Ecological attributes of fish fauna in the Taquaruçu Reservoir, Paranapanema River (Upper Paraná, Brazil): composition and spatial distribution.

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ABSTRACT: Ecological attributes of Fish fauna in the Taquaruçu Reservoir, Paranapanema River (Upper Paraná, Brazil): composition and spatial distribution. Construction of dams leads to several environmental alterations on flora and fauna specially on fish. This study determines the composition and spatial organization of fish fauna, in the longitudinal limnological gradient of the Taquaruçu Reservoir, Paranapanema River Basin. Twenty-nine collections were carried out every three months with gill nets in three zones of the gradient. A total of 73 species of fish were captured, among native, transposed and exotic ones. There were differences in the distribution, along the limnological gradient especially between fluvial and lacustrine zones. Greater values of some ecological attributes (species richness, diversity index, abundance and constancy of species) and trophic groups of ichthyofauna were obtained in the fluvial zone. In general, piscivorous and carnivorous are dominant in this reservoir. Different icththyofaunas were found among the zones, and those most influenced by the damming were similar. Comparing our results with other studies on the Paranapanema and Upper Paraná River Basin, it is noted that the ichthyofauna structure along the limnological gradient is a predictive condition of reservoir formation in this basin. Also, the addition of nonnative species is a differential factor in the reorganization of Taquaruçu reservoir, in relation to other reservoirs of the upper stretch of the Paranapanema River basin.
Key-words: Reservoirs, ichthyofauna, ecology, fish, nonnative species.

RESUMO: Atributos ecológicos da fauna de peixes do Reservatório de Taquaruçu, Rio Paranapanema (Alto Paraná, Brasil): composição e distribuição espacial. A construção de barragens provoca diversas alterações ambientais sobre a flora e a fauna e em especial sobre as populações de peixes. Nesse sentido, o presente estudo objetivou avaliar a organização espacial da fauna de peixes, num gradiente limnológico longitudinal estabelecido pela variação do fluxo da água do reservatório de Taquaruçu, bacia do rio Paranapanema. Foram realizadas 29 coletas com redes de espera em três compartimentos, com periodicidade trimestral. Os resultados demonstraram a ocorrência de 73 espécies de peixes, entre nativas, transpostas e exóticas, cujas populações se distribuem diferencialmente ao longo deste gradiente limnologico entre os compartimentos fluvial e lacustre. A distribuição diferencial da ictiofauna nesses compartimentos foi observada em termos dos seus atributos ecológicos (riqueza, diversidade, abundância e constância das espécies) e dos grupos tróficos, com maiores valores obtidos no compartimento fluvial. De maneira geral, piscívoros e carnívoros são dominantes neste reservatório. Especificamente, diferenças na similaridade ictiofaunística entre os compartimentos foram diagnosticadas, sendo que os mais influenciados pelo barramento são mais similares entre si. Comparando-se os resultados de outros estudos das bacias do Paranapanema e Alto Paraná percebe-se que a estruturação da ictiofauna ao longo do gradiente limnologico é uma condição preditiva da formação dos reservatórios nessa bacia. Revela-se, também, que a adição de espécies não nativas é diferencial nesta reestruturação de ictiofauna para Taquaruçu, em relação a outros do trecho superior da bacia do rio Paranapanema.
Palavras chave: Reservatórios, ictiofauna, ecologia, peixes, espécies não nativas.

Introduction

Large artificial lakes formed from damming large rivers cause a series of impacts which affect chemical, physical and specially biological components in the area of impoundment (Bianchini Jr., 1994), promoting considerable alterations in the hydrological regime and ecological dynamics of the rivers (Henry, 1998).

Britski (1994) states that damming river has severe implications on fish community. In this aspect Agostinho & Gomes (2005) argue that the degree of impacts relates mainly to the characteristics of local fauna, location of the dam in relation to the area of population distribution, basin morphometry, the existence of other impoundments, the design of the dam and operational procedures of the plant. Furthermore, an inevitable impact of dams in relation to aquatic fauna is the alteration in the abundance of animal species, with excessive proliferation of some and reduction or even local extinction of others (Agostinho et al., 1999). In addition, local processes and factors, mainly the limnological and structural characteristics of the aquatic ecosystem and the interactions among species, are regarded as responsible for the composition and structuring of fish communities (Agostinho & Gomes, 2005).

In the spatial context, the construction of dams, as a rule, leads to changes that determine a marked compartmentalization of the dammed water mass (Nogueira et al., 2005), producing a spatial heterogeneity in limnological and biotic variables (Henry, 1998, Nogueira et al., 1999). In large reservoirs, this spatial heterogeneity may lead to formation of a longitudinal gradient, distinguishing the lacustrine, transitional and riverine zones, which one containing distinct biota (Thornton, 1990; Carvalho et al., 1998; Train et al., 2005).

Nevertheless, the relations between such variables and the ichthyofauna characteristics of each site, taking into account its geographic location and position in the basin, make each reservoir a rather particular entity (Dias & Garavello, 1998; Agostinho & Gomes, 2005).

Lowe-McConnell (1987) states that the formation of these artificial "lakes" allows an ample study on how fluvial species become fit for the colonization of these semi-lenthic environments and how lacustrine communities adjust to such conditions. Still, Lyons (1996) affirms that the category of environments reflect a great number of ecological variables, are factors which strongly influence the composition, distribution and abundance of fish.

Thus, this work aims to evaluate the fish composition and to differentiate some ecological attributes of the ichthyofauna collected in three limnologically distinct zones of the Taquaruçu Reservoir, lower Paranapanema River.

Material and methods

Study area

The Taquaruçu Hydro-electrical Plant is located at 22°32 - 22°42' S and 52°01' - 51°22' W, in the low course of the Paranapanema River, between the States of São Paulo and Paraná, Brazil. This reservoir presents maximum depth of 18 meters and a low water hydraulic retention (mean of 8 days), with few water level fluctuation. Further, it's surface area is 105.5 km², with a 301-km perimeter. Also, there are few large tributaries emptying on the reservoir (Fig. 1).

Three zones (compartments), the fluvial, the transition and the lacustrine, were selected along a limnological gradient of the Taquaruçu Reservoir (sensu Pagioro et al. 2005), for the collection of fish. However, for the definition of these zones, measurements of the water flow were carried out with a General Oceanic flowmeter and data on the concentrations of phosphorus and water transparency, according to CESP (1996), and suspended solids published by Nogueira et al. (2002) were compiled (Tab. I). The arithmetic means of these data were statistically compared by ANOVA, with $a = 0.05$.

Twenty nine samplings were carried out in these zones (from October 1993 to November 2000), every three months (a total of 87 samplings). These samplings were performed in a standardized manner, i.e., using gang of gill-nets with different meshes (between 30 and 120 mm between opposed knots), set for 24 hours and checked for fish every 12 hours. All captured fish were identified based on Britski (1972), Nelson (1994) and Reis et al. (2003), and some testimony specimens were deposited at the Museu de Zoologia located in Universidade Estadual de Londrina (MZUEL); Londrina, PR., Brazil.

The ecological attributes used to compare fish communities in the three zones were: i) absolute and relative number (%)

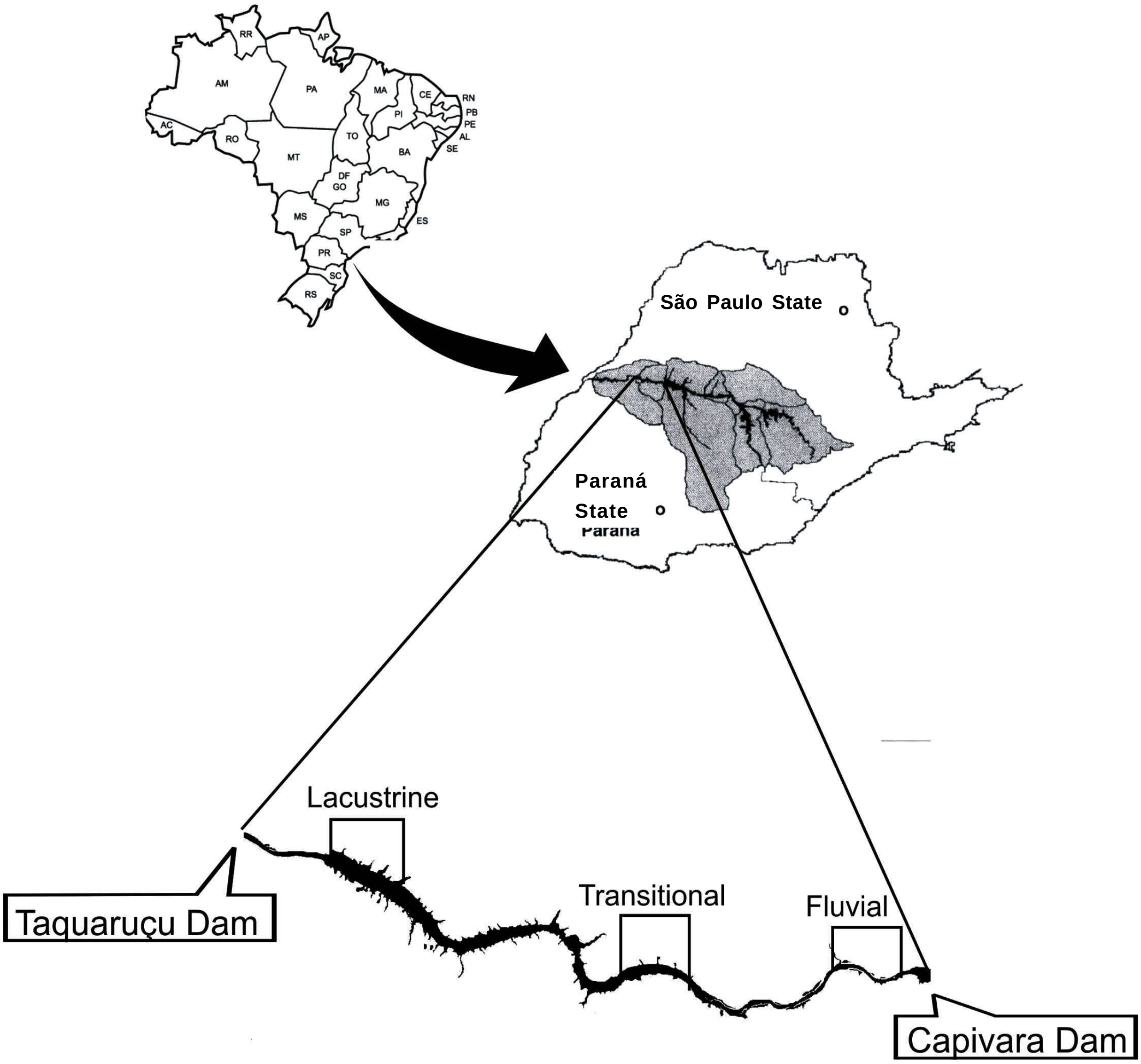

Figure 1: South American hydrographic complex (light grey). The Paranapanema River basin (dark grey), with the Taquaruçu Reservoir, between the States of São Paulo and Paraná.

Table I: Mean values of the limnological data (suspended solids, total phosphorus, water transparency and current velocity) for the three zones of the Taquaruçu reservoir, lower Paranapanema River basin. (N = number of samples; equal letters = differences no statistically significant (ANOVA, a = 0.05).

Limnological variables	**N**	**Lacustrine**	**Transition**	**Fluvial**
Suspended solids (mg/l)*	4	2.43	3.05	
Total phosphorus (mg/l)**	14	19.50^{b}	21.75^{b}	23.30^{b}
Water transparency (m)**	14	1.30^{b}	1.15^{a}	1.17^{a}
Current velocity (m/s)	4	0^{b}	0.02^{b}	1.2^{b}

*(From Nogueira et al. (2002), **CESP (1996) and this work)

of species captured; ii) relative importance curve (in number) of species (Whittaker plot, in Krebs, 1989) adjusting a regression model as Y = A+BX, where Y is the relative abundance (% do individuals) of species (log n+ 1) and X is species order, for the entire reservoir and each zone separated. Pearson´s (r) linear coefficient was also determined (r); iii) indexes of diversity (Shannon-Wiener), evenness (Pielou) and species richness (Margalef) (in Ludwig & Reynolds, 1988); iv) the constancy of species capture (Dajoz, 1972); v) catch per unit of effort (CPUE), in number and weight) according to Carvalho & Silva (1999), whose results were submitted to descriptive statistics and their means statistically compared by ANOVA, with a = 0.05); and vi) the similarity of fish fauna among zones (Jaccard, 1902, in Krebs,1989); and finally, vii) possible trophic structures for the fish communities for each zone of the Taquaruçu were empirically defined. We used the numerical abundance (%) of dominant trophic groups, represented by species with an occurrence › 2%. The classification of trophic groups was based on data on feeding for the same species proposed by Hahn et al. (1998) and Bennemann et al. (2000) in two other tributaries/reservoirs of the upper Paraná River.

Results

Seventy-three fish species were captured, belonging to Characiformes (34 species = 46.57%), Siluriformes (29 species = 39.73%), Gymnotiformes (5 species= 6.85%) and Perciformes (5 species= 6.85%). The dominance (considering the abundance) was greater for Siluriformes (47.59%), followed by Characiformes (40.35%), Perciformes (10.60%) and Gymnotiformes (1.46%). Greater species richness was recorded in the fluvial zone (64 species), as compared to the lacustrine and transition zones which harbored 50 and 55 species, respectively.

Fourteen species, out of 73 contributed with 75% of the total abundance (Tab. II). We verified that among these 14 species, seven were the most representative, regardless of the zone of the reservoir. Out of the total sampled fish (7,874 individuals), 27.21% were caught in the lacustrine, 23.20% in the transition, and almost 50%, in the fluvial zone.

The numerical distribution of species along the gradient was distinct. Then, we notice greater dispersion in the inner parts of the reservoir (r=0.82 lacustrine) and lower dispersion in the upper part (r=0.93 fluvial) (Fig. 2).

The values of the ecological attributes (Diversity index, evenness and species richness) (Tab. III) also support the idea that there is a gradient tendency from the upper (fluvial) to the lower (lacustrine) zone, with smaller values in the lenthic (H = 2.84; E= 0.73 and R= 4.69) and greater in the fluvial (H = 3.32; E= 0.80 and R= 5.91). In a similar manner, a larger number of constant species (14) was observed in the fluvial zone when compared to the lacustrine one (11). However, only 9 species were constant in all zones (Acestrorhynchus lacustris, Serrasalmus marginatus, Steindachnerina insculpta, Leporinus friderici, Schizodon nasutus, Pimelodus maculatus, Iheringichthys labrosus, Loricarichthys platymetopon, Plagioscion squamosissimus).

The analysis of CPUE (in weight) evidenced mean values with statistically significant differences (a = 0.05) between the fluvial and the transition/lacustrine zones and showed that there was a greater abundance in the fluvial in relation to the lacustrine zone (Tab. IV). The differences among zones and the Index of Jaccard showed that the lacustrine and transition zones (J = 0.75) have more common species and, therefore, are more similar than the fluvial and lacustrine zones (J = 0.58).

The empirical characterization of the trophic structure of the Taquaruçu Reservoir ichthyofauna (Tab. V) demonstrated the dominance of piscivorous (23.91%) over the other groups, regardless of the zone. However, this trophic group was quite representative in the three zones (fluvial = 21.73%; transition = 23.07% and lacustrine = 27.79%). There were also verified the great participation of carnivores (33.18%), in the lacustrine zone, and the importance of omnivorous (21.67%) and iliophagous (17.74%) in the transition zone and the expressiveness of detritivorous (21.73%) and omnivorous (19.49%) in the fluvial zone.

Table II: Absolute and relative number (%) of captured fish, and taxonomic position of the species of the Taquaruçu Reservoir, lower Paranapanema River basin.

SPECIES	ORDER / FAMILY	Lacustrine	Transition	Fluvial	TOTAL	%
Loricarichthys platymetopon[1]	Siluriformes / Loricariidae	340	175	566	1081	13.73
Plagioscion squamosissimus[2]	Perciformes / Scienidae	238	131	318	687	8.72
Steindachnerina insculpta	Characiformes / Curimatidae	95	253	307	655	8.32
Auchenipterus nuchalis[1]	Siluriformes / Auchenipteridae	240	53	194	487	6.18
Iheringichthys labrosus	Siluriformes / Pimelodidae	286	81	95	462	5.87
Serrasalmus marginatus[1]	Characiformes / Characidae	112	67	226	405	5.14
Pimelodus maculatus	Siluriformes / Pimelodidae	194	87	116	397	5.04
Parauchenipterus galeatus[1]	Siluriformes / Auchenipteridae	45	96	203	344	4.37
Acestrorhynchus lacustris	Characiformes / Acestrorhynchidae	130	90	115	335	4.25
Trachydoras paraguayensis[1]	Siluriformes / Doradidae	19	43	227	289	3.67
Astyanax altiparanae	Characiformes / Characidae	25	84	142	251	3.19
Schizodon nasutus	Characiformes / Anostomidae	38	83	128	249	3.16
Schizodon intermedius	Characiformes / Anostomidae	30	50	84	164	2.08
Moenkhausia intermedia	Characiformes / Characidae	10	23	130	163	2.07
Leporinus friderici	Characiformes / Anostomidae	38	42	51	131	1.66
Serrasalmus maculatus	Characiformes / Characidae	31	41	46	118	1.50
Hypostomus margaritifer	Siluriformes / Loricariidae	3	15	93	111	1.41
Apareiodon aff. affinis	Characiformes / Parodontidae	4	13	88	105	1.33
Hoplias malabaricus	Characiformes / Herythrinidae	6	35	64	105	1.33
Cyphocharax modestus	Characiformes / Curimatidae	0	16	77	93	1.18
Hypostomus regain	Siluriformes / Loricariidae	24	34	29	87	1.10
Roeboides paranensis[1]	Characiformes / Characidae	18	12	56	86	1.09
Crenicichla sp.	Perciformes / Cichlidae	47	17	11	75	0.95
Eigenmannia virescens	Gymnotiformes / Sternopygidae	11	7	49	67	0.85
Pinirampus pirinampu	Siluriformes / Pimelodidae	41	13	10	64	0.81
Hypostomus ancistroides	Siluriformes / Loricariidae	0	5	54	59	0.75
Loricaria sp.	Siluriformes / Loricariidae	24	19	14	57	0.72
Rinelepis aspera	Siluriformes / Loricariidae	0	50	7	57	0.72
Schizodon borelli	Characiformes / Anostomidae	0	10	36	46	0.58
Leporinus octofasciatus	Characiformes / Anostomidae	6	6	33	45	0.57
Hypostomus sp2.	Siluriformes / Loricariidae	4	11	28	43	0.55
Pimelodella sp.	Siluriformes / Heptapteridae	7	6	22	35	0.44
Myleus tiete	Characiformes / Characidae	8	26	0	34	0.43
Crenicichla britskii	Perciformes / Cichlidae	8	19	7	34	0.43
Loricaria prolixa	Siluriformes / Loricariidae	0	13	15	28	0.36

Table II: Cont.

SPECIES	ORDER / FAMILY	Lacustrine	Transition	Fluvial	TOTAL	%
Galeocharax knerii	Characiformes / Characidae	0	0	27	27	0.34
Pterodoras granulosus[1]	Siluriformes / Doradidae	3	8	15	26	0.33
Hypostomus sp6.	Siluriformes / Loricariidae	3	9	13	25	0.32
Leporinus elongates	Characiformes / Anostomidae	6	7	11	24	0.30
Leporellus vittatus	Characiformes / Anostomidae	2	10	11	23	0.29
Prochilodus lineatus	Characiformes / Prochidodontidae	10	5	7	22	0.28
Rynodoras dorbgnyi	Siluriformes / Doradidae	1	0	19	20	0.25
Crenicichla niederleinii	Perciformes / Cichlidae	0	11	9	20	0.25
Cyphocharax nagelli	Characiformes / Curimatidae	0	8	11	19	0.24
Geophagus brasiliensis	Perciformes / Cichlidae	7	0	12	19	0.24
Gymnotus cf. carapo	Gymnotiformes / Gymnotidae	0	0	19	19	0.24
Sternopygus macrurus	Gymnotiformes / Sternopygidae	2	0	16	18	0.23
Apareiodon piracicabae	Characiformes / Parodontidae	0	0	14	14	0.18
Pseudopimelodus zungaro	Siluriformes / Pimelodidae	1	4	8	13	0.17
Hypostomus sp3.	Siluriformes / Loricariidae	0	0	12	12	0.15
Leporinus striatus	Characiformes / Anostomidae	0	0	12	12	0.15
Hypostomus sp.	Siluriformes / Loricariidae	2	2	7	11	0.14
Hypostomus sp4.	Siluriformes / Loricariidae	3	1	6	10	0.13
Pimelodus ornatus[1]	Siluriformes / Pimelodidae	4	5	0	9	0.11
Leporinus lacustris	Characiformes / Anostomidae	6	1	2	9	0.11
Raphyodon vulpinus[1]	Characiformes / Characidae	0	5	4	9	0.11
Porotergus ellisi	Gymnotiformes / Sternopygidae	0	0	9	9	0.11
Clarias gariepinnus[3]	Siluriformes / Clariidae	0	0	7	7	0.09
Leporinus paranensis	Characiformes / Anostomidae	2	3	2	7	0.09
Metynnis maculatus	Characiformes / Characidae	3	4	0	7	0.09
Leporinus amblyrhynchus	Characiformes / Anostomidae	4	2	0	6	0.08
Schizodon altoparanae	Characiformes / Anostomidae	0	3	2	5	0.06
Megalancistrus aculeatus	Siluriformes / Loricariidae	3	1	0	4	0.05
Hypostomus sp1.	Siluriformes / Loricariidae	4	0	0	4	0.05
Rhamdia sp.	Siluriformes / Heptapteridae	0	0	3	3	0.04
Leporinus obtusidens	Characiformes / Anostomidae	1	2	0	3	0.04
Triportheus angulatus[2]	Characiformes / Characidae	0	0	2	2	0.03
Rhamphychthys sp[1]	Gymnotiformes / Rhamphychthidae	0	2	0	2	0.03
Sorubim lima[1]	Siluriformes / Pimelodidae	1	0	0	1	0.01
Megalonema platanus	Siluriformes / Pimelodidae	0	0	1	1	0.01

Table II: Cont.

SPECIES	ORDER / FAMILY	Lacustrine	Transition	Fluvial	TOTAL	%
Astyanax fasciatus	Characiformes / Characidae	0	0	1	1	0.01
Salminus hilarii	Characiformes / Characidae	0	0	1	1	0.01
Salminus maxillosus	Characiformes / Characidae	0	0	1	1	0.01
		2150	1819	3905	7874	

[1] species transposed from the lower Paraná River; [2] species introduced, originating in other Brazilian basins, [3] species introduced from other continents.

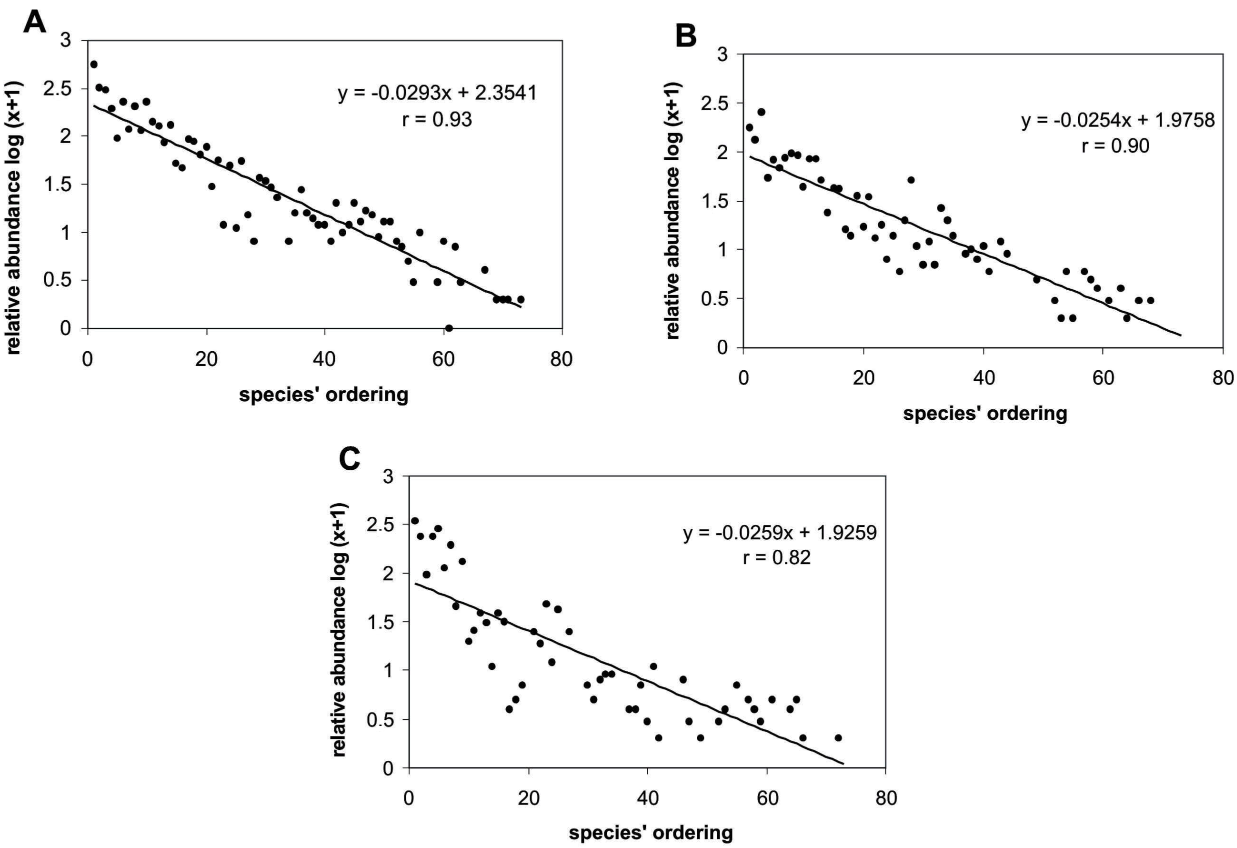

Figure 2: Species importance curve, with the linear lift transformed abundance data (log n + 1) and species orders for A) fluvial zone, B) transition zone and C) lacustrine zone (r = Pearson´s respective coefficients).

Table III: Ecological attributes of the fish communities for the three zones of Taquaruçu Reservoir, lower Paranapanema River basin. (H' = Shannon-Wierner diversity, E = Pielou evenness, R = Margalef species richness, n = number of individuals and N = species.)

	H'	E	R	n	N
Lacustrine	2.84	0.73	4.69	2150	50
Transition	3.30	0.82	5.21	1819	55
Fluvial	3.32	0.80	5.91	3905	64

Table IV: Descriptive statistics of CPUE (kilograms) for three stretches of the Taquaruçu reservoir, lower Paranapanema River basin. (Number of samplings N = 29; equal letters = diferences not statistically significant (ANOVA, a = 0.05)).

Statistics	CPUE(b)		
	Fluvial	Transition	Lacustrine
Total	815.82	620.54	617.96
Maximum	0.63	1.31	5.12
Minimum	131.30	114.80	47.10
Amplitude	130.67	113.49	41.97
Mean	28.13[a]	21.40[a]	21.31[a]
SD	249.70	227.46	107.46
Variation Coefficient (%)	104.76	106.30	50.43

Table V: Relative frequency (%) in number of the trophic groups present in the three zones of the Taquaruçu Reservoir, lower Paranapanema River basin.

Trophic groups	lacustrine	transition	fluvial	reservoir
Piscivorous	27.79	23.07	21.73	23.91
Carnivorous	33.18	12.41	17.02	20.74
Omnivorous	13.84	21.67	19.49	19.35
Detritivorous	19.69	15.78	21.73	18.11
Iliophagous	5.50	17.74	13.03	10.97
Herbivorous	0.00	9.33	6.99	6.92

Discussion

We verified that the 73 species registered in the Taquaruçu reservoir are inserted among the 221 already catalogued for the Upper Paraná Basin (Agostinho & Júlio Jr., 1999). In general, despite the replacement of some species, the composition of the ichthyofauna of this reservoir corroborates Agostinho et al. (1995), in the review on the ichthyofauna of the Upper Paraná Basin, whose majority of species do not undertake long migrations and adjust well to new lacustrine conditions derived from river damming (Carvalho et al., 1998).

However, these species differentially distributed along the reservoir, being strongly influenced by their limnological conditions. Contain still, a greater lato sensu species richness (and abundance) in the fluvial area, to the detriment of the lacustrine one, indicating their strategies of life and capacities of adjustments in the face of environmental characteristics. Several authors (Carvalho et al., 1998; Agostinho et al., 1999; Orsi, 2005), studying the fish communities in reservoirs of the upper Paraná river also discussed this influence of the aquatic environment under the structuring of these fish communities.

Further, as for the lato sensu richness of the Taquaruçu's fish, our result coincides with the theory advocated by Lowe McConnell (1987) and Minns (1989), in which they suggest that, the lato sensu richness of fish in great rivers, shows a spatial trend of increasing from the river source towards the mouth. That is so, because the number registered in this study is greater than those verified in the reservoirs of Jurumirim (Carvalho et al., 1998) and Salto Grande (Dias &

Garavello, 1998), of the Upper and Middle Paranapanema, respectively, with 49 and 51 fish species, but close to those of the Capivara reservoir, in its amount, for which 79 species were identified (Orsi, 2005). A more plausible hypothesis for this "similarity" (number of species, being Taquaruçu = 73 and Capivara = 79) is probably linked to Capivara´s more dentritical condition (owing many more tributaries = habitats). Species richness has been associated with several variables, among which the complexity of the habitat (Wooton, 1998), and the marginal development (Eadie & Keast, 1984).

Fernando & Holcik (1991) claim that the diversity of fish in reservoirs is smaller and directly proportional to that in their forming rivers, while Tonn (1990), discusses the importance of predation/competition processes in the structuring of fish communities. The drainage basin area of the Taquaruçu is small, with a few tributaries, and its main body is almost totally inserted in its accumulation basin, presenting very distinct limnological characteristics among its compartments, mainly concerning water flow (velocity) and water transparence (CESP, 1996). This way, one may infer that the lato sensu species richness in Taquaruçu is most related to factors such as the number of pre-existing species in the phase river; the addition of nonnative species and the inter and intra-specific relations established following the filling of the reservoir.

In other reservoirs, upstream, it is verified that there is always a predominance in the number of Characiformes species over the other Orders (Dias & Garavello, 1998, Carvalho et al., 1998; Bennemann et al., 2000; Orsi, 2005), being this situation maintained in Taquaruçu (in this study). Nevertheless, when abundance is analyzed, a numerical predominance of Siluriformes over Characiformes is seen. We believe that this condition is associated with its geographic localization in the lower Paranapanema river (it is the penultimate of the reservoirs cascade) and the transposition of species originated in the lower Paraná river, upon the filling of Itaipu and the drowning of Sete Quedas in Guairá (Bonetto, 1986).

Also, we verified another inversion in a fish ecological attribute (constancy of capture) between Taquaruçu and two reservoirs upstream, Salto Grande (Dias & Garavello, 1998) and Jurumirim (Carvalho et al., 1998). These authors showed that the lacustrine compartments of these reservoirs contained a greater number of sedentary species (residents) in relation to upper stretches (transition and fluvial). However, we obtained an inverse pattern. One realizes, amidst the number of species constant in these environments, an important participation of nonnative species. The species which comprise the ichthyofauna of the Taquaruçu River and the ecological relations among them, possibly reflect the situation, considering their structure, quite distinct in relation to those of the reservoirs mentioned, given the presence of species not registered upstream. At the same time, it is worth considering that the greater number of constant species, specially nonnative ones, in the fluvial environment, is related to their persistence, given the effectiveness in exploring the niches occupied in the upper stretch (Veregue & Orsi, 2003).

The influence of the limnological conditions of each zone on the structure and distribution of ichthyofauna was quite evident in the analyses for ecological attributes, as it was verified in other reservoirs of the Paranapanema (Carvalho et al., 1998; Orsi, 2005) as well as in the upper Paraná (Benedito-Cecílio et al., 1997; Santos, 1999). We verified that there is a smaller ichthyofaunistic complexity in the lacustrine environment (along the dam), in relation to the fluvial one (downstream the Capivara power plant).

Ichthyofauna compartmentalization deriving from the damming of the Taquaruçu and additional factors (e.g., the transposition of new species) is discriminated in the species´ importance curves (Fig. 2), which shows the species of fish communities, in the fluvial environment (Fig. 2A), better distributed and shared (better adjustment of Pearson's coefficient), as compared to transition (Fig. 2B) and lacustrine (Fig. 2C) environments. This interpretation may, indicate the degree in which damming influences the restructuring of these fish communities, with evidences of a larger unbalance among abundant and rare species, in the lacustrine environment. A similar fact has been described by Santos (1999) for some reservoirs of the Rio Grande.

CPUE (in number and weight), utilized as a measure of fish relative abundance (Santos, 1999), was another tool which evidenced the differentiated fish distribution in the Taquaruçu reservoir. CPUE in number and weight in the fluvial environment was proportionally greater than that of other compartments, indicating a larger seasonal recruitment of fish in this stretch of higher hydraulic instability, owing to pulses of flood in upstream reservoir (Capivara), conditioning the greater variation of CPUE. The lacustrine environment, with smaller variations, reflects a greater stability, associated with a smaller intensity of flooding pulses and small variations of water level (operational characteristics of the plant). This hypothesis is consistent with that proposed by Aggus & Lewis (1977 in Ploskey, 1986).

Further, by comparing the values of CPUE with the data for other reservoirs of this basin, with the same sort of sampling effort (gill-nets) (Dias & Garavello, 1998; Carvalho, et al., 1998; CESP, 1998; Orsi, 2005), we conclude that the Taquaruçu, presents today, a greater fishing production. We postulate that this condition is associated with the reservoir being located in the lower part of the drainage (sensu Lowe McConnell, 1987), besides the presence of transposed species, which have not yet been registered in upper stretches of the Paranapanema's drainages.

Wootton (1990) claims that the number of species present in an aquatic ecosystem is linked to the range of habitats and food sources available, acting as quali/quantitative modulators for the resident fauna, providing the conditions for life cycles to be completed (Carvalho et al., 2005). Taking into account limnological alterations deriving from dammings promote modifications in biotic interactions, particularly those of a trophic nature (Araújo-Lima et al., 1995; Hahn et al., 1998), it is expected that new limnological forces determine an availability of new food niches, ordering a new sharing of these resources with a differential distribution of fish communities.

Following the relation between the supply of food resources and the faunistic composition inserted in a given kind of ecosystem, in that case, lacustrine, transition or fluvial, we verify the presence of differentiated dominant trophic groups, as it was found by Lowe McConnell (1987) and Agostinho & Júlio Jr (1996).

The differentiated structuring of the ichthyofauna in the reservoir's gradient, discriminated in the analyses, reflected, too, in the ichthyofaunistic similarity for the environments studied. According to Jaccard's index, the analysis showed that the lacustrine and transition environments are more similar to each other than the fluvial environment. This disposition indicates a greater connection among these environments, sharing more common species, in relation to the upper fluvial stretch, as it was also, recorded by Dias & Garavello (1998) and Carvalho et al. (1998) for the reservoirs of Salto Grande and Jurumirim, respectively. Thus, for Taquaruçu and the other reservoirs mentioned, the greatest similarity indexes were obtained among areas most affected by water accumulation.

Conclusions

Amidst the main impacts observed by the formation of the reservoir, we can verify that the alteration of the water flow and the creation of distinct environments directly influenced the distribution of fish communities, with an explicit longitudinal vectorial component. It was also verified that the fluvial environment, within the basin of the Taquaruçu's reservoir, accumulates the greatest richness, diversity and abundance, in relation to other stretches, as it was also recorded for various reservoirs of the Paranapanema and Upper Paraná. Therefore, the hypothesis that spatial vectorization of the Ichthyofauna in response to the imposed physical and limnological variations is a predictive (and inherent) factor of the formation of reservoirs in the basin of the Upper Paraná river, with greater abundance and diversity in the superior stretches.

The environmental changes, together with to the colonization of the basin of the Taquaruçu´s reservoir by species originating in the middle Paraná, transposed following the construction of the Itaipu reservoir, and the successful introduction of P. squamosissimus, present a rather unique constitution of the Ichthyofauna, as compared to other reservoirs of the middle and upper Paranapanema.

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