

Population structure, condition and diet of *Oligosarcus paranensis* (Menezes & Gery, 1983) (Osteichthyes: Characidae) at two reservoirs in South Brazil

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Abstract: This study investigated the population parameters, condition and diet of *Oligosarcus paranensis* at Fiú and Mourão Reservoirs, located in Paraná State, Brazil. The fishes were collected quarterly between 1996/1997 and 1998/1999 using gillnets. Food items were quantified by volumetric method. The specimens at Fiú showed comparatively smaller length and worse condition. Sex ratio was statistically equal to 1:1 at Mourão, whereas there was a significant predominance of males at Fiú. Sex ratio also varied among size classes. Allometric growth prevailed among the studied groups. The diet consisted mainly of fishes and was complemented with invertebrates and plant matter in both reservoirs. There was a change in the feeding pattern as the standard length increased. Fishes changed from invertivores to piscivores, except for males in Mourão, for which a reverse trend occurred.
Keywords: fish, sex ratio, feeding, dog-tooth characid, impoundments.

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Resumo: Este estudo investigou parâmetros populacionais, a condição e a dieta de *Oligosarcus paranensis* nos reservatórios de Fiú e Mourão, localizados no Estado do Paraná, Brasil. As coletas foram trimestrais, entre 1996/1997 e 1998/1999 utilizando-se redes de espera. Os itens alimentares foram quantificados pelo método volumétrico. Os espécimes de Fiú apresentaram, comparativamente, menor comprimento e pior condição. A proporção sexual foi estatisticamente igual a 1:1 em Mourão, enquanto que os machos prevaleceram de forma significativa em Fiú. A proporção sexual variou ainda entre as classes de comprimento, com os machos predominando nas classes inferiores e as fêmeas nas superiores em ambos os reservatórios. O crescimento alométrico prevaleceu entre os grupos estudados, com exceção dos machos em Fiú, os quais apresentaram crescimento isométrico. A dieta foi composta principalmente por peixes e complementada com invertebrados e vegetais em ambos os reservatórios. Houve mudança no padrão alimentar com o aumento do comprimento padrão. Os peixes passaram de invertívoros para piscívoros, excetuando-se os machos em Mourão, com os quais ocorreu tendência contrária.

Palavras-chave: peixe, razão sexual, alimentação, peixe-cachorro, barramentos.

Introduction

The geographic distribution of the characid *Oligosarcus* is restricted to South America, with seventeen recognized species (Menezes & Ribeiro 2010). They inhabit the headwaters of Andean rivers in Bolivia and Argentina, north of Uruguay and Brazilian territory, where *Oligosarcus paranensis* is popularly known as 'peixe-cachorro' and is widely distributed in the Upper Paraná River floodplain (Menezes 1988).

Natural habitats with recorded *Oligosarcus* species include low order streams (Teixeira 1989, Castro & Casatti 1997, Vono et al. 1997, Deus & Petre Junior 2003) and lagoons, including coastal lagoons (Hartz et al. 1996, Nunes & Hartz 2006, Garcia et al. 2007) and floodplain lagoons (Meschiatti 1995, Sosnovsky & Quirós 2009).

Oligosarcus has also been recorded in reservoirs (Castro 1996, Gealh & Hahn 1998, Araújo et al. 2005, Luz-Agostinho et al. 2006, Terra & Araújo 2011), and, in the specific case of *O. paranensis*, ichthyofaunal surveys have reported its occurrence in the Atibainha, Cachoeira, Taiaçupeba and Itupararanga Reservoirs in the State of São Paulo (Castro & Arcifa 1987, Smith & Petre Junior 2008) and at Fiú, Mourão, Capivari and Rio dos Patos Reservoirs in the State of Paraná (Luiz et al. 2003). The abundance of this species varied among those ecosystems; however, at Fiú and Mourão, *O. paranensis* stood out during captures (the most and the second most abundant species, respectively). High population abundance is one of the indicators of fish species adaptability to damming, which promotes impacts, such as replacement of the lotic environment by a lentic one, obstruction of migratory activities, progressive loss of environmental heterogeneity and instability of the shoreline as a result of sudden oscillations in water level (Agostinho et al. 1999). Particularly in Brazil, hydroelectric reservoirs are frequent components of the landscape. Even though *O. paranensis* figures among the most successful species to colonize this type of environment (Smith & Petre Junior 2008), its population attributes and trophic ecology are still scarcely known.

The quantification of population parameters such as sex ratio, length distribution, growth type and condition, as well as diet and feeding behavior evaluation, provide valuable information for the understanding of species ecology, as they reflect the prevailing environmental conditions. However, females and males can respond differently to environmental conditions, and variations in population parameters can also be found between the sexes within a single population (Vazzoler 1996, Pope & Kruse 2007). Wootton (1999) emphasized the variability of these parameters for the same species in different environments, and attributed this fact to the flexible nature of growth (length and weight) in fish and its correlation with the energy and nutrients provided by feeding activity. In the reservoirs here studied, significant differences were detected in abiotic parameters and between fish fauna structure (Luiz et al. 2003) indicating that distinct selective forces might be guiding fish species abundance. In spite of that, the reservoirs are similar in the fact of having *O. paranensis* among the dominant species. Such considerations gave rise to the following question: does *O. paranensis* show similar populations parameters, condition and diet in Fiú and Mourão Reservoirs?

Therefore, in order to contribute to the knowledge on the ecology of *O. paranensis* present in hydroelectric reservoirs, the objective of this study was to describe and compare its population parameters, condition and diet composition between the populations and among different length classes of both sexes at the Fiú and Mourão Reservoirs, Paraná State, Brazil.

Material and Methods

1. Study area

The present study involved the Fiú (23° 44' 56,2" S and 50° 56' 27,1" W) and Mourão (24° 06' 25,2" S and 52° 19' 45,9" W) hydroelectric reservoirs, located in Paraná State, Brazil (Figure 1; Table 1), in areas where the economy is based on farming and cattle raising. This anthropogenic use of the environment has resulted, for both reservoirs, in a surrounding area consisting predominantly of pastures and banks occupied by structurally simplified riparian vegetation, dominated by grasses. The reservoirs also have in common the fact that they are old, small, resulting from the damming of low order streams (Júlio Junior et al. 2005; Table 1), oligotrophic, without oxygenation restrictions along the water column (Pagioro et al. 2005), and practically devoid of environmental structure given by aquatic macrophytes, which were seldom observed in both ecosystems.

2. Sampling

The collections were made at quarterly intervals in the period from May/1996 to February/1997 and May/1998 to August/1999 at Fiú; from May/1996 to February/1997 and May/1998 to February/1998 at Mourão. Specimens were collected using 14 gillnets: 11 of them simple nets (mesh sizes 2.4; 3.0; 4.0; 5.0; 6.0; 7.0; 8.0; 10.0; 12.0; 14.0 and 16.0 cm, measured between opposite nodes) and three trammel nets (internal mesh sizes 6.0; 7.0 and 8.0 cm between opposite nodes). Fishing gears were set for 24 hours in the main body of the reservoirs, with harvests in the morning (8 hours), afternoon (16 hours) and evening (22 hours). Specimens were fixed in 10% formaldehyde and taken to the laboratories of the Núcleo de Pesquisa em Limnologia, Ictiologia e Aquicultura (Nupélia) at the Universidade Estadual de Maringá, Brazil, where they were identified and eviscerated. Each exemplar was measured for length (total and standard; cm), total weight (g), gonad weight (g), and stages of gonadal development. Voucher specimens were deposited in the Ichthyological Collection of Nupélia, Universidade Estadual de Maringá, found in: <http://peixe.nupelia.uem.br/>.

3. Data analysis

In the analysis of population structure, the female and male ratios were established by standard length class (1.0 cm intervals) and for total sampled specimens. Differences in the sex ratio were evaluated using the chi-square (χ^2) test. In tables and figures considering the standard length classes, the notation “(-]” indicates an interval closed to the left (parentheses) and open to the right (bracket).

The analysis of covariance (ANCOVA) (García-Berthou 2001, Pope & Kruse 2007) and the Separate Slope Model (SSM) were applied to test for possible differences (including the *pos hoc* Modified Tukey test for Unequal NHSD) in the condition between *O. paranensis* populations as well as among the standard length classes of females and males with numerical representation (20 or more specimens) in both reservoirs. The assumptions of the ANCOVA were tested and the Separate Slope Model was used in the cases in which the data did not meet the assumption of homogeneity of slopes (a test to assess differences in slopes of two or more lines, with the null hypothesis that the regression coefficients are equal; Pope & Kruse 2007). In ANCOVA the length was considered as covariate.

These statistical procedures were applied to the values resulting from the linearization of the weight-length relationship expression $TW = aSL^b$, through its natural logarithm: $\ln TW = \ln a + b \ln SL$, in which TW is the total weight in grams, SL is the standard length in

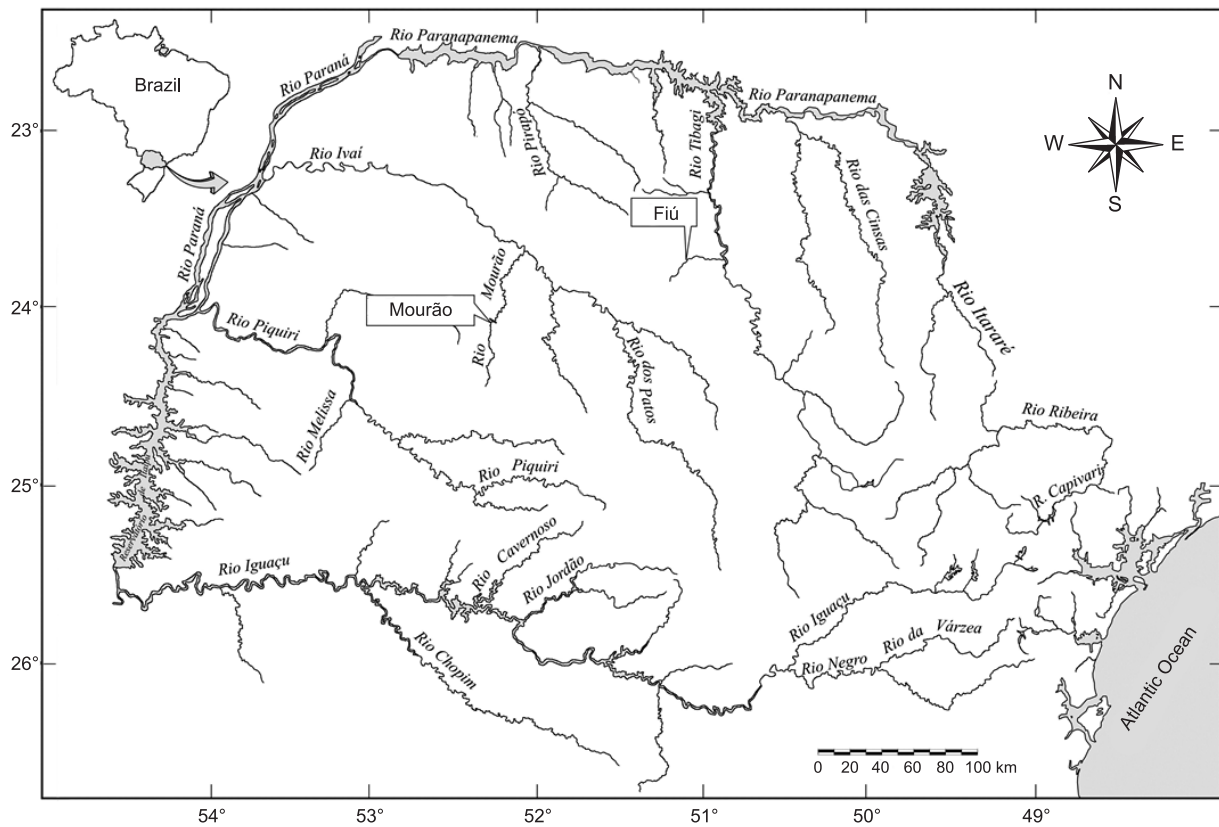


Figure 1. Location of Fiú and Mourão Reservoirs at Paraná State, Brazil.

Figura 1. Localização dos reservatórios Fiú e Mourão no estado do Paraná, Brasil.

Table 1. General characteristics of Fiú and Mourão Reservoirs, Parana State, Brazil (Abelha, 2001).

Tabela 1. Características gerais dos reservatórios Fiú e Mourão, estado do Paraná, Brasil (Abelha, 2001).

Reservoir	Fiú	Mourão
River	Apucarantina	Mourão
Basin	Tibagi	Ivaí
City	Tamarana	Campo Mourão
Dam's closure year	1958	1964
Area (km ²)	1.7	10.5
Mean transparency in the sampling period (m)	0.57	1.07

centimeters, *a* is the intercept, and *b* is the regression coefficient (Pope & Kruse 2007). The latter also provides information on the type of growth of the specimens. The growing is considered isometric if the fish retain the same shape as it grows and, in this case, *b* takes de value 3.0; on the other hand, a *b* value significantly different from 3.0 indicates allometric growth (Wootton 1999, Pope & Kruse 2007). The *t* test was applied on the *b* values obtained for both sexes in the studied populations, in order to evaluate the null hypothesis that *b* = 3.0. The linear regressions and statistical analyses were computed by the program Statistica™ (StatSoft 2005). The significance level used in all statistical tests was $\alpha = 0.05$.

Stomachs contents were analyzed in accordance with the volumetric method (volume percentage of each item in relation to the total volume of stomach contents; Hyslop 1980) and the contribution of food items in the diet was expressed in percentage of volume (%V). The volume of each food item was determined using graduated test tubes and a counting chamber for small items (<1.0 mL) (Hellawell & Abel 1971) with the result converted into milliliters. Food items were identified down to the lowest possible taxonomic level. However, for comparative analyses between the reservoirs, the items were grouped into four broad food resources, named plant matter, invertebrates, fish, and others. The description of items belonging to each resource is shown on Table 5.

Results

In the study, 1,639 specimens (642 females; 997 males) of *O. paranensis* were captured at Fiú, and 5,034 (2,452 females; 2,582 males) at Mourão. A total of 122 stomachs contents were analyzed for Fiú and 200 for Mourão. From all the captured specimens in each reservoir, less than 4% (Fiú = 3.0% and Mourão = 3.9%) showed immature gonads. Therefore, the described results comprise mainly the adult stratum of the studied populations.

The minimum and maximum standard length values for males and females were, respectively, 6.20-13.50 cm and 6.50-16.90 cm at Fiú and 6.40-15.30 cm and 6.70-19.70 cm at Mourão. The relative frequency distribution of specimens by standard length class (Figure 2) indicated that, for total population, fishes measuring

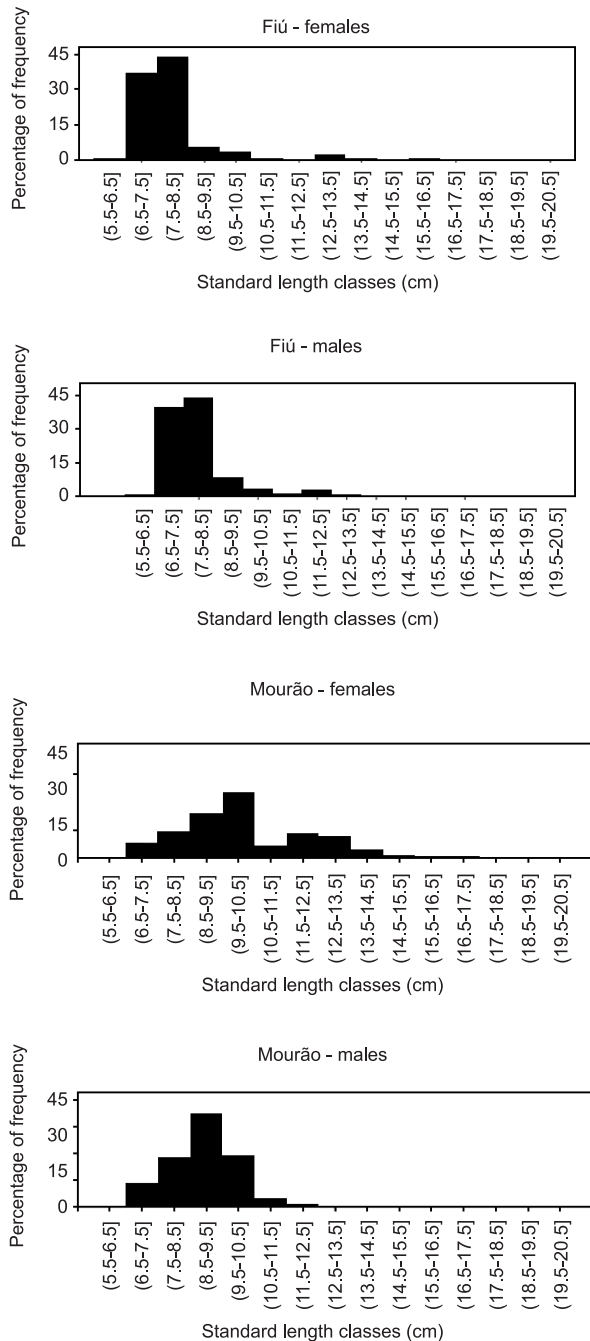


Figure 2. Numeric relative frequency of *Oligosarcus paranensis* females and males per 1.0 cm standard length size classes at Fiú and Mourão Reservoirs, Paraná State, Brazil.

Figura 2. Frequência numérica relativa de fêmeas e machos de *Oligosarcus paranensis* em classes de tamanho padrão de 1.0 cm nos reservatórios de Fiú e Mourão, estado do Paraná, Brasil.

between 6.50-8.50 cm and 8.50-10.50 cm were, respectively, caught more frequently at Fiú and Mourão. Males and females were greater in Mourão.

The results of the chi-square (χ^2) test applied on the differences in sex ratios are presented on Table 2. Considering the total specimens

captured at each reservoir, it was verified that in Mourão, the population was distributed equitably between the sexes, whereas in Fiú, males were significantly predominant (1.6:1.0). However, the analysis of sex ratio by standard length class showed the significant predominance of males in the shorter length classes and of females in the higher classes was common to both reservoirs. Statistically similar sex ratios occurred in only one length class in Fiú (12.50-13.50] and other in Mourão (9.50-10.50].

The results of the ln-transformed weight-length relationship of females and males are shown on Table 3. Figure 3 shows the adjusted lines to the empirical points of that relationship.

The values of b were significantly different than 3.0 for both sexes at Mourão (females: $t_{(df = 2453)} = 2.85$, $p < 0.05$; males: $t_{(df = 2581)} = 3.11$, $p < 0.05$) and for females at Fiú ($t_{(df = 641)} = 5.72$, $p < 0.05$), which characterizes allometric growth. On the other hand, b was statistically equal to 3.0 ($t_{(df = 996)} = 0.03$, $p > 0.05$) for males at Fiú, indicating isometric growth.

For the condition evaluation, the ANCOVA assumptions were met, except for the one regarding the slopes homogeneity, which was valid for part of the evaluated factors (Table 4). The ANCOVA and SSM showed significant differences in condition between the populations of two reservoirs and among the standard length classes for both sexes, with the single exception of the statistically similar condition for males with standard length between 9.50 and 10.50 cm (Table 4). In all cases with detected differences, the results of the *post hoc* test (Modified Tukey test for Unequal NHSD) showed a significantly better condition ($p < 0.01$) of the specimens at Mourão. It is worth mentioning that the standard length classes evaluated in this analysis included those that were most abundant in both reservoirs.

In spite of the taxa diversity of the invertebrates consumed, fishes were the most representative food resource ($\%V > 60$) in the diet of *O. paranensis* at both sexes and reservoirs (Table 5). Small characids (part of them were *Astyanax* spp. and *Bryconamericus iheringi*) prevailed as prey for both sexes at Fiú, while at Mourão, cichlids were consumed predominantly by females and characids by males. There was also evidence of cannibalism at Fiú. Furthermore, it was detected predation on exotic species such as *Tilapia rendalli* and *Micropterus salmoides* at Mourão. Piscivory intensity varied between the sexes, being more expressive among the females at Fiú ($\%V$ fishes = 96.91) and less evident for the same sex at Mourão, where fruits/seeds and invertebrates (aquatic and terrestrial) reached 36.68% of total diet volume. Invertebrates were also representative in feeding supplementation for Mourão males ($\%V$ invertebrates = 18.42) and those at Fiú ($\%V$ invertebrates = 17.66). These results characterized the predominantly piscivorous feeding habit of the species for both reservoirs.

The diet analysis performed in the standard length classes (Figures 4-5) revealed that for Fiú there was a modification of the feeding habit from invertivorous to piscivorous with the increase in standard length for both sexes (for females, there were no stomachs for the 10.5-11.5 cm class and no captured specimens for the 11.5-12.5 cm). This trend was also observed among the females at Mourão. Conversely, among the males at the latter reservoir, invertebrates' intake intensified with the increase in specimen length. The smallest (5.5-6.5 cm) and the largest captured fishes (19.5-20.5 cm) showed empty stomachs, therefore, they were not included in the diet analysis.

Discussion

In fish, a complex set of selective forces (from abiotic environment and biotic interactions) determines the amount of

Table 2. Distribution of females and males per standard length class and results of the chi-square (χ^2) test applied to the sex ratio of *Oligosarcus paranensis* at Fiú and Mourão Reservoirs, Paraná State, Brazil. n = number of specimens; % = frequency; * = 5% level of significance.

Tabela 2. Distribuição de fêmeas e machos por classe de comprimento padrão e resultado do teste de chi-quadrado (χ^2) aplicado sobre a razão sexual de *Oligosarcus paranensis* nos reservatórios de Fiú e Mourão, estado do Paraná, Brasil. n = número de indivíduos; % = frequência; * = nível de significância de 5%.

Length class(cm)	Reservoirs									
	Fiú					Mourão				
	F		M		χ^2	F		M		χ^2
	n	%	n	%		n	%	n	%	
(5.50 - 6.50]	-	0.00	2	100.00	100.00*	-	0.00	1	100.00	100.00*
(6.50 - 7.50]	172	38.31	277	61.69	5.47*	111	35.81	199	64.19	8.06*
(7.50 - 8.50]	364	39.91	548	60.09	4.07*	304	35.39	555	64.61	8.54*
(8.50 - 9.50]	39	32.23	82	67.77	12.63*	382	29.12	930	70.88	17.45*
(9.50 - 10.50]	28	38.89	44	61.11	4.94*	767	50.96	738	49.04	0.04
(10.50 - 11.50]	7	50.00	7	50.00	0.00*	195	63.31	113	36.69	7.09*
(11.50 - 12.50]	-	0	27	100	100.00*	224	87.16	33	12.84	55.23*
(12.50 - 13.50]	13	59.09	9	40.91	3.31	258	97.36	7	2.64	89.71*
(13.50 - 14.50]	8	88.89	1	11.11	60.49*	111	97.37	3	2.63	89.76*
(14.50 - 15.50]	2	100.00	-	0.00	100.00*	36	92.31	3	7.69	71.60*
(15.50 - 16.50]	7	100.00	-	0.00	100.00*	23	100.00	-	0.00	100.00*
(16.50 - 17.50]	2	100.00	-	0.00	100.00*	25	100.00	-	0.00	100.00*
(17.50 - 18.50]	-	-	-	-	-	9	100.00	-	0.00	100.00*
(18.50 - 19.50]	-	-	-	-	-	6	100.00	-	0.00	100.00*
(19.50 - 20.50]	-	-	-	-	-	1	100.00	-	0.00	100.00*
Total	642	39.17	997	60.83	4.69*	2,452	48.73	2,582	51.27	0.07

Table 3. Parameters of the linear regressions resulting from the logarithmic transformation of the weight-length relationship of females and males of *Oligosarcus paranensis* at Fiú and Mourão Reservoirs, Paraná State, Brazil. n = number of specimens, a = intercept, b = regression coefficient, R² = coefficient of determination, SE = standard error of b, F = F statistic.

Tabela 3. Parâmetros da regressão linear resultante da transformação logarítmica da relação peso-comprimento de fêmeas e machos de *Oligosarcus paranensis* nos reservatórios de Fiú e Mourão, estado do Paraná, Brasil. n = número de indivíduos, a = intercepto, b = coeficiente de regressão, R² = coeficiente de determinação, SE = erro padrão de b, F = estatística F.

Parameter	Fiú		Mourão	
	Females	Males	Females	Males
n	642	997	2452	2582
a	-4.22	-3.91	-3.86	-3.99
b	3.13	3.00	2.97	3.05
R ²	0.97	0.95	0.97	0.93
SE	0.02	0.03	0.01	0.02
F	17.71	17,31	84,12	33,36

energy to be directed towards growth (in weight and length) as opposed to important requirements such as maintenance and reproduction (King 1995). Among these forces, the increase in population density is a factor that reduces food availability and frequently leads to premature gonad maturation, resulting in a progressive reduction of specimen's growth which can reach the

extreme condition of stunting (Wootton 1999). The cannibalism observed at Fiú may also indicate increased population density of *O. paranensis*, since this behavior commonly acts as an abundance regulator (Nikolsky 1978, Folkvord 1997). Thus, the shorter length of *O. paranensis* at Fiú could be related to a comparatively higher density in that reservoir.

The classic sex ratio in fish is 1:1 (Wootton 1999), however, it can vary considerably among species and populations of the same species in different environments (Nikolsky 1978), as it was observed in the population of Fiú (prevalence of males; 1.6:1.0) and Mourão (1:1). These results also differed from those found by Nunes & Hartz (2006), who reported the predominance of females in the populations of the congeners *O. jenynsii* and *O. robustus* at Fortaleza lagoon, State of Rio Grande do Sul, Brazil. Vazzoler (1996) commented that distinct environmental conditions (particularly food supply) would be reflected in distinct rates of mortality and/or growth for females and males, resulting in variations, both in the sex ratio among the different length classes and for the population as a whole. On the other hand, the greater length achieved by females, as well as the prevalence of that sex in the classes with greater length for both reservoirs, suggested that this could be a conservative trait of the species. This attribute has an adaptive character in fish, as greater body length can allow a larger number of eggs to be carried, or even to produce larger eggs, which would stand a better chance of larval survival (King 1995).

The different values for regression coefficient (b) for females and males of the same population was consistent with reports on the variation of this parameter for the same species as a function of age, sex, seasonality and/or environmental conditions (Bagenal &

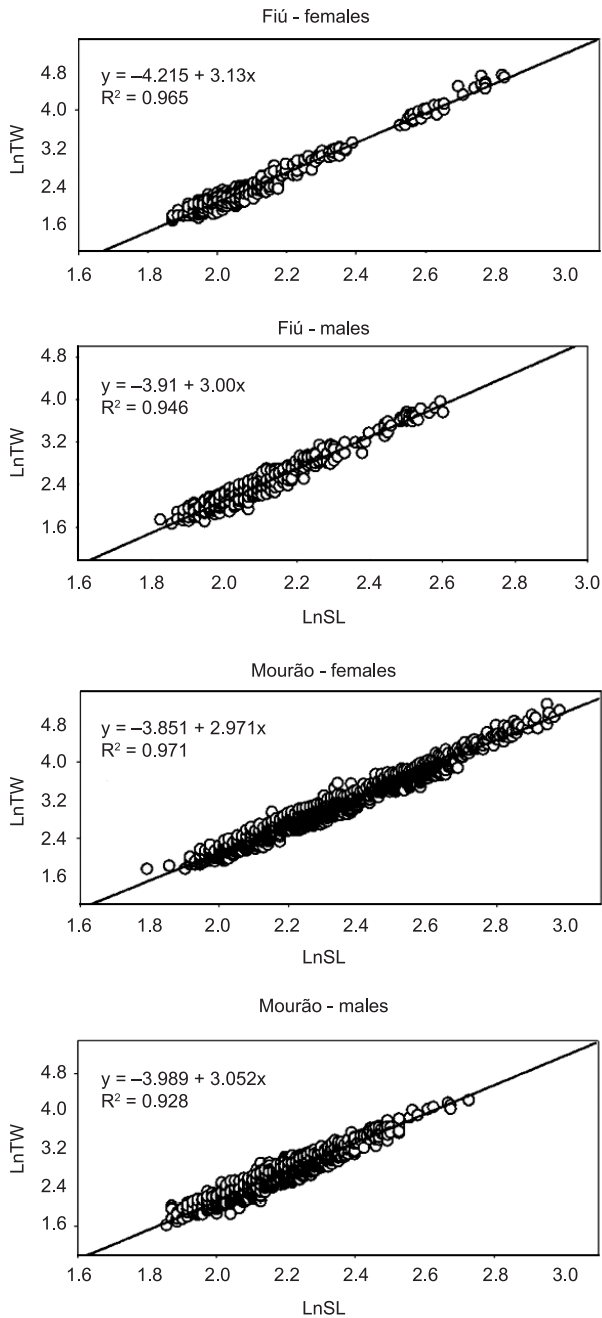


Figure 3. Logarithmic transformation of the weight-length relationship of females and males of *Oligosarcus paranensis* at Fiú and Mourão Reservoirs, Paraná State, Brazil. LnSL = natural logarithm of standard length, LnTW = natural logarithm of total weight.

Figura 3. Transformação logarítmica da relação peso-comprimento de fêmeas e machos de *Oligosarcus paranensis* nos reservatórios de Fiú e Mourão, estado do Paraná Brasil. LnSL = logaritmo natural do tamanho padrão, LnTW = logaritmo natural do peso total.

Tesch 1978, Goulart 1994, Godinho 1997, Peck et al. 2005, Nunes & Hartz 2006). The proposed limit values usually vary between 2.5 and 4.0 according to Pope & Kruse (2007) or between 2.0 and 4.0 according to Bagenal & Tesch (1978). However, for the majority of fish populations b is close to 3.0 (Ney 1993), as it was observed for the presented data. With regard to the predominance

of allometry among the studied groups, it is not possible to infer whether this is a pattern for the species, as information regarding this parameter for other *O. paranensis* population is not available for comparison.

Concerning condition, it is a generic term employed in reference to the well-being, health, strength, nutritional or energy status of animals (Jakob et al. 1996, Schulte-Hostedde et al. 2005, Stevenson & Woods Junior 2006). No matter which is the concept established by the author, by measuring this parameter it is assumed that the heavier specimens of a given size are in better condition (Jakob et al. 1996, Schulte-Hostedde et al. 2005, Pope & Kruse 2007). Thus, it is expected that a fish in better condition will show higher rates of growth, reproductive potential and survival when subjected to environmental pressures compared to another specimen in worst condition (Jakob et al. 1996, Sutton et al. 2000, Pope & Kruse 2007), due to the positive energy budget that can be allocated to growth and reproduction (Wootton 1999). Although there is scarce information about food resources available in the studied reservoirs, fishes were pointed out by Winemiller (1989) as efficient environmental samplers. Thereby, the best condition found for Mourão population, particularly the fact that this condition was maintained among the most abundant length classes of both sexes, supports the hypothesis that food restriction is a relevant modulating factor of the *O. paranensis* population at Fiú.

The information available on the diet of *Oligosarcus* species, such as *O. hepsetus* (Deus & Petrere Junior 2003, Araújo et al. 2005, Botelho et al. 2007), *O. jenynsii* (Nunes & Hartz 2006), *O. longirostris* (Gealh & Hahn 1998, Loureiro-Crippa & Hahn 2006), *O. pintoi* (Meschiatti 1995, Castro & Casatti 1997), *O. planaltinae* (Luz-Agostinho et al. 2006) and *O. robustus* (Nunes & Hartz 2006) characterized the prevalence of piscivory, with the feeding spectrum including an expressive variety of aquatic and/or terrestrial invertebrates, especially insects and decapods. The composition of the diet of *O. paranensis* in both studied reservoirs was similar to the feeding pattern of the above mentioned congeners, with fishes featuring as the main consumed resource. However, the inclusion of fruits/seeds by the female population at Mourão was uncommon, which evidenced the trophic opportunism of these specimens, as it was a food resource classified as abundant by Abelha (2001) in this reservoir. The unusual representative presence of plant matter in the diet of carnivores is related to the limited ability of their digestive tract to efficiently process hard-to-digest materials, such as cellulose and lignin (Okeyo 1989, Gerking 1994). However, *O. paranensis* at Mourão consumed mainly seeds that were considerably fragmented and rich in starch, indicating the digestive viability of this carbohydrate and its consequent use as an energetic food resource. Seeds were also consumed seasonally in large amounts by the piscivorous pimelodid *Rhamdia quelen* in stream environments (Deus & Petrere Junior 2003), which reinforced the assumption of viability of this plant food as an alternative nutrient source, even for carnivores. It should be noted that possible explanations for this females behavior in Mourão demand investigations (i.e., experimental and stable isotope analyzes) that go beyond the scope of this work. It's worth to emphasize the consumption of the exotic species *T. rendalli* and *M. salmoides* in Mourão. This behavior highlighted the predatory activity of *O. paranensis* as a factor regulating the invaders population growth.

The relatively different proportion of the resources composing the diet of females and males (predominance of characins fish intake by females and males at Fiú and the intense predation of cichlids by females and small characids by males at Mourão) suggested resource partition by sex. The use of this tactic is advantageous to reduce or even to avoid competitive interactions, which tend to be accentuated

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Table 4. Result of the Slope Homogeneity, ANCOVA and Separate Slope Model tests applied on the data resulting from the logarithmic transformation of the weight-length relationship of *Oligosarcus paranensis* at Fiú and Mourão Reservoirs, Paraná State, Brazil. The ANCOVA and Separate Slope Model tested differences in the condition between *O. paranensis* studied populations and among standard length classes of two sexes in both reservoirs. $F = F$ statistic, $p = p$ statistic ($\alpha = 0.05$).

Tabela 4. Resultado da homogeneidade de retas, ANCOVA e do Modelo de Inclinação Separada aplicado sobre os dados resultantes da transformação logarítmica da relação peso-comprimento de *Oligosarcus paranensis* para os reservatórios de Fiú e Mourão, estado do Paraná, Brasil. A ANCOVA e o Modelo de Inclinação Separada testaram diferenças na condição entre as populações de *O. paranensis* e entre as classes de comprimento dos dois sexos em ambos os reservatórios. $F =$ estatística F ; $p =$ probabilidade ($\alpha = 0,05$).

Factors/Statistic	Homogeneity of slopes		ANCOVA		Separate Slope Model	
	F	p	F	p	F	p
Between populations	36.00	<0.01	-	-	43.63	<0.001
Female standard length class						
(6.50-7.50]	0.17	0.68	4.60	0.03	-	-
(7.50-8.50]	9.45	<0.01	-	-	8.95	<0.01
(8.50-9.50]	13.54	<0.01	-	-	13.98	<0.01
(9.50-10.50]	0.01	0.97	4.22	0.04	-	-
Male standard length class						
(6.50-7.50]	4.76	0.03	-	-	4.85	0.03
(7.50-8.50]	1.49	0.22	15.70	<0.01	-	-
(8.50-9.50]	7.46	<0.01	-	-	7.55	<0.01
(9.50-10.50]	2.11	0.15	2.89	0.09	-	-

Table 5. Composition of the diet of *Oligosarcus paranensis*, expressed in volume percentage (%V), at Fiú and Mourão Reservoirs, Paraná State, Brazil.

Tabela 5. Composição da dieta de *Oligosarcus paranensis*, expressa em porcentagem de volume (%V), para os reservatórios de Fiú e Mourão, estado do Paraná, Brasil.

Food resource	Fiú (%V)		Mourão (%V)	
	Females	Males	Females	Males
Plant Matter				
Fruits/seedsAngiospermae	-	0.008	21.911	2.986
Leaf/steam/root Angiospermae	0.134	0.626	0.719	0.010
Subtotal	0.134	0.633	22.630	2.995
Invertebrates				
Aquatic Insects				
Diptera (larvae e pupae)	0.006	0.073	0.082	0.042
Ceratopogonidae (larvae e pupae)	0.016	0.010	0.021	0.028
Chaoboridae (larvae e pupae)	0.523	3.211	0.765	1.567
Chironomidae (larvae e pupae)	0.073	0.441	0.204	0.319
Simuliidae (larvae)	-	-	0.000	0.002
Collembola	-	0.001	0.001	0.000
Coleoptera (larvae)	-	0.031	0.233	0.003
Ephemeroptera (nymph)	0.568	1.104	1.047	1.830
Hemiptera	0.000	0.000	0.035	0.218
Megaloptera (larvae)	0.151	1.314	0.000	-
Odonata (nymph)	0.074	1.113	2.128	0.049
Trichoptera (larvae)	0.028	1.221	-	-
Coleoptera (larvae)	0.308	4.400	-	-
Other Aquatic Invertebrates				
Cladocera	0.004	0.533	0.010	0.728
Copepoda	0.033	0.016	0.617	5.363
Hydracarina	0.229	1.094	0.001	0.000

Tabela 5. Continued...

Food resource	Fiú (% V)		Mourão (% V)	
	Females	Males	Females	Males
Nematoda	0.000	0.002	0.012	0.000
Oligochaeta	0.000	0.618	-	-
Ostracoda	0.006	0.443	0.000	0.001
Testacea	0.001	0.000	-	-
Terrestrial Insects				
Coleoptera	0.000	0.000	2.884	1.289
Diptera	0.001	0.021	0.133	0.192
Ephemeroptera	0.519	0.000	0.074	0.749
Hemiptera	0.060	0.274	0.304	0.897
Homoptera	0.000	0.143	0.015	0.003
Hymenoptera	0.036	0.435	1.398	0.810
Isoptera	0.000	0.000	2.224	1.977
Lepidoptera	0.074	0.106	0.457	0.771
Orthoptera	0.062	0.000	1.549	1.176
Thysanoptera	0.000	0.002	0.000	0.000
Trichoptera	0.005	0.000	0.016	0.060
Rests of insects	0.136	1.055	0.203	0.323
Other Terrestrial Invertebrates				
Aranae	-	-	0.356	0.019
Subtotal	2.913	17.661	14.770	18.416
Fishes				
Characidae	17.814	6.657	0.929	0.000
Small characins	35.107	19.019	-	-
<i>Astyanax</i> spp.	0.496	20.921	-	77.613
<i>Bryconamericus iheringi</i>	11.909	21.777	-	-
<i>Oligosarcus paranensis</i>	28.086	0.856	-	-
Cichlidae	-	1.902	28.622	-
<i>Crenicichla</i> sp.	-	1.902	-	-
<i>Tilapia rendalli</i>	-	-	16.383	-
<i>Micropterus salmoides</i>	-	-	0.232	0.582
<i>Synbranchus</i> sp.	-	-	2.322	-
<i>Hoplias malabaricus</i>	0.000	0.209	-	-
Fish scale	1.551	0.198	0.431	0.020
Rests of fish	1.948	7.750	11.891	0.044
Subtotal	96.911	81.192	60.811	78.259
Other				
Detritus/sediment	0.042	0.514	1.789	0.330
Algae				
Bacillariophyceae	<0.001	-	<0.001	-
Chlorophyceae	<0.001	-	-	-
Subtotal	0.042	0.514	1.789	0.330

due to the intraspecific similarity in ecological requirements of the specimens (Pianka 2000).

The diets among distinct length classes of piscivores are frequently influenced by ontogeny, which implies in differences

in energy requirements, morphological limitations (especially mouth gap) and in foraging ability (prey detection, pursuit and manipulation), resulting in a positive relationship between prey size and predator (Gerking 1994, Abelha et al. 2001). Therefore, a gradual

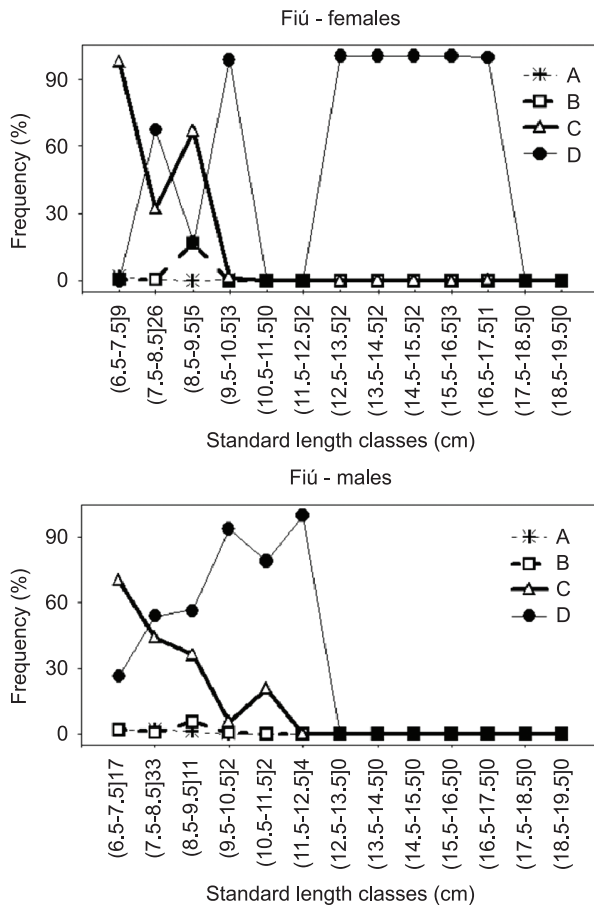
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Figure 4. Frequency of food resources consumed among standard length classes (cm) of *Oligosarcus paranensis* at Fiú Reservoir, Paraná State, Brazil. Values located after class intervals indicate the number of stomachs analyzed per class. Legend: A = other; B = plant matter; C = invertebrates; D = fishes.

Figura 4. Frequência dos recursos alimentares consumidos entre as classes de comprimento padrão (cm) de *Oligosarcus paranensis* no reservatório de Fiú, estado do Paraná, Brasil. Valores localizados depois dos intervalos de classe indicam o número de estômagos analisados por classe. Legenda: A = outro; B = vegetais; C = invertebrados; D = peixes.

replacement of the invertivore diet by the piscivore one is expected with the increase in fish length, as was observed for both sexes of *O. paranensis* at Fiú, and for females at Mourão. This trend was also detected for populations of *O. hepsetus* in reservoir (Araújo et al. 2005) and stream (Botelho et al. 2007) environments, as well as for *O. longirostris* (Gealh & Hahn 1998) in reservoirs. Notwithstanding, these considerations contradicted the invertivory observed for the larger length classes of males at Mourão. However, the low stomach sampling of males with standard length equal to or greater than 10.5 cm does not allow any conclusion.

Considering what was presented here and that predation is a process with a strong impact on the structure and composition of fish communities in reservoirs (Agostinho et al. 1999, Smith & Petrere Junior 2008), it is reasonable to propose that: (i) although *O. paranensis* populations were abundant in both reservoirs, explored similar resources, the population low condition and prevalence of males in Fiú are factors that can threaten their reproductive success, resulting in the impairment of the detected abundance; (ii) the piscivorous feeding habit suggested a relevant ecological role for *O. paranensis* in maintaining the structure and diversity of the

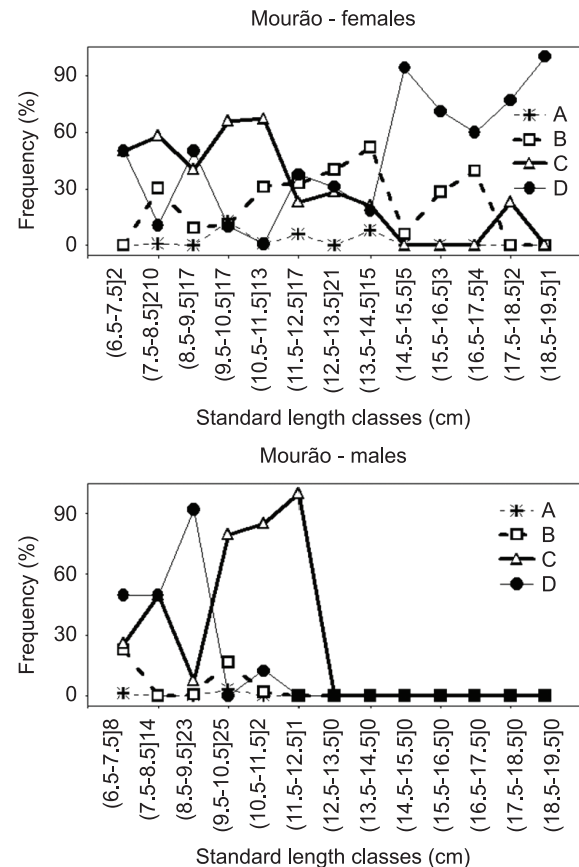


Figure 5. Frequency of food resources consumed among standard length classes (cm) of *Oligosarcus paranensis* at Mourão Reservoir, Paraná State, Brazil. Values located after class intervals indicate the number of stomachs analyzed per class. Legend: A = other; B = plant matter; C = invertebrates; D = fishes.

Figura 5. Frequência dos recursos alimentares consumidos entre as classes de comprimento padrão (cm) de *Oligosarcus paranensis* no reservatório de Mourão, estado do Paraná, Brasil. Valores localizados depois dos intervalos de classe indicam o número de estômagos analisados por classe. Legenda: A = outro; B = vegetais; C = invertebrados; D = peixes.

ichthyofauna at Fiú and Mourão, so that changes in its abundance will probably result in some form of impact in the properties of the other fish populations that inhabit these reservoirs.

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