Biological and ecological aspects of Pinirampus pirinampu (Spix, 1829), Siluriformes, Pimelodidae, in Capivara reservoir, Paranapanema River, Southern Brazil.

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ABSTRACT: Biological and Ecological Aspects of Pinirampus pirinampu (Spix, 1829), Siluriformes, Pimelodidae, in Capivara reservoir, Paranapanema River, Southern Brazil. Temporal and spatial distribution of the catfish Pinirampus pirinampu (Spix, 1829) in Capivara reservoir (middle Paranapanema River basin) and its correlation with water discharges and limnological attributes (water transparency, temperature and dissolved oxygen) were studied from October, 1993 to October, 1995. Monthly samples of fish total were carried out in three sampling sites. The annual abundance of P. pirinampu was 213 individuals and the fish was considered a constant species in the reservoir. Correlation between hydrological and limnological variables and the abundance of the species was not significant, even though a trend of increasing in abundance has been observed after flood periods. The analysis of the structure of P. pirinampu population revealed a predominance of individuals of small size, and there were no significant differences in the proportion between males and females. The weight/length relationship was described by the equation $Wt = 0.0057*LS^{3.2286}$, both for males and females. The mean value of the condition factor obtained was K = 0.48507 ± 0.26726 SD. The smallest value of relative condition factor was observed in the quarter January to March 1995. Significant reproductive activity of this species in Capivara reservoir was not observed, which might indicate that its recruitment occurs in lotic environments of their tributaries.

Key-words: Pinirampus pirinampu, population structure, Capivara reservoir, Paranapanema River.

RESUMO: Aspectos biológicos e ecológicos de Pinirampus pirinampu (Spix, 1829), Siluriformes, Pimelodidae, no reservatório de Capivara, rio Paranapanema, Sudeste do Brasil. As distribuições temporal e espacial de Pinirampus pirinampu (Spix, 1829) no reservatório de Capivara, bacia do médio rio Paranapanema, e suas correlações com vazões e atributos limnológicos, (transparência, temperatura e oxigênio dissolvido da água) foram estudadas no período de outubro de 1993 a outubro de 1995. Foram coletados mensalmente exemplares de peixes (abundância total: 213 indivíduos) em três locais de coleta. A espécie em estudo foi considerada constante no reservatório. Correlações entre as variáveis hidrológicas e limnológicas e a abundância da espécie não foram significativas, embora tenha sido observada uma tendência de incremento da abundância após períodos de cheias. Na estrutura populacional da espécie registrou-se predominância de indivíduos de pequeno porte, não ocorrendo diferença significativa na proporção entre machos e fêmeas no total amostrado. A relação peso/comprimento, válida para ambos os sexos, foi descrita pela equação $Wt = 0.0057.LS^{3.2286}$. O valor médio do fator de condição obtido foi K = 0.48507 ± 0.26726 D.P. O valor mais baixo do fator de condição relativa foi

observado no trimestre de Janeiro a março de 1995. Não foi constatada atividade reprodutiva significativa dessa espécie no reservatório de Capivara, o que pode indicar que seu recrutamento esteja ocorrendo em ambientes lóticos dos seus tributários.
Palavras-chave: Pinirampus pirinampu, estrutura da população, reservatório de Capivara, rio Paranapanema.

Introduction

The Pinirampus pirinampu (Spix, 1829) is a large size pimelodid catfish, with migratory behaviour (Agostinho & Julio Jr., 1999). It has a wide distribution in Brazil, occurring in Amazon, Paraguay and Paraná basins (Torloni et al., 1993; Agostinho et al., 1995; Barthem & Goulding, 1997; Agostinho & Júlio-Jr, 1999; Britski et al., 1999). It reaches about 60 (CEMIG/CETEC, 2000) or 75 cm length (Agostinho & Júlio-Jr, 1999), with average weight ranging from 3 to 5 kg. It is as a non specialized predator, feeding on fish like the catfish Iheringichthys labrosus and the piranha Serrasalmus sp. (Hahn et al., 1997) and shrimps (CEMIG/CETEC, 2000), although in Tucurui reservoir it became strictly piscivorous after dam closure (Merona et al., 2001). The P. pirinampu is a very attractive species both for leisure or professional fisheries, due to tasteful meat and fighting behaviour when captured (CEMIG/CETEC, 2000). According to IBAMA (2000), P. pirinampu is important for the fishery yield in Amazonas, Mato Grosso, Mato Grosso do Sul, Paraná and Roraima States. In Amazon Basin, this species is preyed by Brachyplatystoma flavicans, but it is not important among the big catfishes in industrial fishery (Barthem & Goulding, 1997).

P. pirinampu is one of the ten dominant species in professional landing in Itaipu reservoir, Paraná River (Agostinho et al., 1999), where it is captured with longlines and castnets in the upper half of the reservoir (Agostinho et al., 2002). In Jupiá reservoir, in upper Paraná River, and Água Vermelha reservoir, in Grande River, P. pirinampu is also among the most important fishery resources (Torloni et al., 1993).

This species has a significant ecological importance, due to its role in trophic webs in rivers and reservoirs, mainly in those where it is among larger predators, such as Capivara reservoir. Nevertheless, there is not enough information about its biological and ecological characteristics.

The present study was developed as a part of the Environmental Monitoring Plan of Canoas Complex, which is a set of two hydroelectric power plants in the middle stretch of Paranapanema River. This Monitoring Plan demanded studies in upstream and downstream reservoirs, respectively Salto Grande and Capivara. The specific aims of this study were to characterize the population structure of P. pirinampu, its relationships with the hydrological and limnological attributes in Capivara reservoir.

According to CESP (1993, 1998), Capivara reservoir was shaped by the confluence of Tibagi and Cinzas Rivers with the Paranapanema River in 1975, for energy supplying and hydrological control. This reservoir lies between the geographic coordinates 51º22'-50º30' W and 22º32'-23º00 S, in the border of São Paulo and Paraná states, in Southern Brazil (Fig. 1). The morphometric parameters of the reservoir are: perimeter: 1,550 km; drainage area of 85,000 km^2, covered mainly with pastures and agriculture, with rare occurrence of forest fragments; surface area: 515 km^2; volume: $10,540.10^6$ m^3; normal water level: 334.0 m above sea level; mean depth 14 m, average residence time of water: 119 days; long-term mean outflow in the dam section 1024 $m^3.s^{-1}$. The climatic classification of the region, according to the Köppen system, is Cfa, which means humid climate in all seasons with warm summer, average temperature above 22ºC in the warmest month, and above 18ºC in the coolest month. (Mendonça & Danni-Oliveira, 2002).

Furthermore, the fish fauna of Capivara is composed of 49 species (Britto & Dias, 1997). Even being a large reservoir, Capivara has a low fishery yield and a few number of fishermen.

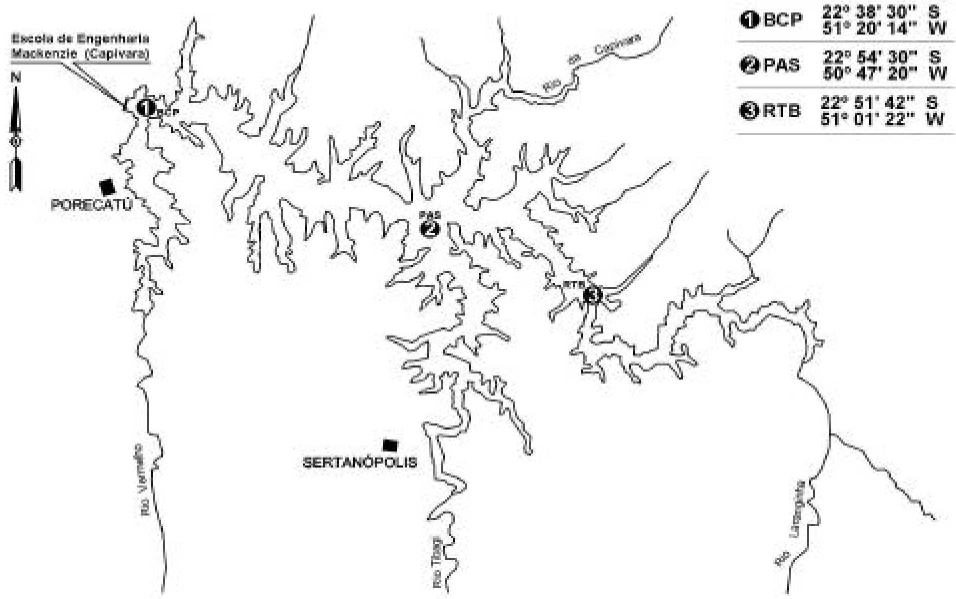

Figure 1: Geographic localization of Capivara reservoir (after CESP, 1998) ; PAS: Assis/Sertanópolis bridge; RTB: Tibagi river; BCP: Capivara dam.

Material and methods

Three sampling sites were adopted in this study, as described in the Tab.I. Hydrological data concerning each of the sites were obtained from stream gauging stations of DNAEE (National Department of Water and Electric Energy) in Tibagi and Paranapanema Rivers. Three limnological variables were measured: water transparency by Secchi disk; water temperature and dissolved oxygen by the electronic analyzer Horiba U-10, measured at 0.2 m below water surface. The experimental fishery was carried out monthly from October, 1993 to October, 1995, using standardized sets of gill-nets, with mesh sizes ranging from 3.0 to 12.0 cm, exposed during 24 hours in each sampling site. The gill-nets were verified each 12 hours.

Table I: Location and characteristics of sampling sites in Capivara reservoir.

Samplin g Site	Geographic Coordinates	Characteristics
PAS	22° 54' 30" S, 50° 47' 20" W	Riverine zone of the reservoir, near to Assis-Sertanópolis bridge; width range from 600 to 1000 m, and maximum depth 25 m.
RTB	22° 51' 42" S, 51° 01' 22" W	Tibagi River, tributary of the reservoir; lentic environment, width range from 2000 to 3000 m, and maximum depth 40 m.
BCP	22° 38' 30" S, 51° 20' 14" W	Lacustrine zone of reservoir, near the Capivara dam; lentic environment, width ranging from 800 to 1000 m, and maximum depth 30 m.

The numerical abundance of *P. pirinampu* collected was expressed in Catches Per Unity of Effort (CPUE), which is the number of individuals trapped in 1,000 m^2 of nets, each 24 hours, and it was determined by the formula CPUE = C/E*1,000, where C is the number of specimens caught and E the effort applied, expressed in m^2 of net (King, 1995).

Variations of spatial (sites) and temporal (months) abundance were compared through the non parametric test of Kruskal-Wallis (Ayres et al., 2000). The coefficient of variation (C.V.) was also computed and used as an indicator of variability of abundance values (Winemiller, 1989).

The multiple linear regression was used in order to verify relationships among abundance of P. pirinampu and monthly water discharge, water transparency, water temperature and dissolved oxygen (Ayres et al., 2000).

For fish fauna, all the species caught were classified in three categories according to Dajoz (1973): constant (when sampled in more than 50% of samples), accessory (when occurred between 25 to 50% of samples) or accidental (when sampled in less than 25% of samples). For the selected species (P. pirinampu), the fishes captured were counted, measured (standard length) and weighted (body and gonadal weights). The sex was identified and the maturation stage and weight of female gonads were analyzed according to Vazzoler (1996). Females were considered matures for reproduction, when their ovaries are swollen, filling almost the whole abdominal cavity, showing great spherical and translucent oocytes, and spawned when showing flabby and bleeding ovaries, with few visible oocytes.

Sexual ratio was calculated and tested using the c^2 test (Vazzoler, 1996) in length classes, and the Komolgorov-Smirnov test for the whole sample (Ayres et al., 2000). The differences between average values of length and weight in males and females were tested using the Z test (Ayres et al., 2000). The relationship between weight and length was calculated by the equation: $Wt = K. LS^b$, where Wt: total body weight, LS: standard length, b: angular coefficient of the linear regression between ln Wt and ln LS, and K: the condition factor estimated by the linear coefficient of the same linear regression (Le Cren, 1951; Vazzoler, 1996).

The condition factor (K) was estimated for each individual, using the same variables according to the formula $K = Wt/LS^b.10^5$. The mean values of K were estimated both for males and females from the individual K values, and its results were tested with Mann-Whitney test (Ayres et al., 2000). Moreover, it was calculated the relative condition factor (Kn), which expresses the differences between the expected and the obtained weight (Le Cren, 1951), allowing inferences about the condition of studied population with relation to the environment (Capivara Reservoir) because it reflects the action of abiotic and biotic factors on the population (Benedito-Cecílio & Agostinho, 1997).

Results

Monthly discharge of Paranapanema River, in sections PAS and BCP, and of Tibagi River, in the section RTB, and limnological variables in each site are presented in Tab. II and Fig. 2. During the study period, the greater discharges occurred in summer (December to March), when the most intensive rains were registered.

Table II: Minimum (min), mean (and standard deviations - SD) and maximum (max) values of limnological variables in three sampling sites of Capivara reservoir.

Sites	**Water Transparency**			**Water Temperature**			**Dissolved Oxygen**		
	min	**mean (SD)**	**max**	**min**	**mean (SD)**	**max**	**min**	**mean (SD)**	**max**
PAS	0.4	1.2 (0.6)	2.1	14.7	22.7 (3.3)	26.0	6.4	7.5 (0.8)	8.9
RTB	0.4	1.0 (0.6)	2.5	16.7	23.1 (2.8)	26.0	6.3	7.6 (0.9)	9.0
BCP	0.9	1.5 (0.4)	2.5	18.7	23.5 (2.4)	26.3	5.7	7.6 (0.8)	9.2

The higher values of transparency were obtained in BCP site, which is located in the lacustrine zone of the reservoir, and the smaller ones in PAS, in the riverine zone. This pattern is consistent with the model presented by Thornton (1990). Values of dissolved oxygen and water temperature obtained were suitable to aquatic life, which means that availability of DO and the temperature were not restrictive factors for fish fauna.

Results of experimental fisheries carried out are shown in Tab. III. P. pinirampu was more abundant in PAS site and less abundant in BCP site. Its constancy reached high values in all sites, being a constant species in Capivara reservoir.

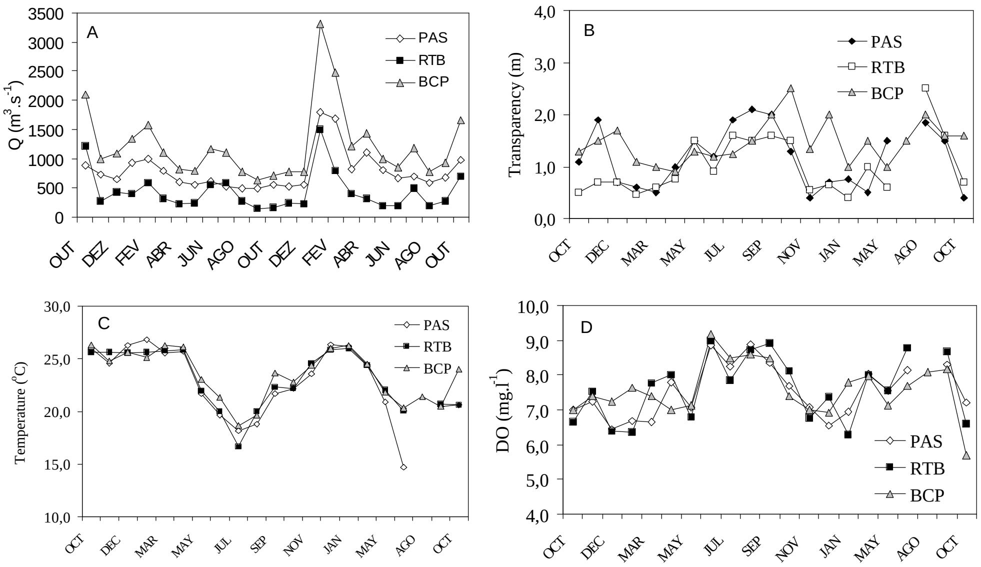

Figure 2: Monthly discharge (A), water transparency (B), water temperature (C) and dissolved oxygen (D) in three sampling sites of Capivara reservoir (PAS, RTB and BCP), from October, 1993, to October, 1995.

Table III: Number of individuals (N), average CPUEn and constancy (C) in samples of P. pirinampu of Capivara reservoir.

Sites	N	Average CPUEn	C
PAS	90	7.16	77.8 (C)
RTB	55	4.03	83.3 (C)
BCP	68	5.3	77.8 (C)

There were not significant differences in effect of sampling sites (H = 0.724, p = 0.696) on the abundance, expressed as CPUE, meaning that there was not a spatial stratification, despite the greatest abundance in PAS and the smallest one in RTB (Fig. 3A). The differences observed among the months were not significant either (H = 27.51, p = 0.051). This denotes an absence of seasonal pattern in the abundance of P. pirinampu in Capivara reservoir, despite the low occurrence, or even absence in the driest months, and a greater occurrence in rainy months. The widest temporal variation in abundance occurred in PAS site, where the coefficient of variation reached the highest value (108.4 %), but variations were high in all sites (Fig. 3B).

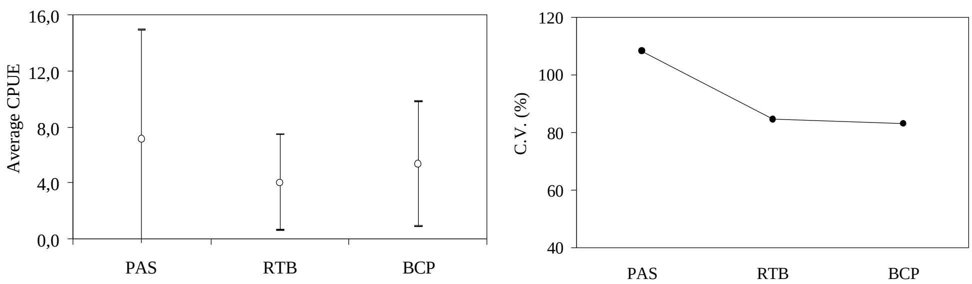

Figure 3: (A) Spatial distribution of CPUEn ($\overline{x}$ ± SD) of P. pinirampu in three sampling sites (PAS, RTB and BCP) of Capivara reservoir.(B) Coefficient of variation (C.V.) of average CPUE in sampling sites (PAS, RTB and BCP), from October, 1993, to October, 1995.

The variation in numerical abundance of P. pirinampu in each sampling site is revealed in Fig. 4. Comparing these data with the water discharge data (Fig. 2A), it is verified a general trend of increasing in abundance after higher discharge periods. However, the results of the multiple linear regression did not reveal dependence of the abundance of P. pirinampu on water discharge, transparency, water temperature and dissolved oxygen (Tab. IV).

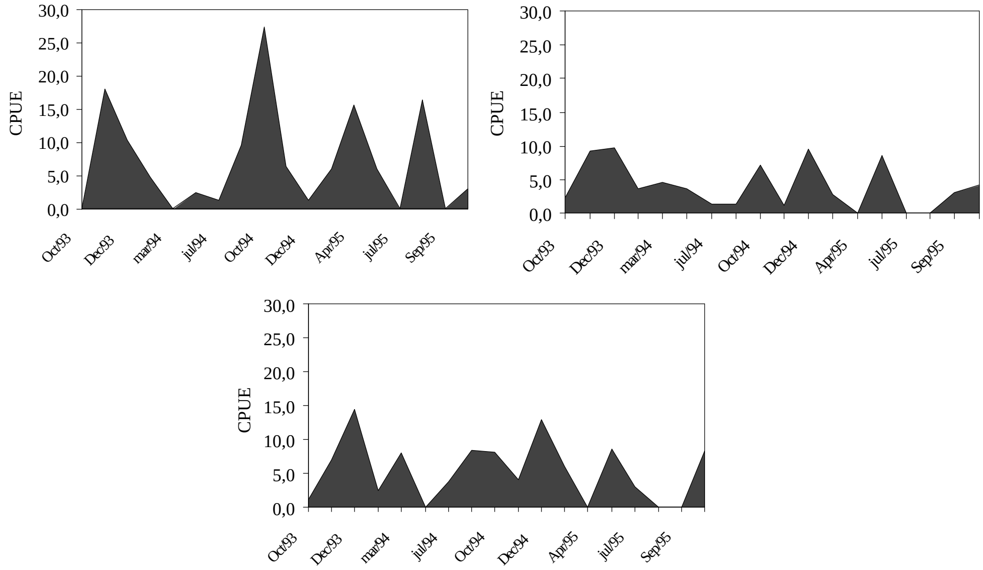

Figure 4: Monthly distribution of CPUE of P. pinirampu in PAS (A), RTB (B) and BCP (C) sampling sites from October, 1993 to October, 1995.

Table IV: Multiple linear regression equations of the abundance of P. pirinampu, expressed as CPUE, in function of hydrological (Q: water discharge) and limnological variables (Transp: water transparency; Temp: water temperature; DO: dissolved oxygen) in Capivara reservoir, from October, 1993 to October, 1995.

Sites	Multiple Linear Regression equations	F	p	R^2	d.f.
BCP	CPUE = 22.01 - 0.002.Q + 1.068.Transp + 0.253.Temp - 2.947.DO	1.483	0.268	0.331	4, 12
RTB	CPUE = 13.18 - 0.004.Q - 2.593.Transp - 0.010.Temp - 0.771.DO	1.709	0.217	0.383	4, 11
PAS	CPUE = -28.91 - 0.001.Q + 1.531.Transp + 1.531.Temp + 3.66.DO	0.291	0.878	0.089	4, 12

The values of standard length and total weight are revealed in Tab. V. Differences of length and weight between males and females were not significant ($z = -1.136$, $p = 0.128$ for length; $z = -1.062$, $p = 0.144$ for weight).

Table V: Mean, standard deviation (SD), maximum and minimum values for standard length (LS) and total weight (Wt) for males and females of P. pinirampu in Capivara reservoir from October, 1993 to October, 1995.

STATISTICS	Males		Females	
	LS (cm)	Wt (g)	LS (cm)	Wt (g)
maximum value	62.4	3,400	56.0	2,800
minimum value	13.9	28.5	14.9	36.8
mean (SD)	26.1 (9.1)	311.9 (449.9)	27.9 (9.8)	410.1 (523.0)

The modal length classes were 10.0 to 20.0 and 20.0 to 30.0 cm both for males and females. Significant differences between sexes were revealed in smaller and larger classes, but not in the whole sample. Proportions between males and females in whole sample and in length classes are showed in Tab. VI and Fig. 5.

Table VI: Length classes for males and females of P. pirinampu collected in Capivara reservoir, from October, 1993 to October, 1995.

Length Class		Absolute Frequency		χ^2	Relative Frequency		Accumulated Frequency	
		M	F		M	F	M	F
10.0	20.0	32	15	6.15 *	68	32	34.4	18.1
20.0	30.0	35	42	0.64	45	55	72.0	68.7
30.0	40.0	20	14	1.06	59	41	93.5	85.5
40.0	50.0	4	10	2.57	29	71	97.8	97.6
50.0	60.0	1	2	0.33	33	67	98.9	100.0
60.0	70.0	1		1.00	100	0	100.0	-
Total		93	83	0.57	53	47		

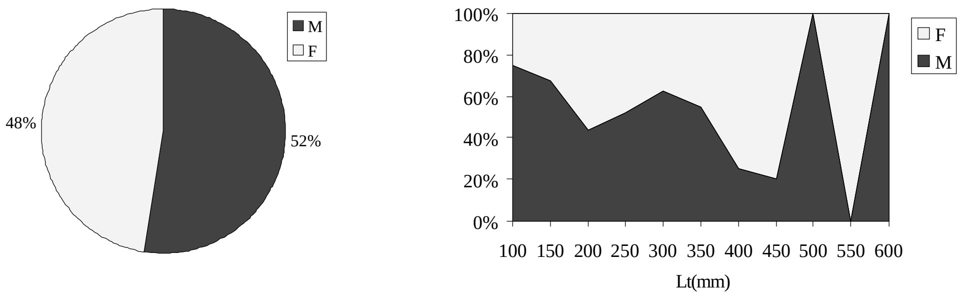

Figure 5: Proportion between males (M) and females (F) of P. pirinampu collected in Capivara reservoir from October, 1993, to October, 1995, in the whole sample (A) and in the different lenght classes (B).

In an indirect form, the Man-Whitney test indicated that there was not significant differences between the weight/length relationship of males and females of P. pirinampu (Fig. 6). In this case, the relationship of the whole sample (Fig. 7), is representative both for males and females. The equation which describes that relationship is $Wt = 0.0057.LS^{3.2286}$. The value obtained of b (3.2286) indicates that P. pirinampu has an allometric type of growth.

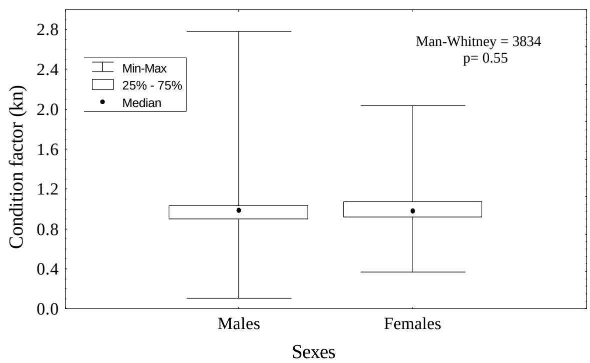

Figure 6: Box-plot of median condition factor in males and females of P. pirinampu caught in Capivara reservoir, from October, 1993, to October, 1995, compared through the a Man-Whitney test.

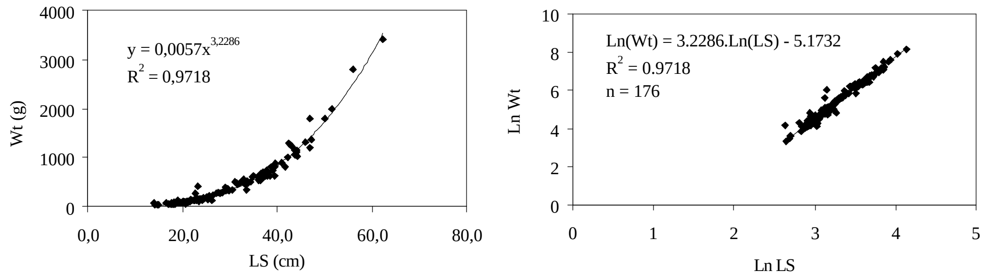

Figure 7: (A) Weight (g)/length (cm) relationship of P. pirinampu from Capivara reservoir. (B) Transformed data of weight (ln Wt) and length (ln LS) of P. pirinampu from Capivara reservoir.

The mean condition factor obtained was K = 0.48507 ± 0.26726 SD. Concerning the relative condition factor (Kn), the quarterly means and respective standard errors and standard deviations are showed in Fig. 8. The smallest value of Kn occurred in the period from January to March 1995, probably when the less favorable environmental conditions for the P. pirinampus population of Capivara reservoir were observed.

Reproductive activity of P. pirinampu was not significant in the reservoir. A very low percentage of females with mature ovaries was found, restricted to BCP site, and a slightly higher percentage of ovaries in regression stage was observed in all sites (Tab. VII).

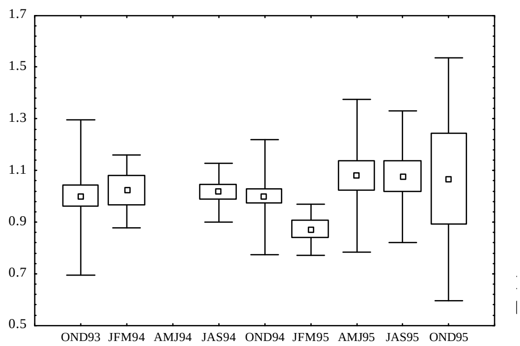

Figure 8: Box-plot (mean values ± standard errors and ± standard deviation) of relative condition factor (Kn) of P. pirinampu caught in Capivara reservoir, (OND93: from October to December, 1993; JFM94: from January to March, 1994; AMJ94: from April to July, 1994, JAS94: from July to September, 1994; OND94: from October to December, 1994; JFM95: from January to March, 1995; AMJ95: from April to July, 1995; from JAS95: from July to September, 1995; OND95: October, 1995).

Table VII. Percentage of P. pirinampu mature females in reproductive processes in Capivara reservoir from October, 1993 to October, 1995. (N: total number of females analized; n (III) percentage of females with mature ovaries; n (IV): percentage of spawned females).

	PAS	**RTB**	**BCP**	**TOTAL**
N	25	20	38	83
n (i, r)	23	17	33	73
% (i,r)	92.0	85.0	86.8	88.0
n (III)	0	0	1	1
% III	0.0	0.0	2.6	1.2
n (IV)	2	3	4	9
% IV	8.0	15.0	10.5	10.8

Discussion

P. pirinampu occurs in middle and low stretches of Paranapanema basin (Romanini et al., 1994; Bennemann et al. 1995; Britto & Dias, 1997; CESP, 1998; Bennemann et al. 2000), but is not found in the stretches above Canoas Complex (Dias, 1995; Britto & Dias, 1997; Carvalho et al., 1998; Dias & Garavello, 1998; Carvalho & Silva, 1999). Bennemann et al. (1995) pointed out the occurrence of P. pirinampu mainly in low stretches of Tibagi River.

This species was constant in all sampling sites of Capivara reservoir, even in lentic environments. It occurs in several reservoirs in Upper Paraná basin (Torloni et al., 1993; Santos & Formagio, 2000; Agostinho et al., 2002). According to Romanini et al. (1994), P. pirinampu was an accidental species in the low stretch of Paranapanema before the filling of Rosana reservoir, and became a constant species after that.

P. pirinampu probably has adopted reservoirs as growing and feeding sites, and the lotic environments of tributaries or riverine stretches as spawning and nursery areas. The stock of P. pirinampu in Capivara reservoir shows a high percentage of juveniles: 72.0% of males and 68.7% of females were collected with standard length below 30.0 cm, less than the length (37.0 cm) of the first maturation in Itaipu reservoir (Agostinho et al., 1999). This species is using the reservoir mainly for growing and feeding activities. The very low percentage of mature females found in Capivara reservoir also evidenced an absence of reproductive activities in that area.

The hypothesis of reservoirs as growing and feeding sites for P. pirinampu is also supported by researches in Itaipu reservoir, where there is a stock of this migratory species whose recruitment is performed in the lotic upstream stretch of the Paraná River (Agostinho et al., 2002).

Statistical analysis did not evidence dependence of the abundance of this species on hydrological and limnological variables in Capivara reservoir. Concerning limnology, this probably occurred due the fact that the variables studied remained within the critical thresholds for fish. Certainly, severe conditions of the studied variables would be harmful for most fish species, but this situation was not found in Capivara reservoir, which presents a good water quality (CESP, 1998). However, it was observed a general trend for P. pinirampus to increase its abundance after flood periods.

Concerning the hydrology, a significant influence of flood dynamics on fish abundance was expected (Lowe-McConnell, 1979, 1987; Welcomme, 1979; Oldani, 1990; Agostinho & Zalewski, 1995), mainly through recruitment process. The rise of water levels allows the connection between the river and the surrounding environments, such as marginal lakes, channels and floodplains, improving the availability of food and shelters for larvae and young forms of fish. In Paraná River, significant floods are followed by increase of migratory fish abundance, and the lack of floods implies in losses in this abundance (Agostinho & Zalewski, 1995). Nevertheless, in more homogeneous environment such as reservoirs, this influence could be reduced. According to Lowe-McConnell (1987), fish assemblage shows wider fluctuations under changing conditions and less in the more stable ones. In Capivara reservoir, the effects of hydrological variations would be more correlated with the recruitment of P. pinirampu, which probably occurs in lotic environments upstream the reservoir, or in its tributaries. Gomes & Agostinho (1997) showed that abundance of juveniles of Prochilodus lineatus in Itaipu reservoir is influenced by flood regime of Paraná River through the increase of recruitment in marginal lagoons on floodplain when the flood reaches suitable water level and span, or decrease when these conditions are not reached. Similar process could be occurring with P. pirinampu upstream Capivara reservoir or in its tributaries: the recruitment of this species could occur during the rainy seasons, under the influence of floods, and the juveniles performs dispersion migrations to the reservoir, searching for trophic resources. This would explain the increase of abundance after higher discharges. However, this dispersion was restricted downstream in the Capivara dam, and upstream, in the studied period, in Salto Grande dam, and nowadays in Canoas dam.

A promising approach for ecological studies of P. pirinampu in the middle Paranapanema basin would be the surveying and the identification of its spawning and nursery areas, which are probably located in Cinzas, Laranjinhas and Congonhas Rivers, where the recruitment probably occurs. As stated by Agostinho et al. (2002), the protection of critical habitats is the most effective management action for fish. Then, identification and protection of these habitats seems to be the immediate and best management strategy for the conservation of P. pirinampu in this region.

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References

Agostinho, A.A., Vazzoler, A.E.A. de M. & Thomaz, S.M. 1995. The high river Paraná basin: limnological and ichthyological aspects. In: Tundisi, J.G., Bicudo, C.E.M. & Matsumura-Tundisi, T. (eds.) Limnology in Brazil. Brazilian Academy of Science, Brazilian Limnological Society, Rio de Janeiro. p. 59-103.

Agostinho, A.A. & Zalewski, M. 1995. The dependence of fish community structure and dynamics on floodplain and riparian ecotone zone in Paraná river, Brazil. Hydrobiologia, 303:141-148.

Agostinho, A.A. & Julio Jr., H.F. 1999. Peixes da bacia do alto rio Paraná. In: Lowe-McConnell, R.H. (Ed.) Estudos ecológicos de comunidades de peixes tropicais. EDUSP, São Paulo. p.374-400

Agostinho, A.A., Okada, E.K & Gregoris, J. 1999. A pesca no reservatório de Itaipu: aspectos sócioeconômicos e impactos do represamento. In: Henry, R. (ed.) Ecologia de reservatórios: estrutura, função e aspectos sociais. FAPESP/FUNDIBIO, Botucatu. p.281-319.

Agostinho, A.A., Okada, E.K., Gomes, L.C., Fernandez, D.R. & Fontes Jr., H. 2002. Fishery management in the Itaipu reservoir. Proceedings of International Symposium on Reservoir Management in Tropical and Sub-Tropical Regions. ICOLD-CBDB, Foz do Iguaçu. 725p.

Ayres, M., Ayres Jr., M., Ayres, D.L. & Santos, A.S. 2000. BioStat 2.0: aplicações estatísticas nas áreas das ciências biológicas e médicas. Sociedade Civil Mamirauá/MCT-CNPq, Belém/Brasília. 259p.

Barthem, R. & Goulding, M. 1997. Os bagres balizadores: ecologia, migração e conservação de peixes amazônicos. Sociedade Civil Mamirauá/MCT-CNPq/IPAAM, Tefé/Brasília. 130p.

Benedito-Cecílio, E. & Agostinho, A.A. 1997. Estrutura das populações de peixes do reservatório de Segredo. In: Agostinho, A.A. & Gomes, L.C. (ed.). Reservatório de Segredo: bases ecológicas para o manejo. EDUEM, Maringá. p.113-140.

Bennemann, S.T., Silva-Souza, A.T. & Rocha, G.R.A. 1995. Composición ictiofaunistica en cinco localidades da la cuenca del rio Tibagi, PR – Brasil. Interciencia, 20:7-13.

Bennemann, S.T., Shibatta, O.A. & Garavello, J.C. 2000. Peixes do rio Tibagi: uma abordagem ecológica. Ed. UEL, Londrina. 62p.

Britski, A.A., Silimon, K.Z.D & Lopes, B.S. 1999. Peixes do Pantanal: manual de identificação. EMBRAPA-SPI/EMBRAPA-CPAP, Brasília, Corumbá. 184 p.

Britto, S.G.C. & Dias, J.H.P. 1997. Ictiofauna do Médio Paranapanema: impactos prováveis do Complexo Canoas. In: Anais do XXII Seminário Nacional de Grandes Barragens. São Paulo. v.1, p.185-194.

Carvalho, E.D., Fujihara, C.Y. & Henry, R. 1998. A study of the ichthyofauna of Jurumirim reservoir (Paranapanema River, São Paulo state, Brazil): fish production and dominant species at three sites. Verh. Int. Verein. Limnol., 26:2199-2202.

Carvalho, E.D. & Silva, V.F.B. 1999. Aspectos ecológicos da ictiofauna e da produção pesqueira do reservatório de Jurumirim (Alto do Paranapanema, São Paulo). In: Henry, R. (ed.) Ecologia de reservatórios: estrutura, função e aspectos sociais. FAPESP/FUNDIBIO, Botucatu. p.771-799.

CEMIG/CETEC. 2000. Guia ilustrado de peixes da bacia do rio Grande. CEMIG/CETEC, Belo Horizonte. 141p.

CESP. 1993. Informações gerais: CESP - Companhia Energética de São Paulo, São Paulo. 73p.

CESP. 1998. Conservação e manejo nos reservatórios. Limnologia, ictiologia e pesca. CESP, São Paulo. 166 p. (Série Divulgação e Informação, 220).

Dajoz, R. 1973. Ecologia geral. 2ª ed. Vozes/EDUSP, São Paulo. 474 p.

Dias, J.H.P. 1995. Estudos ecológicos na comunidade de peixes do reservatório de Salto Grande, Médio Paranapanema (Estados de São Paulo e Paraná). São Carlos, UFSCar, 107p. (Dissertação).

Dias, J.H.P. & Garavello, J.C. 1998. Ecological studies on the fish community of Salto Grande Reservoir, Paranapanema River Basin, São Paulo. Verh. Int. Verein. Limnol. 26:2228-2231.

Gomes, L.C. & Agostinho, A.A. 1997. Influence of the flood regime on the nutritional state and juvenile recruitment of Prochilodus scrofa, Steindachner in upper Paraná river, Brazil. Fish. Manag. Ecol., 4:263-274.

Hahn, N.S., Andrian, I.F., Fugi, R. & Almeida, V.L.L. 1997. Ecologia trófica. In: Vazzoler, A.E.A. de M., Agostinho, A.A. & Hahn, N.S. A planície de inundação do alto rio Paraná: aspectos físicos, biológicos e socioeconômicos. EDUEM, Maringá. p.209-228.

IBAMA. 2000. Estatística da pesca 1998: Brasil – grandes regiões e unidades da Federação. IBAMA, Tamandaré. 96p.

King, M. 1995. Fisheries biology, assessment and management. Fishing News Books, Oxford. 341p.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). J. Anim. Ecol., 20:201-219.

Lowe-McConnell, R.H. 1979. Ecological aspects of seasonality in fishes of tropical waters. Symp. Zool. Soc. London, 44:219-241.

Lowe-McConnell, R.H. 1987. Ecological studies in tropical fish communities. Cambridge Univ. Press, Cambridge. 382p.

Mendonça, F.A. & Danni-Oliveira, I.M. 2002. Dinâmica atmosférica e tipos climáticos predominantes na bacia do rio Tibagi. In: Medri, M.E., Bianchini, E., Shibatta, O.A. & Pimenta, J.A. (eds.) A bacia do rio Tibagi. Londrina: M.E.Medri. p.63-68.

Merona, B., Santos, G.M. & Almeida, R.G. 2001. Short effects of Tucuruí Dam (Amazonia, Brazil) on the trophic organization of fish communities. Environ. Biol. Fishes, 60:375-392.

Oldani, N.O. 1990. Variaciones de la abundancia de peces del valle del río Paraná (Argentina). Rev. Hydrobiol. Trop., 23:67-76.

Romanini, P.U., Shimizu, G.Y., Cruz, J.A., Fontana, S.C., Carvalho, M.A.J. & Bicudo, C.E.M. 1994. Alterações ecológicas provocadas pela construção da barragem da UHE de Rosana sobre o baixo rio Paranapanema, SP/PR. CESP/IBUSP, São Paulo. 153p.

Santos, G.B. & Formagio, P.S. 2000. Estrutura da ictiofauna dos reservatórios do rio Grande, com ênfase no estabelecimento de peixes piscívoros exóticos. Inf. Agropec., 21(203):98-106.

Thornton, K.W. 1990. Perspectives on reservoir limnology. In: Thornton, K.W., Kimmel, B.L. & Payne, F.E. (eds.) Reservoir limnology: ecological perspectives. Wiley-Interscience Publ., New York. p.1-13.

Torloni, C.E.C., Corrêa, A.R.A., Carvalho JR., A.A.C., Santos, J.J., Gonçalves, J.L., Gereto, E.J., Cruz, J.A., Moreira, J.A., Silva, D.C., Deus, E.F.& Ferreira, A.S. 1993. Produção pesqueira e composição das capturas em reservatórios sob concessão da CESP nos rios Tietê, Paraná e Grande, no período de 1986 a 1991. CESP). São Paulo. 73p. (Série Produção Pesqueira, 1)

Vazzoler, A.E.A. de M. 1996. Biologia da reprodução de peixes teleósteos: teoria e prática. EDUEM, Maringá. 169p.

Welcomme, R.L. 1979. Fisheries ecology of foodplain rivers. Longman, London. 317 p.

Winemiller, K.O. 1989. Patterns of variation in life history among South American fishes in seasonal environments. Oecologia, 81:225-241.

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