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Drosophilids (Insecta, Diptera) of the Paranã Valley: eight new records for the Cerrado biome

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Abstract: The Paranã Valley, located in the Central Brazil Plateau, within the domain of the Cerrado biome, is frequently cited as a center of endemism and diversity. Nonetheless, this region is poorly known, mainly considering its invertebrate fauna. Here, drosophilid flies were used as biological tools to contribute to a broader inventory, whose goals were mapping the Cerrado biodiversity and identifying areas to be conserved. Three previously unsampled areas in the Paranã Valley were sampled. Amongst the 12,297 specimens collected 45 species were identified, which represents 50% of the drosophilid species previously recorded in the Cerrado. Moreover, this sampling presented eight new occurrences for the biome (*Drosophila annulosa*, *D. calloptera*, *D. papei*, *D. neomorpha*, *D. roehrae*, *Gitona bivisualis*, *Rhinoleucophenga lopesi*, and the genus *Diathoneura*) and three species that had only one record for the biome, or that were recorded only in a specific area. Therefore, this study confirms the importance of the Paranã Valley as a center of biodiversity in the Cerrado biome, and recommends the establishment of conservation units in this region.

Keywords: biodiversity, Brazilian savanna, Central Brazil Plateau, conservation, *Drosophila*, inventory.

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Resumo: O Vale do Paranã localiza-se no Brasil Central, no domínio do bioma Cerrado, e é frequentemente citado como um centro de diversidade e endemismo. Entretanto, essa região ainda é pouco conhecida, principalmente no que se refere à fauna de invertebrados. Este estudo apresenta a fauna de drosofilídeos de três áreas nunca avaliadas anteriormente no Vale do Paranã, visando contribuir para um inventário mais amplo, cujos objetivos foram mapear a biodiversidade da região e identificar áreas para serem preservadas. Dentre os 12.297 espécimes coletados foram identificadas 45 espécies, correspondendo a 50% dos drosofilídeos previamente registrados no Cerrado. Além disso, este trabalho acrescentou oito novas ocorrências para o Cerrado (*Drosophila annulosa*, *D. calloptera*, *D. papei*, *D. neomorpha*, *D. roehrae*, *Gitona bivisualis*, *Rhinoleucophenga lopesi* e o gênero *Diathoneura*) e três outras espécies com apenas uma única ocorrência para o Cerrado, ou registradas em apenas uma área específica do bioma. Nesse contexto, este estudo confirma a importância do Vale do Paranã como um centro de biodiversidade do Cerrado, e recomenda o estabelecimento de unidades de conservação nessa região.

Palavras-chave: biodiversidade, Planalto Central do Brasil, conservação, *Drosophila*, inventário, savana brasileira.

Introduction

The Cerrado biome is one of the 25 hotspots of the world (Myers et al. 2000), because it shows high endemism of plants and is extremely threatened. Moreover, this biome combines a set of ecological and historical context of special interest to those studying the complexities of tropical communities. Therefore, it is subject of great interest for research and conservation. Actually, Cerrado is quite understudied and the lack of information about the arthropod diversity is particularly notorious (Diniz & Kitayama 1998, Pinheiro et al. 2002).

The Paran Valley, located in the Northeast Cerrado, is considered an area having high value for both scientific studies and conservation (Cavalcanti 1999). It is characterized by the large amount of physiognomies, geomorphologic and vegetation formations that are singular, but still little known (Oliveira & Marquis 2002). Some previous studies suggested that this region corresponds to a center of diversity and endemism for the Cerrado biome (Silva 1997, Silva & Bates 2002, Werneck & Colli 2006). At the same time, these areas suffer intense exploration by the implementation of cattle farms. Consequently, the landscape is becoming extremely fragmented and few areas still remain native (Scariot & Sevilha 2005). For all these reasons, inventories that allow a better understanding of biodiversity are very urgent for this region.

Andersen (2004) has emphasized that any program aiming at conserving biodiversity cannot be reliable without including insects. Firstly, insects represent a large proportion of the world biodiversity and, secondly, they play an essential role in maintaining ecosystem functions (Brown 1997, McGeoch 1998, Hilty & Merelender 2000). Moreover, insects are a rich data source for the conservation planning and management, as well as for reserves selection and drawing. They supply delineation of distinct biogeographical zones, areas of endemism, community types, and precise centers of evolutionary radiation, improving the spatial resolution of conservation planning (Kremen et al. 1993, Morrone 2006).

Drosophilids, in particular, have played an important role in the progress of genetics, evolution, and developmental biology (Brookes 2001). According to Powell (1997), no other biological model has been so thoroughly studied as the flies of the genus *Drosophila*. However, the geographic distribution and ecology of drosophilids is still poorly known, especially in tropical areas (Val et al. 1981, Brncic et al. 1985, Saavedra et al. 1995).

In tropical South America, systematic samplings of drosophilids have been taken only after the 1940-decade (Dobzhansky & Pavan 1943; Pavan & Cunha 1947, Pavan 1950, 1959; Mouro et al. 1965). Subsequently, based on the previous studies and on an extensive sampling program, Sene et al. (1980) and Vilela et al. (1983) discussed the drosophilid fauna of the Brazilian morphoclimatic domains, aiming at investigating the geographical distribution of the most common species. The fauna of Central Brazil Plateau, however, was little sampled by those surveys. In the Cerrado biome, where drosophilid have been collected regularly only after 1998, 90 species were recorded, 80 of them endemic to the Neotropical Region (Chaves & Tidon 2005, Roque et al. 2006). The drosophilid fauna of the Cerrado, however, is well known only for the neighborhoods of Braslia city, the capital of Brazil. Even areas widely recognized as important for biodiversity maintenance have not been sampled yet, which indicates that drosophilid diversity in the biome is still an underestimate.

It was suggested that studies investigating insect diversity, mainly in poorly known neotropical areas showing high conservation value, are likely to help formulating effective management strategies for the Cerrado biome (Brown & Gifford 2002), and for improving biodiversity knowledge. This project was a part of a broader inven-

tory, supported by the government of Brazil (MMA/PROBIO) and aimed at both mapping the Cerrado biodiversity and identifying areas to be conserved. Here, drosophilids were used to provide subsidies for the broad project goals. Therefore, this paper presents the drosophilid checklist of the Paran Valley, bringing new information on Neotropical drosophilid species ranges, emphasizing the new occurrences for the Cerrado, as well as the species that have not been sampled throughout last years in the biome, or have only occurred in a specific Cerrado area.

Material and Methods

Here we present data of three previously unsampled areas, in the Paran Valley Region (Figure 1). The samples were taken in two expeditions: one during the dry season (Aug-Sep/2003) and another in the wet season (March 2004). Three sites were chosen in each area (Figure 1), representing in total four habitat types: cerrado sensu stricto, cerrado, gallery forest, and seasonally dry tropical forest. Sampling different seasons and habitat was important for improving the sampling representative, since drosophilid assemblage composition varies throughout the seasons (Tidon 2006). The drosophilids were caught using a trap developed to minimize bias in capturing different species of flies attracted to banana baits (Medeiros & Klaczko 1999). In each site 10 traps (sampling units) were placed at least 20 m away from each other, in a 200 m transect. These sites were revised daily during 6 days. Details of each sampling areas, such as the geographical location and the habitat types, are shown

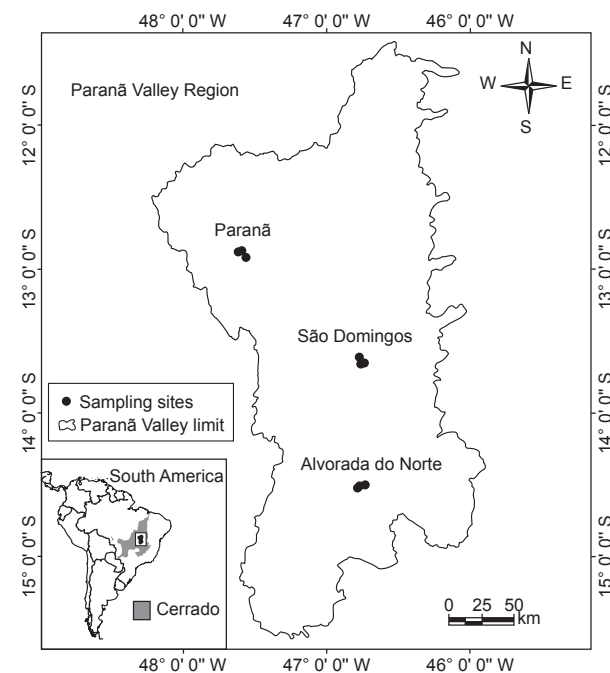


Figure 1. Location of Paran Valley Region, showing the sampling areas and sites. Alvorada do Norte encompassed cerrado sensu stricto (1 site), cerrado (1 site), and seasonally dry tropical forest (1 site); So Domingos encompassed only seasonally dry tropical forests (3 sites); and Paran encompassed cerrado sensu stricto (2 sites) and gallery forest (1 site).

Figura 1. Localizao do Vale do Paran, mostrando as reas e scios amostrados. Alvorada do Norte inclui cerrado sensu stricto (1 scio), cerrado (1 scio) e floresta estacional decidual (1 scio); So Domingos inclui apenas florestas estacionais deciduais (3 scios); e Paran inclui cerrado sensu stricto (2 scios) e mata de galeria (1 scio).

in Table 1. The drosophilid were identified by identification keys, species description and, in some cases, by the male *terminalia* (Dobzhansky & Pavan 1943, Pavan & Cunha 1947, Freire-Maia & Pavan 1949, Frota-Pessoa 1954, Val 1982, Vilela 1983, Vilela & Bachli 1990, Vilela 1992). Females of cryptic species (*D. cardini* and *D. cardinoides*, *D. prosaltans* and *D. austrosaltans*, *D. simulans* and *D. melanogaster*) were not identified due to the lack of reliable diagnostic characters, and they were classified according to the relative abundance of the males captured. Voucher specimens of the flies have been deposited in the Laborat rio de Biologia Evolutiva of the Universidade de Bras lia.

Results and Discussion

In this study 12,297 specimens belonging to 45 drosophilid species were collected, 40 of which are endemic of the Neotropical Region and five are exotic (*Drosophila busckii*, *D. malerkotliana*, *D. simulans*, *Scaptodrosophila latifasciaeformis*, and *Zaprionus indianus*) (Table 2). This number of species represents 50% of all drosophilid species known for the Cerrado biome until this moment (Chaves & Tidon 2005, Roque et al. 2006). Since this is the first inventory of drosophilids in Paran  Valley, all species correspond to new records to this region, representing new important information on Neotropical and exotic drosophilid species' geographic ranges. Moreover, considering the entire Cerrado biome, this study presented eight new drosophilid occurrences: *Drosophila annulosa* (770 specimens), *D. calloptera* (2), *D. papei* (1), *D. neomorpha* (1), *D. roehrae* (1), *Gitona bivisualis* (164), *Rhinoleucophenga lopesi* (5), and one undetermined species of the genus *Diathoneura* (2). Except for *Rhinoleucophenga personata* (3, Malogolowkin 1946), recorded in the biome in Miranda (MS) in 1946, the other three morphospecies of this genus, as well as the six undetermined species of *Drosophila*, are being evaluated and can represent new records for the Cerrado, or even new species (Table 2).

Although *D. canalinea* did not represent a new occurrence for the Cerrado, its first and unique record in the biome was made by Dobzhansky and Pavan in 1950, in An polis (GO), in a locality described by the authors as constituted mainly of savannas, but that shows, however, some forests in the valleys around the mountains that exist there (Pavan 1959). *Drosophila caponei* and *D. trapeza* were previously recorded only in the Serra do Cip  (Tidon-Sklorz et al. 1994, Vilela & Mori 1999), a part of Espinha  Plateau that is considered a center of biodiversity and endemism for the Cerrado biome (Silva & Bates 2002). The *Drosophila* studies conducted in the Serra do Cip  confirm this proposition, since they record a relatively high number of species of *Drosophila* (about 60) there,

when compared to other Cerrado areas (Tidon-Sklorz et al. 1994, Vilela & Mori 1999).

Likewise the Serra do Cip , the Paran  Valley was pointed as a region presenting high conservation value because of its elevated species richness, singularity in species composition and threat level (Cavalcanti 1999). Silva (1997) and Silva & Bates (2002) have also proposed that this region corresponds to an important center of avifauna endemism for the Cerrado biome, and these propositions have been supported by studies considering other taxa. Moojen et al. (1997) described a new rodent species, belonging to the genus *Kerodon*, and Werneck & Colli (2006) found a new reptile species of the genus *Mabuya*, both of them endemic to the seasonally dry tropical forests of the Paran  Valley. The great diversity and singularity of the regional biota are largely due to these seasonally dry tropical forests.

Seasonally dry tropical forests are considered the most threatened tropical ecosystem. They occur in fertile soils highly favorable for agriculture, contain plant species of commercial interest, and little attention is given for the conservation of these habitats (S nchez-Azofeifa et al. 2005, Prance 2006, Vieira & Scariot 2006). Currently, these seasonally dry tropical forests are strongly fragmented, isolated from each other, and the less known fragments in the Cerrado biome (Oliveira & Marquis 2002).

This drosophilid inventory in the Paran  Valley supports the importance of this region as a diversity center. The numbers of species, as well as the new occurrences found during this study, were extremely high when compared to other Cerrado areas at the same sampling period (data not shown). However, the Paran  Valley has not a single reserve area protecting its biological resources, and the creation of such reserves still remains as a high priority for the conservation of this unique biological region of the Cerrado biome (Silva 1997). Thus, to value the spent public investment, the efforts of several research groups, and mainly the knowledge produced by these studies, the creation of ecological reserves that preserve the richness and singularity of the region is urgent.

It is widely recognized that knowledge of biodiversity, mainly in tropical regions, is severely restricted. Although there have been an increasing effort to improve sampling data sets, and to provide available information on biodiversity, there are still immense gaps to be covered. In fact, the lack of knowledge creates challenges that were recently discussed under the names of "Wallacean" and "Linnean" shortfalls (Lomolino 2004, Whittaker et al. 2005). Most of the species were not yet described and named (the Linnean shortfall), and the geographic ranges and biogeographic patterns of the majority of the known species are poorly known (the Wallacean shortfall) (Lomolino 2004, Whittaker et al. 2005, Bini et al. 2006). Part of the problem is that across most tropical regions predominate developing

Table 1. Characterization of the sampling areas of Paran  Valley region.

Tabela 1. Caracteriza  o das  reas amostradas na regi o do Vale do Paran .

Area	Habitat	Sites location
Alvorada do Norte - Goi�s State	cerrado sensu strictu	14� 31' S and 46� 47' W
	cerrad�o	14� 30' S and 46� 46' W
	seasonally dry tropical forest	14� 30' S and 46� 43' W
S�o Domingos - Goi�s State	seasonally dry tropical forest	13� 39' S and 46� 45' W
	seasonally dry tropical forest	13� 39' S and 46� 46' W
	seasonally dry tropical forest	13� 36' S and 46� 46' W
	seasonally dry tropical forest	13� 36' S and 46� 46' W
Paran� - Tocantins State	cerrado sensu strictu	12� 52' S and 47� 37" W
	cerrado sensu strictu	12� 54' S and 47� 34' W
	gallery forest	12� 52' S and 47� 35' W

Table 2. Checklist of species of Drosophilidae recorded in the Paran  Valley Region. The geographical distribution of these species can be found at <http://taxodros.unizh.ch/>

Tabela 2. Lista de esp cies de Drosophilidae registradas na regi o do Vale do Paran . A distribui o geogr fica dessas esp cies pode ser acessada em <http://taxodros.unizh.ch>

Species	Authorship	Dry season	Wet season	Total abundance
<i>Drosophila cardini</i>	Sturtevant, 1956	183	1641	1824
<i>D. sturtevanti</i>	Duda, 1927	15	1776	1791
<i>D. willistoni</i> subgroup	Sturtevant, 1916	2	1696	1698
<i>Zaprionus indianus</i> †	Gupta, 1970	1005	648	1653
<i>Scaptodrosophila latifasciaeformis</i> †	(Duda), 1940	43	1369	1412
<i>D. annulosa</i> *	Vilela & B�chli, 1990	1	769	770
<i>D. nebulosa</i>	Sturtevant, 1916	157	384	541
<i>D. simulans</i> †	Sturtevant, 1919	325	170	495
<i>D. malerkotliana</i> †	Parshad & Paika, 1964	7	405	412
<i>D. mercatorum</i>	Patterson & Wheeler, 1942	107	169	276
<i>D. gouveai</i>	Tidon-Sklorz & Sene, 2001	143	110	253
<i>D. mediostrata</i>	Duda, 1925	8	166	174
<i>Gitona bivisualis</i> *	Patterson, 1943	127	37	164
<i>D. prosaltans</i>	Duda, 1927	23	108	131
<i>D. paranaensis</i>	Barros, 1950	44	77	121
<i>D. trapeza</i>	Heed & Wheeler, 1957	0	105	105
<i>D. ararama</i>	Pavan & Cunha, 1947	7	62	69
<i>D. repleta</i>	Wollaston, 1858	45	8	53
<i>D. canalinea</i>	Patterson & Mainland, 1944	1	27	28
<i>D. paramediostrata</i>	Townsend & Wheeler, 1955	1	26	27
<i>D. busckii</i> †	Coquillett, 1901	13	10	23
<i>D. pallidipennis</i>	Dobzhansky & Pavan, 1943	0	8	8
<i>D. flexa</i>	Loew, 1866	6	1	7
<i>Rhinoleucophenga lopesi</i> *	Malogolowkin, 1946	2	3	5
<i>D. ornatifrons</i>	Duda, 1927	0	4	4
<i>D. medioimpressa</i>	Frota-Pessoa, 1954	1	2	3
<i>D. polymorpha</i>	Dobzhansky & Pavan, 1943	0	3	3
<i>R. personata</i>	Malogolowkin, 1946	1	2	3
<i>D. calloptera</i> *	Schiner, 1868	0	2	2
<i>D. caponei</i>	Pavan & Cunha, 1947	0	2	2
<i>D. hydei</i>	Sturtevant, 1921	1	0	1
<i>D. neomorpha</i> *	Heed & Wheeler, 1957	0	1	1
<i>D. papei</i> *	B�chli & Vilela, 2002	0	1	1
<i>D. roehrae</i> *	Pipkin & Heed, 1964	0	1	1
Undetermined species				
<i>Drosophila</i> (6 species)	-	2	225	227
<i>Diathoneura</i> (1 species)*	-	0	2	2
<i>Rhinoleucophenga</i> (3 species)	-	5	1	6
<i>Zygothrica</i> (1 species)	-	0	1	1
Total of specimens			12,297	
Total of species			45	

* New occurrences for the Cerrado biome; † exotic species

* novas ocorr ncias no bioma Cerrado; † esp cie ex tica

countries, with few research tradition and relatively small amount of resources for biodiversity research. This problem certainly constrains the development of deeper biodiversity studies in the tropics, especially those involving large-scale surveys, covering an extensive area, which has serious implications for biodiversity conservation of those regions.

Important and new information about Neotropical and exotic species ranges has been presented here, as this is the first inventory of drosophilids species in the Paran  Valley, located at northeast part of Cerrado biome. The present survey has also contributed to increase the drosophilid checklist of Cerrado biome in eight species. However, because some of those flies are extremely seasonal, only appearing

in some times of the year (Tidon 2006), this sample can still be an underestimate of the real drosophilid diversity in this region. Despite this, such fact does not invalidate the results obtained here. Surely, as discussed by Balmford & Gaston (1999), the best way to circumvent both Wallacean and Linnean shortfalls is to invest in biodiversity inventories. Such surveys, whose objective is to produce knowledge on diversity of still unknown areas, will provide a solid baseline that will improve the biodiversity knowledge in tropical regions and help the development of conservation and management policies. Therefore, the inventories in other areas that are considered centers of diversity or endemism in Brazil (e.g. as those suggested by Silva & Bates 2002, to the Cerrado), that are poorly known for the great majority of the taxa, are still extremely necessary.

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