Spatial and temporal variation of Odonata larvae associated with macrophytes in two floodplain lakes from the upper Paraná River, Brazil

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ABSTRACT. Samples of aquatic macrophytes were collected on Guaraná (*Eichhornia azurea*) and Patos (*E. crassipes* and *E. azurea*) Lakes from March 1992 to February 1993. On Guaraná Lake the highest density and diversity were registered during the high water phase with dominance of *Telebasis* and *Acanthagrion,* while on Patos Lake, highest density and diversity were observed during the low water phase. The dominant taxa on Patos Lake were *Telebasis*, *Acanthagrion*, *Neoneura* (?), *Coryphaeschna adnexa*, *Miathyria*, *Diastatops intensa* and *Erythemis*. DCA and ANOVA differentiated Patos Lake mainly, because of the high abundance of *C. adnexa*, *Miathyria*, *D. intensa* and *Erythemis* which may be due to morphology of *E. crassipes* that shelters larger number of invertebrates. Water level variation of rivers influenced concentration of dissolved oxygen and pH. This variation was related the monthly fluctuation of larvae density. Difference between lakes shown in DCA analysis was chiefly due to variation of Odonata density.

Key words: Odonata, aquatic macrophytes, flood plain, varzea lakes, Paraná River.

RESUMO. Variação espacial e temporal de larvas de Odonata associadas com macrófitas aquáticas em duas lagoas da planície de inundação do alto rio Paraná, Brasil. Amostras de macrófitas aquáticas foram coletadas de março de 1992 a fevereiro de 1993, nas lagoas do Guaraná (*Eichhornia azurea*) e dos Patos (*E. crassipes* e *E. azurea*). Na lagoa do Guaraná, a maior densidade e a maior diversidade foram registradas nas águas altas, com dominância de *Telebasis* e *Acanthagrion*, enquanto na lagoa dos Patos a maior densidade e a maior diversidade foram verificadas na fase de águas baixas. Os táxons dominantes na lagoa dos Patos foram *Telebasis*, *Acanthagrion*, *Neoneura* (?), *Coryphaeschna adnexa*, *Miathyria*, *Diastatops intensa* e *Erythemis*. A lagoa dos Patos diferenciou-se da lagoa do Guaraná principalmente pela alta densidade de *C. adnexa*, *Miathyria*, *D. intensa* e *Erythemis*, sugerindo que a morfologia de *E. crassipes* abrigue maior número de invertebrados. A variação do nível hidrométrico dos rios influenciou na concentração de oxigênio dissolvido e pH. Essa variação foi um dos fatores determinantes na flutuação mensal da densidade das larvas. A diferença entre as lagoas, mostrada na análise DCA, deveu-se, principalmente, à variação da densidade de Odonata.

Palavras-chave: Odonata, macrofitas aquáticas, planície de inundação, lagos de várzea, rio Paraná.

Introduction

Roots of *Eichhornia* are an excellent substrata for the development of many aquatic organisms such as periphytic algae (Dawkins and Donoglaue, 1992), invertebrates, fish and other vertebrates. These biotopes present many individuals of different trophic categories, as primary producers and consumers, which, favour the development of predators.

Odonata larvae may use macrophytes as a place for egg laying, for food and shelter against predators. These larvae are important in the food chain because they are voracious predators which feed chiefly on some species of Diptera (Capitulo, 1992) and they serve as preys for fish and amphibians (Westfall Jr. and Tennessen, 1996).

In Brazil research on Odonata has emphasized taxonomy (Santos, 1968; 1969 a, b, c; 1970 a, b, c; 1972; 1978; Capitulo, 1983; Costa and Assis, 1992; Costa and Pujol-Luz, 1993; Büttow *et al.,* 1993; Assis

and Costa,1994; Costa *et al*., 1999). Researches on ecology and biology come from temperate zones, such as Corbet (1980); Pierce *et al*. (1985); Larson and House (1990); Lounibos *et al*. (1990); Hawking and New (1996). In the floodplain of the upper Paraná River, this paper is the first ecological research on Odonata community.

The aim of this paper is to identify spatial temporal variations patterns of Odonata larvae density associated with *Eichhornia azurea* (Swartz) Kunth and *E. crassipes* (Mar.) Solm from Guaraná and Patos Lakes and asses any relationships among density and abiotic water fators.

Study area

Guaraná Lake (22°43'21"S and 53°18'42"W) is a black water lake on the right margin of the Baía River, an affluent of the Paraná River. Its margin is completely colonized by aquatic macrophytes and gramineae. The lake is affected by the flood pulse on the Paraná River. Two sites were chosen on the lake: G1 on the margin and G2 on the channel that connects the lake to the Baía River (Figure 1).

Patos Lake (22°49'19"S and 53°31'33"W) is composed of at least 3 overflowing lakes without definite boundaries. Its depth varies between 2.8 and 4.8m and has an area greater than 1.2 km^2 (Souza-Filho and Stevaux, 1997). The lake lies on the left margin of the Ivinheima River to which it is permanently connected, even in the dry season. Dense banks of aquatic macrophytes colonize its margin. Collection sites on the lake are: P1 at the margin and P2 on the channel that connects the lake to the Ivinheima River (Figure 1).

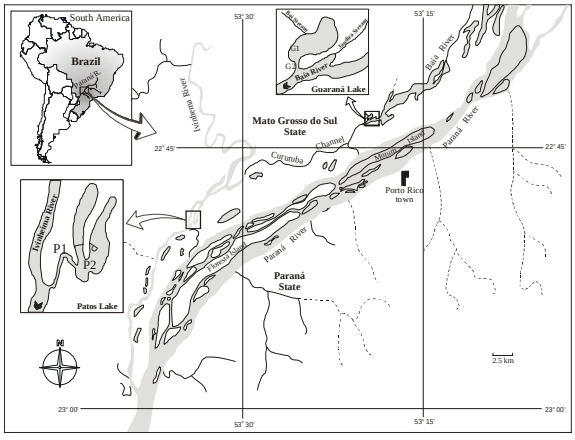

Figure 1. Study area and sampling stations. Guaraná Lake: sites G1 and G2 (region marginal and channel of connects with Baía river, respectively); Patos Lake: sites P1 and P2 (region marginal and channel of connects with Ivinheima River, respectively)

Material and methods

Samples of *E. azurea* (sites G1, G2 and P1) and *E. crassipes* (site P2) were collected monthly in the period between March 1992 and February 1993, being collected a total of 48 samples(12 samples in each point). One-meter long *E. azurea* stolons were drawn and taken out of the water, cut and conditioned in plastic bags. *E. crassipes* were samples random, always in similar quantities.

Invertebrates adhering to macrophytes were removed by dipping the plant in three recipients, two with formaldehyde (40%) diluted in water and one with water only. Contents of recipients were filtered by a 300 μm mesh net. Invertebrates were counted and identified in laboratory. Odonata larvae were identified to the lowest taxonomic level and conserved in alcohol 80°GL. Identification was based on Gloyd and Wright (1959); Smith and Pritchard (1981); Roldán Pérez (1988); Capitulo (1992); Westfall Jr. and Tennessen (1996). Larvae found in the first instars of development were identified at family level.

Macrophytes were dried in stove at 80°C and weighted. Density of Odonata larvae was calculated according to dry weight of plant and values expressed in number of individuals per 100 g dry weight (ind/100g dry weight).

In each site, physical and chemical characteristics variables of the water, such as transparency (cm, by Secchi disc), depth and temperature (°C, by thermistor), were measured. Surface water samples were collected in a Van Dorn bottle for pH (portable pH meter), electrical conductivity, total alkalinity and concentration of dissolved oxygen (Winkler method, modified by Golterman *et al*., 1978). The determination of the physical and chemical characteristics variables of the water, was done by Nupelia laboratory (Núcleo de Pesquisa em Limnologia, Ictiologia e Aqüicultura) of the State University of Maringá, PR, Brazil. Values of river water level were given by DNAEE (National Department of Waters and Electrical Energy). Average of the six days' water preceding collection was taken into account (Thomaz *et al*., 1997).

Shannon-Wiener diversity index (Pielou, 1975), eveness (Pielou, 1966) and dominance (Kownacki, 1971) were calculated for all sites in two water level phases (high and low water) by average density of genera of Odonata larvae.

Principal Components of Analysis (PCA) was used to ordinate sites/months, concerning abiotic variables. DCA (Detrended Correspondence Analysis) was used to ordenate sites/months based

on density of Odonata larvae. Abiotic variables were standardized and biotic variables were normalized by logarithmic transformation log (x+1). Statistic programs 5.0 and PC-ORD 2.0 were used for PCA and DCA respectively. Scores of axes 1 and 2 of DCA were used in Analysis of Variance (ANOVA) for difference between environment and the hydrological phases.

Results

Abiotic factores

Guaraná Lake is affected by water level fluctuation of the Paraná River in which two phases were established: high water (April to June 1992 and November 1992 to February 1993) and low water (March and July to October 1992). Patos lake also presented two phases (influenced by the Ivinhema River): high water from May to June 1992 and low water for other months (Figure 2).

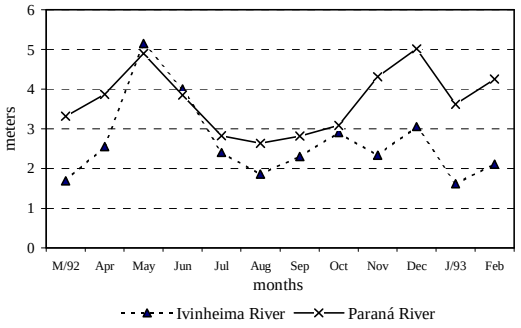

Figure 2. Average water level of six days previous to collection in the Paraná and Ivinheima Rivers. (Source DNAEE)

In Table 1, the mean values, standard deviation and range of abiotic variables of lakes during high and low water phase are given. Concentration of dissolved oxygen in both lakes was greater during low water phases. The greatest concentration was recorded on Patos Lake. The greatest electrical conductivity was verified on Guaraná Lake, but both lakes, greater values occurred during the water phases. pH oscillated from slightly acid to neutral (6.0 to 7.0).

Community of odonata larvae

Nine Odonata genera from families of the Coenagrionidade, Protoneuridae (Zygoptera), Aeschinidae and Libellulidae (Anisoptera) were registered throughout the year.

The greatest density of larvae was recorded on Patos Lake at site P2 ($\bar{x}$ = 166 ind/100g dry weight); lowest density was at P1 ($\bar{x}$ = 36 ind/100g dry weight). Average density on Guaraná Lake was 92 ind/100g dry weight and 108 ind/100g dry weight at sites G1 and G2 respectively. In the high water phase highest density was recorded on Guaraná Lake with a predominance of Libellulidae in both sites. On Patos Lake highest density occurred in the low water phase with predominance of Coenagrionidae at site P1 and with predominance of Libellulidae at site P2 (Table 2).

High density and dominance of *Telebasis* (Selys, 1965) were registered in all sampling sites. *Acanthagrion* (Selys, 1976) was the second most abundant genus, with predominance on Guaraná Lake during both hydrological phases, whereas on Patos Lake it was dominant only in the high water phase. The greatest abundance and dominance of *Miathyria* (Kirby, 1889), *Coryphaeschna adnexa* (Hagen, 1861), *Erythemis* (Hagen, 1861) and *Diastatops intensa* (Montgomery, 1940) occurred on Patos Lake, especially at site P2. Genera *Micrathyria* (Kirby, 1889), *Brechmorhoga* (Kirby, 1894) and *Neoneura* (Selys, 1860) showed low density in all sites. Only *Neoneura* was dominant at P1 during low water (Table 2).

The greatest diversity was verified on Guaraná Lake during high water, whereas greatest diversity during the low water period occurred on Patos Lake (Figure 3).

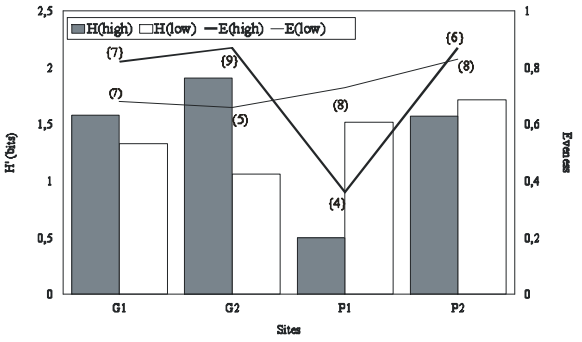

Figure 3. Shannon-Wiener Diversity (H'), Eveness (E) and number of taxa: high water { }and low water ( ), for Guaraná and Patos lakes in the study period

Table 1. Physical and chemical variables of water in collection sites in two hydrological phases (high and low water). Average values, standard deviation (between parentheses) and variation range are given

Environment	Water Temperature	Secchi disc	pH	Electrical Conductivity	Total Alkalinity	Dissolved Oxygen	Depth
Guaraná Lake							
G1 high water	25.9 (2.85)	0.92 (0.44)	6.03 (0.46)	33.43 (8.38)	0.35 (0.21)	1.76 (1.42)	2.09 (0.45)
	20.9 – 29.10	0.38 - 1.55	5.4 - 6.6	23 - 50	0.14 - 0.80	0.72 - 4. 57	1.60 - 2.80
G1 low water	21.26 (3.71)	0.55 (0.17)	6.06 (0.51)	27 (12.71)	0.19 (0.15)	6.13 (2.47)	1.0 (0.45)
	18.0 – 27.0	0.35 - 0.80	5.5 - 6.7	17 - 49	0.09 - 0.45	2.6 - 9.23	0.8 - 1.80
G2 high water	25.89 (2.78)	1.01 (0.39)	6.27 (0.55)	34.57 (11.37)	0.26 (0.11)	2.69 (2.17)	2.63 (0.55)
	20.8 – 28.1	0.50 – 1.40	5.6 – 7.2	23.0 – 57.0	0.08 – 0.40	0.63 – 6.91	2.0 – 3.4
G2 low water	21.36 (4.13)	0.69 (0.13)	6.22 (0.63)	25.4 (11.72)	0.18 (0.13)	6.99 (0.89)	1.64 (0.67)
	17.5 – 27.9	0.55 – 0.85	5.5 – 7.0	17.0 – 46.0	0.10 – 0.41	5.73 – 8.24	1.2 – 2.8
Patos Lake							
P1 high water	23.8 (0.5)	1.1 (0.9)	6.30 (0.1)	41.5 (9.2)	0.3 (0.04)	2.0 (0.5)	3.10 (0.14)
	23.4-24.1	0.5-1.7	6.2-6.4	35.0-48.0	0.28-0.33	1.6-2.3	3.0-3.20
P1 low water	24.7 (4.1)	0.9 (0.3)	6.60 (0.4)	38.1 (4.7)	0.4 (0.03)	4.5 (3.1)	1.78 (0.54)
	18.6-29.3	0.6-1.3	6.0-7.5	32.0-49.0	0.3-0.5	1.3-10.4	1.0-2.8
P2 high water	23.5 (0.6)	0.9 (0.6)	6.3 (0.2)	41.0 (8.5)	0.3 (0.05)	2.4 (0.7)	3.0 (0.0)
	23.1-23.9	0.5-1.4	6.1-6.4	35.0-47.0	0.30-0.32	1.9-2.9	3.0
P2 low water	24.6 (4.3)	1.0 (0.2)	6.7 (0.3)	40.9 (3.8)	0.4 (0.01)	4.8 (3.0)	1.76 (0.56)
	17.6-29.0	0.6-1.4	6.1-7.2	36.0-46.0	0.3-0.4	1.2-9.2	1.0-2.8

Table 2. Average values of density (ind/100 g dry weight) of Odonata larvae, standard deviation (between parentheses) and dominance index

	Guaraná Lake				Patos Lake			
Taxa	G1(WH*)	G1(WL**)	G2(WH)	G2 (WL)	P1(WH)	P1(WL)	P2(WH)	P2(WL)
Coenagrionidae								
Telebasis (Selys. 1965)	5.98 (6.51)	7.67 (6.76)	1.53 (2.18)	2.55 (1.80)	11.85 (16.76)	4.94 (5.48)	21.31 (27.74)	10.40 (12.57)
	36.00	37.53	5.25	19.45	43.95	23.48	36.25	16.92
Acanthagrion (Selys. 1976)	1.73 (2.75)	5.32 (9.88)	4.40 (9.36)	6.46 (7.20)		0.87 (0.83)	11.41 (0.70)	0.27 (0.85)
	5.21	19.55	15.06	49.19		3.44	19.4	0.06
Protoneuridae								
Neoneura (?) (Selys. 1860)	0.37 (0.98)		1.07 (2.83)			0.14 (0.41)	4.09 (5.79)	
	0.37		1.22			11.00	3.48	
Aeschnidae								
C. adnexa (Hagen. 1861)	0.66 (0.87)	1.48 (1.82)	1.51 (2.21)	0.71 (1.06)		4.31 (12.23)	1.70 (2.40)	5.13 (11.47) 4.77
	1.99	5.40	6.91	2.71		10.24	1.45	
Libellulidae								
Micrathyria (Kirby. 1889)	0.98 (2.60)	0.42 (0.93)	0.42 (1.12)			0.11 (0.33)		4.24 (5.75)
	0.96	0.51	0.47			0.09		4.92
Miathyria (Kirby. 1889)	1.15 (1.40)	0.94 (1.44)	1.64 (1.17)	0.24 (0.54)	0.47 (0.67)	2.49 (3.79)	13.04(12.43)	11.09 (11.59)
	4.62	2.30	1.46	0.46	1.80	11.82	22.17	23.18
D. intensa (Montgomery 1940)		0.22 (0.49)	1.77 (4.68)	0.53 (0.89)	0.47 (0.67)	0.93 (1.85)		9.44 (11.62)
		0.27	2.02	2.02	1.80	1.47		13.16
Erythemis (Hagen. 1861)	3.40 (6.77)	0.29 (0.65)	0.87 (1.48)		0.70 (0.99)	0.11(0.33)	7.25 (9.05)	2.31 (4.15)
	0.60	0.36	1.99		2.60	0.09	12.32	2.68
Brechmorhoga (Kirby. 1894)			0.29 (0.78)					0.17 (0.54)
			0.33					0.04
Coenagrionidae***	40.29 (36.84)	28.94 (30.84)	42.76 (36.87)	34.83 (18.96)	3.49 (4.93)	23.99 (32.97)	23.19 (32.80)	27.73 (24.92)
Libellulidae***	82.94(144.79)		92.21 (183.92)	22.14 (47.86)	7.44 (9.19)	8.86 (18.54)	69.60 (44.34)	108.55 (115.94)

Dominant (10–100) – bold values, subdominant (1–9.99) and no dominant (0-0.99); * high water; ** low water; *** no indentified

Environmental influence on Odonata larvae associated with *E. azurea*

Principal Components of Analysis (PCA) of abiotic variables explained 68.5% of total data variance (axis 1 = 45.2% and axis 2 = 23.3%). Water temperature, water transparency, electrical conductivity, total alkalinity, dissolved oxygen and depth (negative correlation) were variables that contributed to form axis 1 with correlation higher than 0.50; pH and dissolved oxygen (positive correlation) to form axis 2.

Score order of sites/months from PCA (Figure 4) showed a sharp distinction between hydrological phases evidenced by a greater concentration of dissolved oxygen and more alkaline water in the low water phase.

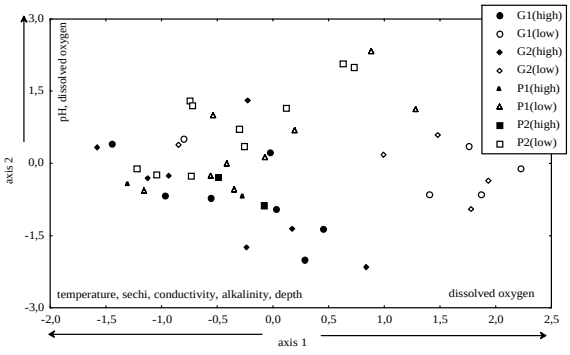

Figure 4. Ordenation diagran at first two axes the Principal Component analysis (PCA) according to physical and chemical variables in both lakes

DCA showed differences between lakes in density and occurrence of Odonata taxa. Patos Lake (P2) was chiefly characterized by abundance of *Miathyria*, *C. adnexa*, *Erythemis*, *D. intensa* and *Micrathyria*; Guaraná Lake was characterized by *Acanthagrion* and Coenagrionidae. *Telebasis* and Libellulidae were abundant in both (Figure 5).

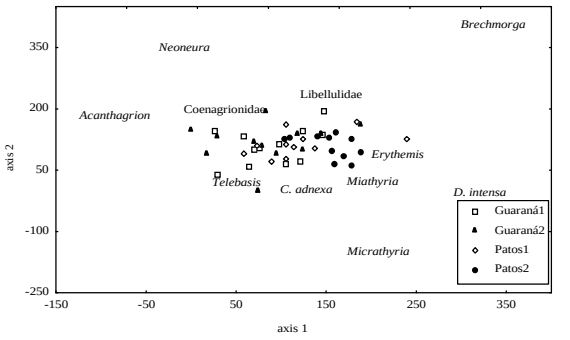

Figure 5. Ordenation of scores of DCA axes 1 and 2 according to density of Odonata taxa, for Guaraná and Patos lakes. Eigenvalue: axis 1 = 0.22 and axis 2 = 0.16

Analysis of Variance (ANOVA) calculated applied on the scores of collection sites/months of DCA axis 1 showed significant difference between sites ($p = 0.037$). No significant difference between hydrological phases was observed; significant difference was rather verified between sites and water level ($p = 0.030$).

Discussion

The difference of density larvae on Patos Lake was less pronounced between hydrological phases, probably due to its greater size and to less flooding pulse of the Ivinheima River. These facts may have influenced differences in density and dominance of Odonata larvae. On Guaraná Lake the greatest density and the diversity were verified in high water phase, whereas on Patos Lake greatest density and diversity were recorded in low water. Diagram of PCA order showed extreme scores on Guaraná Lake caused by low concentration of dissolved oxygen and more acid water in the high water phase. The above was not recorded on Patos Lake.

Association of genera *Miathyria*, *Coryphaeschna*, *Erthemis*, *Diastatops* and *Micrathyria* showed in DCA, especially in P2 was probably due to the morphology of *E. crassipes* whose more voluminous roots that favor better shelter and great quantities of food. Consequently a greater abundance of invertebrates occurs which favor predators such as Odonata larvae. According to Capitulo (1992) and Hopper *et al*. (1996), main food of Odonata larvae consists of larvae of dipterous; however they may also feed on small fish, crustaceans and other invertebrates. Although larvae of *D. intensa* are known to inhabit (Carvalho and Nessimian, 1998) chiefly detritus and clay and silt sediments, they were also found in this study on the roots of *E. crassipes*. Their abundance suggests that these larvae look for their food in roots of aquatic plant.

The association *Acanthagrion*, *Telebasis* and Coenagrionidae on Guaraná Lake shows that such genera are characteristic of vegetation of lentic environments, a fact which corroborates research done by Roldán-Pérez (1988), Carvalho and Nessimian (1998).

The hottest months of the year during the high water phase on Guaraná Lake certainly affected the abundance and the diversity of larvae. According to Corbet (1980), temperature and food availability affects growth rate and the development of Odonata larvae.

Many taxa found on both lakes are characteristic of aquatic macrophytes, with the exception of *Brechmorhoga* which are typically benthic and found in sandy sediments and detritus (Carvalho and Nessimian, 1998). Individuals collected on both lakes showed characteristics of final instar (size and developed wing-like theca) which suggest that they have only used macrophytes as substrata for emergence.

It may be concluded that the fluctuation of the water level of the Paraná and Ivinheima Rivers affected the concentration of dissolved oxygen and pH of sampling sites and was one of the factors in the spatial variation of Odonata larvae of the flood plain. This fact also suggests the increase of density larvae especially during the hottest months. The difference between lakes consisted only in the monthly variation of density and not in larvae composition. This may suggest a wide distribution

of these genera in the flood plain of the upper Paraná River.

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