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Invertebrate fauna associated with floating macrophytes in the floodplain lakes of the Orinoco (Venezuela) and Paraná (Argentina)

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Introduction

Very little is known about the energy flux structure of tropical floodplains (Hamilton et al. 1992). One of the most important links of the food web and energy flux in tropical floodplain lakes is the invertebrate fauna associated with the root-system of floating macrophytes. Although a variety of aquatic macrophytes grow in these floodplain lakes, *Eichhornia crassipes* seems to be one of the most important in this study; like *Paspalum repens,* its high adaptability to different enviromental changes and its continous presence on both river floodplains show as an interesting "bioform index" at meadow borders when submitted to a biocenosis dynamic comparison for the two river floodplain systems. The purpose of this study is to compare the impact of flood pulses on the seasonal evolution of invertebrate fauna associated with the root-system of *E. crassipes* (water hyacinth) in tropical-subtropical floodplain lakes of two large South American rivers. In addition to taking stage height measurements of the Orinoco and Paraná rivers, records were made of the dissolved oxygen and conductivity of macrophyte beds to relate changes in invertebrate densities and functional feeding groups for the purpose of identifying a faunal response.

Habitat investigated

The Paraná River drains the second largest watershed of South America (area: 3×10^6 km^2; length: 4,000 km; discharge: 16,000 m$^3 \cdot$ s), whereas the Orinoco drains the third largest watershed of the continent (area: 1×10^6 km^2; length: 2,150 km; discharge: 36,000 m$^3 \cdot$ s). The lower Paraná River exhibits a plurimodal seasonal innundation pattern with relatively small water level fluctuations (2–6 m) that last from 2 weeks to 3 months (Fig. 1). This phenomena makes it necessary to take into account magnitude, intensity and residence time of river water in order clearly to record biological changes (Neiff 1990). The Lower Orinoco River, on the other hand, demonstrates a unimodal seasonal pattern (Fig. 2) that typically lasts for 4–6 months with a higher water-level fluctuation (10–12 m).

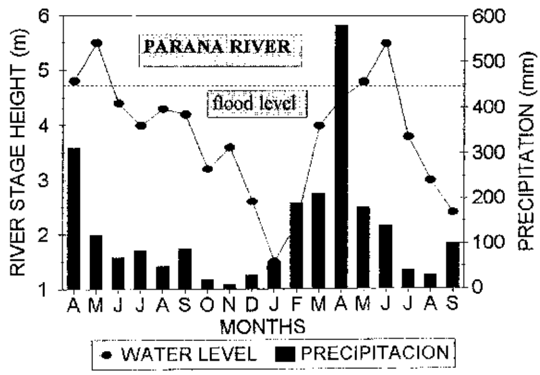

Fig. 1. Water level fluctuation.

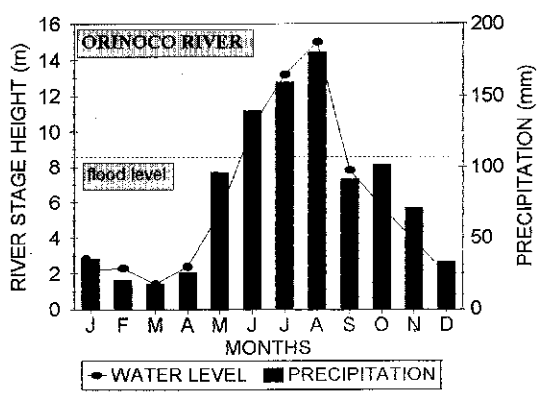

Fig. 2. Water level fluctuation.

The fringing floodplain of the lower Paraná River is wide (10–50 km) and contains small (100–500 m wide, 500–3000 m long) and shallow (1–5 m) lakes (Carignan & Planas 1994) (Fig. 3), whereas that of the lower Orinoco is narrow (mean, 6 km), in which 60 % of the lakes are smaller (10–200 m wide, 100–200 m long) and similarly shallow (0.1–6 m) lakes (Vásquez 1991, Hamilton & Lewis 1990) (Fig. 4).

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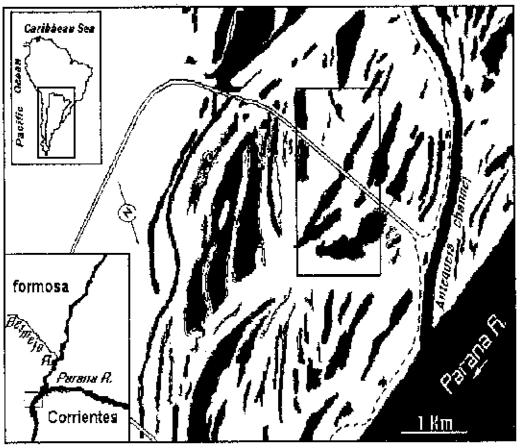

Fig. 3. Floodplain along Middle Paraná at Corrientes (After Carignan & Planas 1994).

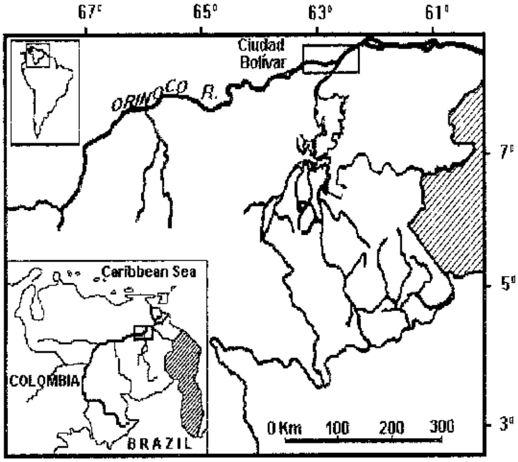

Fig. 4. Location of the study site. Samplers were collected from Castillos, lagoven, Mamo, floodplain lakes of the Orinoco River.

This study was conducted in three Orinoco lakes (Castillos, Lagoven and Mamo) and in two Paraná lakes (Esperanza and San Nicolas).

The San Nicolas lake (27°27′S, 58°55′W) is located about 2 km from the river and it could be classified as a meander scroll pond, representing a caracteristic landscape of Middle Paraná River. (Drago 1976). *Eichhornia crassipes* forms cohesive mats covering from 5 to 100 % of the surface at the end of low water phase (Carignan & Planas 1994).

The Esperanza Lake is classified as a levee pond and is located south of Corrientes city (Argentina). *Eichhornia crassipes* is not the most important aquatic plant; between a 5 to 10 % of its cover is shared with *Victoria cruziana, Salvinia, E. azurea, Paspalum, Pistia, Cyperus,* etc. (Vásquez 1991).

The Castillos Lake (8°30′N, 62°21′W) is an old meander scroll pond which is practically embeded at the end of granitic rock at the left bank of the Orinoco. *E. crassipes* along with *Paspalum* form important mats which cover as much as a 30 % of lake's surface.

The Lagoven Lake (8°24′N, 62°37′W) is a lateral levee pond in which floating vegetation is not important during isolation period. A mosaic of different species (*Nymphaea, Pistia, Ludwidgia, Eleocharis, Paspalum, Oxycarium, Eichhornia, Salvinia*) develops right after river enter the lake.

Materials and methods

Samples were taken at the border of numerous macrophyte beds. Four to eleven replicate samples (n = 4 to 11) were taken with a net of 250 µm mesh fixed to a quadrat sampler. Optimal size of quadrat and number of replicates were selected according to Downing's recomendations (Downing & Anderson 1985). The sampler was operated in the field as described by Blanco (1990). Following a root agitation process, the samples were preserved in 5 % formol and stored in plastic bags.

In the laboratory, the entire plant was rinsed to obtain the organisms. The rinsed water was then filtered through a battery of three sieves (8, 10 and 100 µm). Organisms obtained from the first two sieves were counted directly under a Wild-M5 stereomicroscope. The product of the first sieve was stained with 1 % aqueous solution of rose bengal and subsampled by a method described by Blanco (1988) for microorganisms. Taxonomic identification was generally carried out to genus level in Insecta with the exception of Diptera and some orders of Crustacea, Annelida and Hydracarina. The taxa were assigned to functional feeding groups according to Merrit & Cummins (1978), Pennak (1978), Usinger (1975) and our own observations.

Results

Densities are expressed by Org m^{-2} and Org 100 g^{-1} DWR (Dry Weight of the Roots) ($r = 0.75$ $p < 0.01$ between both expressions). Fig. 7 shows the mean population densities and stage river height at San Nicolas lake (Argentina). With regard to population abundancy, During IP (Isolation phase) low densities (39,700 Org $^{-2}$, 28,000 Org 100 g^{-1} DWR) were found, increasing almost four-fold, for both expressions, when the Paraná River reached at 5.7 m during its "normal innundation period" in 1989 (154,190 Org m^{-2}, 240,170 Org 100 g^{-1} DWR). A similar response was found for the Esperanza Lake during same year (IP = 49,450 Org m^{-2}, 41,180 Org 100 g^{-1} DWR; FP = 271,370 Org m^{-2}, 879,277 Org 100 g^{-1} DWR). During FP (Filling phase), abundance peaks were exhibited by cladocerans, copepods, hydracarids, oligochaetes, coleopteran larvae.

During 1990, an extraordinary inundation took place. The Paraná River reached 8 m and overflowed the southern side of the San Nicolas Lake. San Nicolas water flowed like a small stream, moved mats from one side to the other. On average, this major flood event only occurs every 5 to 10 years. During this exceptional flood, densities did not increase as expected. *Cyclestheria hislopi,* whose presence was not recorded during the first filling phase, appeared among *Cyrnellus* sp. in an obvious higher densitys. It seems important to point out that these organisms, during their early stages, are found equally in the Paraná lakes during extraordinary floods and in the Orinoco lakes during their FP.

On a functional level, similarities were observed regardless of intensity differences between the flood pulses of Paraná River. Percentage-wise, collector-gatherer (mainly chironominae, *Caenis* sp., *Mansonia* sp., *Oligochaeta, Hyalella* sp.) and collector-filterer (copepods, cladocerans and ostracods) were significantly higher during the Isolation phase, while those for the latter (*Cyclestheria hislopi,* cladocerans, copepods and ostracods) were significant during the filling phase (Fig. 6). Correlations from each functional group (logarithmic transformation $X' = \log(x+1)$) with temperature, pH, oxygen concentration and conductivity were made. Positive correlations were found between collector-gatherers ($r = 0.927$ $p = 0.05$) and scraper ($r = .908$ $p = 0.05$) with pH, and shredders with conductivity ($r = 0.958$ $p = 0.05$).

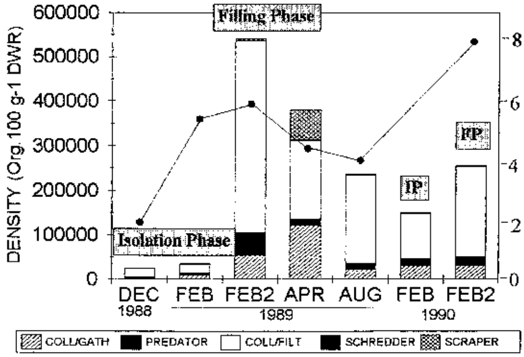

Fig. 6. Lake San Nicolas (Arg.). Functional Groups. River Height (m). ●

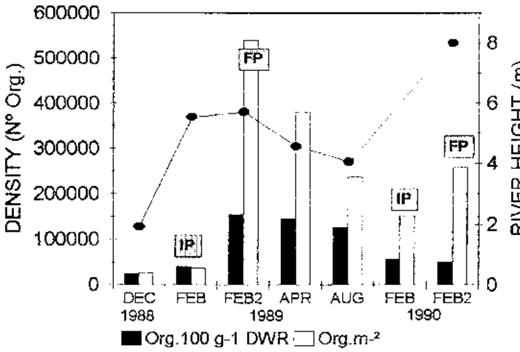

Fig. 7. Lake San Nicolas (Arg.). IS = isolation phase, FP = filling phase.

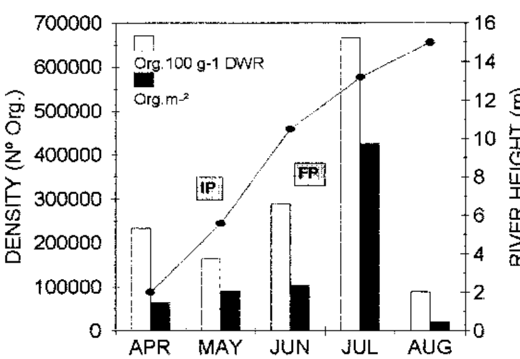

Fig. 5. Lake Castillos (Vzla.). IS = isolation phase, FP = filling phase. River Height. ●

The results shown in Fig. 5 for those lakes in the Orinoco floodplain such as Castillo, Tineo, Maldonado, Merecure, etc., where a permanent vegetation border developed, indicate the presence of two annual density peaks among the invertebrate fauna; one during IP and the other during FP. The mean totals recorded for these two annual peak densities were similar (200,000 org. m^{-2} and 190,000 org. m^{-2} for IP and FP respectively).

In Orinoco floodplain lakes, where the development of macrophytes occurs only during the rainy season, there exists only one observed

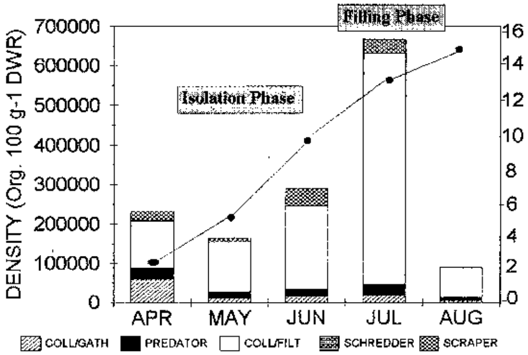

Fig. 8. Lake Castillos (Vzla.). Functional Groups. River Height (m). ●

annual density peak at the end of the throughflow phase. Even though peak densities (38,000 org. m^{-2} *E. crassipes,* 68,000 org. m^{-2} *Paspalum repens,* up to 600,000 org. m^{-2} *Nymphaea*) differed from those found on the floodplain lakes previously described, *E. crassipes* mats were not observed to outweigh the other species. The development of macrophyte beds on these lakes is probably higher and faster.

On a functional level (Fig. 8), Orinoco floodplain lakes showed a similar structure to that of the Paraná although scrapers showed an important fraction in the Orinoco lakes. Correlations of each functional group (logarithmic transformation $X' = \log(x+1)$) with temperature, pH, oxygen concentration and conductivity showed a high scraper-oxygen concentration correlation coefficient ($r = 0.908$; $p < 0.05$).

Discussion

The results for functional groups showed similarities regardless of intensity and duration of flood pulses in both invertebrate communities. The main difference is the scraper fraction which is more important in Orinoco lakes. The significant positive correlation of the latter functional group with oxygen concentration explains, in part, invertebrate response to a better environmental condition during IP in Orinoco lakes.

Higher densities in the Orinoco during IP and the presence of organisms such as nonportable case a trichopteran hydropsyche larvae, demonstrate an important response of the invertebrate fauna to better oxygen conditions. On the other hand, the significant number and species of beetles (70 % predators and 30 % collector-gatherer; 13 families, 48 species) found in Paraná lakes during IP appears to be related more to a invertebrate faunal response to low oxygen concentrations ($r = -0.8151$ $p = 0.05$), probably due to the ability of this group to carry a supply of air under its elytra.

During the filling phase (FP), in both floodplains, there seems to appear a "trigger" phenomenon in invertebrate density when "normal floods" occur. In contrast to the Orinoco, floods in Paraná are less pronounced, which probably explains the higher mean number of organisms during FP found in 1989. During the second flood, in 1990, mean densities did not increase as expected. The latter flood was more pronounced and the presence of organisms such as *Cyclestheria hislopi* and *Cyrnellus* sp., commonly found in Orinoco lakes during FP, seems to respond better to a higher water level stress in both floodplains.

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