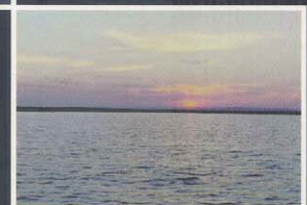
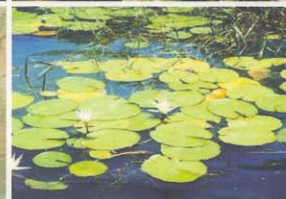


Structure and functioning of the Paran River and its floodplain

LTER - site 6
(PELD stio 6)



Angelo Antonio Agostinho
Liliana Rodrigues
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Fish Assemblages of the Seasonally Isolated Lagoons of the Upper Paraná River Floodplain

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Pitágoras Augusto Piana
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Angelo Antonio Agostinho

Abstract

Diversity of the ichthyofauna and stock size of large-body migratory species of the Upper Paraná River floodplain depend in large part on the conservation and integrity of the marginal lagoons. The objectives of this study were to characterize the fish assemblage of the seasonally isolated lagoons and identify the possible sources of variation between subsystems (Paraná, Baía, and Ivinheima Rivers) and collection years (2000 and 2001). Significant differences in density, captured biomass and species richness were found between subsystems. The Ivinheima was characterized by the highest occurrence of migratory species, while forage species predominated in the Paraná. Species richness and the various reproductive and feeding strategies seem to result from environmental heterogeneity and the differentiated pressures of the biotic and abiotic factors to which the ichthyofauna of these sites have been submitted.

Key words: Fish assemblage. Marginal lagoons. Paraná River.

Resumo

A diversidade da ictiofauna e o tamanho do estoque de espécies migradoras de grande porte da planície de inundação do alto rio Paraná depende em grande parte da conservação e integridade das lagoas marginais. Os objetivos deste estudo foram caracterizar a assembléia de peixes das lagoas sazonalmente isoladas e identificar as possíveis fontes de variação entre subsistemas (rios Paraná, Baía e Ivinheima) e anos de coleta (2000 e 2001). Diferenças significativas na densidade, biomassa capturada e riqueza de espécies foram encontradas entre subsistemas. O subsistema Ivinheima foi caracterizado pela maior ocorrência de espécies migradoras, enquanto espécies forrageiras predominaram no Paraná. A riqueza de espécies e as várias estratégias reprodutivas e alimentares parecem resultar da heterogeneidade ambiental e das pressões diferenciadas dos fatores bióticos e abióticos aos quais a ictiofauna desses locais tem sido submetida.

Palavras-chave: Assembléia de peixes. Lagoas marginais. Rio Paraná.

Introduction

Marginal lagoons in river floodplains are widely recognized for their importance in the maintenance and integrity of regional biodiversity, and as natural nurseries of commercially important species, the majority of which are long-distance migratory species (AGOSTINHO; VAZZOLER; GOMES; OKADA, 1993; AGOSTINHO; THOMAZ; MINTE-VERA; WINEMILLER, 2000). Additionally, they are recognized as a preferential habitat of sedentary and small-sized species. Factors such as heterogeneity of microhabitats, availability of resources, and seasonal connection to the rest of the system through periodic floods permit the species to find conditions favorable to survival in the lagoons. However, adverse factors such as recruitment failure and mass mortality of individuals (including local extinctions during the period of water retraction) are intensified in systems subject to flow regulation by upstream hydroelectric power stations due to the long period of isolation and/or abrupt level reductions.

Considering the spatial-temporal heterogeneity to which the Upper Paraná River floodplain is subject (AGOSTINHO; THOMAZ; MINTE-VERA; WINEMILLER, 2000), this study has as its objectives the characterization of the fish assemblage of the seasonally isolated lagoons and identification of the possible sources of variation in a wide area sampled for two consecutive years.

Characterization of the Hydrological Cycle

The hydrological cycle was characterized from November to May (flood period) from 1999 to 2002. The number of days in which the hydrometric level of the Paraná River exceeded critical flood thresholds (>350 cm; VERÍSSIMO, 1994) - (*duration*), the annual average of the flood levels - (*intensity*) and the coefficient of variation of the levels - (*variability*) were recorded and are shown in Figures 1A and 1B. The duration of the floods on the Upper Paraná River floodplain was shorter from May 2000 to April 2001 (19 days), occurring intermittently and late, and their intensity and variability were lower. The more lasting and intense flood years were also those in which the variability in the level was more conspicuous. This is to be attributed to the operation of Porto Primavera Dam (closed at the end of 1998). In addition to the virtual absence of floods in 2000/2001, and considering the historical November-March seasonality (AGOSTINHO; ZALEWSKI, 1996), floods in the other study years occurred late (March 2000 and the end of January 2001).

Characterization of the Assemblage

Fish were sampled quarterly from February 2000 to November 2001 in nine seasonally-isolated lagoons within three subsystems on the Upper Paraná River floodplain, i.e. the Paraná (4 lagoons), Baía (2 lagoons), and Ivinheima (3 lagoons). Samples were taken with 20-m seining nets, with the numerical

abundance expressed in no. ind./100 m² (density) and the biomass expressed in g/100 m² (captured biomass). The characterization of the assemblage was based on the captured biomass data (reproductive strategy and trophic category) and the frequency of immature individuals. Dominance (1-Equitability), the Shannon Diversity Index (H') and species richness (S) described assemblage structure. Analyses of density, captured biomass and species richness used two-way analysis of variance (ANOVA; general linear models-GLM). A Tukey test was applied when significant differences were detected between means. Analyses of dominance and diversity indices used one-way analysis of variance (ANOVA; EcoSim) using null models (5000 randomizations) when the assumptions of the analysis (normality and homoscedasticity) were not met (GOTELLI; ENTSMINGER, 2003). The temporal (2000 and 2001) and spatial (Paraná, Baía, and Ivinheima subsystems) scales were considered sources of variation.

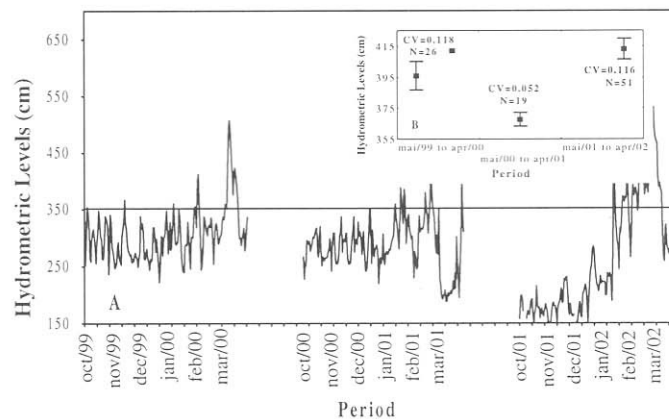


Figure 1 - Hydrometric levels of the Paraná River recorded in Porto São José, Paraná State (A). Data supplied by DENAEE (Departamento Nacional de Águas e Energia Elétrica). Straight line at the 350 cm level represents the overflow level of the channel (VERÍSSIMO, 1994). Mean (\pm standard error; SE) of the hydrometric levels above the critical flood threshold (>350 cm; VERÍSSIMO, 1994). CV = coefficient of variation, N = number of flood days (B).

Neither the density nor the captured biomass of the ichthyofauna of the seasonally isolated lagoons of the Upper Paraná River floodplain reflected the differences observed in the hydrological cycle during the period studied ($p>0.05$). We suspect this lack of relationship is associated with the alteration of the extensive flood regime in the years considered. Differences were found only between the subsystems, both for density ($F_{2, 61}=18.35$; $P<0.01$; Figure 2A) and captured biomass ($F_{2, 61}=10.29$; $P<0.01$; Figure 2B), and the Paraná subsystem differed significantly from the others ($P<0.05$). These tendencies may be attributed to the high concentration of fishes in the lagoons of the Paraná River, a consequence of the low water levels observed during the study years,

which differed over subsystems.

Captured biomass, when distributed over the main reproductive strategies, revealed contribution from migratory species (higher in 2001) only in the Ivinheima subsystem (Figure 3A, 3B). *Prochilodus lineatus*, a large-sized iliophagous and typical migratory species whose young inhabit floodplain lagoons, occurred only in samples in this subsystem, where the floods occurred regularly inasmuch as this basin has not been impounded.

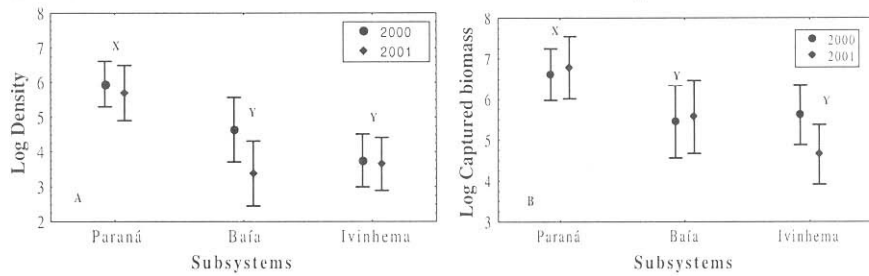


Figure 2 - Density (A) and captured biomass (B) (mean±SE) of the fish assemblage of the seasonally isolated lagoons of the Upper Paraná River floodplain. X and Y indicate significant differences between the means.

The drastic reduction in the occurrence of *P. lineatus* in the floodplain in relation to previous periods (OKADA, 1995; AGOSTINHO; JÚLIO JUNIOR; GOMES; BINI; AGOSTINHO, 1997) confirms that the success in its recruitment is intimately related to the occurrence of floods (GOMES; AGOSTINHO, 1997). Captured biomass of non-migratory fishes predominated in all subsystems, being more abundant in the Paraná River.

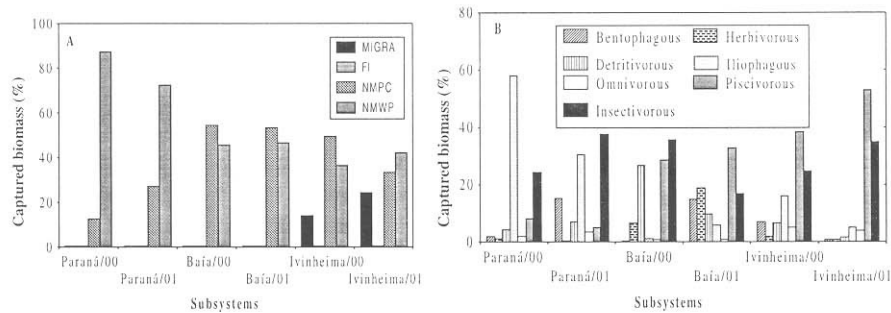


Figure 3 - Captured biomass per reproductive strategy (A) and trophic category (B) of the fish assemblage of the seasonally isolated lagoons of the Upper Paraná River floodplain. MIGRA (migratory), FI (internal fecundation), NMPC (non-migratory with parental care), NMWP (non-migratory without parental care).

The iliophagous, especially *Steindachnerina insculpta*, a small-sized sedentary fish, made up the main trophic category in the catches in the lagoons of the Paraná subsystem, followed by the insectivorous *Astyanax altiparanae* and *Moenkhausia sanctaefilomenae*. Although the insectivorous had made important

contributions to all the subsystems, they were surpassed by the piscivorous in the Ivinheima subsystem.

Dominance per sample varied from 0.05 (Ivinheima; Capivara Lagoon; August 2000) to 0.85 (Paraná; Pousada Lagoon; February 2000), being higher in 2000 (mean 0.38; SE±0.02) than in 2001 (mean 0.32; SE±0.03) and higher in the Paraná subsystem (mean 0.39; SE±0.03) than in the other subsystems (Baía mean 0.32; SE±0.04; Ivinheima mean 0.34; SE±0.03). Variability in dominance is reflected in the diversity indices that varied from 0.41 to 2.35, being lower in 2000 (mean 1.48; SE±0.07) than in 2001 (mean 1.63; SE±0.07) and similar between the Paraná (mean 1.57; SE±0.08), Baía (mean 1.54; SE±0.10), and Ivinheima (mean 1.55; SE±0.08) subsystems. Species richness per sample varied from 3 to 23. In 2000 and 2001, 12 species (SE±0.70) were recorded on average. A larger number of species was recorded in the Paraná subsystem than in the Baía and Ivinheima subsystems. Significant differences between the mean values were determined only for species richness on a spatial scale ($F_{2, 61}=4.22$; $P=0.02$) between the Paraná and Baía subsystems ($P=0.04$; Figure 4).

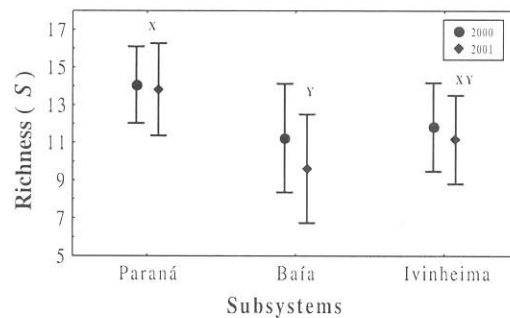


Figure 4 - Species richness (mean±SE) of the fish assemblage of the seasonally isolated lagoons of the Upper Paraná River floodplain. X and Y indicate significant differences between the means.

Considering their location on the fluvial islands of the Paraná River, hydrological connections between the lagoons of this subsystem and the rest of the floodplain occur only during great floods, absent in the period investigated. Thus, the lagoons of the Paraná subsystem remained isolated longer than the others. When there was contact, it was intermittent and late in relation to the spawning period of most species.

The heterogeneity of the lagoons and the differentiated pressures from the biotic and abiotic factors at these sites may have contributed to the greater ichthyofaunistic richness of the Paraná subsystem. However, the high dominance in some of these lagoons reveals possible reductions or even failures in the recruitment of most of the species that are more sensitive to prolonged periods of drought, as well as better survival by better-adapted species, resulting in the absence of differences in the diversity index between the subsystems.

This tendency has been recorded in areas under the effect of the flow control exercised by hydroelectric power stations on the Upper Paraná River floodplain (VERÍSSIMO; AGOSTINHO; OKADA; GOMES, in press) and in Australian rivers (GEHRKE; BROWN; SCHILLER; MOFFATT; BRUCE, 1995).

The reduced occurrence of large-sized migratory species in the seasonally isolated lagoons of the Upper Paraná River floodplain emphasizes the importance of adopting mitigating measures for the impacts to which the floodplain is submitted, especially the flow regulation of the Paraná River by the hydroelectric power stations upstream. Factors such as the high richness of life forms, due to the reproductive and feeding strategies exhibited by the ichthyofauna, as well as the importance of the lagoons as preferential habitats in the initial phases of commercially important species, demonstrate that these environments constitute true reservoirs of regional biodiversity.

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