Diet and functional feeding groups of Chironomidae (Diptera) in the Middle Paraná River floodplain (Argentina)

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ABSTRACT. The gut contents of nine genera of benthic Chironominae and Tanypodinae from the Middle Paraná River floodplain habitats (a lake and a secondary channel) were analyzed to determine their feeding patterns and functional feeding groups. Amorphous detritus, animal and vegetal tissues, and mineral materials (predominantly sand) were observed in the larval guts. Amorphous detritus were the main food item found for Polypedilum (Tripodura) sp., Chironomus gr. decorus sp., Endotribelos sp., Phaenopsectra sp., Cladopelma sp., and Pelomus sp. (Chironominae), while animal tissues (mainly oligochaetes) were the most important food item found for Ablabesmyia (Karelia) sp., Coelotanypus sp., and Procladius sp. (Tanypodinae). Dietary overlap was calculated for all pairs of genera. Within predators, the highest overlap was obtained between Coelotanypus sp. and Ablabesmyia (Karelia) sp., while within detritivores the highest niche overlap was obtained between Endotribelos sp. and Phaenopsectra sp.

KEYWORDS. Gut content, niche overlap, Chironominae, Tanypodinae.

Resumen. Dieta y grupos funcionales tróficos de Chironomidae (Diptera) de la llanura aluvial del río Paraná Medio (Argentina). Se analizó el contenido intestinal de nueve géneros de Chironominae y Tanypodinae bentónicos en ambientes de la llanura aluvial del río Paraná Medio (laguna y cauce secundario) para determinar su patrón alimentario y los grupos funcionales tróficos. En los contenidos intestinales se observaron detrito amorfo, material mineral (principalmente arena), tejidos vegetal y animal. El principal ítem alimentario encontrado en Polypedilum (Tripodura) sp., Chironomus gr. decorus sp., Endotribelos sp., Phaenopsectra sp., Cladopelma sp. y Pelomus sp. (Chironominae) fue detrito amorfo, mientras que en Ablabesmyia (Karelia) sp., Coelotanypus sp. y Procladius sp. (Tanypodinae) el ítem más importante fue tejido animal (principalmente restos de oligoquetos). Se calculó el solapamiento trófico entre todos los pares de géneros, obteniéndose el mayor solapamiento dentro de los depredadores entre Coelotanypus sp. y Ablabesmyia (Karelia) sp., y dentro de los detritívoros entre Endotribelos sp. y Phaenopsectra sp.

PALABRAS-CLAVE. Contenido intestinal, solapamiento de nichos, Chironominae, Tanypodinae.

The knowledge of the diet offer important information to analyze the ecological role of species in any ecosystem. Interactions between species and with their environment, the life history strategies, and their ecologic role determine the structure of communities, the species diversity, the relative abundance of organisms and resource distribution patterns within systems. In addition, the studies related to biotic interactions give essential information to plan adequate strategies for the management of natural resources. Indeed, the partitioning of resources amongst closely related species as a structuring force for communities has been a central theme in the development of modern ecology (Leibold, 1995; Tokeshi, 1999; Pulliam, 2000; Death, 2004).

Benthic invertebrates are functionally important in the aquatic food webs as they process basal resources that are transferred to the higher trophic levels. Benthic invertebrates were first assigned to FFGs (functional feeding groups) in relation to their feeding mechanisms and the type and size of food they consumed (Cummins, 1973). Therefore, shredders break and condition leaves favouring the colonization of processed detritus by microorganisms and other invertebrates, while scrapers consume algae and microbes attached to the coarse particulate organic matter (CPOM) (Magee, 1993). The collector-filterers and collector-gatherers filter the fine and ultrafine particulate organic matter (FPOM, UFPOM) from the water column and directly from the substrate respectively (Graca, 2001). Moreover, predators consume animals or some of their parts.

The structure of benthic invertebrate assemblages may also be analyzed through the degree of niche overlap between species. The niche represents the conditions and resource quality within which an individual or species can reproduce and survive (Ricklefs, 1998; Townsend Peterson, 2006; Sohron, 2007). Niche overlap occurs when species use the same resources simultaneously and it is used to test the hypothesis of limiting similarity, which states that species with high niche overlap will be unable to coexist (MacArthur & Levins, 1967).

The feeding habits of invertebrates of different Neotropical streams were studied by Graça et al. (2001); Henriques-Oliveira et al. (2003); Motta & Uieda (2004); Cummins et al. (2005); Albaríño & Diaz Villanueva (2006); Gill et al. (2006); Tomanova et al. (2006); Callisto et al. (2001, 2007); Sanseverino & Nessimmian (2008); Reynaga (2009); Saigo et al. (2009). Furthermore, shredders are important in first-order streams and therefore their diet was widely described by several authors (e.g. Palmer et al., 1993; Ross-Marshall & Wallace, 2002; Cheshire et al., 2005). However, the feeding patterns of the dominant benthic invertebrates in the Paraná River system, like in many other large rivers, are still scarcely known. Therefore, the main objectives of this study were to analyze the diet and to determine the functional feeding group of benthic
Chironomidae commonly found in floodplain habitats of the Middle Paraná River. Besides, also the niche overlap was calculated for all genera to determine coexistence degree in trophic dimension.

MATERIALS AND METHODS

Larvae of chironomids were collected between 2002-2005 in the bank of a secondary channel (the Tiradero River) and a floodplain lake (31°40’S – 60°33’W) of the Middle Paraná River. The bottom sediment in both habitats was silt-clayed (44-50% of clay and 27-44% of silt) with 2-9% of bottom organic matter (ZILLI et al., 2008).

To collect the same number of individuals required to analyze the gut content by species, qualitative samplings were carried out in the floodplain habitats in different periods. Larvae were preserved in 70% ethanol. The foreguts of 10 individuals per taxa were removed by dissection, mounted in glycerin and examined at 400x magnifications.

The percentage of each food item was obtained by a volumetric method, where the guts of chironomids were approximated to cylinders. The food contained in the guts was assumed as the 100% and the proportions of the different types of food were estimated using an eyepiece micrometer scale of 10 x 10 (CHESHIRE et al., 2005).

The genera were identified following PAGGI (2009), TRIVINHO-STRIXINO & STRIXINO (1995) and TRIVINHO-STRIXINO (2011) and were assigned to the corresponding functional feeding groups (FFGs) based in the dominant food item. These results were compared with the widely used categories of MERRIT & CUMMINS (1984). Although POLYPEDILUM (TRIPODURA) sp., CHIRONOMUS gr. decorus sp., ENDOTRIBELOS sp., PHAENOPSIS sp. and ABLABESMYIA (KARELIA) sp. were collected from the lotic environments and PELOMUS sp., CLADOPELMA sp., COELOTANYPUS sp., and PROCLADIUS sp. from the floodplain lake in the present study, all the genera are common in both habitats.

The Chi-square test ($\chi^2$) was applied to evaluate significant differences in the diet of the chironomid larvae, considering the relative proportion of each food item for the studied genera.

To assess differences in the feeding patterns among the individuals of each genus similarity analysis were performed by Non-Metric Multidimensional Scaling (NMDS) applying Bray-Curtis dissimilarity with log_{10} transformed data and ANOSIM, using PRIMER-E® software (version 6.1). In a NMDS a ≤0.2 stress gives a potentially useful picture of the data structure, while a ≤0.1 stress corresponds to a good ordination with no prospect of misleading interpretation (CLARKE & WARWICK, 2001). Besides, a 2D NMDS plot with ≤0.1 stress indicate that higher-dimensional solutions and increasing quantity of data will not add any additional information about the overall structure.

Niche overlap was calculated using Pianka’s Index (PIANKA, 1973, 1974), using EcoSim, 7.0 Version (GOTELLI & ENTSINGER, 2001). This index has been widely used in similar studies of stream invertebrate communities (WOODWARD & HILDREW, 2002).

Where $P_{ij}$ and $P_{ik}$ represent the proportions of the $i$th item used by the $j$th and the $k$th genus, respectively. This equation generates a single value of niche overlap between zero (no overlap) and one (complete overlap) for each pairwise comparison.

RESULTS

The food items registered in the gut content of the detritivorous chironomids (Chironominae) included amorphous detritus and mineral materials (predominantly sand), while the guts contents of the predators (Tanypodinae) also included algae (mainly Bacillariophyceae) and animal tissues (oligochaetes, parts of arthropods, rotifers, etc.). POLYPEDILUM (TRIPODURA) sp., CHIRONOMUS gr. decorus sp., PELOMUS sp., CLADOPELMA sp., ENDOTRIBELOS sp. and PHAENOPSIS sp. led mainly on amorphous detritus (Fig. 1). Some specimens of CHIRONOMUS gr. decorus sp. and ENDOTRIBELOS sp. showed variations in their diet (Fig. 1). ABLABESMYIA (KARELIA) sp., COELOTANYPUS sp. and PROCLADIUS sp. fed primarily on animal tissues (mainly oligochaetes) (Fig. 2). Thus, POLYPEDILUM (TRIPODURA) sp., CHIRONOMUS gr. decorus sp., PELOMUS sp., CLADOPELMA sp., ENDOTRIBELOS sp. and PHAENOPSIS sp. were detritivores while ABLABESMYIA (KARELIA) sp., COELOTANYPUS sp. and PROCLADIUS sp., were predators.

The diet of the chironomids of each genus did not show significant differences ($\chi^2$ 16.91, p>0.05, df=9). On the other hand, the dissimilarity among genera was

Fig. 1. Food items obtained from the gut content analysis of ENDOTRIBELOS sp., PHAENOPSIS sp., CHIRONOMUS gr. decorus sp., POLYPEDILUM (TRIPODURA) sp., PELOMUS sp. and CLADOPELMA sp. (n=10) in the Middle Paraná River floodplain during the study period.
(0.98) within the predator guild was obtained between Coelotanypus sp. and Ablabesmyia (Karelia) sp. Furthermore, the highest niche overlap within the detritivores (0.99) was calculated between Endotribelos sp. and Phaenopsectra sp. (Tab. I). Furthermore, a low niche overlap was calculated among the guilds (predators and detritivores). Dietary overlap decreased from Phaenopsectra > Endotribelos > Polypedilum > Chironomus > Cladopelma to Pelomus within detritivores and from Ablabesmyia > Coelotanypus to Procladius within predators (Tab. I).

DISCUSSION

According to our results, most genera of chironomids consumed detritus as part of their diet. Benthic larvae of midges can reach high densities, and may process high amounts of food and remove suspended matter transferring it into the benthic webs (Malmqvist et al., 2001). Polypedilum (Tripodura) sp. and Phaenopsectra sp. use detritus as their main food source in coincidence with results reported by Henriques-Oliveira et al. (2003). On the other hand, Motta & Uieda (2004) suggested that individuals of the same genus acted as predators. Larvae of Ablabesmyia (Karelia) sp., Coelotanypus sp. and Procladius sp. consumed larger proportions of animal tissues and therefore they were categorized as predators in coincidence with Motta & Uieda (2004). However, other results showed that Ablabesmyia consumed mainly detritus (Henriques-Oliveira et al., 2003). The differences in the diet of genera may be attributed not only to the existence of different species into the same genus but also to the development of opportunist strategies when resources availability varies.

Larvae of Chironomus gr. decorus sp. and Endotribelos sp. consumed mainly amorphous detritus in coincidence with Henriques-Oliveira et al. (2003) and Motta & Uieda (2004). However, in our study we observed that some larvae also consumed vegetal tissues. Additionally, some specimens of Chironomus gr. decorus sp. consumed vegetal tissues corresponding to the coarse fraction and therefore acted as facultative

![Food items obtained from the gut content analysis of Coelotanypus sp., Ablabesmyia (Karelia) sp. and Procladius sp. (n=10) in the Middle Paraná River floodplain during the study period.](image)

Fig. 2. Food items obtained from the gut content analysis of Coelotanypus sp., Ablabesmyia (Karelia) sp. and Procladius sp. (n=10) in the Middle Paraná River floodplain during the study period.

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<tr>
<td>Coelotanypus sp.</td>
<td>0.83</td>
<td>0.98</td>
<td>0.59</td>
<td>0.37</td>
<td>0.30</td>
<td>0.27</td>
<td>0.26</td>
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<tr>
<td>Procladius sp.</td>
<td>0.83</td>
<td>0.62</td>
<td>0.38</td>
<td>0.15</td>
<td>0.17</td>
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<tr>
<td>Ablabesmyia sp.</td>
<td>0.64</td>
<td>0.39</td>
<td>0.30</td>
<td>0.32</td>
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<tr>
<td>Pelomus sp.</td>
<td>0.92</td>
<td>0.80</td>
<td>0.85</td>
<td>0.84</td>
<td>0.79</td>
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<tr>
<td>Cladopelma sp.</td>
<td>0.94</td>
<td>0.92</td>
<td>0.89</td>
<td>0.84</td>
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<tr>
<td>Chironomus gr. decorus</td>
<td>0.94</td>
<td>0.90</td>
<td>0.83</td>
<td>0.85</td>
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<tr>
<td>Endotribelos sp.</td>
<td>0.99</td>
<td>0.96</td>
<td>0.98</td>
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Tab. I. Values obtained for niche overlap among genera using the Pianka index in the Middle Paraná River floodplain during the study period.
shredders as was suggested by Callisto et al. (2007) and found for the third and fourth instar larvae in floodplain lakes of the Middle Paraná River (Florence Zilli, unpubl. data). Rosi-Marshall & Wallace (2002) and Motta & Uieda (2004) indicated the importance of FPOM as an unlimited food resource that deeply influence tropical and subtropical aquatic assemblages. According to the results obtained in this study, Polypedilum (Tripodura) sp., Phaenopspectra sp., Chironomus gr. decorus sp., Endotribelos sp. and Pelomus sp. performed as collector-gatherers in coincidence with the classification given by Cummins et al. (2005). However, Chironomus gr. decorus sp. and Endotribelos sp. may also be considered as facultative shredders.

The ANOSIM showed that the proportions of food items in the diet of chironomids are different in coincidence with the results reported by Palmer et al. (1993); Rosi-Marshall & Wallace (2002); Henriques-Oliveira et al. (2003); Motta & Uieda (2004); Cheshire et al. (2005); Sanseverino & Nessimian (2008).

Our data revealed high niches overlap among Polypedilum (Tripodura) sp., Phaenopspectra sp., Endotribelos sp., Chironomus gr. decorus sp. and Pelomus sp., mainly in relation to amorphous detritus. Thus, these genera compete for food resources but may coexist in the same habitats because the detritus in floodplain environments of the Middle Paraná River is unlimited. Predators had a lower niche overlap, while the lowest value was obtained for Procladius sp.; thus, in this study the genus showed a better use of the resources. Interspecific competition as results of ecological niches similarity is one of the most important mechanisms organizing and limiting the number of species that participate in an assemblage (Jaksic & Marone, 2007). Several studies have demonstrated that genera reported in the present research commonly coexist in the benthic assemblages of the Middle Paraná River (Poi de Neiff & Neiff, 1988; Neiff & Poi de Neiff, 1990; Bruquetas de Zozaya & Neiff, 1991; Poi de Neiff & Casco, 2001; Marchese et al., 2002; Capello et al., 2004; Poi de Neiff et al., 2006; Montalti & Paggi, 2006; Zilli et al., 2008). In spite of the consumption of similar food items by genera, the wide availability of resources in natural environments of the Middle Paraná River, allow the development and coexistence of their populations.

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