-specific. Even with a lack of consistency in some results, we can draw some suggestions for future investigations. Responses to these questions will certainly contribute to aggregate data to help better explain the body condition of fish species in dammed environments.

Keywords: dominant fish fauna, nutritional status, environmental impact, tropical reservoir.

Resumo: Objetivo: O objetivo deste estudo foi avaliar a condição nutricional de *Acestrorhynchus pantaneiro, Auchenipterus osteomystax, Pimelodus maculatus, Psectrogaster curviventris* e *Schizodon borellii* no reservatório de Manso, MT, Brasil, durante os primeiros anos após a sua formação (anos I, II, III e IV). Partimos da premissa que, mudanças ambientais repentinas alteram de forma diferente a condição nutricional, de acordo com o tempo e o sexo dos indivíduos. Nós predizemos também que a quantidade de alimento ingerida e o estado reprodutivo são fatores que interferem na condição. **Métodos:** A condição nutricional (*Kn*), a atividade alimentar (IR) e reprodutiva (GSI) foram calculadas somente para indivíduos adultos. As diferenças entre os anos de coleta e sexo (usado como fator) foram testadas através do teste não paramétrico de Kruskal-Wallis, enquanto que a influência temporal foi testada pela Correlação de Spearman e a interação entre ambos pela PERMANOVA. **Resultados:** Com os resultados do *Kn* observam-se dois grupos: grupo 1- espécies cuja condição decresceu no ano II, aumentando nos anos subsequentes (*A. pantaneiro*, *P. curviventris* e *S. borelli*) podendo ser consideradas mais sensíveis ao alagamento; grupo 2- espécies cuja condição aumentou no ano II (*A. osteomystax* e *P. maculatus*), mostrando uma adaptação mais rápida as novas condições ambientais. Ainda, os parâmetros avaliados foram influenciados ao longo dos anos, especialmente o fator de condição e a atividade reprodutiva. A atividade alimentar foi o fator com menor influência temporal. **Conclusões:** Os resultados não evidenciaram um mesmo padrão, seja ele de acréscimo ou decréscimo do *Kn* para todas as espécies, como era esperado, pois tudo indica que as respostas sejam de natureza espécie-específica. Entretanto, a falta de consistência de alguns resultados permitiu levantar algumas suposições para estudos futuros, cujas respostas certamente contribuirão para agregar dados que ajudem a explicar as variações no *Kn* dos peixes em ambientes represados.

Palavras-chave: ictiofauna dominante, condição nutricional, impacto ambiental, reservatório tropical.

1. Introduction

The nutritional status reflects the health or overall welfare of an animal and is usually associated with physiological parameters related to energy storage in tissues, in the form of carbohydrates, lipids and proteins (Le Cren, 1951).

The energy stored can be measured by diverse criteria that include physiological (weight of liver and gonads), biochemical (lipid or protein content) and morphometric (weight-length) measurements (Lloret et al., 2002). Among morphometric ones, stand out the body condition factors or indices.

Body condition was firstly developed for fish, in order to estimate, indirectly, the energy reserves in tissues from its weight and its length (Bolger and Connolly, 1989; Nash et al., 2006). It is assumed that individuals with greater weight in a given length are in better condition, with growth and survival rates, and reproductive potential higher than those in worst condition, under comparable environmental conditions (Pope and Kruse, 2001).

The nutritional status of the fish can be influenced by abiotic (Oliva-Paterna et al., 2003; Bojsen, 2005; Araújo et al., 2011) and biotic factors (Lima-Junior and Goitein, 2004; Felizardo et al., 2011). In this way, to survive and leave offspring in active systems such as rivers, fish populations face many challenges and respond to changes in the environment with changes in their metabolism. In other words, fish begin to allocate part of the energy to be invested in the maintenance, growth and reproduction to minimize the effects of changing environmental conditions (Wootton, 1998), thereby compromising their nutritional status.

One of the most prominent environmental changes in continental waters is impoundments of rivers. Although important for economic development, they promote irreversible changes in the natural hydrological regime, also altering habitat quality and the dynamics of the whole biota (Baxter, 1977; Agostinho et al., 2008), including fish assemblage.

The initial stages of reservoir formation are highly productive increasing the food supply (Williams et al., 1998; Mérona et al., 2003). Thus, the high food availability in this period possibly affected the nutritional status of fishes. On the other hand, this high availability does not ensure improvements in the nutritional status of fish, considering the quality of the food available (Abujanra et al., 2009) and the ability of fish in using this food. Also, the low nutritional quality of the food negatively affects the reproduction, important for successful colonization and persistence of species in reservoirs (Agostinho et al., 1999).

In this context, the present study assessed five fish species, with distinct feeding habits, based on the assumption that sudden changes in environmental conditions caused by the formation of reservoirs affect the body condition of the fish differently (increasing or decreasing), according to time (sampling years) and sexes (male and female). We also assumed that the amount of food consumed and the reproductive status interfere with the nutritional status of the fish species.

2. Material and Methods

2.1. Study area

The Manso reservoir localized close city Cuiabá, Mato Grosso, formed in November 1999 (the filling phase was short – from November to February), was built on the Manso River (14°32'-15°40'S and 54°40'-55°55'W), in the Cuiabá River basin (State of Mato Grosso, Brazil) (Figure 1). This is the most important river forming the Cuiabá River, which presents a dense drainage network and a regular rainfall regime and flows into the Pantanal of Mato Grosso, one of the largest wetlands of the world. The reservoir has an area of 427 km^2. The main purpose of this reservoir is the hydropower generation and

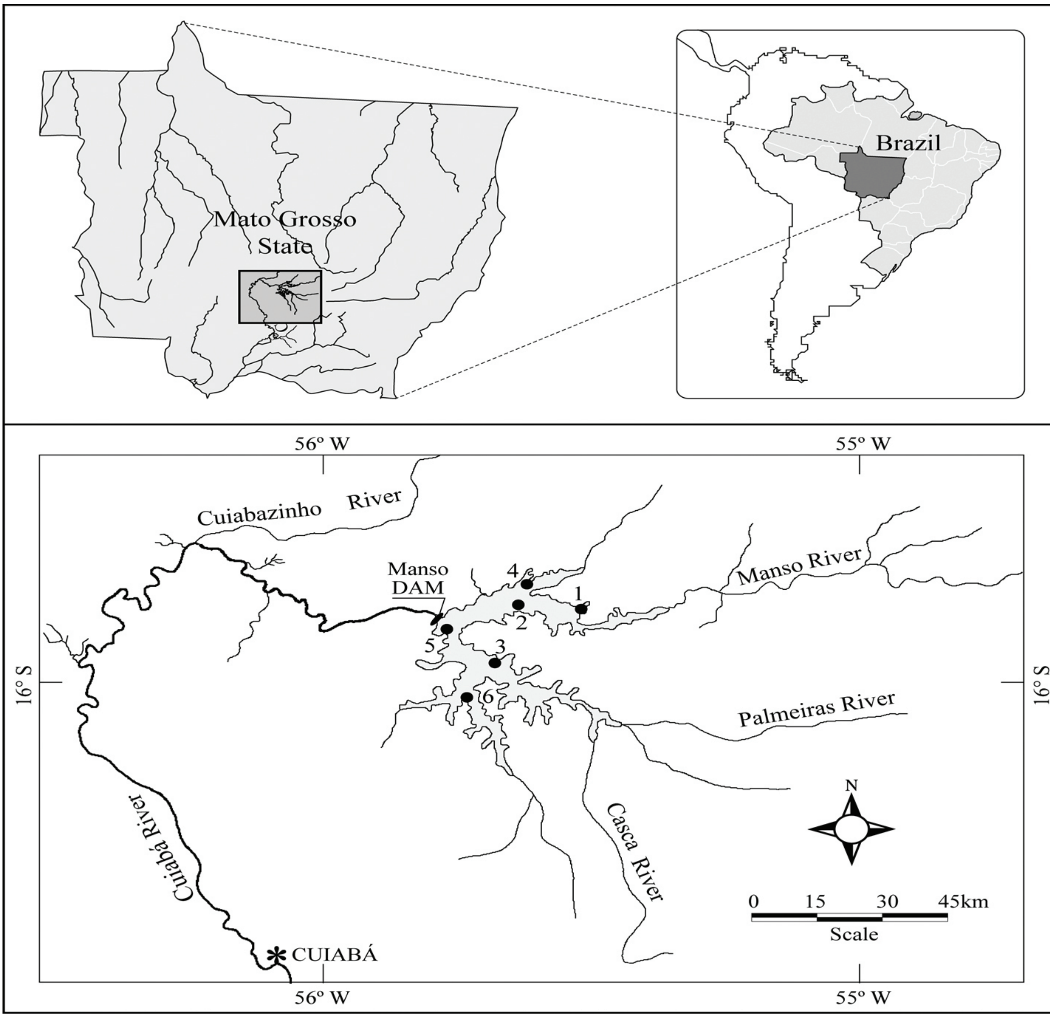

Figure 1. Study area and location of the sampling sites (1, 2, 3, 4, 5 and 6) in the reservoir of APM Manso, state of Mato Grosso, Brazil.

regulation of flood and drought cycles, in order to protect large cities downstream.

2.2. Fish sampling

Fish were sampled monthly from March 2000 to February 2001 (year I, shortly after the filling of reservoir), March 2001 to February 2002 (year II), March 2002 to February 2003 (year III) and March 2003 to February 2004 (year IV), in six fixed sampling sites, distributed across the Manso reservoir (Figure 1). Fish were collected by a set of gillnets with different mesh sizes (2.4, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18 cm, opposite knots). Nets were assembled simultaneously in open areas, littoral areas and bottom during 24h and fish were removed in the morning, evening and at night. The fishing effort was the same in all sampling sites and during all study period.

Immediately after capture, all individuals were identified, measured (standard length, cm), and weighed (total weight, and gutted weight, g). For the identification of the sexes, gonads were evaluated by visual observation. We also weighed the stomachs (g) and gonads (g).

Representative specimens of the five studied species were deposited in the Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura (Nupélia, Universidade Estadual de Maringá, State of Paraná) with the following catalog number: *Acestrorhynchus pantaneiro* Menezes, 1992 (Characiformes, Acestrorhynchidae) – NUP 874; *Auchenipterus osteomystax* (Miranda-Ribeiro, 1918) (Siluriformes, Auchenipteridae) –NUP 928; *Pimelodus maculatus* La Cepède, 1803 (Siluriformes, Pimelodidae) – NUP 880; *Psectrogaster curviventris* (Eigenmann and Kennedy, 1903) (Characiformes, Curimatidae) – NUP 896 and *Schizodon borellii*

(Boulenger, 1900) (Characiformes, Anostomidae) -NUP 873.

2.3. Data analysis

The body condition was calculated only for adult individuals, through the relative body condition factor (*Kn*), for each sampling year and sex, using the formula *Kn* = *W* / *a* * *Ls*, where *W* is the weight (gutted weight, g), *a* and *b* are parameters of length-weight relationships and *Ls* is the standard length (cm). Parameters *a* and *b* were estimated after logarithmic transformation of length and weight data. In agreement with Le Cren (1951) it is relatively easy to eliminate the effect of length on *K* and correlated factors, by calculating a "condition factor", which is not based on the "ideal" weight-length relationship (*W=aL*), but rather on an empirical weight-length relationship (*W=aL*). On the other hand, the relative body condition factor allows comparisons between different length classes within a single sample, because it represents a real population variation around the average value of the body condition (Baigún et al., 2009).

Beyond the condition factor were analyzed feeding activity and reproductive. Feeding activity was obtained through the stomach repletion index [SRI = (WE / WT) * 100, where, WE is the stomach weight (g) and WT, the total weight (g)]. Reproductive activity was calculated using the gonadosomatic index [GSI = (WG / WT) * 100, where WG is the gonadal weight and WT, total weight].

The difference between the sampling years (used as factors) by sexes was assessed using the nonparametric Kruskal-Wallis (KW) test (the assumptions of homogeneous variances and normality were tested) (Zar, 1999). If significant differences were detected, the *pos hoc* test multiple comparisons z' values were conducted to determine where the difference occurred. The relationship between body condition (*Kn*) and the feeding and reproductive activity was assessed by the Spearman rank correlation (Zar, 1999). The permutational multivariate analysis of variance (PERMANOVA, Anderson, 2005) was used to detect any differences in the condition factor, stomach repletion index and gonadosomatic index, between the sexes. In this analysis, year and sexes were treated as factors. The PERMANOVA was run using the software PAST (2.17) (Hammer et al., 2001). All the other analyses and graphs were made using the software STATISTICA 7.0.

3. Results

A total of 11,403 individuals of five species were analyzed. Numerical abundance and feeding habit of each species during all studied period is showed in the Table 1.

Acestrorhynchus pantaneiro showed significant differences in the *Kn* for both sexes. The condition decreased from the year II. However, females showed a recovery in the year III, similar to values recorded in the year IV ($H=1106.70$; $p<0.01$). The males returned to higher values only in the year IV ($H=2425.72$; $p<0.01$). For females, the multiple comparisons z' values test differentiated the years I and II from the others. For males, the post hoc test distinguished each year (Figure 2).

The feeding activity for both sexes decreased until the year III, with significant differences between the sampling years ($H=652.98$; $p<0.01$ females; $H=677.86$; $p<0.01$ males) (Figure 2). The investment in reproduction was also significantly different between the sampling years ($H=837.10$; $p<0.01$ females; $H=423.90$; $p<0.01$ males), females showed an increase and for males, the increase was small (Figure 2). SRI and GSI differed between the sampling years.

Auchenipterus osteomystax showed an increase in the *Kn*, for females, with significant variations between the years ($H=478.73$; $p<0.01$). For males, the variations were also different ($H=518.65$; $p<0.01$) with the highest value in the year III and the lowest in the next year (Figure 3). The *post hoc* test distinguished all years for both sexes.

Table 1. Number of individuals, by sampling years and sexes, of the five fish species captured in the reservoir of APM Manso, state of Mato Grosso, Brazil. F= female and M = male. In parentheses the author's name who described the feeding habits of the species.

Species and feeding habit	Year I		Year II		Year III		Year IV	
	F	M	F	M	F	M	F	M
A. pantaneiro – piscivorous (Cantanhêde et al., 2008)	1754	1581	363	402	852	667	1117	816
A. osteomystax – insectivorous (Barili et al., 2012)	121	180	85	42	78	90	285	315
P. maculatus – omnivorous (Silva et al., 2007)	21	26	21	40	33	17	71	70
P. curviventris – detritivorous (Pereira et al., 1996)	137	104	78	42	235	199	234	140
S. borellii - herbivorous (Ferretti et al., 1996)	234	266	127	186	95	93	78	108

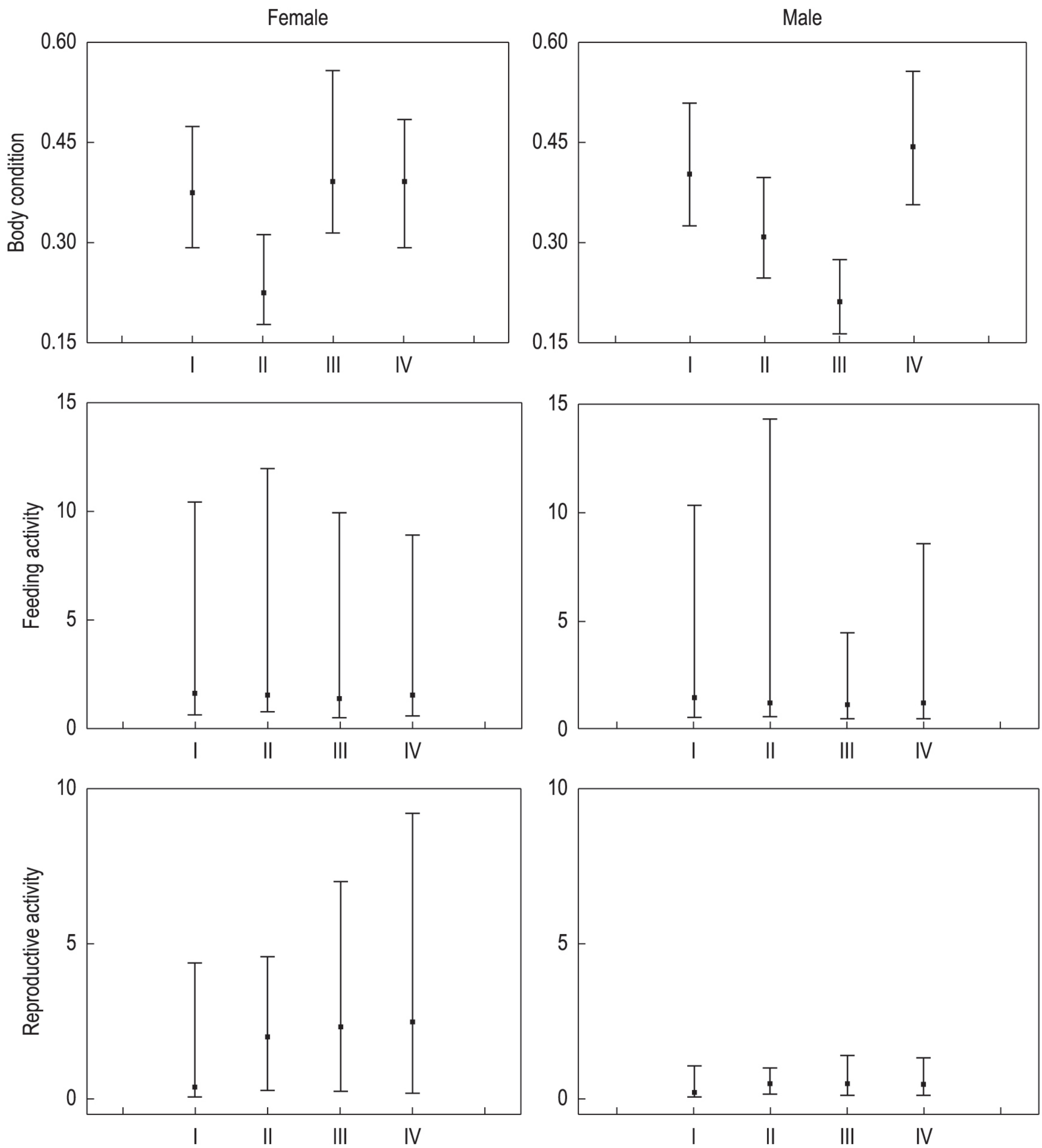

Figure 2. Body Condition (*Kn*), Feeding Activity (SRI) and Reproductive Activity (GSI) by sampling years and sexes, of *Acestrorhynchus pantaneiro* captured in the reservoir of APM Manso, state of Mato Grosso, Brazil. (▪ Median; min-max 1%-99%).

The feeding activity was higher in the year II and declined in the following years (H=41.33; p<0.01 females; H=122.61; p<0.01 males), however the values were higher than in the year I (Figure 3). For females, this activity was different in the years II and IV from the other years, and for males, the year IV was different from the others. The reproductive activity of females showed little variation from the median values over the years, yet the differences were significant (H=214.03; p<0.01). To males the differences were significant (H=76.96; p<0.01), the values declined in the year II, being more intense in the year III and IV (Figure 3). Years II and IV were different for both sexes.

Pimelodus maculatus showed variations in the *Kn.* For females the values were significant (H=109.40; p <0.01); the years II and III were distinct from the years I and IV. The values were also different for males (H=133.44; p <0.01); the year III showed a high body condition, with significant differences between all years (Figure 4).

The feeding activity of females remained relatively constant over the years, but significant differences were found (H=31.73; p<0.01), revealing that the year II was statistically distinct. The years II and III were distinguished by the *post hoc* test (H=54.86; p<0.01) for males (Figure 4). The reproductive activity was different between

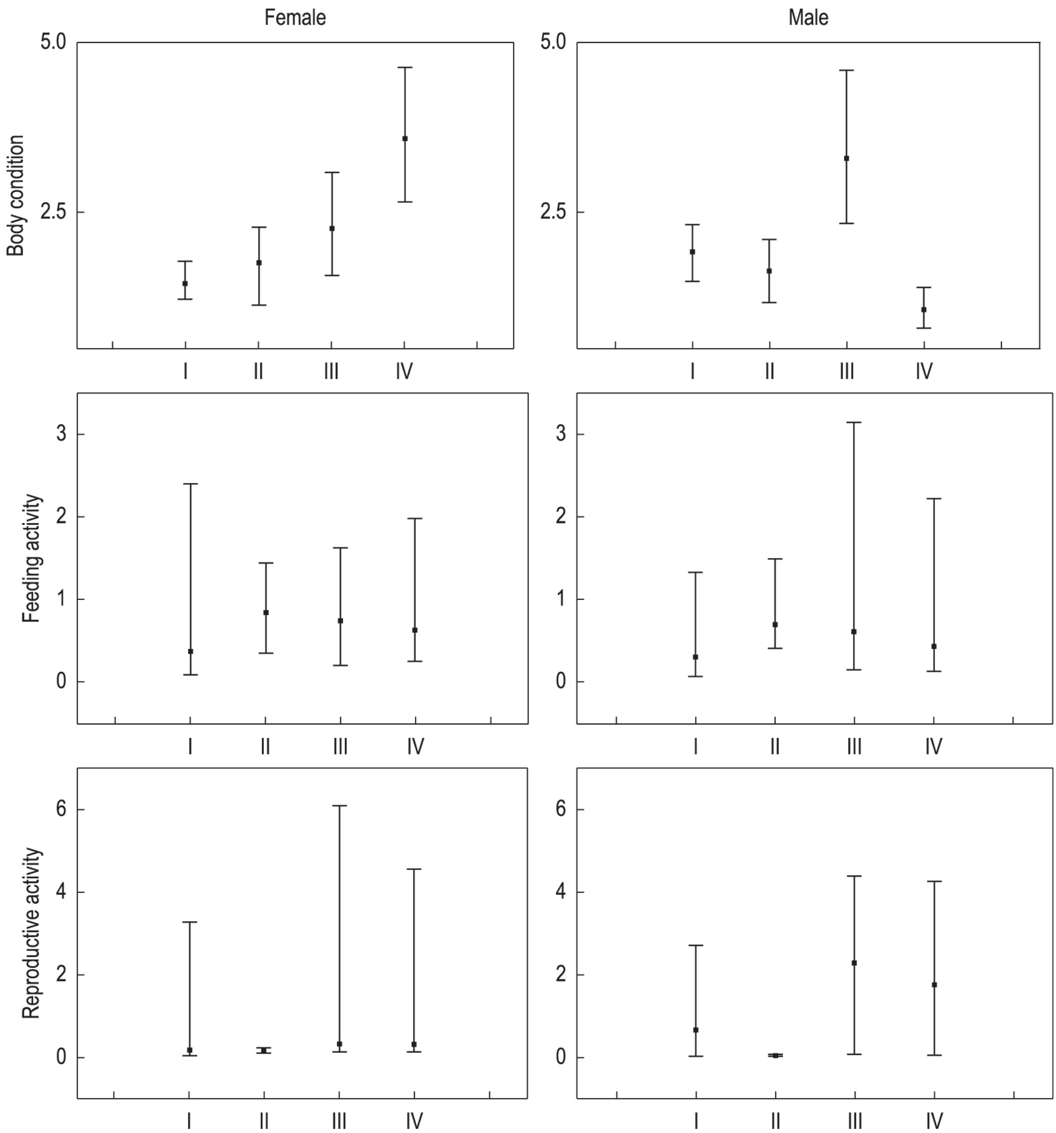

Figure 3. Body Condition (*Kn*), Feeding Activity (SRI) and Reproductive Activity (GSI) by sampling years and sexes, of *Auchenipterus osteomystax* captured in the reservoir of APM Manso, state of Mato Grosso, Brazil. (▪ Median; min-max 1%-99%).

years (H=35.81; p <0.01 females; H=40.20; p<0.01 males) since that the year II was different from the other years. For females, the highest value was registered in the year I, and for males remained relatively constant over the years (Figure 4).

Psectrogaster curviventris revealed a similar pattern between the sexes, with a drop in the *Kn* in the year III, and a increase in the year IV (H=588.98, p<0.01 females; H=362.41; p<0.01 males). For females, significant differences were detected between all the years and for males, the values were different in the year III (Figure 5).

The feeding activity for females (H=149.83; p<0.01) was differentiated and more intense (higher median) in the year I. For males (H=89.47; p<0.01), the greatest values were found in the year II (Figure 5). However, there was distinction between all years for both sexes. For reproductive activity the median values were significantly different (H=243.08; p<0.01 females; H=140.91; p<0.01 males), especially for the years I and III, for both sexes (Figure 5).

Schizodon borellii showed a similar pattern in the *Kn* for both sexes, with significant differences between sampling years (H=449.52; p<0.01 females; H=528.75; p<0.01 males). Regardless of sexes, there was a drop in the values in the year II, with a subsequent increase in the years III and IV (Figure 6). It is worth noting that the years were distinct from each other, for both sexes.

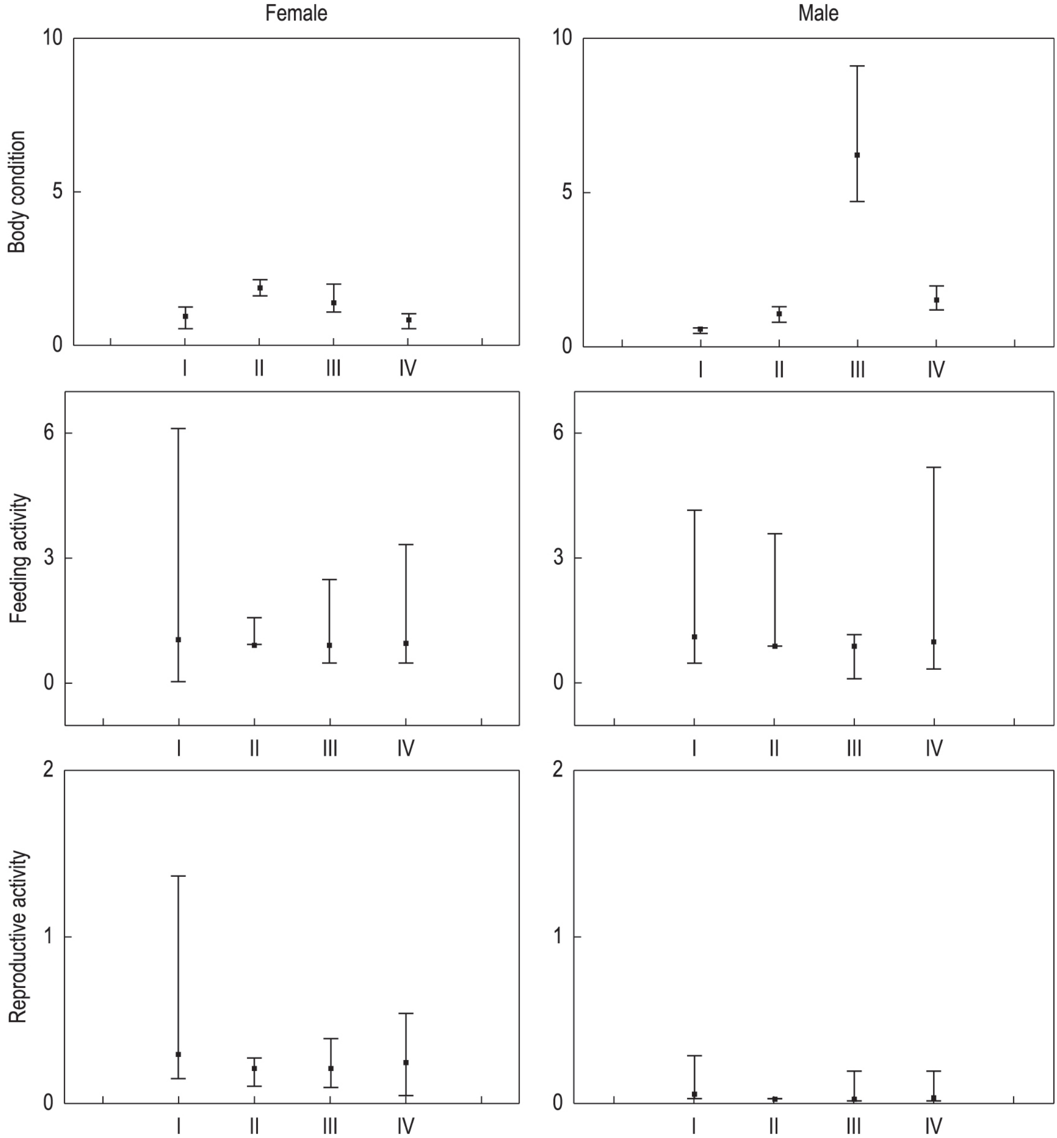

Figure 4. Body Condition (*Kn*), Feeding Activity (SRI) and Reproductive Activity (GSI) by sampling years and sexes, of *Pimelodus maculatus* captured in the reservoir of APM Manso, state of Mato Grosso, Brazil. (▪ Median; min-max 1%-99%).

The highest feeding activity was found in the year I, and significant differences were found ($H=46.69$; $p<0.01$ females; $H=39.45$; $p<0.01$ males). The years II and III were different from the others, showing lower feeding activity to both sexes (Figure 6). The reproductive activity was different for both sexes ($H=28.84$; $p<0.01$ females; $H=32.39$; $p<0.01$ males), distinguishing the year IV from the others (Figure 6).

The temporal influence on the analyzed factors (*Kn*, SRI and GSI) was more evident for *A. osteomystax* (Table 2) according to the results of the Spearman correlation (r). There was a positive trend and significant correlation for females of this species, for all analyzed factors, mainly for the *Kn*. For males of this species, the *Kn* was negatively correlated with years, while SRI and GSI were positive (Table 2).

Females and males of *P. maculatus* also showed significant correlations between *Kn* and years analyzed. However, this correlation was negative for females and positive for males (Table 2); for other components evaluated (SRI and GSI) the correlations were positive, but GSI was not significant for males. *Schizodon borellii* was the species with lower correlation values (*r*), with emphasis on *Kn* of the females.

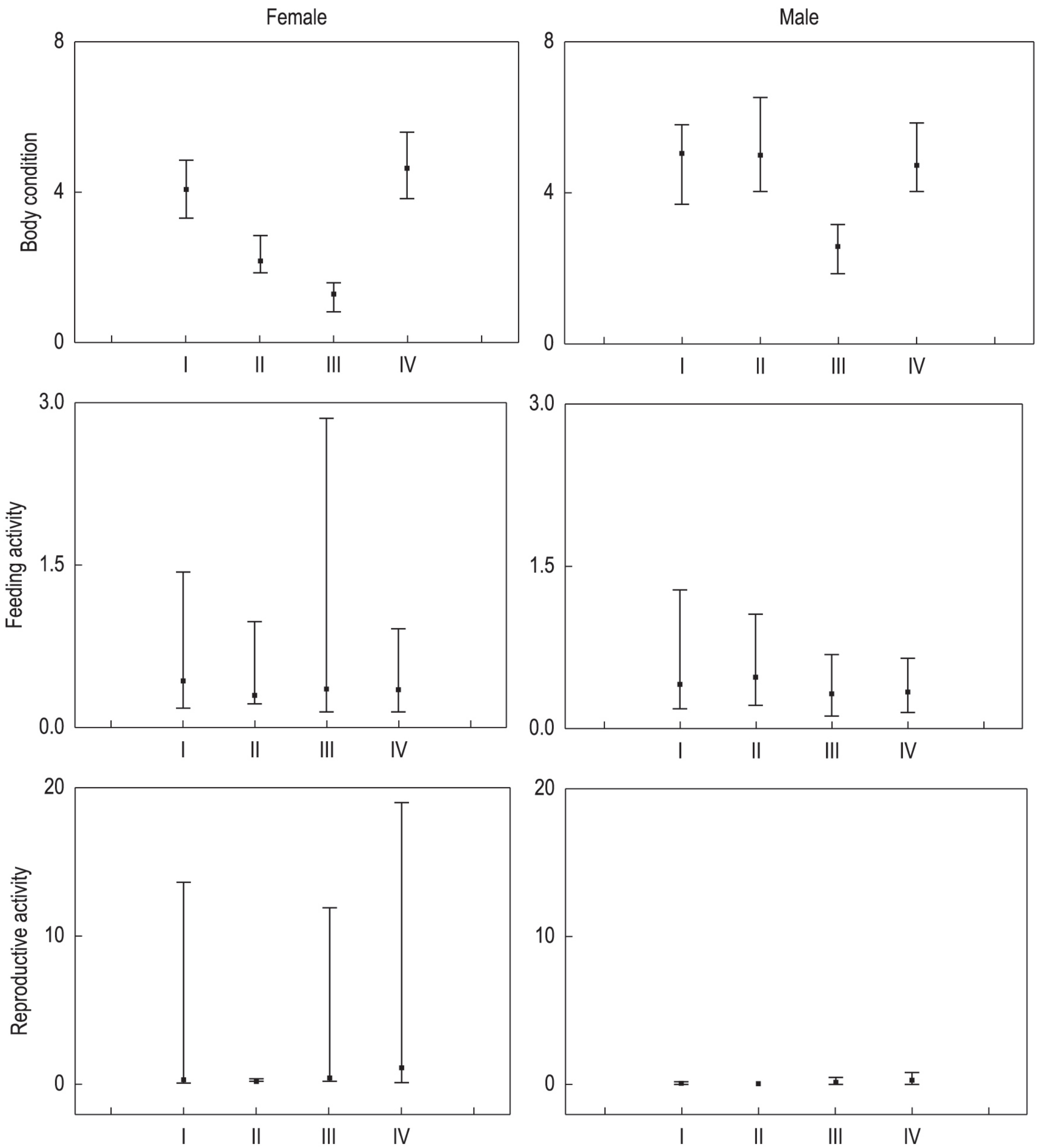

Figure 5. Body Condition (*Kn*), Feeding Activity (SRI) and Reproductive Activity (GSI) by sampling years and sexes, of *Psectrogaster curviventris* captured in the reservoir of APM Manso, state of Mato Grosso, Brazil. (▪ Median; min-max = 1%-99%).

4. Discussion

After filling a reservoir there follows a heterotrophic phase, when all populations reach maximum densities (Straskraba et al., 1993), due to the amount of nutrients released by the submerged organic matter in decomposition (Goldyn et al., 2003; Mérona et al., 2003). The changes are observed in the abundance of all aquatic communities (Agostinho et al., 1999; Hahn and Fugi, 2008) and combined with a large input of allochthonous material (mainly plant and invertebrate), become food resources available for fish (Loureiro-Crippa and Hahn, 2006). In this way, fishes are favored by the large supply of food and according to Agostinho et al. (1999), this phenomenon occurs mainly during filling of reservoirs and in the first years after. It is expected that some populations are more favored than others because they are more or less opportunistic. Thereby, depending on the feeding habit, fish may take advantage and possibly increase the nutritional condition, on the other hand, the feeding habit can be so restrictive to the point of extinguishing a local population. In accordance with Mérona et al. (2003), the trophic limitation is the main factor for the success of fish in tropical reservoirs.

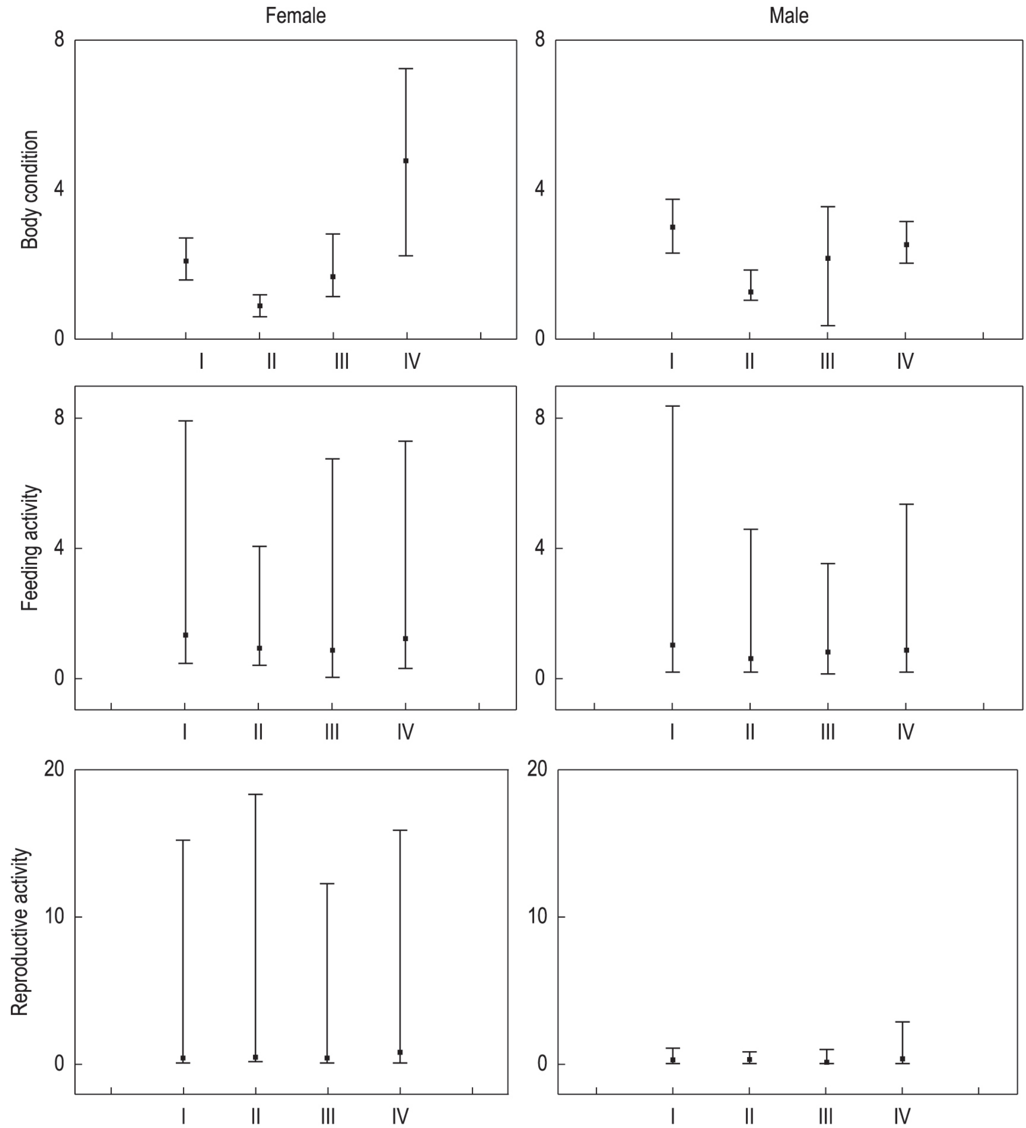

Figure 6. Body Condition (*Kn*), Feeding Activity (SRI) and Reproductive Activity (GSI) by sampling years and sexes, of *Schizodon borellii* captured in the reservoir of APM Manso, state of Mato Grosso, Brazil. (▪ Median; min-max 1%-99%).

Table 2. Spearman correlation (*r*) between the sampling years with the body condition (*Kn*), feeding activity (SRI) and reproductive activity (GSI) to five fish species captured in the reservoir of APM Manso, state of Mato Grosso, Brazil. (Bold values mean p<0.05). F= female and M = male.

	A. pantaneiro		*A. osteomystax*		*P. maculatus*		*P. curviventris*		*S. borellii*	
	F	M	F	M	F	M	F	M	F	M
	Years	Years	Years	Years	Years	Years	Years	Years	Years	Years
Kn	**0.17**	0.015	**0.91**	**–0.74**	**–0.58**	**0.75**	**0.38**	**–0.19**	0.004	**–0.47**
SRI	**–0.17**	**–0.24**	**0.38**	**0.20**	**0.22**	**0.20**	–0.02	–0.05	**–0.20**	**–0.13**
GSI	**0.40**	**0.31**	**0.51**	**0.26**	**0.25**	0.11	**0.53**	**0.52**	**0.15**	0.05

Samplings in the Manso Reservoir were conducted in the first four years after impoundment, therefore, a period when this type of environment is still new and undergoing ecological adjustments (Agostinho et al., 1999). The results of our study revealed variations in nutritional status along the study period, depending on the species and occasionally on the sex of individuals. Some of the results cannot be yet explained because no temporal or sexual pattern was found within a population, which lead us to infer that perhaps four years after filling was not enough for the adaptation of such populations.

First, the condition factor is not an instantaneous measure, and the results will only be detected over a period of time under favorable or unfavorable environmental conditions. In general, it was observed two distinct groups.

Group 1: species whose body condition decreased in the year II, with a posterior increase (*A. pantaneiro*, *P. curviventris* and *S. borelli*), species considered sensitive to the reservoir filling. Environmental conditions were considered favorable for *A. pantaneiro* from the year II, when there was a remarkable increase in the capture of *Moenkhausia dichroura* (A.A. Agostinho, unpublished), a potential prey that came to represent 95% of the diet of this fish predator (Cantanhêde et al., 2008). In this way, the increase in body condition was related to the high cost-benefit given by the availability of this prey, thus maximizing the energy gain (Milinsiki and Heller, 1978; Cantanhêde et al., 2009). In turn, for *P. curviventris*, the reduced body condition from the year II (mainly in females) is explained by its bottom feeding habit. As the reservoir fills up, depth increases, oxygen levels decreases, and the bottom become hostile for species that exploit it. Thus, it is believed that this species has had great difficulty to forage, and may have fed on a food different from usual. *Schizodon borelli*, a herbivorous species, at first, the formation of a reservoir can be favorable, due to the large amount of submerged plant material, but this is rapidly degraded, which may explain the decline in the body condition from the year II. Studies analyzing this species demonstrated that its diet was predominantly made up of terrestrial plants in the year I, and started to include filamentous algae, aquatic plants and detritus in the year IV (Gimenes, 2011), which may indicate an increase in nutritional value of food available.

Group 2: species whose body condition increased in the year II (*A. osteomystax* and *P. maculatus*), indicating a more rapid adaptation to new environmental conditions. For *A. osteomystax* (mainly females), body condition progressively increased up to the year IV, this is an insectivorous species that changed the composition of its diet over time (between years I and IV) (Barili et al., 2012); at the beginning of the period, this species mainly consumed Chaoboridade larvae, and at the end, Chironomidade pupae, Hymenoptera and Hemiptera. The broadening of the food spectrum over time possibly aggregated nutritional value to the diet of *A. osteomystax. Pimelodus maculatus* is a species easily adapted to reservoirs and according to some studies, species of this genus have great capacity to establish themselves in lentic environments (Abujanra et al., 1999; Lima-Junior and Goitein, 2004). This ability may be associated with the capacity of this species to explore diverse niches, in addition to the opportunistic feeding behaviour (Abujanra et al., 1999; Lima-Junior and Goitein, 2004). Trophic studies on this species showed that in the year I, its diet consisted mainly of aquatic and terrestrial insects, and in the year, in addition to these items, the diet included fish accounting for 50% of the diet (Gimenes, 2011). The nutritional value of fish preyed combined with insects would probably increase the body condition, however, the results varied little between the sexes with a peak in the year III, which complicates the explanation of results on the basis of its diet.

Moreover, all parameters investigated were somehow affected by the formation of the Manso Reservoir, mainly the body condition and gonadosomatic index for several species. On the other hand, the least affected factor was the feeding activity, that is, the amount of food consumed by fish. The results often very divergent between males and females of the same species are difficult to explain, because variations in population parameters, between the sexes, can be found within a single population, according to Pope and Kruse (2007).

In the present study, we sought to investigate the highest possible number of variables (sampling years, sexes, feeding habit, feeding activity and reproductive activity) to detect the effects of the formation of the Manso Reservoir on the body condition of fish. Nevertheless, the results did not evidence a same pattern of either increase or decrease of body condition for all species examined, since everything indicates that responses are species-specific. Even with a lack of consistency in some results, we can draw some suggestions for future investigations, such as: i) to analyze the degree of parasitism of fish, once parasite populations tend to increase in a confined environment and worsen body condition; ii) to study the digestibility of food, because although it is available, certain species are not adapted to digest it; iii) to examine the nutritional value of the available food, since quantity does not guarantee quality. Responses to these questions will certainly contribute to aggregate data to help better explain the body condition of fish species in dammed environments. According to Godinho (1997) the condition factor, a standard index in fish ecology (Bolger and Connolly, 1989), is used to monitor the environmental influence on populations over time.

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References

ABUJANRA, F., RUSSO, MR. and HAHN, NS. 1999. Variações espaço-temporais na alimentação de *Pimelodus ortmanni* (Siluriformes, Pimelodidae) no reservatório de Segredo e áreas adjacentes (PR). *Acta Scientiarum*, vol. 21, no. 2, p. 283-289.

ABUJANRA, F., AGOSTINHO, AA. and HAHN, NS. 2009. Effects of the flood regime on the body condition of fish of different trophic guilds in the Upper Paraná River floodplain, Brazil. *Brazilian Journal of Biology*, vol. 69, no. 2, p. 469-479. PMid:19738954. http://dx.doi.org/10.1590/S1519-69842009000300003

AGOSTINHO, AA., MIRANDA, LE., BINI, LM., GOMES, LC., THOMAZ, SM. and SUZUKI, HI. 1999. Patterns of colonization in neotropical reservoirs, and prognoses on aging. In TUNDISI, JG. and STRASKRABA, M., org. *Theoretical reservoir ecology and its applications*. São Carlos: International Institute of Ecology. p. 227-266.

AGOSTINHO, AA., PELICICE, FM. and GOMES, LC. 2008. Dams and the fish fauna of the neotropical region: impacts and management related to diversity and fisheries. *Brazilian Journal of Biology*, vol. 68, no. 4, p. 1119-1132. PMid:19197482. http://dx.doi.org/10.1590/S1519-69842008000500019

ANDERSON, MJ. 2005. *PERMANOVA*: a FORTRAN computer program for permutational multivariate analysis of variance. Auckland: Department of Statistics, University of Auckland. 24 p.

ARAÚJO, CC., FLYNN, MN. and PEREIRA, WRL. 2011. Fator de condição e relação peso-comprimento de *Mugil curema* Valenciennes, 1836 (Pisces, Mugilidae) como indicadores de estresse ambiental. *Revista Intertox de Toxicologia, Risco Ambiental e Sociedade*, vol. 4, p. 51-64.

BAIGÚN, RM., COLAUTTI, DC. and GROSMAN, F. 2009. Assessment of condition in pejerrey *Odontesthes bonariensis* (Atheriniformes: Atherinopsidae) populations: which index works best? *Neotropical Ichthyology*, vol. 7, no. 3, p. 439-446. http://dx.doi.org/10.1590/S1679-62252009000300011

BARILI, E., FUGI, R., NOVAKOWSKI, GC. and AGOSTINHO, AA. 2012. Impoundment effects in the population of *Auchenipterus osteomystax* (Siluriformes: Auchenipteridae): a Neotropical reservoir case. *Revista de Biologia Tropical*, vol. 60, no. 2, p. 699-708. PMid:23894939. http://dx.doi.org/10.15517/rbt.v60i2.3985

BAXTER, RM. 1977. Environmental effects of dams and impoundments. *Annual Review of Ecology and Systematics*, vol. 8, p. 255-283. http://dx.doi.org/10.1146/annurev.es.08.110177.001351

BOJSEN, BH. 2005. Diet and condition of three fish species (Characidae) of the Andean foothills in relation to deforestation. *Environmental Biology of Fishes*, vol. 73, no. 1, p. 61-73. http://dx.doi.org/10.1007/s10641-004-5330-y

BOLGER, T. and CONNOLLY, PL. 1989. The selection of suitable indices for the measurement and analysis of fish condition. *Journal of Fish Biology*, vol. 34, no. 2, p. 171-182. http://dx.doi.org/10.1111/j.1095-8649.1989.tb03300.x

CANTANHÊDE, G., HAHN, NS., FUGI, R. and GUBIANI, EA. 2008. Alterations on piscivorous diet following change in abundance of prey after impoundment in a Neotropical river. Neotropical Ichthyology, vol. 6, no. 4, p. 631-636.

CANTANHÊDE, G., FUGI, R. and HAHN, NS. 2009. Variation in prey selection of a piscivorous fish after the impoundment of a neotropical reservoir: prey size and type. Journal of Fish Biology, vol. 75, no. 1, p. 75-86. PMid:20738483. http://dx.doi.org/10.1111/j.1095-8649.2009.02264.x

FELIZARDO, VO., MURGAS, LDS., WINKALER, EU., PEREIRA, GJM., DRUMOND, MM. and ANDRADE, ES. 2011. Fator de condição relacionado a aspectos reprodutivos da piapara (*Leporinus obtusidens*) (Characiformes: Anostomidae) coletadas a jusante da usina hidrelétrica do Funil, Minas Gerais, Brasil. *Ciência Animal Brasileira*, vol. 12, no. 3, p. 471-477.

FERRETTI, CML., ANDRIAN, IF. and TORRENTE, G. 1996. Dieta de duas espécies de *Schizodon* (Characiformes, Anostomidae) na planície de inundação do alto rio Paraná e sua relação com aspectos morfológicos. *Boletim do Instituto de Pesca*, vol. 23, p. 171-186.

GIMENES, MF. 2011. *Uso dos recursos alimentares e estrutura trófica da ictiofauna do reservatório de Manso* (*Bacia do Rio Cuiabá, MT, Brasil*) *em diferentes períodos da fase de colonização*. Maringá: Programa de Pós-graduação em Ecologia de Ambientes Aquaicos Continentais; Universidade Estadual de Maringá. 70 p. [Tese de Doutorado].

GODINHO, AL. 1997. Weight-length relationship and condition of the characiform *Triportheus guentheri*. *Environmental Biology of Fishes*, vol. 50, no. 3, p. 319-330. http://dx.doi.org/10.1023/A:1007316028288

GOLDYN, R., JONIAK, T., KOWALCZEWSKA-MADURA, K. and KOZAK, A. 2003 Trophic state of a lowland reservoir during 10 years after restoration. *Hydrobiologia*, vol. 506-509, no. 1-3, p. 759-765. http://dx.doi.org/10.1023/B:HYDR.0000008585.37813.fa

HAHN, NS. and FUGI, R. 2008. Environmental changes, habitat modifications and feeding ecology of freshwater fish. In CYRINO, JEP., BUREAU, DP. and KAPOOR, BG., org. *Feeding and digestive functions of fishes*. New Hampshire: Science. p. 36-65.

HAMMER, O., HARPER, DAT. and RYAN, PD. 2001. *Past*: Palaeonthological statistics software package for education and data analysis. Version. 2.17. Available from: <http://palaeoelectronica.org/2001_1/past/issue1_01.htm>. Access in: 12 june 2014.

LE CREN, ED. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *The Journal of Animal Ecology*, vol. 20, no. 2, p. 201-219. http://dx.doi.org/10.2307/1540

LIMA-JUNIOR, SE. and GOITEIN, R. 2004. Diet and feeding activity of *Pimelodus maculatus* (Osteichthyes, Pimelodidae) in Piracicaba River (State of São Paulo, Brazil): the effect of seasonality. *Boletim do Instituto de Pesca*, vol. 30, no. 2, p. 135-140.

LLORET, J., SOLA, LG., SOUPLET, A. and GAZIN, R. 2002. Effects of large-scale habitat variability on condition of demersal exploited fish in the north-western Mediterranean. *ICES Journal of Marine Science*, vol. 59, no. 6, p. 1215-1227. http://dx.doi.org/10.1006/jmsc.2002.1294

LOUREIRO-CRIPPA, VE. and HAHN, NS. 2006. Use of resources by the fish fauna of a small reservoir (Rio Jordão, Brazil) before and shortly after its filling. *Neotropical Ichthyology*, vol. 4, no. 3, p. 357-362. http://dx.doi.org/10.1590/S1679-62252006000300007

MÉRONA, B., VIGOUROUX, R. and HOREAU, V. 2003. Changes in food resources and their utilization by fish assemblages in a large tropical reservoir in South America Petit-Saut Dam, French Guiana. *Acta Oecologica*, vol. 24, no. 3, p. 147-156. http://dx.doi.org/10.1016/S1146-609X(03)00065-1

MILINSIKI, M. and HELLER, R. 1978. Influence of a predator on the optimal foraging behaviour of sticklebacks (*Gasterosteus aculeatus*). *Nature*, vol. 275, p. 643-644.

NASH, RDM., VALENCIA, AH. and GEFFEN, AH. 2006. The origin of fulton's condition factor: setting the record straight. *Fisheries*, vol. 31, no. 5, p. 236-238.

OLIVA-PATERNA, FJ., VILLA-GISPERT, A. and TORRALVA, M. 2003. Condition on *Barbus sclateri* from semi-arid aquatic systems: effects of habitat quality disturbances. *Journal of Fish Biology*, vol. 63, no. 3, p. 699-709. http://dx.doi.org/10.1046/j.1095-8649.2003.00183.x

PEREIRA, RAC., RESENDE, EK. and MORAES, AS. 1996. *Alimentação de peixes detritívoros em meandros abandonados da planície de inundação do Rio Miranda, Pantanal, Mato Grosso do Sul, Brasil*. Brasilia: Embrapa-SPI. p. 68-69.

POPE, KL. and KRUSE, CG. 2007. Condition. In GUY, CS. and BROWN, ML., ed. *Analysis and interpretation of freshwater fisheries data*. Mariland: Bethesda. p. 996.

SANTOS, GM., JEGU, M. and MÉRONA, B. 1984. *Catálogo de peixes comerciais do baixo rio Tocantins*. Manaus: Eletronorte/CNPq/INPA. 83 p.

SILVA, EL., FUGI, R. and HAHN, NS. 2007. Variações temporais e ontogenéticas na dieta de um peixe onívoro em ambiente impactado (reservatório) e em ambiente natural (baía) da bacia do rio Cuiabá. *Acta Scientiarum: Biological Sciences*, vol. 29, no. 4, p. 387-394.

STRASKRABA, M., TUNDISI, JG and DUNCAN, A. 1993. *Comparative reservoir limnology and water quality management*. Dordrecht: Kluwer Academic Publishers. 293 p.

WILLIAMS, JD., WINEMILLER, KO., TAPHORN, DC. and BALBAS, L. 1998. Ecology and status of piscivores in Guri, an oligotrophic tropical reservoir. *North American Journal of Fisheries Management*, vol. 18, no. 2, p. 274-285. http://dx.doi.org/10.1577/1548-8675(1998)018<0274:EASOPI>2.0.CO;2

WOOTTON, RJ. 1998. *Ecology of teleost fishes*. London: Chapman and Hall. 386 p.

ZAR, JH. 1999. *Biostatistical analysis*. New Jersey: Prentice-Hall. 663 p.

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