Composition and structure of a Miridae (Hemiptera, Heteroptera) assemblage from a relict of deciduous rainforest in southern Brazil

Aline Barcellos[1], Letícia S. Schmidt[1] & Paulo Sergio F. Ferreira[2]

1. Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Rua Dr. Salvador França, 1427, 90690-000 Porto Alegre, RS, Brazil. (alinebar@fzb.rs.gov.br; leticiaschmidt@yahoo.com.br)
2. Departamento de Biologia Animal, Universidade Federal de Viçosa, Av. Bueno Brandão, 220/901, 36570-000 Viçosa, MG, Brazil. (pfiuza@ufv.br)

ABSTRACT. A two-year study was carried out to evaluate the composition, abundance and species richness of Miridae from Parque Estadual do Turvo, municipality of Derrubadas, state of Rio Grande do Sul, Brazil. Samplings were made in the springs of 2003 and 2004 (October), and autumns of 2004 and 2005 (May), using a beating tray method, along two trails of the park. Sampling effort (hours x collectors) in the quantitative collections totaled 153 hours. Two-hundred mirid specimens of 50 species were collected. The most abundant mirid was *Prepops setosipes* (Reuter, 1910), representing 23% of the collected individuals, followed by *Collaria capixaba* Carvalho & Fontes, 1981 (10.5%) and *Tropidosteptes cribratus* (Stål, 1860) (7%), the latter recorded in all sampling periods. The highest abundance was observed in the springs of 2003 and 2004, with 53 and 78 individuals, respectively. Rarefaction method showed that estimated species richness was higher in autumn/2004 than in the other sampling periods, and higher along Yucumã than in Garcia trail. Besides a higher species richeness, Yucumã had more exclusive species than Garcia trail. The percent of species represented by one or two specimens in quantitative samplings (singletons and doubletons) was 60%. Additional samplings including hand collection, random beating tray and light trap collections added 20 species not recorded in the quantitative samplings.

KEYWORDS. Diversity, mirids, species richness, subtropic.

RESUMO. Composição e estrutura de uma assembléia de Miridae (Hemiptera, Heteroptera) de um remanescente de Floresta Estacional Decidual no sul do Brasil. Um estudo de dois anos foi desenvolvido para avaliar a composição, abundância e riqueza de espécies de Miridae no Parque Estadual do Turvo, em Derrubadas, Rio Grande do Sul, Brasil. Amostragens foram efetuadas nas primaveras de 2003 e 2004 (outubro) e outonos de 2004 e 2005 (maio), usando guarda-chuva entomológico, ao longo de duas trilhas do parque. O esforço amostral (horas x coletores) nas coletas quantitativas totalizou 153 horas. Duzentos espécimes de mirídeos foram coletados, representando 50 espécies. O mirídeo mais abundante foi *Prepops setosipes* (Reuter, 1910) com 23% dos indivíduos coletados, seguido por *Collaria capixaba* Carvalho & Fontes, 1981 (10,5%) e *Tropidosteptes cribratus* (Stål, 1860) (7%), esta última registrada em todos os períodos amostrais. A maior abundância foi observada nas primaveras de 2003 e 2004, com 53 e 78 indivíduos, respectivamente. O método de rarefação mostrou que a riqueza estimada de espécies foi maior no outono/2004 do que nos outros períodos amostrais, e ao longo da trilha do Yucumã do que na do Garcia. A porcentagem de espécies representadas por um ou dois indivíduos nas amostragens quantitativas (*singletons* e *doubletons*) foi de 60%. Amostragens adicionais incluindo coleta manual, coletas aleatórias com guarda-chuva entomológico e armadilhas luminosas acrescentaram 20 espécies não registradas nas amostragens quantitativas.

PALAVRAS-CHAVE. Diversidade, mirídeos, riqueza de espécies, subtrópico.

Species diversity, as measured by inventories, is an essential parameter for selection of areas for conservation, management decisions, nearly all environmental impact assessments and most political discussions on biodiversity (Green *et al.*, 2009). However, theses studies are frequently neglected, especially when the target group does not include charismatic species, such as butterflies, birds and mammals.

Hemiptera represent the richest order among hemimetabolous insects, and Miridae its most speciose family, with about 10,000 described species and about 1,300 genera worldwide (Ferreira *et al.*, 2006). Also known as plant bugs, mirids are among the most abundant insects on herbs, shrubs and trees (Wheeler, 2000). Their highest diversity is recorded in the Neotropics, and about 1,000 species are known from Brazil (Ferreira *et al.*, 2001). Although most mirids are plant feeders, as many as one half of the species feed as scavengers or facultative predators (Wheeler, 2000). Studies on biology and diversity of mirids are still scarce.

Knowledge on this group is focused primarily on economically important species, especially from temperate regions of northern hemisphere. In the Neotropics, Carvalho & Hussey (1954) listed 49 species of mirids from Paraguay. In the province of Corrientes, Argentina, Melo *et al.* (2004) recorded 33 species by using different collection methods. Logarzo *et al.* (2005) sampled mirids on road-side vegetation and recorded five species in Paraguay and 22 in Argentina, besides 86 insect-plant associations. In Brazil, Ferreira (1999) listed 43 genera and 69 species for the state of São Paulo, based on literature and data from deposited specimens. Ferreira *et al.* (2001) cited 141 species of mirids for the state of Minas Gerais, southeastern Brazil. For the same state, Ferreira *et al.* (2006) presented distribution data for Miridae based on data from literature and collections, and recorded 311 species. With the exception of Barcellos (2007), who studied terrestrial hemipterans from the coastal plain of the state of Rio Grande do Sul, published data on diversity of mirids in southern Brazil are unknown.

This study aimed to describe the composition and structure of an assemblage of Miridae from Parque Estadual do Turvo (Rio Grande do Sul), during two years, allowing future comparisons with other ecosystems of southern Brazil. Additionally, we provide new records of mirids for the state, and basic knowledge to support preservation of this conservation area.

MATERIAL AND METHODS

The Parque Estadual do Turvo (PET) is located in northwestern Rio Grande do Sul (27º00', 27º20'S; 53º40', 54º10'W), in the municipality of Derrubadas. The park, with an area of 17,491.40 ha, is considered a relict of the deciduous subtropical rainforest from Upper Uruguay river region (DIAS *et al*., 1992). This forest is currently restricted to the park and some minor fragments, embedded in an essentially agricultural matrix, dominated by soybean, wheat and corn crops. The climate, according to MALUF (2000), is subtropical sub humid (ST SB) with the mean temperature of the coldest month between 13 and 20°C and mean annual temperature between 18.1 and 22ºC.

This paper is part of a broader study that included terrestrial invertebrates from PET. The beating tray was chosen as the most efficient collection method for most of the target groups (snails, spiders, hemipterans and beetles). Beating is considered an efficient method for mirids on trees and bushes (FAUVEL, 1999). Samplings were carried out in four five-day expeditions to PET, respectively in October/2003, May/2004, October/2004 and May/2005. Due to logistic constraints, we opted for a two-year survey instead of an one-year, seasonal study. Two trails (Garcia and Yucumã) were sampled, and each sampling unit was represented by the total of specimens collected during one hour by the same three collectors, at each point of the trail. Distance among sampling points was at least 300 m. The total sampling effort was 153 hours, 78 hours for Yucumã and 75 hours for Garcia. Vehicle traffic occurs on both trails, but only Yucumã has open access to visitors. The sampling effort in the four periods totaled 41, 28, 33, and 51 hours, in spring/2003, autumn/2004, spring/2004, and autumn/2005, respectively. Additional qualitative collections were made aiming to complete the survey, by using random beating tray, light trap (SILVEIRA-NETO & SILVEIRA, 1969) for 12 hours, and hand collection (39 hours).

Identifications were made through comparison with previously identified specimens from collections and/or literature. Classification at subfamily and tribe levels followed SCHUH & SLATER (1995). Only adult specimens were collected, as immatures are difficult to identify. The material was deposited in the collection of terrestrial Hemiptera at Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil. Some duplicates were deposited in the Museu Regional de Entomologia, Universidade Federal de Viçosa, Minas Gerais, Brazil.

As the sampling effort was not the same in all periods and trails, estimated richness between trails and among periods was compared through rarefaction curves (MORENO, 2001), with the softwares Biodiversity Pro v. 2.0 (MCALEECE, 2004) and Past v. 1.18 (HAMMER & HARPER, 2004). Significance of the differences was inferred from confidence intervals (95%) at the level of maximum species richness of the smallest sample, according to MAGURRAN (2004).

We also compared the observed with the expected richness by using the estimators Chao 1, Chao 2, first (Jack 1) and second order (Jack 2) Jackknife, and Michaelis-Menten (MM), randomized 500 times, with Estimates v. 7.5.2 (COLWELL, 2005). For calculating Chao 2, we used the "classic" setting. Chao 1 is based on the proportion of species represented respectively by one and two individuals in the sample (singletons and doubletons). The remaining estimators use only incidence data – Jackknife 1 based on uniques, Chao 2 and Jackknife 2, both on uniques and duplicates (MAGURRAN, 2004). The structure of mirid assemblage from PET was also evaluated by plotting rank/abundance curves, with Biodiversity Pro v. 2.0 (MCALEECE, 2004).

RESULTS

We collected 200 mirids in the quantitative samplings with beating tray method. The highest abundance was observed in spring/2004 (39% of the specimens), followed by spring/2003 (26.5%), autumn/2004 (21%) and autumn/2005 (13.5%). Yucumã trail showed a higher abundance than Garcia, with 60.5% of the individuals collected along this trail (Tab. I).

Mirinae was the most abundant subfamily, with 74% of the individuals, followed by Bryocorinae (15%), Orthotylinae (5.5%) and Deraeocorinae (3.5%). The most abundant species were the mirines *Prepops setosipes* (Reuter, 1910), totaling 46 individuals or 23% of the specimens, *Collaria capixaba* Carvalho & Fontes, 1981 (10.5%) and *Tropidosteptes cribratus* (Stål, 1860) (7%). *Prepops setosipes* occurred only in the spring (both in 2003 and 2004). Most of the species were represented by one (44%) or two (16%) specimens (Tab. I). Most of the recorded species belong to Mirinae (30), followed by Bryocorinae (9), Orthotylinae (5), Deraeocorinae (4) and Phylinae (2). *Prepops* Reuter, 1905 was represented by seven species in the quantitative samplings, and three more in the additional samplings. The second richest genus in this study was *Phytocoris* Fallen, 1814, with five and one species in the quantitative and additional samplings respectively (Tab. I).

The observed species richness, considering only quantitative samples obtained with the same sampling effort, was 48 species. Estimators indicate that this value corresponds to 58.6%, 63.2%, 64.1%, 69.2% and 71.6% of the mean estimated richness by, respectively, Jackknife 2 (S_{est}=81.9), Michaelis-Menten (S_{est}=75.9), Chao 2 (S_{est}=74.9±15.4), Jackknife 1 (S_{est}=69.4±4.9) and Chao 1 (S_{est}=67±11.3). The accumulation curves resulted nonasymptotic.

Table I. Miridae recorded at Yucumã (Y) and Garcia (G) trails in the quantitative samplings with beating tray method and all sampling efforts, Parque Estadual do Turvo, Derrubadas, Rio Grande do Sul, Brazil, 2003-2005. Names followed by "A" represent undescribed taxa.

Subfamily Species/morphospecies	Spring 2003		Autumn 2004		Spring 2004		Autumn 2005		Total	
	G	Y	G	Y	G	Y	G	Y	G	Y
BRYOCORINAE										
Eccritotarsus stieglmayri (Reuter, 1907)	1	7				1			1	8
Monalocoris pallidiceps (Reuter, 1907)		1		1	2	1			2	3
Aspidobothrus basalis (Walker, 1873)	1	1			1	1			2	2
Pachymerocerus fairmairei (Stål, 1860)		1		1				1		3
Pycnoderes sp. 2			1	2					1	2
Cyrtocapsus femoralis Reuter, 1892				3						3
Aspidobothrus signaticollis Reuter, 1907					1				1	
Adneella sp. "A"								1		1
Eccritotarsus carioca Carvalho & Gomes, 1971	1								1	
DERAEOCORINAE										
Annona fuscata Carvalho & Schaffner, 1977			1	1		1			1	2
Antias sp.			2						2	
Lundiella rubra Carvalho, 1952								1		1
Hyaliodes sp.				1						1
MIRINAE										
Prepops setosipes (Reuter, 1910)	12	3			20	11			32	14
Collaria capixaba Carvalho & Fontes, 1981	5	7	1		3	5			9	12
Tropidosteptes cribratus (Stål, 1860)		2			1	1	3	7	4	10
Piasus cribricolis (Stål, 1860)		2	3	1	2	2			5	5
Phytocoris subvittatus (Stål, 1860)				1		2	1	2	1	5
Neostenotus confluentus Carvalho & Fontes, 1972				2	1	1		2	1	5
Proba vittiscutis (Stål, 1860)	2	1	1	1		1			3	3
Phytocoris sp. 3				5		1				6
Creontiades sp.					1	3			1	3
Phytocoris sp. 4				2			1		1	2
Phytocoris guaranianus Carvalho & Gomes, 1970				1				1		2
Taedia sulina Carvalho, 1954					1	1			1	1
Piasus sp. "A"		2								2
Prepops seminiger (Stål, 1860)					2				2	
Phytocoris sp. 5				2						2
Phytocorisca sp. "A"					1	1			1	1
Prepops sp. 9						1				1
Calocorisca sp. "A"		1								1
Taedia pernobilis (Reuter, 1907)					1				1	
Prepops **cf.** *teutonianus*		1								1
Tropidosteptes sp. 4				1						1
Prepops paranaensis Carvalho & Fontes, 1969	1								1	
Calocorisca chontalensis Distant, 1893					1				1	
Henicocnemis sp. 3						1				1
Adxenetus petiolatus (Stål, 1860)					1				1	
Horciasinus signoreti (Stål, 1859)				1						1
Tropidosteptes sp. 3						1				1
Prepops sp. 10		1								1
Henicocnemis sp. 2						1				1
Prepops sp. 8								1		1
ORTHOTYLINAE										
Orthotylus **cf.** *catarinensis*			1			1		2	1	3
Ceratocapsus sp. "A"				3						3
Ceratocapsus sp. 2				2						2
Orthotylus sp. 2						1				1
Adparaproba novateutonia Carvalho, 1987							1		1	
PHYLINAE										
Sthenaridea carmelitana (Carvalho, 1948)							1	2	1	2
Sthenaridea sp. 2				1						1
Abundance	23	30	10	32	39	39	7	20	79	121
Species richness	7	13	7	19	15	21	5	10	27	41

Considering all the quantitative sampling efforts with beating tray method, estimated richness by rarefaction showed that, for a subsample of 27 individuals, autumn/2004 (S_{est}=17.4±1.3) was significantly richer than autumn/2005 (S_{est}=12) and spring/2003 (10.5±1.4), but did not differ from spring/2004 (S_{est}=13.2±1.8). The estimated species richness was statistically similar among spring/2004, spring/2003 and autumn/2005 (Fig. 1).

Rarefaction indicated that Yucumã trail (S_{est}=33.7±2.0) had significantly higher species richness than Garcia (S_{est}=27.0), for a subsample of 79 individuals (Fig. 2). Yucumã trail also presented a higher number of exclusive species (22) than Garcia (nine) (Tab. I). Most of the exclusive species of both trails were represented by one or two specimens (Tab. I, Fig. 3). Yucumã trail showed higher evenness than Garcia, thus suggesting higher species diversity (Fig. 3).

Qualitative collections added 133 individuals, 39 of them from 20 species not recorded in the quantitative samplings; only three of these species were represented by more than two specimens (Tab. II).

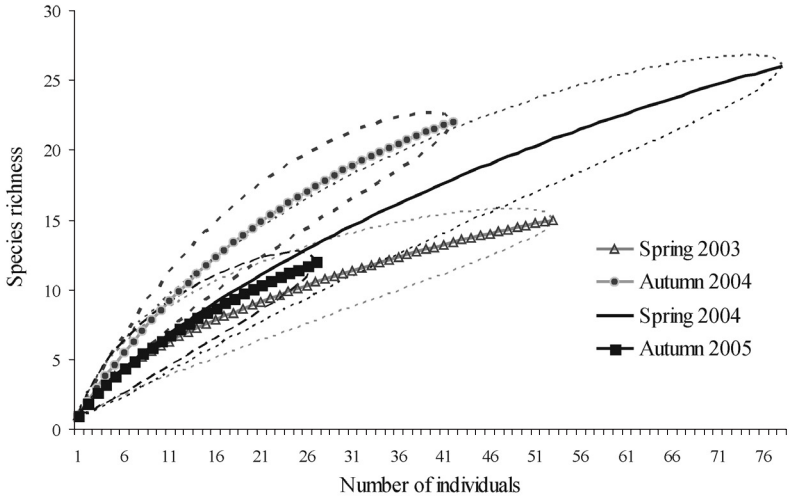

Figure 1. Rarefaction curves and 95% confidence intervals for the estimated richness of Mirid species obtained in the quantitative samplings with beating tray method and all sampling efforts in the four sampling periods, Parque Estadual do Turvo, Derrubadas, RS, Brazil, 2003-2005.

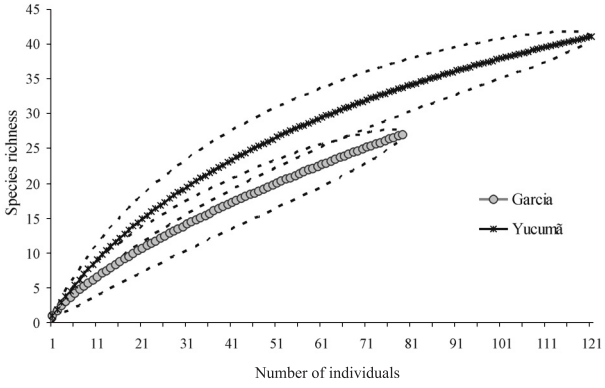

Figure 2. Rarefaction curves and 95% confidence intervals for the estimated richness of Miridae species obtained in the quantitative samplings with beating tray method and all sampling efforts along Garcia and Yucumã trails, Parque Estadual do Turvo, Derrubadas, RS, Brazil, 2003-2005.

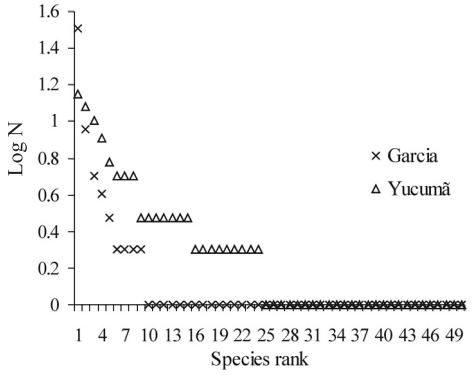

Figure 3. Rank/abundance plot of mirids collected along Garcia and Yucumã trails in the quantitative samplings with beating tray method and all sampling efforts, Parque Estadual do Turvo, Derrubadas, RS, Brazil, 2003-2005.

Table II. Additional Miridae species recorded exclusively in the qualitative samplings, Parque Estadual do Turvo, Derrubadas, Rio Grande do Sul, Brazil, 2003-2005 (BT, random beating tray; HC, hand collection; LT, light trap). Names followed by "A" represent undescribed taxa.

Species	Method	N
Platytylus handlirschi Reuter, 1907	HC	11
Sinervus baerensprungi Stål, 1860	BT	4
Tropidosteptes hirsutus (Distant, 1884)	LT	3
Derophtalma minuscula Carvalho, 1944	BT	2
Phytocoris sp. 6	LT	2
Prepops cruciferus (Berg, 1878)	BT	2
Taylorilygus pallidus (Blanchard, 1852)	BT	2
Deraeocorini "A"	HC	1
Henicocnemis patellata Stål, 1860	BT	1
Neella lutescens Stål, 1860	HC	1
Neoneella bosqui (Carvalho, 1954)	HC	1
Neoneella milzae Carvalho, 1946	HC	1
Neostenotus fuscipennis (Reuter, 1909)	BT	1
Opistheurista derrubadensis Ferreira & Coelho, 2006	BT	1
Parafurius discifer (Stål, 1860)	BT	1
Polymerus testaceipes (Stål, 1860)	BT	1
Prepops sp. 6	HC	1
Prepops sp. 7	BT	1
Pycnoderes albipes (Berg, 1892)	BT	1
Trigonotylus sp.	BT	1
Total		39

DISCUSSION

The observed and expected species richness curves showed that more species would probably be added with increasing sampling effort, which is a frequent result in invertebrate surveys (GOTELLI *et al.*, 2011).

Mirinae, the most abundant and species rich subfamily in this study, has diverse food preferences,

including phytophagous and predaceous species. *Prepops* contains 198 species in the western hemisphere, with 75 recorded in Brazil. Their known host plants include *Ludwigia* (Onagraceae) (Henry, 1990; Ferreira *et al*., 2001). Specimens of *Collaria* Provancher, 1872 feed on grasses (Poaceae) (Carvalho & Fontes, 1981; Ferreira *et al*., 2001). *Phytocoris*, the largest mirid genus (about 650 species), includes prey-specific predators which are usually restricted to a single plant species (Schuh & Slater, 1995). All the Deraeocorinae are considered predaceous.

The high proportion of singletons and doubletons surpasses by far those recorded for Pentatomoidea (45%, Schmidt & Barcellos, 2007) and Coreoidea (32.1%, Barcellos *et al.*, 2008) from PET in the same occasions. Sampling method might have influenced this result. Adult mirids are agile and good fliers when compared to pentatomoids and coreoids. As the specimens were hand collected from the beating sheet, it is possible that some of them have escaped before being caught.

We should be cautious when comparing our results to other studies, as they have used different methods and sampling efforts. Despite these differences, the observed species richness was higher at PET than that reported by Melo *et al.* (2004) in Argentina, and Logarzo *et al.* (2005) in Paraguay and Argentina, and lower than that observed by Paula & Ferreira (1998) and Ferreira (1999) in southeastern Brazil. Melo *et al.* (2004), using light traps, sweeping, beating and fogging, obtained 1,102 specimens belonging to 33 species of Miridae in the Natural Reserve of Iberá, province of Corrientes, Argentina. The most abundant species in their study was *Campyloneuropsis cincticornis* (Stål, 1860) (Bryocorinae), followed by the mirines *Taedia stigmosa* (Berg, 1878), *Derophthalma fluminensis* Carvalho, 1944 and *Taylorilygus apicalis* (Fieber, 1861). The latter, an exotic species, was the most abundant mirid in the study of Logarzo *et al*. (2005), representing 87% of the specimens collected. These authors studied mirid-host plant associations for 22 species along road side habitats in Argentina and Paraguay by collecting and rearing more than 35,000 nymphs. Most of the species were found to be associated with Asteraceae flower buds. Both Melo *et al*. (2004) and Logarzo *et al*. (2005) reported much higher abundance, but fewer species than we observed at PET. Paula & Ferreira (1998) recorded 1,082 individuals from 96 species of Miridae by using a light trap over 64 months. The most abundant mirid in that study was *Fulvius quadristillatus* (Stål, 1860) (Cylapinae), followed by an unindentified *Fulvius* sp., and *Collaria oleosa* (Distant, 1883).

Abundance and species richness at PET were also studied in the same occasions for Coreoidea (Barcellos *et al*., 2008) and Pentatomoidea (Schmidt & Barcellos, 2007). Comparing the four sampling periods, the highest estimated species richness observed for mirids during autumn/2004 was also recorded for coreoids, despite being statistically similar to spring/2003 for that group. For Pentatomoidea, there was no significant difference among the spring of 2003 or 2004 and autumn/2004 for this parameter.

The highest observed and estimated species richness for mirids at Yucumã trail was also recorded for Pentatomoidea. This trail showed more exclusive species of Pentatomoidea and Coreoidea than Garcia trail as well. Schmidt & Barcellos (2007) related their result to apparently higher plant heterogeneity along Yucumã trail. Also the higher evenness along this trail suggests that it is more diverse than Garcia. In a study of Heteroptera diversity in semi-natural habitats, in Europe, vegetation structure and flower abundance were considered key factors for species richness, abundance and composition (Zurbrügg & Frank, 2006). Further studies are needed in order to test the influence of these factors on Neotropical fauna, including analyses of vegetation composition, diversity and structure. The six undescribed species found in this study reveal the scarcity of data on Miridae diversity in southern Brazil. Additionally, the presence of new taxa highlights the importance of this relict area for insect conservation in subtropics.

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