Effet des macrophytes aquatiques sur la structure des assemblages de poissons dans la plaine inondée du Haut Paraná (Brésil)

Influence of Aquatic Macrophytes on Fish Assemblages Structure of the Upper Paraná River Floodplain (Brazil)

Angelo A. Agostinho, Sidinei Magela Thomaz, Solma L.S.M.A.Baltar, Luiz C. Gomes
Universidade Estadual de Maringá-Nupélia, Av. Colombo 5790 - 87020-900 Maringá, PR, Brazil
Phone +55 44 2614610, Fax +55 44 2631424, E-mail: agostinhoaa@nupelia.uem.br

Résumé: La richesse spécifique, l'abondance et la composition spécifique des poissons ont été observées à l'intérieur et à l'extérieur de bancs de macrophytes dominés par *Eichhornia azurea* dans 4 habitats semi-lentique de la plaine inondée du Haut Paraná (Brésil), et à différentes périodes du jour. La richesse spécifique et l'abondance étaient toujours plus élevées sur le bord des bancs de macophytes qu'à l'extérieur. Les longueurs moyennes étaient significativement plus élevées dans la zone ouverte. La structure de l'assemblage de poissons et ses variations au cours de la journée peuvent être expliquées par la disponibilité des ressources alimentaires, la pression de prédation et les restrictions en oxygène.
Mots-clé: Relation poisson-macrophytes, Fleuve Paraná, Eichhornia azurea, structure des assemblages de poissons, poissons néotropicaux.

Abstract: *The species richness, abundance and length composition of fishes were assessed inside and outside stands of macrophytes dominated by* ***Eichhornia azurea*** *in four semi-lentic habitats of the Upper Paraná River floodplain (Brazil), in different periods of the day. Species richness and abundance were consistently higher in the stand borders and lower outside. Mean length values were significantly higher in the open area. The structure pattern of the fish assemblage and its variation during a day can be explained by food resource availability, predation pressure and oxygen restrictions.*
Key words: *Fish-macrophytes relationship, Paraná River,* ***Eichhornia azurea****, fish assemblage structure, neotropical fishes.*

Introduction

In general it is accepted that aquatic macrophytes have a strong influence on fish assemblages structure. They provide benefits due to their effects on the balance of the forage efficiency of predators with refuge needs for prey, provide higher carrying capacity for food resources due to the availability of substrates for food items and higher productivity by the positive effect on light penetration in pelagic areas (Miranda & Hodges, 2000). Thus, stands of macrophytes present higher concentration of food and shelter to avoid predation, contributing to increase habitat heterogeneity, promoting diversity and stability (Schramm, Jirka & Hoyer, 1987). However, high density of macrophytes can generate physical and chemical restrictions to fish assemblages, specially hypoxic condition during the hot season, at night (Miranda et al., 2000). It is expected that these positive and negative effects on the fish fauna can explain the horizontal distribution and diel displacement of fishes in lentic environment surrounded by stands of macrophyte. Fish assemblage responses to these conditions are variable depending on species composition, predominant life strategies and ontogenetic phase.

Most research on this subject compares fish fauna between lakes with different macrophyte covers (Delariva et al., 1994; Fernandez et al., 1998; Meschiatti et al., 2000; Suarez et al., 2001; Vono & Barbosa, 2001). Meso-scale studies (comparisons between littoral and open areas) are scarce for the neotropical fauna (Araujo-Lima et al., 1986), probably because of difficulties related to accuracy of sampling fish in vegetated habitats. In this context, the aim of this study was to assess the influence of marginal macrophyte stands on the horizontal distribution and diel displacement of fishes in semi-lentic habitats of the Upper Paraná River, at a meso-habitat scale.

Methods

Fish samplings were carried out in the Baía River, a semi-lentic environment of the Upper Paraná River floodplain, in four stands dominated by *Eichhornia azurea*, one of the most frequent species in the floodplain (Bini et al., 2001). This plant is rooted in the sediment and its long floating stems (up to 8 meters) develop few centimeters below the water surface, forming dense stands which can reach more than 50 meters wide. The existence of aquatic roots and emergent leaves, together with the floating stems, increase the spatial structure of the littoral regions colonized by this species.

A squared floating enclosure trap type "pool up net" (1.0 x 1.0 m) was used to capture fish. This gear has a net (5 mm mesh size) attached to a floating frame which is maintained close to the bottom by a heavy metallic structure. An electronic mechanism activated by remote control liberates the floating frame which suddenly reaches the surface, enclosing plants and fishes inside it. Before sampling, the trap remained at least 6 hours onsite to minimize the effects of disturbance on fish. To test the effect of aquatic vegetation on fish distribution, the trap was positioned in the pelagic region (open area) and in two places underneath the floating vegetation: in the middle of the stand and in its border (close to the pelagic zone), named here "position" (4 replicates). To test the effect of time on spatial distribution of fishes, the samplings were carried out at 6h00, 12h00 and 18h00, named here "time of the day"(4 replicates). In all 36 sampling, fishes and aquatic macrophytes from inside the trap were collected. Fishes were measured, weighted, identified and counted. Values of dissolved oxygen were obtained simultaneously to the samplings.

Two way ANOVA was used to determine differences in dissolved oxygen concentration according to position and time of the day (factors). A detrended correspondence analysis (DCA) was performed to summarize fish assemblage abundance and composition. The scores of the ordination were generated and analyzed through two-way ANOVA (position and time of the day as factors). We assumed that samples apart on the ordination presented distinct fish abundance and composition. Two-way ANOVA was also used to assess the effect of position and time of the day on species richness and size structure of fish assemblage.

Results and discussion

Dissolved oxygen is one of the most important abiotic variables determining fish distribution and it experiences wide diel fluctuations inside littoral regions (Miranda & Driscoll, 2000). Mean oxygen concentration (Fig.1a) differed significantly only among positions (Two Way ANOVA; $F=3.51$; $p=0.04$). Open area presented higher oxygen concentration (8.31mg.L^{-1}) than middle (6.53mg.L^{-1}) and border (7.68mg/l) of the macrophyte stand, and the former differed from the others (Tukey Test a posteriori; $p<0.02$). Despite such differences, oxygen probably did not affect fish distribution during our samplings, given that concentrations were usually higher than 6.0 mg/L and the lowest concentrations (3.4-4.4 mg/L) were obtained in only one sampling occasion, in all positions (either inside and outside the stand).

A total of 538 individuals belonging to 16 species were caught, most of them Characiformes (11) and Gymnotiformes (3). The fishes collected were juveniles or small sized species (size ranging from 1.1 to 26.2cm; total length), with 87% smaller than 10.0cm. The most abundant species were three characids (*Roeboides paranensis*, 41,6%; *Moenkhausia sanctafilomenae*, 20,8%; *Hyphessobrycon* sp., 8,4%) and one gymnotid (*Eigenmannia trilineata*, 7,3%). The dominance of small characids in vegetated water areas has been described for some neotropical environments (Araujo Lima et al., 1986; Delariva et al., 1994; Meschiatti et al., 2000), but with different fish composition. In opposite to the regional trend of fish fauna (170 species; Agostinho & Julio Jr, 1999), the Siluriformes were rare both in abundance and in species richness (only one species caught; *Hypostomus* sp.). In general, species that occupy such habitats need adaptations to inhabit the most oxygenated water of the more superficial layers, what confers advantage to small characids.

The patterns of species composition and abundance according to position and time of the day were summarized by a DCA. Two-way ANOVA revealed significant differences (interaction position*time; $F=3.71$; $p=0.02$) only for the first DCA axis (eigenvalues=0.84). Then, the distribution patterns among position (middle and border of the macrophyte stands and open area) were strongly influenced by the time (6h, 12h and 18h), suggesting an intense fish movement in the area (Fig.1b).

The total number of fishes caught was greater in the border of the macrophyte stands (67.5%) and lower in the open area (8.7%). This trend was verified all day long, but the differences in abundance increased in the morning. In the open area, the maximum abundance was verified at noon, while in the middle of the macrophyte stands fishes were concentrated at dusk. Species richness presented similar trend (Fig.1c). However, only the factor position showed significant differences (Two-way ANOVA; $F=10.6$; $p<0.01$), and the richness was greater at the border (Tukey test a posteriori; $p<0.05$). All 16 species were recorded at the border of the macrophyte stands. Six species were restricted to this microhabitat (*Hypostomus* sp., *Serrapinnus* spp, *Schizodon borelli*, *Aphyocharax anisitisi* and *Crenicichla britski*), while other six were recorded in the three positions, however in different abundances.

Mean total length of fishes also presented spatial and temporal differences (Fig.1d). ANOVA revealed strong interaction among position and time of the day (Two-way ANOVA; $F=3.71$; $p<0.02$), indicating that fish with different sizes moved in distinct ways in the area. Larger fishes were recorded at morning in the open area (*Hoplias malabaricus*; *Eigenmannia* sp.). Similar trend was verified at noon, but the main species was *Eigenmannia virescens*. During dusk, the total lengths among the position were more homogeneous. Intra-specific variations on the total length among position were conspicuous for the six species with generalized distribution. In general, the largest individual were caught in the open area, while the smallest in the middle of the macrophyte stands.

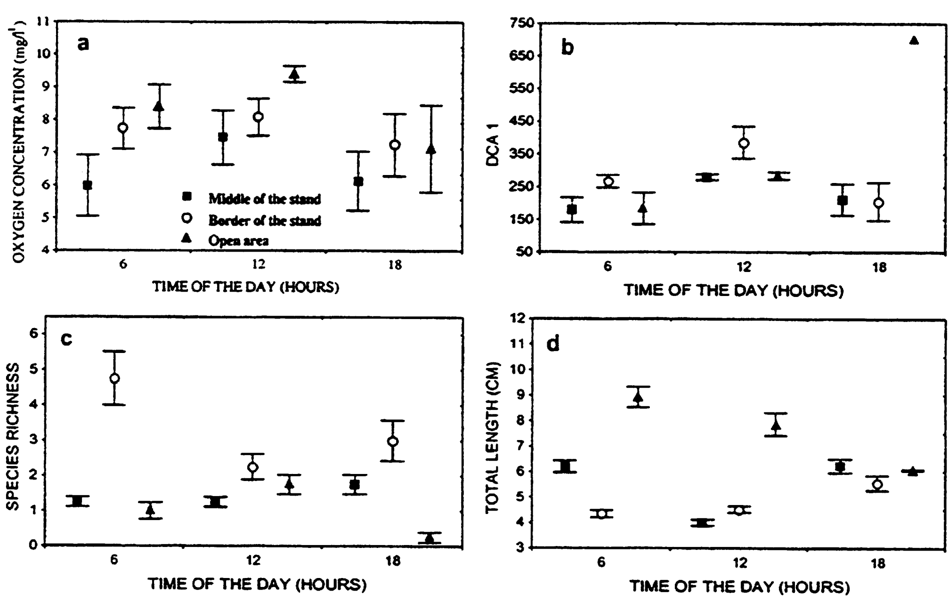

Figure 1 : Variations of mean oxygen concentration (a), scores of DCA (b), species richness (c) and mean total length (d) according to sample position and time of the day (vertical bars=standard error).

Figure 1 : Variations de la concentration moyenne en oxygène (a), des scores de l'analyse des correspondances (b), de la richesse spécifique (c) et de la longueur totale moyenne (d) selon la position de l'échantillon et le moment de la journée. (barres verticales = déviation standard).

In relation to feeding, only two species use macrophytes directly as food (*Schizodon borelli* and *Astyanax fasciatus*). They contributed with 3% of the total catches, and were registered essentially in the border of the stands (93%). Other species intake invertebrates, mainly insects that live on macrophytes (7 species; 84% of the total catches), or algae (3 species; 10%), and they were concentrated in the middle or in the border of the macrophyte stands. Three piscivores species were collected, one obligatory (*Hoplias malabaricus*) and two facultative (*Crenicichla britskii* and

Serrasalmus marginatus), but their captures occurred essentially in the open area (67%) or close to the border (33%). Their presence in the open area can be related to the low abundance of small sized species and juveniles outside the macrophyte stands. The open area was restrictive to smaller individuals of every species.

In spite of the oxygen concentrations recorded during sampling being not restrictive to fish, the trend of lower values in the middle of the stands can be related to the absence of some species (lower richness) and lower abundance compared with the border position.

Finally, we can conclude that the structure pattern of the fish assemblage (composition and abundance) and its variations during a day, described in this study, can be explained by factors like food resource availability, predation pressure (presence of piscivorous fishes) and oxygen restrictions, recognized as important for fish distribution in such type of habitat (Mittlebach, 1981; Savino & Stain, 1982; Miranda et al., 2000).

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