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Emergence of Chironomidae (Insecta: Diptera) in a floodplain lake of the upper Paraná river, Mato Grosso do Sul State, Brazil

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ABSTRACT. To investigate the emergence of Chironomidae in different habitats of a floodplain lake of the upper Paraná river floodplain, four collection points were established: marginal regions (one with numerous macrophytes species, other dominated by only *Polygonum* sp.), central region and linking channel. Adults were captured by surface emergence traps assembled every three months, from May 2001 to March 2002. The traps remained for a period of about 48 hours, obtaining quantitative data for richness and abundance. 944 adults distributed into three subfamilies and 40 taxa were captured. The taxa identified at the species level were: *Goeldichironomus neopictus*, *G. petiolicola*, *G. maculatus*, *Tanytarsus ligulatus*, *Parachironomus atroari*, *P. guarani* and *P. cayapo*. Higher abundances were observed for *Polypedilum (Tripodura)* sp.1 and *Tanytarsus ligulatus*. There was a considerable variation in the richness among the collection points, mainly on the marginal area, with 38 taxa. In the central region (five taxa) and in the linking channel, were registered the predominance of *Aedokritus* sp. The higher diversity and abundance of Chironomidae in the littoral area may be related to the presence of aquatic macrophytes that provide shelter and food, resulting in increased recruitment of new individuals in this region.

Keywords: aquatic insects, habitats, neotropical floodplain, diversity, emergence traps.

Emergência de Chironomidae (Insecta: Diptera) em uma lagoa de inundação do alto rio Paraná, Estado do Mato Grosso do Sul, Brasil

RESUMO. Para investigar a emergência de Chironomidae em diferentes habitats foram estabelecidos quatro pontos em uma lagoa de inundação da planície do alto rio Paraná: dois na região litorânea (um em região com muitas espécies de macrófitas e outro dominado somente por *Polygonum* sp.), um na região central e um no canal de ligação. Os adultos foram capturados em armadilhas de superfície de emergência (flutuantes) instaladas trimestralmente, de maio/2001 a março/2002. As armadilhas permaneceram por um período de 48±2h, obtendo-se dados quantitativos para riqueza e abundância. Foram capturados 944 adultos distribuídos em três subfamílias e 40 táxons. Os táxons identificados em nível específico foram: *Goeldichironomus neopictus*, *G. petiolicola*, *G. maculatus*, *Tanytarsus ligulatus*, *Parachironomus atroari*, *P. guarani* e *P. cayapo*. As maiores abundâncias foram de *Polypedilum* (*Tripodura*) sp.1 e *Tanytarus ligulatus*. Houve considerável variação na riqueza de adultos entre os pontos de coleta, principalmente na região litorânea, com 38 táxons. Na região central (cinco táxons) e no canal de ligação, foi registrada a predominância de *Aedokritus* sp. As maiores abundâncias e riquezas nas regiões litorâneas podem estar relacionadas à presença de macrófitas aquáticas, que fornecem abrigo e recursos alimentares, resultando em maior recrutamento de novos indivíduos nessa região.

Palavras-chave: insetos aquáticos, habitats, planície de inundação Neotropical, diversidade, armadilhas de emergência.

Introduction

Chironomidae is a group of aquatic insects frequently dominant among aquatic macroinvertebrates (CRANSTON, 2000). Few studies have evaluated the emergence of Chironomidae in aquatic communities because they are much diversified (MARCONDES; PINHO, 2005), exhibit multivoltine cycles (SONODA et al., 2005; STUR et al., 2006) and short life cycle, of only a few weeks (RAUNIO et al., 2007).

In Brazil, the description of new genera or species has been carried out through experiments (TRIVINHO-STRIXINO; STRIXINO, 2000, 2003, 2004; TRIVINHO-STRIXINO; SANSEVERINO, 2003; ROQUE; TRIVINHO-STRIXINO, 2003), through emergence of adults in laboratory (SERPA-FILHO et al., 2007; INOUE et al., 2008) or with the use of traps and observations of the life cycle (CORBI; TRIVINHO-STRIXINO, 2006).

The description of Chironomidae stages is concentrated in the São Paulo State, southeast Brazil (ROQUE et al., 2004; TRIVINHO-STRIXINO; SONODA, 2006; TRIVINHO-STRIXINO et al., 2009). Serpa-Filho et al. (2007) have reported the population dynamics in floodplain of the Amazon Basin.

Chironomidae adult lifetime is usually very short, ranging from two to four days or several weeks, for reproduction, maturation and oviposition (CRANSTON, 2000). In the adult phase, individuals do not eat and some dominant species can exhibit a fast and highly synchronized, spatial and temporal emergence (VERBERK et al., 2008), with adults capable of flying immediately (SILVER; MCCAL, 2004).

The knowledge of the Chironomidae ecology in the Neotropical Region is primarily based on immature stages, often analyzed at the genus level, which consequently may limit the interpretation of population dynamics, habitat associations, and seasonal patterns of abundance (WILLIAMS; WILLIAMS, 1998). With regard to the identification at species level, most species recorded in the region was analyzed mainly by the morphology of adult forms, hindering the associations with immature forms and leading to a knowledge gap between larva and adult (TRIVINHO-STRIXINO, 2011). In this context, there is little information about the ecology of the different genera of adult Chironomidae, whose larvae are usually found associated with different habitats in a water body.

In this context, the present study investigated the spatial and seasonal patterns of emergent Chironomidae in different habitats (marginal region, central region and linking channel) of a Neotropical floodplain lake. We analyzed abundance, richness, diversity and dominance of adult Chironomidae.

Material and methods

Study area

The Ivinhema river is one of the large tributaries of the right bank of the Paraná river, surrounded by flooded areas and several marginal lakes (STEVAUX et al., 1997; SOUZA FILHO; STEVAUX, 2004). The Patos floodplain lake is a lentic water body, located at 22°43'12"S and 53°17'37"W, which remains permanently connected with the left bank of the Ivinhema river.

Four points of collection were established: PM1 – margin region, with predominance of *Eichhornia. crassipes*, *Eichhornia. azurea*, *Salvinia auriculata* and *Polygonum* sp.; PM2 – margin region next to the margin that separates the two water bodies, dominated by *Polygonum* sp., PRL – central region, and PM3 – linking channel between the lake and the river (Figure 1).

The Patos floodplain lake is characterized by similar limnological variables in all points (Table 1).

Adults of Chironomidae were captured every three months, from May 2001 to March 2002, with surface emergence traps (Figure 2). Each trap had a pyramidal form, whose base had 1.96 m^2 area, formed by four floating PVC tubes (10 cm of diameter) and it sustained nets with mesh of 0.1 mm

On the top of the trap a collector containing 100 mL of formalin 4% was attached. Adults were collected 48 ± 2 hours after assembling the trap. The material collected was transferred to a funnel containing a support with a 0.2 mm mesh and all material was fixed in 70% alcohol.

Slides were mounted according to Pinder (1989), Murray and Fittkau (1989), Cranston et al. (1989), Spies et al. (1994).

Statistical analysis

The assemblage structure was analyzed using the Shannon-Wiener (H') diversity index (PIELOU, 1975), Margalef richness index, Evenness index (E) and dominance index of Kownacki (1971). The dominance index was subdivided into two groups: dominant ($10 \leq d \leq 100$) and subdominant ($1 < d < 9.99$) groups. Levene test was used for checking for the homogeneity of variance. The two-way ANOVA was used to test the differences between mean values of abundance in the habitats and months.

Results

The total of 944 adults (364 males and 580 females) was distributed into three subfamilies (Chironominae, Tanypodinae and Orthocladiinae) and six tribes. 67% were represented by Chironomini, Tanytarsini (24%), Pentaneurini (8%). Procladiini, Coelotanypodini and Orthocladiinae together represented only 1%. On the marginal regions, 38 taxa were registered, in the central region only 5 and in the linking channel, 9 taxa.

Eight morphotypes of *Polypedilum* (*Tripodura*) were found on marginal regions of the lake. *Polypedilum* (*Tripodura*) sp.1 contributed with 28% of the total of individuals from marginal regions and from the linking channel. *Tanytarsus ligulatus* contributed with 21%, and was registered only on marginal regions (Table 2).

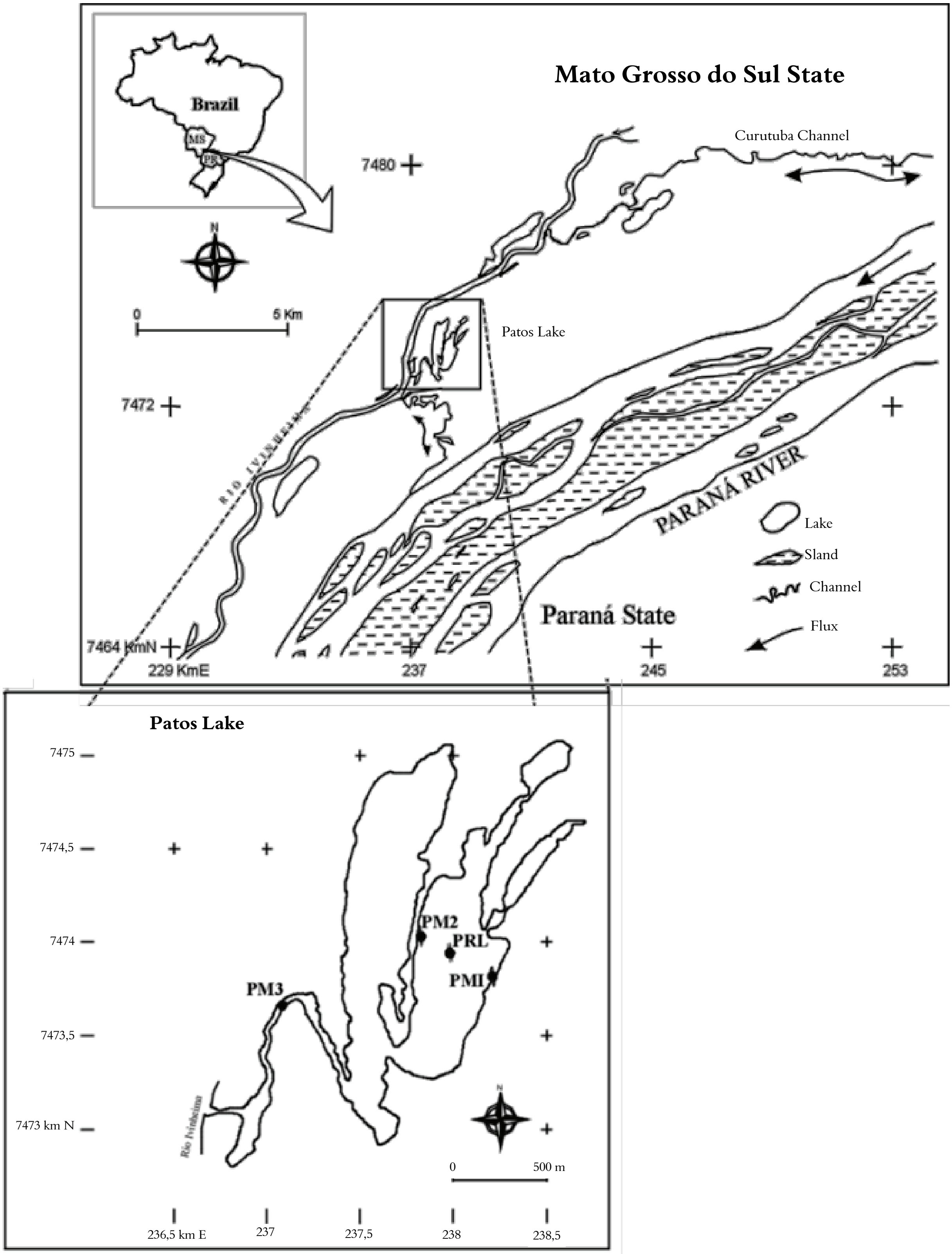

Figure 1. Map of the study area: PM1 – marginal region with macrophytes; PM2 – margin regional without macrophytes; PRC – Central region and PM3 – margin region of the linking channel.

Table 1. Mean values and standard deviation of environmental variables in the collection points with emergence traps. Margin 1 – marginal region with macrophytes; Margin 2 –margin regional, with predominance of *Polygonum* sp.

Points	Temperature (°C)	Depth (cm)	pH	Conductivity (μS cm^{-1})	DO (mg L^{-1})
Margin 1	25.67 (±3.36)	91.25 (±40.91)	7.12 (±1.31)	34.00 (±5.42)	5.51 (±0.52)
Margin 2	25.65 (±3.31)	80.00 (±34.88)	6.35 (±0.15)	34.25 (±6.34)	6.03 (±1.04)
Channel	24.15 (±3.22)	96.51 (±12.07)	6.70 (±0.56)	31.28 (±5.05)	6.45 (±0.13)
Central	25.26 (±2.74)	331.25 (±55.43)	6.41 (±0.56)	36.65 (±8.01)	5.38 (±2.29)

Figure 2. Model of floating emergence trap for capturing adult insects.

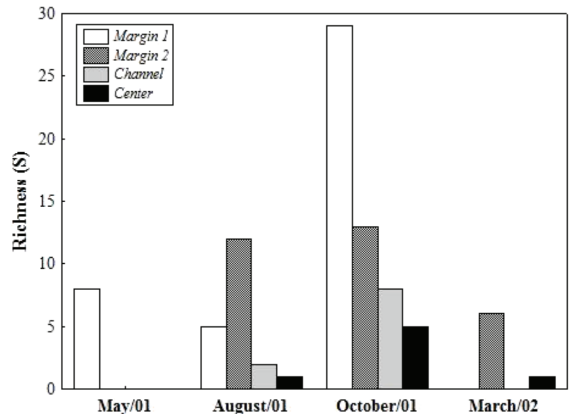

Figure 3. Taxonomic richness in sampling months and habitats.

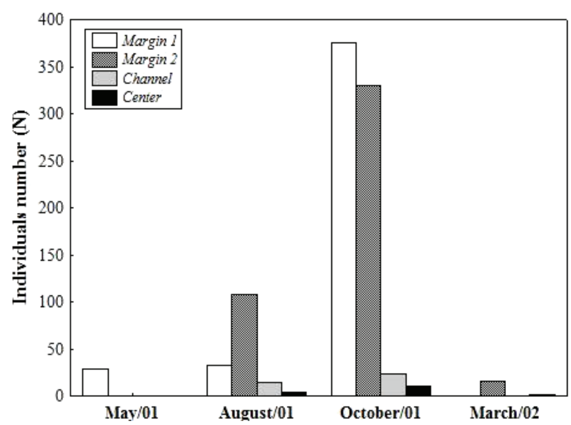

Figure 4. Individual's number in sampling months and habitats.

Polypedilum (*Tripodura*) sp.1 was the dominant taxa (10.57), while *Aedokritus* sp. (6.34), *Tanytarsus ligulatus* (2.60) and *Goeldichironomus maculatus* (1.21) were subdominants (Table 2).

Procladius sp. was captured in three habitats while Cladopelma forcipis was registered only in the linking channel.

The taxonomic richness (Figure 3) and the abundance (Figure 4) were higher in the marginal regions, especially in October 2001, with 32 taxa and 352 individuals (SD±338 ind.)

Both marginal regions showed the highest mean values of richness, evenness, and diversity indices (Simpon's and Shannon-Wiener's) (Table 3).

Table 2. Mean abundance (standard deviation) and dominance index of Chironomidae adults in the habitats of the Patos Lake. *Dominants (10 ≤ d ≤ 100); **Subdominants (1 ≤ d ≤ 9.99).

	Margin 1	Margin 2	Channel	Center	Kownacki
CHIRONOMINAE					
Chironomini					
Aedokritus	10.50 (±11.62)	6.00 (±5.16)	3.75 (±6.85)	1.50 (±1.73)	6.34
Asheum	1.50 (±3.00)				0.04
Chironomus cf. gigas Reiss, 1974		0.50 (±1.00)	0.25 (±0.50)		0.04
Chironomus sp.1	2.25 (±2.87	1.25 (±1.89)	0.25 (±0.50)		0.50
Chironomus sp.2	0.75 (±1.50)				0.02
Chironomus sp.3	0.25 (±0.50)				0.01
Cladopelma forcipis Rempel, 1939			1.75 (±3.50)		0.05
Cyptochironomus brasiliensis Silva et al., 2010	0.75 (±1.50)	2.50 (±3.79)		0.25 (±0.50)	0.37
Cyptochironomus reshchikov Silva et al., 2010	0.50 (±1.00)				0.01
Dicrotendipes cf. californicus Johannsen, 1905	0.50 (±1.00)	0.25 (±0.50)			0.04
Goeldichironomus sp.	3.75 (±7.50)				0.10
Goeldichironomus maculatus Trivinho-Strixino and Strixino, 1991**	9.25 (±18.50)	6.00 (±11.34)			1.21
Goeldichironomus neopictus Trivinho-Strixino and Strixino, 1998	1.75 (±3.50)	4.50 (±7.72)			0.50
Goeldichironomus peliolicola Trivinho-Strixino and Strixino, 2005	2.25 (±4.50)				0.06
Parachironomus atroari Spies et al., 1994	1.75 (±3.50)				0.05
Parachironomus cayapo Spies et al., 1994	1.25 (±2.50)				0.03
Parachironomus guarani Spies et al., 1994	2.50 (±3.79)				0.13
Paranilothauma reissi Soponis, 1987	0.25 (±0.50)				0.01

Continue...

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	Margin 1	Margin 2	Channel	Center	Kownacki
Polypedilum (*Tripodura*) sp.1 *	5.25 (±9.22)	59.25 (±99.41)	2.00 (±4.00)		10.57
Polypedilum (*Tripodura*) sp.2	0.25 (±0.50)	1.00 (±1.41)			0.10
Polypedilum (*Tripodura*) sp.3	0.50 (±0.58)	1.50 (±3.00)			0.16
Polypedilum (*Tripodura*) sp.4		1.00 (±2.00)			0.03
Polypedilum (*Tripodura*) sp.5	1.50 (±2.38)				0.08
Polypedilum (*Tripodura*) sp.6		14.50 (±29.00)			0.38
Polypedilum (*Tripodura*) sp.7	0.25 (±0.50)				0.01
Polypedilum (*Tripodura*) sp.8					0.00
Tanytarsini					
Caladomyia sp.1		1.00 (±2.00)			0.03
Caladomyia sp.2					
Caladomyia sp.3	0.50 (±1.00)	3.50 (±5.74)			0.32
Tanytarsus sp.	0.25 (±0.50)	1.50 (±2.38)			0.14
Tanytarsus ligulatus Reiss**	43.00 (±86.00)	6.00 (±12.00)			2.60
ORTHOCLADIINAE					
Corynoneurini	0.25 (±0.50)		0.25 (±0.50)		0.03
TANYPODINAE					
Tanypodinae sp.	0.75 (±1.50)	0.50 (±1.00)	0.50 (±1.00)	0.50 (±1.00)	0.24
Coelotanypodini					
Coelotanypus	0.25 (±0.50)			1.00 (±2.00)	0.07
Procladini					
Procladius	0.50 (±0.58)		0.25 (±0.50)	0.75 (±1.50)	0.16
Pentaneurini					
Ablabesmyia (Karelia) sp.1		0.75 (±1.50)			0.02
Denopelopia cf. sp.	0.25 (±0.50)				0.01
Labrundinia					0.00
Labrundinia sp.1	2.00 (±3.37)	0.75 (±1.50)			0.22
Labrundinia sp.2			0.50 (±1.00)		0.01
Larsia	11.25 (±22.50)				0.30
Pentaneurini sp.	1.50 (±3.00)				0.04

Table 3. Attributes of Chironomidae taxa in the different habitats of the Patos floodplain lake. H' = Shannon & Wiener's Diversity Index.

	Richness	Eveness	Shannon-Wiener diversity	Simpson diversity
Margin 1	10.50 (±12.77)	0.54 (±0.38)	1.25 (±0.98)	0.54 (±0.37)
Margin 2	7.75 (±6.02)	0.54 (±0.39)	1.20 (±0.87)	0.52 (±0.37)
Channel	2.50 (±3.79)	0.29 (±0.39)	0.49 (±0.82)	0.22 (± 0.37)
Center	1.75 (±2.22)	0.23 (±0.46)	0.37 (±0.73)	0.19 (±0.37)

Discussion

From a developmental perspective, Chironomidae as well as many other aquatic insects are holometabolous, resulting in four distinct life stages: egg, larvae, pupa, and adult. The larval stage consists of an active benthic period, followed by a short pupal phase, also benthic, where the adult characteristics develop (OLIVER, 1971). After reaching maturity, the pupae begin the process of emergence where they move to the water surface, either through the water column or by crawling along vegetation. In the last stage of the life cycle, the insect undergoes both a metamorphosis to the adult form and a transition from the aquatic to the terrestrial environment (DAVIES, 1984). There is a short period of waiting at the water surface while the wings dry and open completely, after which the insect will emerge and fly away as an adult.

The high abundance of Chironomidae in the Patos floodplain lake was also observed for the larvae of this group by Higuti and Takeda (2002). The availability of *Eichhornia azurea* and *E. crassipes* on the marginal region could favor the colonization and development of larvae.

The emergence of Chironomidae over all collected months demonstrates that unlike studies developed in temperate or polar lakes (see SHERK; RAU, 1996), in the subtropical region the breeding activity is constant, with different species reproducing year round (TAKEDA et al., 2004; SIQUEIRA et al., 2008).

The high abundance in October indicates that this period is more favorable for the reproduction of Chironomidae, when temperatures and rainfall are beginning to increase. Associated with these conditions, the highest abundance in the marginal regions can be related with more shelter and resource in these areas, resulting in a high number of new recruitment. The highest abundance of Chironomidae adults in the Patos floodplain lake coincide with hotter and drier periods, probably related to the life cycle of each species and higher stability of the habitat.

On the other hand, the results showed low abundance in emergence of adults in flood periods (March), mainly of *Chironomus* sp.3, *Coelotanypus* sp., *Corynoneurini* sp., *Denopelopia* cf. sp., *Paranilothauma reissi* and *Polypedilum* (*Tripodura*) sp.7. This result is probably related to the sediment washout and consequent reduction of organisms and parts of decaying macrophytes through advection (transfer of matter and organisms related to the horizontal movement of water masses) (SILVER; MCCAL, 2004).

These observations indicate that Chironomidae emergence is not a random event, but rather presents a relationship with environmental variables such as, temperature, water level, and oxygen concentration (NEUMANN; KRUGER, 1985; ARMITAGE, 1995). The emergence often occurs over a particular time of year depending on environmental conditions, however overall patterns are derived from the more specialized timing of each species.

Species of Chironomidae have short life cycle and the fecundity can also be related to certain periodicity (TRIVINHO-STRIXINO; STRIXINO, 2000, 2005, 2008; SIQUEIRA et al., 2008). In this study, the emergence of some species such as *Polypedilum* (*Tripodura*) sp.1, *Aedokritus* sp. and *Tanytarsus ligulatus* has increased in the spring (October 2001). These species have adjusted to changes, thus presenting rapid life cycle and synchronism with environmental factors (SIQUEIRA et al., 2008). Species with rapid development and broad reproductive success were more abundant in water bodies with less predictable environmental conditions (VERBEK et al., 2008).

Tanytarsus larvae were found at high densities in many lakes of the alluvial plain of the upper Paraná river (HIGUTI; TAKEDA, 2002), which can be related to the high density of adults of *T. ligulatus* collected in this study. Many species of this genus living in lentic environments are associated with aquatic plants or living on sandy substrates (TRIVINHO-STRIXINO; SANSEVERINO, 2003).

Higuti and Takeda (2002) and Higuti (2004) mentioned that larvae of *Tanytarsus* and *Polypedilum* (*Tripodura*) live on the surface of sediments with large amounts of debris and are found at higher densities in both shallow and marginal regions of sites from the upper Paraná river floodplain (HIGUTI, 2004). In this way, besides *Polypedilum* (*Tripodura*) sp.1 and *Aedokritus* sp., *Tanytarsus ligulatus* and *Goeldichiromus maculatus* species, respectively, dominant and subdominant in the habitats, they have adaptations to a multiplicity of environments, mainly during the dry season.

Environments such as linking channels can be important for the dispersion of organisms that comes from the main channel, especially for species presenting short life cycle, whose adults lay egg masses on the water surface (SILVER; MCCAL, 2004).

Despite of significant abundance and richness of Chironomidae, or possibly because of it, the group is often neglected in biological surveys (ARMITAGE, 1995, WILLIAMS; WILLIAMS, 1998; REYNOLDS; BENKE, 2006). The small size, superficial similarity, and high diversity make tempting to neglect the species level and treat Chironomidae at upper taxonomic levels. By doing so, researchers inhibit their ability to infer about ecological relationships, report changes in the community, and make adequate comparisons between systems.

Conclusion

This study brings an important contribution among the several researches on the diversity of the upper Paraná river floodplain. The knowledge of the whole life cycle is decisive for the maintenance and increase the diversity of aquatic insects, mainly the transition between the two developmental stages. Each species represents differences in the succession stages and transfer of energy and nutrients to external environments, providing food for higher trophic levels such as fish and birds.

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