Relationship between space distribution of the benthic macroinvertebrates community and trophic state in a Neotropical reservoir (Itupararanga, Brazil)

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Abstract: The purpose of this work was to verify the benthic macroinvertebrates community responses through environmental factors along a headwater tropical reservoir. Samplings were taken with a Van-Veen grab along the reservoir in littoral and profundal regions and in the headwater, next to the dam and the middle of the reservoir. Samples were taken during both wet and dry seasons. Dissolved oxygen concentrations, electric conductivity, temperature and pH near the sediment have been performed *in situ,* at every sampling station by using a multiprobe and Secchi disc. Total water phosphorus and chlorophyll *a* concentrations were analyzed to determine the trophic state index. Sediment's organic matter, total phosphorus, nitrogen concentrations and granulometric composition were measured. In order to verify which environmental variables would have more influence over the benthic macroinvertebrates community, a canonical correspondence analysis (CCA) was performed. The total number of recorded taxa was 28. Among them, the family Chironomidae (Diptera) was the richest group (19 taxa). It can be proposed that the benthic macroinvertebrates community may be influenced by environmental conditions such as nutrient and organic matter availability, as well as dissolved oxygen concentration. Macroinvertebrates are adequate bioindicators of water quality due to their sensibility to environmental changes mentioned before. *Chironomus* sp, *Limnodrilus hoffmeisteri* and *Branchiura sowerbyi* comprises a group that can be considered bio-indicators of eutrophic conditions. A second group can be considered as indicator of mesotrophic conditions. The presence of two or more members from that group which comprises Tanytarsini spp, *Fissimentum* sp, *Pelomus* sp and *Goeldichironomus* sp, like predominant taxa, may indicates mesotrophic conditions.
Keywords: *benthos, Chironomidae, Limnology, bioindicator, water quality.*

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Resumo: O objetivo deste trabalho foi verificar as respostas da comunidade de macroinvertebrados bentônicos a fatores ambientais ao longo de um reservatório tropical de cabeceira. As amostras foram coletadas com uma draga do tipo Van-Veen ao longo do reservatório nas regiões profunda e litorânea bem como na cabeceira, próximo à barragem e no meio do reservatório. Amostras foram coletadas tanto na estação seca quanto na estação chuvosa. Foram determinadas as concentrações de oxigênio dissolvido, condutividade elétrica, temperatura e pH próximos ao sedimento, *in situ*, em todas as estações amostrais com a utilização de um multisensor e disco de Secchi. Foram ainda determinadas as concentrações de fósforo e clorofila *a* da água para cálculo do índice de estado trófico. Com relação ao sedimento, foram determinados o teor de matéria orgânica, concentrações totais de fósforo e nitrogênio bem como a composição granulométrica. Para se verificar quais variáreis ambientais tiveram maior influência sobre a comunidade de macroinvertebrados bentônicos, uma análise de correspondência canônica (ACC) foi realizada. Foram registrados, ao todo, 28 táxons. Dentre estes, o grupo taxonômico com maior riqueza foi a família Chironomidae (Diptera) com 19 táxons. O estudo indicou que a comunidade de macroinvertebrados bentônicos respondeu às condições ambientais como disponibilidade de nutrientes e matéria orgânica, bem como às concentrações de oxigênio dissolvido. Assim sendo, os macroinvertebrados foram considerados bons indicadores da qualidade da água devido à sua sensibilidade frente às possíveis alterações ambientais supramencionadas. *Chironomus* sp, *Limnodrilus hoffmeisteri* e *Branchiura sowerbyi* formaram um grupo que pode ser considerado como bioindicador de condições eutróficas. Um segundo grupo pôde ser considerado como indicador de condições mesotróficas. A presença de dois ou mais membros deste grupo, que inclui os táxons Tanytarsini spp, *Fissimentum* sp, *Pelomus* sp e *Goeldichironomus* sp, como táxons dominantes, pode indicar tais condições.
Palavras-chave: *bentos, Chironomidae, Limnologia, bioindicadores, qualidade da água.*

Introduction

The water quality is a very important issue to the human life nowadays. Because of this, a wide variety of indicators have been employed to monitoring the water quality and the integrity of the aquatic ecosystems. There is not a unique indicator that may point to all the variations and impacts that a water body receives. Furthermore, variables like time, costs, skilled human resources, method's accuracy, extent of the answer, possibility of spatial and temporal identification and mainly what kind of disturbance is necessary to identify or to monitoring in the environment are factors that will determine which will be the more adequate indicator in each case.

The trophic state indices are usually the most used among the water quality indicators. The most traditional indices use phosphorus and chlorophyll concentrations in the water as its components (Carlson 1977, Lamparelli 2004). There are still those, among the biological ones, which show differentiated sensitivity to pollutants concentrations or other impacts such riparian forest suppression. The benthic macroinvertebrates are good examples of this as well as other organisms are as, for instance, the zooplankton (Brito et al. 2011) or fishes' communities (Terra & Araújo 2011). But, the first one, are better when the objective is to localize spatially the influence of the disturbance, due to their low mobility (Mandaville 2002), or is preferable when the goal is to measure the effects of impacts accumulation along the time as, for example, the nutrients or metals in the bottom (Arslan et al. 2010, Bettinetti et al. 2012).

The benthic macroinvertebrates are considered excellent bio-indicators because they can be found in most of the aquatic environments from temporary ponds to large rivers, lakes and deep reservoirs. Further, these animals present an elevated species richness. Since benthic macroinvertebrates, are mainly sedentary or has low mobility, the environmental disturbances can be easily localized. Furthermore, since they are in the sediment and have a long life cycle when compared to others bio-indicators like plankton organisms, the macroinvertebrates can indicate environmental conditions through the time providing long period recordings (Rosenberg 1998). Moreover, they are capable to react to both water column and sediment impacts which amplifies the response to environmental conditions spectrum, since the others indicators usually responses to one or another compartment (Carew et al. 2007).

Natural environmental conditions like sediment grain size, pH, temperature, currents, depth, oxygen as well as organisms interactions like predation, competition or food availability are relevant too and their influence will be according to the macroinvertebrates species populations multidimensional niches (Hutchinson 1965, Cowell & Rangel 2009) and so this influence must be considered in any environment that is being monitored by biological indicators.

Many works demonstrate that benthic macroinvertebrates community can also be altered in response to anthropogenic environmental changes, as land uses (Miserendino et al. 2011), riparian forest impacts and effluents loading (Baptista et al. 2007, Couceiro et al. 2007, Gamito & Furtado 2009, Sharma & Rawat 2009) and also by pollution by industrial effluents (Moreno & Callisto 2006). Several taxa from benthic macroinvertebrates community and a wide range of biological indexes and metrics have been widely employed as environmental indicators (Bode et al. 2002, Mandaville 2002, Fusari & Fonseca-Gessner 2006, Baptista et al. 2007, Baptista 2008, Angradi et al. 2009).

Our hypothesis is that the benthic macroinvertebrates communities' shows significative differences in abundance; distribution and composition when they are under diverging environmental conditions witch could be related to human impacts.

Moreover, there are few works that clearly demonstrates relationship between water and sediment environmental conditions and the benthic macroinvertebrates composition and distribution in the Neotropical region.

Hence, the aim of this work was to verify the responses of macroinvertebrates to environmental conditions and human impacts in a tropical reservoir. In that sense, the present research can provide tools for future studies and in monitoring or in restoring programs.

Materials and Methods

1. *Study area*

Itupararanga Reservoir is placed on Alto Sorocaba Basin (SP, Brazil), that corresponds to the main headwater of the left margin effluent of Tiete River (Figure 1).

The Itupararanga reservoir is located into an Environmental Preservation Area (EPA) created in 1998, with the main purpose to protect the water resources in the influenced area of the reservoir. More than 1/3 of the (EPA) is occupied by native vegetation fragments in a matrix of rural environment (Beu et al. 2011). The predominant vegetation can be classified as semideciduous forest (Almeida 2009). The EPA is located in the area of dense rainforests, but many of the original vegetation has been removed, and the majority of remaining plants are composed of secondary forest or pioneer formations (Almeida et al. 2011).

The region climate can be classified as Cwa according the Köppen classification. That classification is used to describe humid subtropical climates, with average temperatures in the warmest months of summer above 22 ° C. With respect to precipitation, there is characteristically a cold, dry season and a warm rainy season. The average annual rainfall in the Basin region of Alto Sorocaba is 1493 mm. The wettest month is January when the average rainfall is 248 mm. August is the driest one and average rainfall of its month is 43 mm (Salles et al. 2008).

The high Sorocaba basin is surrounded mainly by small cities. Those cities usually have the agriculture as their major economic resource (vegetable farming). Despite the forming rivers (Sorocabuçu, Sorocamirim and Una) of the reservoir drain peripheral regions of the Metropolitan Region of São Paulo, where a disordering marginal occupation is observed in almost every cities. The domestic effluents treatment is incipient and, as a consequence, sewage is discharged "in natura" in the forming rivers (Salles et al. 2008, Beu et al. 2011).

There are multiple uses for the water stored by that rivers damming. The main uses are energy supply for a large industry and the water supply for four cities (Votorantim, 2012) providing 85% of the treated water consumed by the city of Sorocaba that has approximately 600,000 habitants. Therefore, the water supply from this reservoir is given to about 850,000 people. In addition, this water body plays an important hydraulic regulatory role to Sorocaba River water, which crosses the metropolitan area of the city of Sorocaba.

The area of Itupararanga Reservoir is about 29.49 km^2 and its maximum capacity of water reaches 355×10^6 L of water. Its water is also used to some other activities like irrigation, recreation area and fishing (Beu et al. 2011).

2. *Collection and identification*

The samplings were taken in three distinct zones of the reservoir (Table 1) which were chosen in order to obtain samples longitudinally

Table 1. Geographic coordinates of the sample points.

Entrance	Profundal	23° 37' 3.8" S and 47° 13' 41.4" W
	Littoral	23° 37' 7.8" S and 47° 13' 39.8" W
Middle	Profundal	23° 37' 16.6" S and 47° 21' 30.5" W
	Littoral	23° 37' 16.6" S and 47° 21' 46" W
Dam	Profundal	23° 36' 44.6" S and 47° 23' 40.9" W
	Littoral	23° 36' 35.9" S and 47° 23' 16.9" W

along the reservoir. The first zone was near the headwater of the reservoir where there is higher turbulence, the edges are near each other and this is the closest region of the former rivers which receives many sewage discharges. The second was in the middle and can be considered as a transitional region and the last samples were taken close to the dam, far away from the impacted rivers and it is lentic as the middle region (Figure 2). The material was sampled twice: one profundal and another littoral in order to detect different degrees of terrestrial environment impact in the communities. All samplings were taken in December 2009 and in February 2010 (wet season) and in June and in August 2010 (dry season) during the day.

The measurements of water pH, dissolved oxygen content, temperature and electric conductance were performed *in situ*, near the sediment until 15m depth by using an YSI 556 model multiprobe. The water transparency was measured by a Secchi disk and the photic zone extension was calculated multiplying the disk lecture value by 2.27 (Padial & Tomaz 2008).

In order to calculate the trophic state index (TSI) of Carlson (1977) modified by Lamparelli (2004) (Table 2), the samplings taken in three reservoir zones in the central region near the surface to determine the total phosphorus (4500B (item 5) American... 2005) and chlorophyll *a* (Nush 1980).

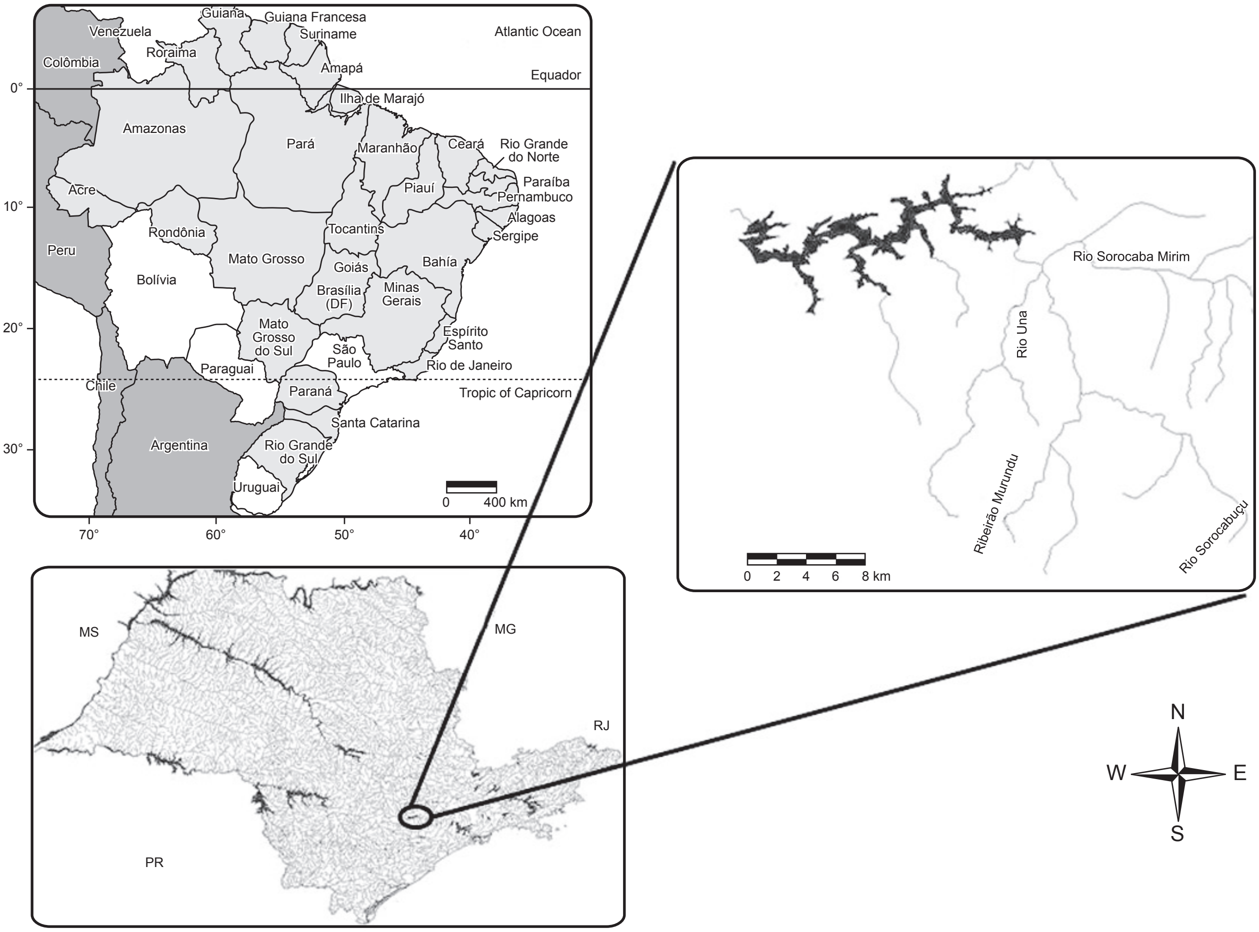

Figure 1. Map showing Itupararanga Reservoir location in the state of São Paulo. Modified from Environmental Information System – SinBiota – FAPESP. Available on http://sinbiota.cria.org.br/atlas/. Accessed January 14th, 2011.

Table 2. Water body classification according to the trophic state index of Carlson (1977) modified by Lamparelli (2004). TP = Total Phosphorus concentration; CL = Chlorophyll *a* concentration.

Classification	Range	Secchi – S (m)	TP (mg.m^{-3})	CL (mg.m^{-3})
Ultraoligotrophic	IET $\leq$ 47	S $\geq$ 2.4	P $\leq$ 8	CL $\leq$ 1.17
Oligotrophic	47 < IET $\leq$ 52	2.4 > S $\geq$ 1.7	8 < P $\leq$ 19	1.17 < CL $\leq$ 3.24
Mesotrophic	52 < IET $\leq$ 59	1.7 > S $\geq$ 1.1	19 < P $\leq$ 52	3.24 < CL $\leq$ 11.03
Eutrophic	59 < IET $\leq$ 63	1.1 > S $\geq$ 0.8	52 < P $\leq$ 120	11.03 < CL $\leq$ 30.55
Supereutrophic	63 < IET $\leq$ 67	0.8 > S $\geq$ 0.6	120 < P $\leq$ 233	30.55 < CL $\leq$ 69.05
Hypereutrophic	IET > 67	0.6 > S	233 < P	69.05 < CL

At each sample point, it was collected sediment samplings in order to determine the granulometric composition (Camargo et al. 2009), phosphorus (Andersen 1976) and nitrogen concentrations (4500 $N_{Org}C$; American... 2005), and organic matter proportion (Wetzel & Likens 2000).

The macroinvertebrates were collected with a Van Veen grab (0.045 m^2 sampling area); at each point three sampling units were taken, performing cumulative samples. The samplings were washed over a 212µm pore opening web, sorted and identified usually until genera or species level. The Chironomidae larvae were identified to genera level, because for species safe identification it is necessary to examine larva, pupa and imago and in the present work it was possible to take only larvae. The Tanytarsini tribe was not identified beyond the tribe level because the safe differentiation between *Caladomyia* and *Tanytarsus* requires the last instars larvae and most of them was first or second instars larvae. It was reached the species or genera level for Oligochaeta. The morphospecies concept was used to low representative taxa when the identification at genera level was not possible. The identification was performed in the laboratory by using stereomicroscope and optic microscope and it was also used the following identification keys and manuals: Brinkhurst (1971), Saether (1980), Brinkhurst & Gelder (2001), Hilsenhoff (2001), Pinho (2008), Epler (2011), Trivinho-Strixino (2011).

3. *Data analysis*

The total density per sampling was calculated by dividing the number of specimens sampled by the total sampled area at each point, resulting in the number of organisms per m^2.

Additionally, a matrix of Correspondence Canonical Analysis among the environmental variables and the density logarithm of the main taxa – considering only the taxa that had abundance higher than 10% in at least one sampling and frequency of, at least 30% – were performed and so, the variables that presented significant correlation with at least one of the analyzed taxa were selected to the Canonical Correlation Analysis (CCA).

The following variables had correlations with greater number of taxa: sediment phosphorus (six taxa) and nitrogen (five taxa); dissolved oxygen (five taxa) and organic matter in the sediment (four taxa). Depth, pH and sediment grain size also had some correlations but, in these cases with less than three taxa. The other environmental variables were omitted once that them had not shown any correlation with the main taxa.

The CCA significance was verified by a permutation test (1,000 permutations). After that, the groups and the main environmental variables that differentiate each one were identified. The softwares Multi Variate Statistical Package 3.12 (Kovach... 2001); Bioestat 5.0 (Ayres 2007) and Past 2.01 (Hammer et al. 2001) were employed to perform that analysis.

Two UPGMA (Unweighted pair-group average) cluster analysis, one for wet season and other for dry season, with binary data and a two-way ANOVA (similarity analysis) considering all samplings were performed in order to verify the spatial heterogeneity of the community based on species composition.

Results

According to the calculated TSI, Itupararanga Reservoir can be classified as meso – eutrophic water body. In general, the headwater of reservoir can be considered eutrophic, whereas the middle and dam are mesotrophic zones (Table 3). The mean water temperature during the wet season was 6.82° higher than during the dry season, the pH was usually neutral in both but higher during the dry season (Table 4). The electric conductivity can be considered intermediate and it was not recorded considerable variations between the seasons (Table 4). The oxygen concentrations were low and had great variation considering the spatial heterogeneity; the lowest values were recorded near the rivers entrance and in the profundal regions (Table 4).

The sediment nutrients concentrations were higher during the wet season. Average granulometric composition shows predominance of the finest grains in the sediment but, with great amplitude considering it was taken littoral and profundal samplings. The organic matter content remained similar in both seasons (Table 5).

A total of 2087 individuals were collected, belonging to 28 taxa (Tables 6 and 7). Densities varied from zero to 2963 ind.m^{-2} for sampling. The mean density was 704 ind.m^{-2} with a standard deviation of 756 including all samples. The recorded taxa number by period were 13, 12, 20 and 16 taxa, in December 2009, February 2010 (wet season), June and August 2010 (dry season), respectively. During the wet season 17 taxa were recorded, in contrast to the 25 taxa collected during the dry one.

The Tubificinae (Oligochaeta, Naididae) and Chironomidae (Diptera) were the most abundant taxonomic groups and was present in every sampling period and along all reservoir. The Tubificinae here is represented by four taxa: *Branchiura sowerbyi* Beddard; *Bothrioneurum* sp; *Limnodrilus hoffmeisteri* Brinkhurst; *Peloscolex* sp and one non identified taxa named here as Tubificinae sp1.When considering all reservoir, it was the more abundant taxa during the wet season and the Chironomidae, represented by 19 taxa, was the most abundant during the dry one.

The abundance was concentrated in the headwater during the wet season, while this distribution was more heterogenic during the

Figure 2. Schematic sampling points location in Itupararanga Reservoir, SP, Brazil showing the sampling stations adopted in this work (points) and the position of the dam and headwater in the reservoir.

Table 3. Calculated trophic state index of Carlson (1977) modified by Lamparelli (2004) (mean for each zone considered in this work) .TSI (TP) = TSI based on total Phosphorus concentration; TSI (CL) = TSI based on Chlorophyll *a* concentration. SD = standard deviation.

	Head	Middle	Dam
TSI (TP)	60.29	54.90	51.56
SD	2.36	3.85	0.98
TSI (CL)	59.29	58.72	59.42
SD	2.71	0.33	3.81
Secchi (m)	0.98	1.80	1.90
SD	0.21	0.41	0.61
TSI (mean)	61.04	57.26	55.72
SD	2.40	1.92	2.09
Category	Eutrophic	Mesotrophic	Mesotrophic

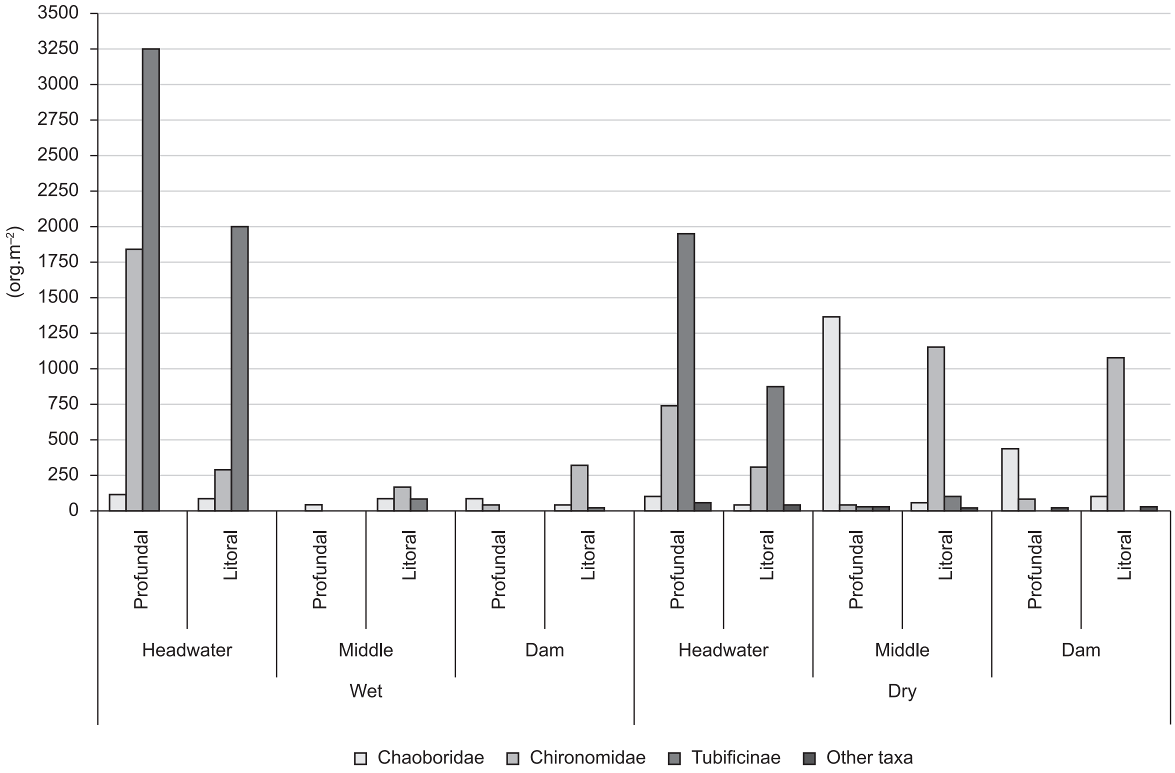

Figure 3. Densities (org.m^{-2}) for main taxonomic groups recorded by season in Itupararanga Reservoir, SP, Brazil.

Table 4. Mean, maximum, minimum, amplitude and standard deviation (SD) recorded for the abiotic variables of water of Itupararanga Reservoir, High Sorocaba Basin, SP, Brazil in wet season (December 2009, February, 2010) and in dry season (June 2010 and August 2010). Temp. = temperature; Cond. = electric conductance; DO = dissolved oxygen; Depth; Zeu = photic zone extension.

		Temp. (°C)	pH	Cond. (µS.cm^{-1})	DO (mg.L^{-1})	Depth (m)	Zeu (m)
Wet	Max	26.83	7.83	65.00	7.75	20.50	6.2
	Min	21.28	2.48	40.00	0.20	2.25	1.4
	Mean	23.46	5.84	51.33	4.10	9.23	3.6
	Amplitude	5.55	5.35	25.00	7.55	18.25	4.9
	SD	1.53	1.98	8.33	3.13	6.60	1.5
Dry	Max	17.80	7.39	97.00	9.05	20.00	4.1
	Min	14.45	5.15	40.00	3.07	2.50	1.8
	Mean	16.54	6.28	54.33	5.62	8.68	3.0
	Amplitude	3.35	2.24	57.00	5.98	17.50	2.3
	SD	0.99	0.70	17.42	1.71	6.04	0.8

Table 5. Mean, maximum, minimum, amplitude and standard deviation (SD) recorded for the abiotic variables of sediment of Itupararanga Reservoir, High Sorocaba Basin, SP, Brazil in wet season (December 2009, February, 2010) and in dry season (June 2010 and August 2010). Sand, Sil+Cl = fine sediment fractions (silt and Clay); P = total phosphorus, N = total nitrogen; OM = organic matter content.

		Sand (%)	Sil + Cl (%)	P (mg.g^{-1})	N (mg.g^{-1})	OM (%)
Wet	Max	85.10	99.70	8.48	2.67	18.00
	Min	0.30	12.47	0.18	0.00	2.00
	Mean	31.99	57.66	4.76	1.22	9.83
	Amplitude	84.80	87.23	8.30	2.67	16.00
	SD	30.23	35.89	2.59	0.99	5.98
Dry	Max	88.16	99.90	7.73	2.98	22.00
	Min	0.10	0.04	0.38	0.00	2.00
	Mean	26.51	52.26	3.57	0.87	9.92
	Amplitude	88.06	99.86	7.35	2.98	20.00
	SD	33.71	43.79	2.38	1.10	7.35

Table 6. Densities (org.m^{-2}) for each recorded taxa by sample point during the wet season in Itupararanga Reservoir, SP, Brazil. P = Profundal and L = Littoral. The Tanytarsini spp taxa represent *Caladomyia* sp and *Tanytarsus* sp larvae.

	Dec./09						**Feb./10**					
	Head		**Middle**		**Dam**		**Head**		**Middle**		**Dam**	
	P	**L**	**P**	**L**	**P**	**L**	**P**	**L**	**P**	**L**	**P**	**L**
Ablabesmyia sp	--	--	--	--	--	--	--	--	--	--	--	--
Asheum	--	--	7	--	--	--	--	--	--	--	--	--
Chironomus sp	630	7	--	7	--	--	1133	237	--	--	15	7
Coelotanypus sp	--	--	--	--	--	7	--	--	--	--	--	--
Corynoneura sp	--	--	--	--	--	--	--	--	--	--	--	--
Cricotopus sp	--	--	--	--	--	--	--	--	--	--	--	--
Fissimentum sp	--	--	--	7	--	30	--	--	--	--	--	119
Goeldichironomus sp	--	--	15	37	--	--	--	--	--	74	--	15
Nilothauma sp	--	--	--	--	--	--	--	--	--	--	--	--
Paralauterborniella sp	--	--	--	--	--	7	--	--	--	--	--	--
Pelomus sp	--	--	--	--	--	--	--	--	--	--	--	67
Pentaneurini sp1	--	--	--	--	--	--	--	--	--	7	--	--
Polypedilum sp	--	--	--	--	--	--	--	3--	--	--	--	--
Procladius sp	--	--	15	--	--	15	--	--	--	--	--	--
Stempellina sp	--	--	--	--	--	--	--	--	--	--	--	--
Saetheria sp.	--	--	--	--	7	--	--	7	--	--	--	--
Tanypus sp	--	--	--	--	--	--	67	--	--	--	--	--
Tanytarsini spp	--	--	--	15	--	52	--	--	--	--	7	--
Chaoborus sp	--	52	--	--	--	7	100	15	--	81	81	15
Ceratopogonidae sp1	--	--	--	--	--	--	--	--	--	--	--	--
Trichoptera sp1	--	--	--	--	--	--	--	--	--	--	--	--
B. sowerbyi	148	--	--	--	--	--	33	44	--	--	--	--
L. hoffmeisteri	2141	1296	--	37	--	15	933	644	--	37	--	--
Tubificinae sp1	--	--	--	--	--	--	--	--	--	--	--	--
Peloscolex sp	7	--	--	--	--	--	--	--	--	--	--	--
Bothrioneurum sp	--	--	--	--	--	--	--	--	--	--	--	--
Hirudinea sp1	--	--	--	--	--	--	--	--	--	--	--	--
Total abundance	2926	1355	37	103	7	133	2266	977	0	199	103	223
Total richness	4	3	3	5	1	7	5	6	0	3	3	5

dry one. The family Chaoboridae (Diptera) was also an abundant taxonomic group (Figure 3; Tables 6 and 7).

Ablabesmyia sp, *Corynoneura* sp, *Cricotopus* sp and *Nilothauma* sp. were found only in dry period on the other hand, 13 taxa were found only in wet period (Tables 6 and 7).

The CCA results indicate that water variables as dissolved oxygen and pH, as well as sediment variables as total nitrogen and phosphorus, organic matter content and granulometric composition may explain the high variation ($p < 0.0001$ and canonical $R = 0.9968$) in the distribution, abundance and structure of the benthic macroinvertebrates community (Table 8). Additionally, through CCA values, benthic macroinvertebrates could be separated in three groups compromising different taxa which are influenced by specific environmental conditions (Figure 4). Group I includes taxa which present tolerance to high sediment nutrient concentrations, as well as to lower dissolved oxygen water availability. Group II displays a higher heterogeneity and seems to be less tolerant to water hypoxia and more tolerant to low phosphorus, nitrogen and organic matter concentrations in the sediment. Group III correspond to the genera *Chaoborus* sp and *Procladius* sp. Only the first taxa showed significant correlation with the variables that were considered. *Chaoborus* sp was related to higher organic matter content in the sediment and to a higher proportion of fine granulometric fractions.

The spatial heterogeneity analyzes indicate that this occurs both transversely (littoral and profundal) and longitudinally (Figure 5). The *p* value for the ANOSIM was 0.049 for heterogeneity in the transverse direction and 0.009 for heterogeneity longitudinal sense.

Discussion

Some researches (Pamplin et al. 2006, Carew et al. 2007, Jorcin & Nogueira 2008, Buss & Vitorino 2010, Cortelezzi et al. 2011, Miserendino et al. 2011) have improved the knowledge of the bio-indicator potential of the benthic macroinvertebrates.

Carew et al. (2007) analyzed the response of Chironomidae taxa indicators to pollution, especially in the sediment. These authors identified taxa *Riethia stictoptera* Kieffer, *Tanytarsus inextentus* Skuse, *Coelopynia,* and *Chironomus februarius* Martin as potential low anthrophic pressure environment bio-indicators and *Chironomus duplex* Walter species as a high sediment pollution condition indicator.

In this study, Tubificinae and Chironomidae were the predominant taxa during both seasons reaching 66 and 29%, respectively, of the total organisms sampled during the wet season, and 35 and 40% during the dry one. Other studies suggest that these two groups, as well as most of macrobenthic components in lentic environments (including reservoirs) have some predominance variation due to both

Table 7. Densities (org.m^{-2}) for each recorded taxa by sample point during the dry season in Itupararanga Reservoir, SP, Brazil. P = Profundal and L = Littoral. The Tanytarsini spp taxa represent *Caladomyia* sp and *Tanytarsus* sp larvae.

	Jun./10						Aug./10					
	Head		Middle		Dam		Head		Middle		Dam	
	P	L	P	L	P	L	P	L	P	L	P	L
Ablabesmyia sp	--	--	--	--	--	--	--	--	--	--	--	7
Asheum	--	--	--	--	9	--	--	--	--	--	--	--
Chironomus sp	220	53	--	--	--	--	496	59	--	--	--	--
Coelotanypus sp	--	--	--	--	--	--	--	--	--	--	--	--
Corynoneura sp	--	--	--	--	9	--	--	--	--	--	--	--
Cricotopus sp	--	--	--	--	18	--	--	--	--	--	--	--
Fissimentum sp	--	--	--	53	--	35	--	--	--	22	--	7
Goeldichironomus sp	--	--	--	9	--	44	--	--	--	22	--	7
Nilothauma sp	--	--	--	--	--	9	--	--	--	--	--	--
Paralauterborniella sp	--	--	--	--	--	--	--	--	--	--	--	--
Pelomus sp	--	35	--	9	9	--	7	44	--	59	--	--
Pentaneurini sp1	--	--	--	--	--	--	7	--	--	--	--	--
Polypedilum sp	--	9	--	--	--	--	--	81	--	178	--	--
Procladius sp	--	--	--	9	9	--	--	22	30	119	22	--
Stempellina sp	--	--	--	--	--	--	--	--	--	--	--	15
Saetheria sp.	--	--	--	9	--	9	7	7	--	7	--	44
Tanypus sp	--	--	--	--	--	--	--	--	--	--	--	--
Tanytarsini spp	--	--	--	370	--	414	--	--	--	252	--	452
Chaoborus sp	26	--	802	9	168	97	67	37	563	37	259	--
Ceratopogonidae sp1	--	--	--	--	--	--	7	--	--	--	--	--
Trichoptera sp1	--	--	--	--	9	--	--	--	--	--	--	--
B. sowerbyi	26	--	18	--	--	9	--	7	--	--	--	--
L. hoffmeisteri	1517	115	18	--	--	--	407	726	--	104	--	--
Tubificinae sp1	35	--	--	--	--	--	--	--	--	--	--	--
Peloscolex sp	--	9	--	--	--	--	--	--	--	--	--	--
Bothrioneurum sp	--	18	--	--	--	--	--	--	--	--	--	--
Hirudinea sp1	--	18	9	--	--	--	7	--	--	7	--	--
Total abundance	1824	257	847	494	231	643	1005	983	593	807	281	532
Total richness	5	7	4	7	7	7	8	6	2	9	2	6

Table 8. Correlation matrix generated from canonical correspondence analysis. Only the variables with marked with an asterisk (*) had significative correlation with the correspondent taxon ($p < 0.05$). DO = dissolved oxygen; Ns = total sediment nitrogen; Ps = total sediment phosphorus; OM = organic matter sediment content; Cl+Sil = Clay + silt granulometric fractions. *Branchiura sowerbyi* = Bra; *Chironomus* spp – Chi; *Limnodrilus hoffmeisteri* = Lim; *Saetheria* sp = SAE; *Pelomus* sp = Pel; spp = Tant; *Fissimentum* sp = Fis; *Goeldichironomus* sp = Goe; *Chaoborus* sp = Cha; *Procladius* sp = Pro.

	pH	DO	Depth	Ns	Ps	OM	Sand	Cl + Sil
Cha	–0.35	–0.06	0.28	0.18	0.39	0.64*	–0.32	0.63*
Pro	0.07	0.39	0.18	–0.04	–0.10	0.09	–0.10	0.11
Bra	–0.06	–0.42*	–0.07	0.55*	0.48*	0.12	0.26	0.05
Chi	–0.13	–0.54*	–0.27	0.30	0.28	–0.08	0.40	–0.21
Lim	–0.00	–0.46*	–0.42	0.23	0.33	–0.07	0.45*	–0.16
Fis	0.49*	0.59*	–0.53*	–0.52*	–0.62*	–0.51*	0.16	–0.50*
Goe	0.19	0.62*	–0.39	–0.43*	–0.44*	–0.45*	0.15	–0.17
Pel	0.09	0.33	–0.38	–0.48*	–0.57*	–0.42	0.19	–0.47*
Sae	0.10	0.25	–0.31	–0.42	–0.46*	–0.48*	0.41	–0.51
Tant	0.27	0.41	–0.34	–0.43*	–0.48*	–0.38	0.11	–0.38

environmental conditions and historical factors (Callisto et al. 2005, Pamplin et al. 2006, Lucca et al. 2010).

The richness observed in Itupararanga Reservoir, which has eutrophic and mesotrophic conditions, suffering human impacts especially in the headwater, can be considered intermediate when compared with that described to other lentic environments in Neotropical Regions. Lucca et al. (2010) analyzed the benthic macroinvertebrates communities in an oligotrophic lake and recorded 23 taxa. Fusari & Fonseca-Gessner (2006) reported 20 and 34 taxa in an eutrophic and an oligotrophic reservoir, respectively. In the

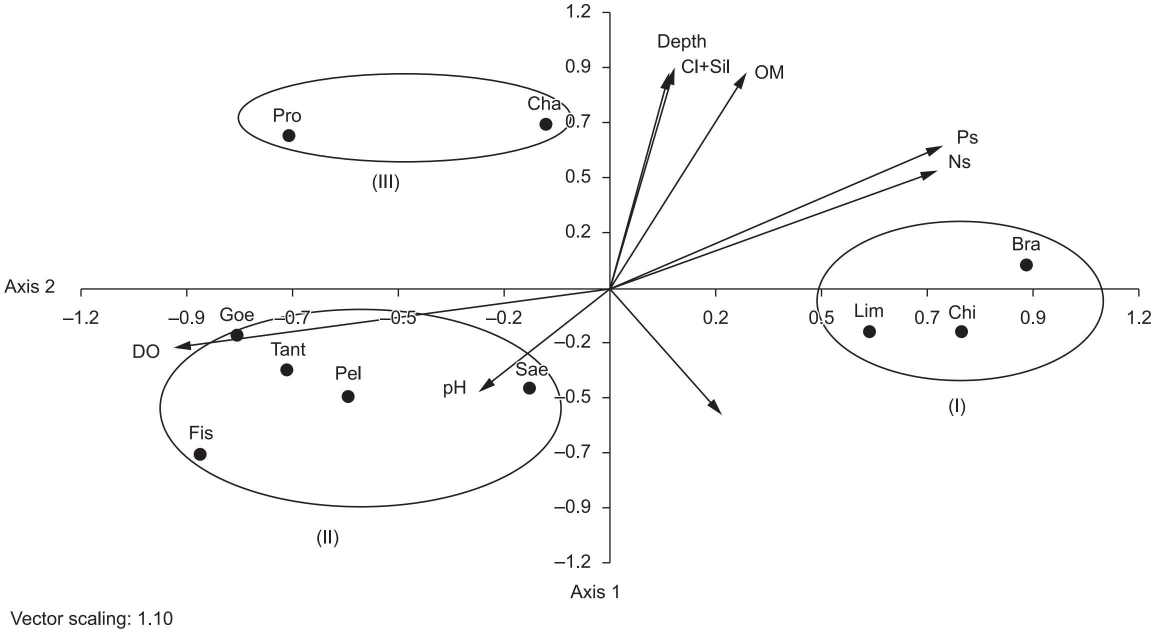

Figure 4. Correspondence Canonical Analysis considering the abundance and distribution of the benthic macroinvertebrates community and environmental variables from Itupararanga Reservoir, SP, Brazil, highlighting the relationship between the main taxa (*Branchiura sowerbyi* = Bra; *Chironomus* spp – Chi; *Limnodrilus hoffmeisteri* = Lim; *Saetheria* sp = SAE; *Pelomus* sp = Pel; spp = Tant; *Fissimentum* sp = Fis; *Goeldichironomus* sp = Goe; *Chaoborus* sp = Cha; *Procladius* sp = Pro) and the environmental variables (Ps = total sediment phosphorus; Ns = total sediment nitrogen; OM = sediment organic matter content; Cl+Si = fine sediment fractions (Clay + silt); Depth; Sand = sand sediment fractions; pH = water; DO = water dissolved oxygen concentrations. (I) = Group I, (II) = Group II and (III) = Group III.

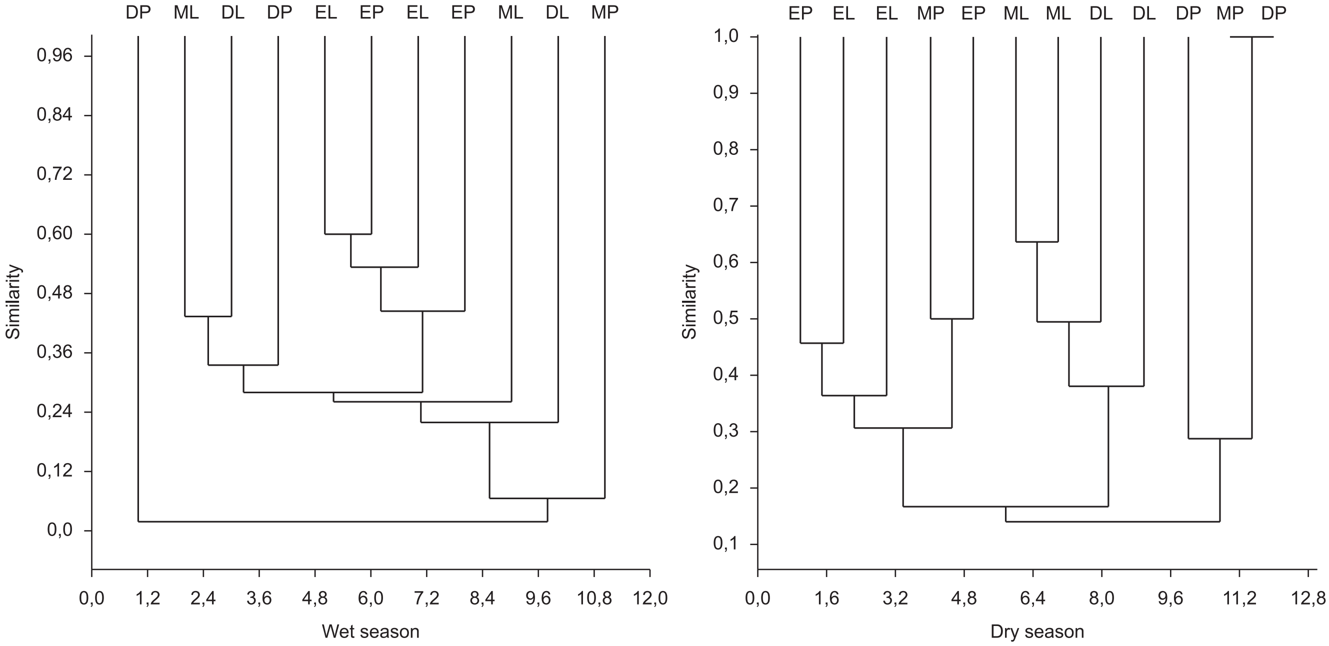

Figure 5. UPGMA Analysis for binary data (taxonomic composition) showing spatial heterogeneity. Letter E indicates samplings collected near the reservoir's entrance, letter M is for that collected in the middle of the reservoir and letter D represents the samplings near the dam. The letters P and L indicates respectively the profundal and littoral regions.

present study, we have recorded 19 Chironomidae among the 27 taxa identified. The major importance of that taxonomic group for the total richness may be understood as a standard for benthic macroinvertebrates when lentic environments or reservoirs are analyzed (Callisto et al. 2005, Fusari & Fonseca-Guessner 2006, Pamplin et al. 2006, Shostell & Williams 2007, Jorcin & Nogueira 2008, Lucca et al. 2010).

The benthic macroinvertebrates respond quickly and locally to the disturbances by changing the structure and the composition of the community, as well as altering the taxa distribution (Mandaville 2002). The abiotic analyses provided evidences that Itupararanga Reservoir is a heterogenic water body and that many relevant differences could be noticed. Because of this heterogeneity the reservoir can be analyzed as having at least three distinct areas as evidenced by ANOSIM and UPGMA analyses when considered together. The riverine (entrance) zone is evidenced as the most differing one in a longitudinal sense while in a transversal sense the heterogeneity is more pronounced in the middle of the reservoir and near the dam where the margins are farther each other.

In general, we could identify an eutrophicated zone that comprises the headwater profundal and littoral regions; a mesotrophic littoral one which comprises the middle and the near the dam areas in the littoral regions and a mesotrophic profundal zone with the profundal regions of the middle and near the dam areas.

In the present study, a significant correlation among environmental factors with the abundance and the distribution of the main taxa that formed the benthic macroinvertebrates communities of Itupararanga Reservoir was observed. These taxa can be divided into three groups according to their relationship with environmental factors. Group I has been formed by *L. hoffmeisteri*, *Chironomus* sp and *B. sowerbyi*; this group acts as an eutrophication bioindicator. *L. hoffmeisteri* is considered the Oligochaeta species that is the most tolerant to pollution according to Verdonschot (1989). High densities of them followed by the decrease of the diversity of other taxa may be seen as an organic enrichment indicator to continental water bodies (Dornfeld et al. 2006, Martins et al. 2008). In the same way, some studies pointed out the *Chironomus* genera as one of the most resistant benthic organisms to organic pollution (Adriansens et al. 2004, Simião-Ferreira et al. 2009). *B. sowerbyi* was reported in impacted environments (Suriani et al. 2007).

The relevant abundance of these organisms can be associated to high trophic level environmental conditions such as sediment nutrients accumulation and low dissolved oxygen concentrations in the water. This group has been recorded as predominant only in the headwater zone where it was present in every sampling. This zone was the only classified as eutrophic by TSI. Therefore, this data suggests that the group I is characteristic of impacted areas, then reflecting eutrophication of water and sediment.

Group II is a more diverse one. It comprises the Chironomidae *Fissimentum* sp, *Goeldichironomus* sp, *Pelomus* sp, *Saetheria* sp and *Tanytarsini* spp. The distribution of these animals is related to water conditions as well to the sediment. There is some preference for high oxygenated waters and low nutrient and organic matter content in the sediment. These organisms are also related to less clay and silt proportion in the sediment. Altogether, these conditions suggest that these organisms are indicators of oligo or mesotrophic environments, since nutrients or organic matter accumulation is not observed in littoral areas of the samples taken in the middle or near the dam zones. Group II organisms were recorded in mesotrophic littoraneous areas with, at least, two members in the same sample dominating the community. In general *Tanytarsini* spp. or *Goeldichironomus* sp. In contrast, this group are almost absent in the eutrophicated headwater – even in the deep or littoral region – and, when some group II member was recorded, it appears isolated from the other taxa that characterizes its group and never as predominant taxon. Moreover, the results point out that there are some more equitative taxa distributions, corroborating that metrics like richness or indexes like dominance and diversity may be considered as environmental quality indicators.

Finally, Group III is composed by *Chaoborus* sp and *Procladius* sp. While *Chaoborus* sp presented a significant correlation with sediment variables (higher organic matter content and finer sediments), it was not observed to *Procladius* sp. Considering that both taxa belong to the trophic guild of the predators, it can be suggested that prey availability, as well as the presence of the predators, regulate the distribution of these organisms that have migratory ability and a varied diet. *Chaoborus* sp eats mainly planktonic organisms and usually migrates daily in the water column (Castilho-Noll & Arcifa 2007) while *Procladius* sp eats as benthic organisms as rotifers, ostracods and cladocerans (Vodopich & Cowell 1984). Despite of the fact that these taxa were mainly recorded in mesotrophic areas, the groups have only two members and one of them was recorded in the eutrophicated headwater area too. So, it is more plausible that the main environmental factors that influenced their predominance were the depth and oxygen availability. So, this group can be considered more like a profundal specialists group that an indicator of other environmental conditions.

Pamplin et al. (2006), studying the benthic macroinvertebrates of Tropical Reservoir, Americana, SP, Brazil, observed that there was a strong correlation among fine sediment fractions (silt and clay) and high organic matter contents with *Chironomus decorus* Johansen and *Limnodrilus hoffmeisteri*. These results are different of that obtained in Itupararanga Reservoir. The Itupararanga Reservoir's data show also L. hoffmeisteri from group I associated with sediment granulometric composition but, here, the association is with sand fractions while the results from Pamplin et al. (2006) shown association of *Chironomus* sp and *L. hoffmeisteri* with the finest sediment fractions.

Some hypotheses can be considered when comparing these results: firstly, in Itupararanga Reservoir, sediment nitrogen and phosphorus concentrations were included in the analysis whereas in Americana Reservoir they were not included. So, it is plausible that when the sediment's nutrients are considered, the relative importance of the sediment granulometry loses some importance.

Another fact that must be mentioned is that in the present study, the *L. hoffmeisteri* group is composed in association with *Chironomus* sp and *B. sowerbyi* but in the Pamplin et al. (2006) research, the *L. hoffmeisteri* is associated with more three different taxa and *B. sowerbyi* is in another group, indicating that the communities structures are someway different.

On the other hand, *Chironomus* sp and *L. hoffmeisteri* were correlated in both reservoirs with high organic matter content and low oxygen conditions corroborating the hypothesis that these organisms are good indicators for these conditions, which usually are influenced by human activities.

Moreover, these authors demonstrated that other important factors that can influence macroinvertebrate composition and distribution are the depth and sand proportion in the sediments. The high density from the group I species is generally correlated to the water eutrophication (Martins et al. 2008, Simião-Ferreira et al. 2009).

Shostell & Williams (2007) analyzed the benthic macroinvertebrates community patterns in relation to the physical and chemical parameters in a shallow eutrophic reservoir (Lake Conway, AR, USA). In this study, spatial and seasonal variations in biomass, diversity and organisms' abundance were observed and the explanation was the proximity to the land environment corroborating with the Itupararanga Reservoir's data when considering the transversal heterogeneity separating communities from littoral and profundal regions as evidenced by CCA analysis.

In sum, this research demonstrated the influence of the environmental factors over the benthic macroinvertebrates community of Itupararanga Reservoir. Some of these factors (e.g., nutrient concentrations, organic matter content or the oxygen concentrations) may be greatly influenced by human activities. Therefore, anthropogenic actions can alter indirectly the composition and distribution of those organisms. The results provide strong evidences that groups I and II can be used as biological indicators. The record of the entire group is a more feasible indicator than analyzing only one member studied separately. However, it must be also emphasized the influence of some other non-anthropogenic impacts on benthic macroinvertebrates distributions, such as depth and mineral grains size of the sediment are. As a consequence, environmental peculiarities must be considered to perform a study with monitoring.

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Non-volant small mammals at an Atlantic forest area situated nearby a limestone quarry (Limeira quarry), state of São Paulo, Brazil

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Abstract: Our aim was to survey the non-flying small mammals inhabiting an Atlantic forest area situated nearby a limestone quarry (Limeira quarry), located at Ribeirão Grande municipality (SP), southeastern Brazil. Species were captured with pitfall and Sherman traps along eight pairs of 60 m transects distributed at four different distances from the quarry (60, 220, 740 and 1300 m). Between October 2005 and January 2008, 20 small mammal species (11 rodents and nine marsupials) were captured through 4080 pitfall trap-nights and 2040 Sherman trap-nights. The high values of richness, diversity (H' = 2.65) and equability (J = 0.88), and the presence of endemic and threatened species indicates a preserved study site and small mammal assemblage. *Marmosops incanus*, *Monodelphis americana* and *Oligoryzomys nigripes* were the commonest species at the study site. Trapping sites located closer to the quarry (60 and 220 m away from the quarry) presented lower richness and were dominated by disturbance-tolerant species, such as *O. nigripes*, that usually benefit from habitat alterations. On the other hand, sites located away from the quarry and closer to Serra do Mar Protected Area (740 and 1300 m away from the quarry) presented higher richness and diversity, and a higher abundance of disturbance-intolerant species. These results suggest a negative distance-dependent impact of quarrying on small mammal communities. In this way, our results point out to the importance of long-term monitoring of quarrying impacts on small non-flying mammal communities and populations, and the need of conservation strategies in order to ensure species persistence in these areas.
Keywords: *biodiversity, faunistic inventory, mining impacts, Didelphimorphia, Rodentia.*

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Resumo: O objetivo desse estudo foi elaborar uma lista das espécies de pequenos mamíferos não-voadores que ocorrem em uma região de Mata Atlântica localizada nas proximidades de uma área de mineração de calcário (Mina Limeira), situada no município de Ribeirão Grande (SP), sudeste do Brasil. Para tal, foram montadas estações de captura contendo linhas de balde e armadilhas do tipo *Sherman* em oito transectos de 60 m, agrupados em pares e localizados a diferentes distâncias da cava da mina (60, 220, 740 e 1300 m de distância), partindo da área antropizada em direção à área de proteção ambiental da Serra do Mar. Entre outubro de 2005 e janeiro de 2008, com um esforço de 4080 baldes-noite e 2040 armadilhas-noite, foram capturadas 20 espécies de pequenos mamíferos, sendo 11 roedores e nove marsupiais. A alta riqueza, diversidade (H' = 2,65) e equabilidade (J = 0,88) estimada na área de estudo, além da presença de espécies endêmicas e ameaçadas, indicam o grau de preservação da área de estudo e da assembléia de pequenos mamíferos. As espécies mais comuns foram *Marmosops incanus*, *Monodelphis americana* e *Oligoryzomys nigripes*. Os transectos localizados mais próximos da cava (60 e 220 m de distância) foram dominados por espécies indicadoras de habitats alterados, como *O. nigripes*, que tende a proliferar nessas situações. Por outro lado, os sítios mais distantes (740 e 1300 m de distância da cava) apresentaram maior riqueza e diversidade, e espécies mais sensíveis a perturbações. Esses resultados sugerem um possível impacto negativo dependente de distância em relação à mina de calcário. Dessa maneira, nossos resultados apontam para a importância de monitoramentos de longo prazo sobre os impactos da mineração sobre as populações e a comunidade de pequenos mamíferos não-voadores, além da elaboração de planos de conservação para assegurar a persistência das espécies na região.
Palavras-chave: *biodiversidade, inventário faunístico, impacto da mineração, Didelphimorphia, Rodentia.*

Introduction

Currently, the Atlantic Forest corresponds to only 12% of its original range, which is restricted to small forest fragments and areas disturbed by anthropogenic activities (Ribeiro et al. 2009). Among the disturbances, forest clearance, habitat loss and alterations in landscape configuration and vegetation structure at the local scale represent the major threats to biodiversity (Primack 2004). Despite such threats, this biome retains at least 7% of the world biodiversity, along with several endemic species (Myers et al. 2000).

Opencast mining, which is used to extract surface minerals such as coal and limestone, imposes important risks to the surrounding ecosystem. First, mining activities require suppression of original vegetation, thus causing habitat loss and changes in plant species composition and habitat structure due to edge effects (Harper et al. 2005). Second, blasting of rocks for mining excavation presents several impacts such as 1) air pollution, 2) enhancement of dust deposition, which may affect plants by reducing their photosynthesis, respiration and transpiration (Farmer 1993) and soil dwelling invertebrates through changes in soil chemical parameters (MacKenzie et al. 1990), 3) noise and vibrations, which may influence soil stability, water regimes (Ak et al. 2009), and sound perception by terrestrial animals, thus reducing their foraging and reproductive abilities (Barber et al. 2009). Finally, these activities may also cause soil erosion, alterations in nutrient cycling and hydrological flows (Farias 2002, Companhia... 2003). Such habitat deterioration, along with habitat reduction, may alter the structure of animal communities and species distribution (Tews et al. 2004).

Non-volant small mammals are highly diverse in the Neotropics (Ceballos & Ehrlich 2006, Patterson 2000, Voss & Emmons 1996). Besides their numerical importance, members of this group may function as good biological indicators due to their susceptibility to environmental impacts and disturbances related to alterations in habitat structure (Pardini et al. 2005). Moreover, both didelphids and rodents are crucial to the maintenance of trophic links and regulation of predator populations through their role as food supply to birds (Cabral et al. 2006), snakes (Henderson et al. 1987) and carnivorous mammals (Facure & Monteiro-Filho 1996). Finally, both may contribute to ecosystem functioning and habitat restoration, since they act as pollination agents (Vieira et al. 1991) and dispersers of seeds and mycorrhizal fungi (Grelle & Garcia 1999, Mangan & Adler 2000).

The main objective of this study was to provide an inventory of the non-volant small mammal fauna inhabiting an Atlantic Forest area directly affected by a limestone quarry (“Limeira quarry”), located in the Planalto de Guapiara, Ribeirão Grande municipality. This region, along with Vale do Ribeira, contains approximately 40% of São Paulo’s state conservation units (Capobianco 1992). In this way, our results may 1) contribute to the understanding of the impacts of mining activities on the small mammal communities, and 2) provide information for the elaboration of conservation and management plans for small mammal species in the region.

Materials and Methods

Limeira limestone quarry (24° 9’ 41” S and 48° 21’ 3” W) is located approximately 15 km from Ribeirão Grande municipality, southeastern São Paulo state. The quarry is situated nearby to a large Atlantic forest area, which is part of the Paranapiacaba ecological *continuum*, considered one of the largest remnants of Atlantic forest along with four other conservation units in the proximities (Parque Estadual Intervales, Estação Ecológica de Xitué, Parque Estadual Carlos Botelho and Parque Estadual Turístico do Alto Ribeira) (Figure 1). The climate is characterized as subtropical humid (Cfb in Koeppen´s classification), with a rainy season from October to March and a cold and less rainy season from April to September. Mean annual temperature is approximately 19 °C and precipitation ranges from 1600 to 1800 per year. During the cold and less rainy season, average monthly temperature is about 14.3 °C (SD = 1.97 °C) and average monthly rainfall is 44.4 mm (SD = 36.52 mm), while in the rainy season average monthly temperature is about 18.7 °C (SD = 2.41 °C) and average monthly rainfall is 196.1 mm (SD = 93.64 mm). The vegetation in the region is composed by disturbed forests, to mature forests dominated by Myrtaceae, Rubiaceae, Annonaceae and Melastomataceae (Companhia... 2003).

Animals were captured using pitfall and Sherman traps, which were set at four different distances (60, 220, 740 and 1300 m) from the limestone quarry. Closer to the mine (Site 1), the habitat is characterized by secondary, disturbed forest, with a dense understory situated in steep hills and high abundance of rocks covering the soil. Site 2 is also composed by secondary forest, with several vegetation gaps. The canopy is about 15-20 m high, understory is very dense and there is a shallow leaf litter layer. Site 3 is the most preserved, with canopy reaching 30-35 m high, open understory, high leaf litter abundance and a large bromeliad and liana density. Site 4 resembles site 3, but contains vegetation gaps dominated by secondary forest embedded in the preserved forest.

At each distance, a pair of 60 m transects distant approximately 300 m from each other were set, totalizing eight independent transects. We trapped monthly during three consecutive nights from October 2005 to March 2006, and then bimonthly until January 2008, totalizing 17 capture sessions (Table 1). At each transect we set a 60 m sequence of pitfall traps (buckets of 60 l), located approximately 6 m from each other, and connected by a wire mesh fence of 0.5 m high. To capture strictly arboreal species, Sherman traps (31 × 8 × 9 cm) baited with smoked sausage were fixed at trees (1.5-2 m high), equidistant in 12 m, along each transect (see Table 1). Two previous studies using smoked sausage at nearby Fazenda Intermontes achieved high capture success of several small mammal species, including *Brucepattersonius* spp., *O. nigripes*, *S. angouya*, *Oxymycterus* spp. and *Akodon* spp. (Gaspar, unpublished results, Leiner 2009).

Each captured individual was processed immediately, by recording body mass, sex and reproductive condition. Females were considered reproductive when they presented swollen nipples, young in the pouch (marsupials), or if they were pregnant, which could be observed in a few cases by palpation. Male rodents were considered reproductive whenever they presented scrotal testes. On the other hand, reproductive condition of male marsupials was not assessed; once the male’s testes become scrotal when they reach sexual maturity, they stay in this position permanently, precluding an accurate evaluation of their reproductive activity (Quental et al. 2001). Individuals were also marked with numbered ear tags (Zootech,

Table 1. Sampling effort at Limeira quarry and surroundings from October 2005 to January 2008.

Sampling effort	Number of capture nights	Sherman	Pitfall	Total
Per transect	3	5	10	15 Sherman and 30 pitfall traps
Per capture session	3	40	80	120 Sherman and 240 pifall traps
Total (17 capture sessions)	51			2040 Sherman trap-nights and 4080 Pitfall trap-nights

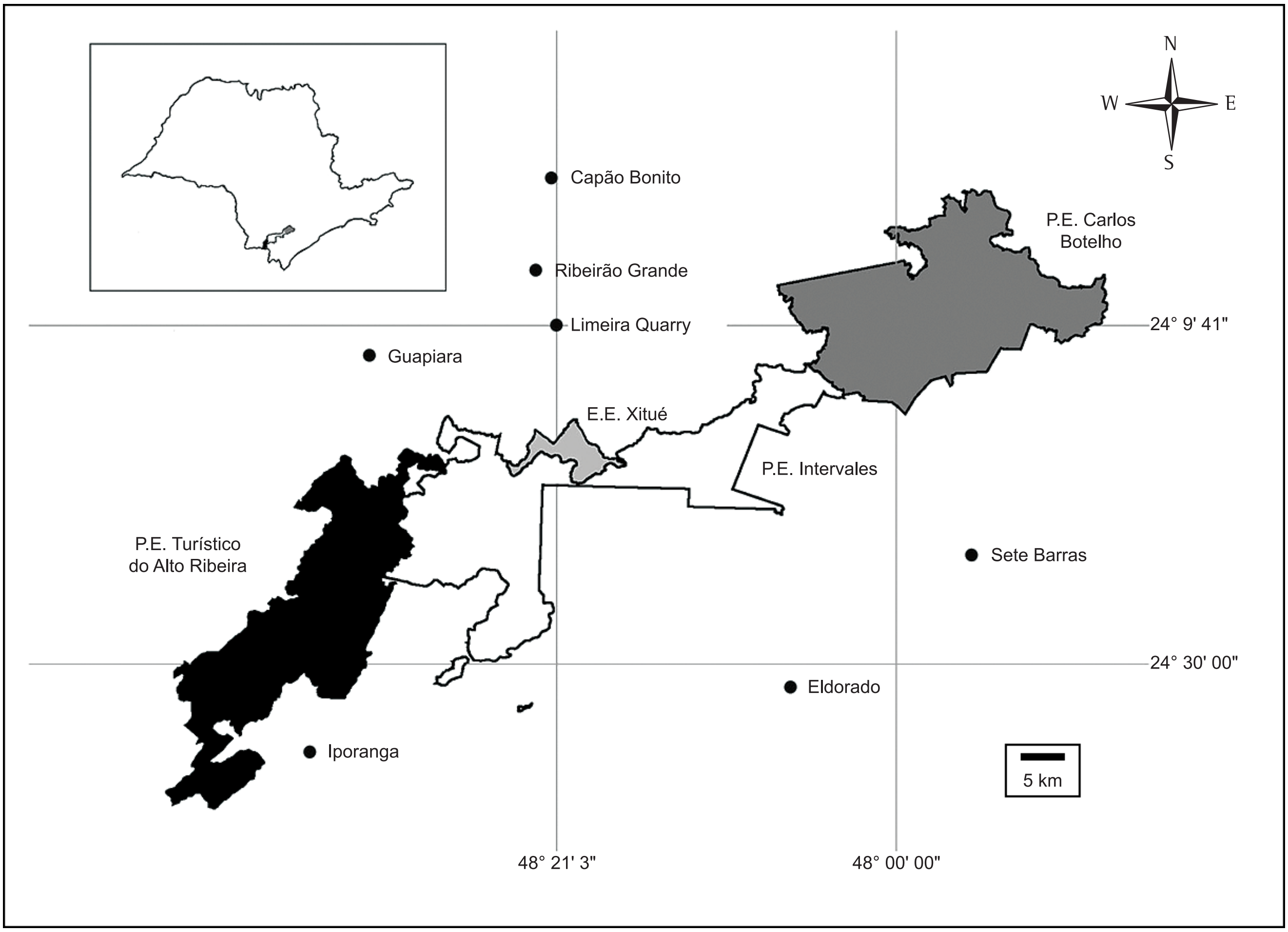

Figure 1. Paranapiacaba ecological *continuum* location in São Paulo state, and in detail the location of Limeira quarry in relation to Capão Bonito and Ribeirão Grande municipalities and their nearby state conservation units, which are part of the ecological *continuum* of Paranapiacaba Range.

Curitiba), and their species diagnosed using external characters, such as biometric data (body length, tail length, hind foot length and ear length – all measured in mm) and patterns of dorsal and ventral coloration (Bonvicino et al. 2008, Emmons & Feer 1997), and released in the same capture point. Both pitfall and Sherman traps were closed in the end of each capture session.

Between August 2006 and July 2007, 28 individuals were collected and had their skins prepared and their skulls cleaned with dermestid beetles, for further identification based on cranial characters. Such specimens were deposited as voucher specimens in the mammal collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP) (IBAMA/ICMBio License number 296/2007).

Sample rarefaction curves were constructed in order to evaluate if sampling effort was adequate to capture most species at the study site. We used Jackknife second-order estimator to estimate expected species richness in the community. Sampling rarefaction and species richness were estimated using software PAST, which was also used to calculate Shannon-Wiener diversity index (H') for the community and per sampled site and equability (J´) for the whole community. Diversity indices were also compared between sites by Hutcheson's t test using PAST.

Results

From October 2005 to January 2008, 99 non-volant small mammal specimens were captured through a sampling effort of 2040 live trap-nights and 4080 pitfall trap-nights. A total of 20 species (H' = 2.65) were recorded, including eight sigmodontinae rodents, three echimyid rodents and nine didelphid marsupials (Table 2). The number of genera and species captured were very similar, since only *Marmosops*, *Didelphis* and *Monodelphis* presented two species in the study site. Voucher specimens received field numbers (in parenthesis) and were identified as follows: *P. frenatus* (56), *P. nigrispinus* (55), *S. angouya* (53, 54), *K. amblyonyx* (38), *E. subspinosus* (45), *D. sublineatus* (5, 36, 49, 51, 62), *O. nigripes* (34, 46, 66), *E. russatus* (50) and *D. albimaculatus* (47, 48 – fluid preserved). We were unable to identify *Brucepattersonius* (37, 52 and 57) and *Akodon* (59) at the species level, due to the lack of tissues for molecular and karyotipic analysis.

The rarefaction curve (Figure 2) indicates a decrease in the rate of capture of new species, thus demonstrating that we approached the real number of species with our sampling effort. Actually, richness estimated by Jackknife 2 (21.42 ± 4.7) corroborates this result. Marsupials represented 49% of the captured individuals, followed by Muridae (44%) and Echymyidae (2%). Among Sigmodontinae, tribes Akonditini (three species registered – *Akodon* sp. 1, *Brucepattersonius* sp. 1 and *Thaptomys nigrita*), and Oryzomyini (four species registered – *Drymoreomys albimaculatus*, *Euryoryzomys russatus*, *Oligoryzomys nigripes* and *Sooretamys angouya*) were equally abundant (20 and 19% of captured individuals, respectively), while *Delomys sublineatus*, which is classified as *incertae sedis*, was underrepresented (7%). Captured species were mainly omnivorous,

Table 2. List of non-flying small mammals trapped at Limeira quarry and surroundings from October to 2005 to January 2008, containing information about species abundance per sample site, trapping method used to capture species, locomotion habits (based on Bonvicino et al. 2008, Emmons & Feer 1997) and species conservation status in São Paulo state (based on Percequillo & Kierulff 2009).

Taxonomic category	Abundance per site				Trap	Habit	Conservation status
	1	2	3	4			
ORDER DIDELPHIMORPHIA							
Family Didelphidae							
Didelphis albiventris Lund, 1840	0	0	1	1	S	Sc	LC
Didelphis aurita Wied-Neuwied, 1826	0	0	1	0	P	Sc	LC
Gracilinanus microtarsus (Wagner, 1842)	0	2	0	0	P	Sc	LC
Marmosops incanus (Lund, 1840)	6	3	5	1	P,S	Sc	NT
Marmosops paulensis (Tate, 1931)	0	4	3	2	P	Sc	LC
Metachirus nudicaudatus (É. Geoffroy, 1803)	0	0	0	1	S	T	NT
Monodelphis americana (Muller, 1776)	2	2	5	1	P	Se	NT
Monodelphis scalops (Thomas, 1888)	0	1	1	1	P	Se	NT
Philander frenatus (Olfers, 1818)	1	0	5	1	P,S	Sc	LC
ORDER RODENTIA							
Family/Tribe Sigmodontinae							
Akodon sp. 1 Meyen 1833	3	0	3	1	P	T	LC
Brucepattersonius sp. 1 Hershkovitz, 1998	1	0	2	0	P	S	LC
Delomys sublineatus (Thomas, 1903)	3	0	1	3	P	T	LC
Drymoreomys albimaculatus Percequillo et al., 2011	0	0	0	2	P	A	DD
Euryoryzomys russatus (Wagner, 1848)	0	0	2	0	P	T	VU
Oligoryzomys cf. *nigripes* (Olfers, 1818)	6	4	1	1	P	T	LC
Sooretamys angouya (Fischer, 1814)	0	0	2	1	P	T	LC
Thaptomys nigrita (Lichtenstein, 1829)	0	5	1	4	P	Se	VU
Family Echimyidae							
Euryzygomatomys spinosus (Fischer, 1814)	0	0	1	0	P	Se	LC
Kannabateomys amblyonyx (Wagner, 1845)	0	1	0	0	P	A	LC
Phyllomys nigrispinus (Wagner, 1842)	0	0	1	0	P	A	LC

S represents captures only in Sherman traps, P represents captures only in pitfall traps and P, S represent captures in both. A – arboreal, Se – semifossorial, Sc – scansorial and T – terrestrial. DD – data deficient, LC – least concern, NT – near threatened and VU – vulnerable.

and exploited a wide range of locomotion modes, including six terrestrial, five semi-fossorial, six scansorial and three arboreal species (Bonvicino et al. 2008, Emmons & Feer 1997, Leiner et al. 2010, Nowak 2005, Pardini & Umetsu 2006, Table 2).

Species relative abundances varied from 1 to 15%, reflecting the higher equitability (J = 0.88) found at the study site. The species with higher abundance (*O. nigripes*, *M. incanus*, *M. paulensis*, *T. nigrita* and *M. americana*) represented 47% of the community, while the other 15 species represent 32%. Most species were captured exclusively by pitfall traps. The number of species varied between sites, with sites 1 and 2 presenting lower richness and diversity than sites 3 and 4 (Table 3). Actually, diversity values in site 3 were higher than the values estimated for sites 1 and 2, while diversity in site 4 was only different from site 1 (Table 4). The similarity in species diversity

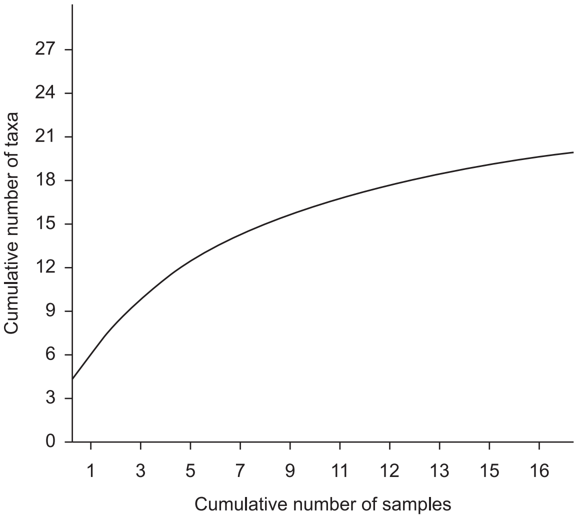

Figure 2. Mean curve of the increased number of species registered with the increase in sampling effort (rarefaction curve) at Limeira quarry and surroundings from October 2005 to January 2008.

Table 3. Species richness (S) and Shannon's diversity index (H') of small non-flying mammals captured at the four trapping sites, which were located at different distances from the quarry, and considering the entire Limeira quarry Atlantic forest remnant.

Site	Richness	Diversity
1	7	1.75
2	8	1.94
3	16	2.55
4	14	2.41
Total	20	**2.65**

Table 4. Comparison of diversity (H's) values between sites located at different distances from the quarry, using Hutcheson´s t test. Significant differences between sites are marked in bold.

Site	2	3	4
1	t = 0.87, p = 0.4	**t = 3.7, p = 0.0005**	**t = 2.18, p = 0.03**
2	-	**t = 2.97, p = 0.004**	t = 1.49, p = 0.14
3	-	-	-
4	-	-	-

between site 2 and 4 is probably due to similarities in habitat structure prior to mining activities. Site 4, although far away from the quarry (1300 m), presents several vegetation gaps dominated by secondary forest.

A few marsupials and rodents were restricted to one or two sites. However, the low number of captures for most species, usually inferior to five, precludes habitat selection evaluation. *Marmosops incanus*, *Monodelphis americana* and *Oligoryzomys nigripes*, were captured at all sites. Actually, *O. nigripes* was more abundant at disturbed sites, since a high number of individuals belonging to this species were found in the sites closer to the quarry (six and 4 individuals in sites 1 and 2) when compared to sites away from the quarry (2 individuals in sites 3 and 4), which are considered less-disturbed. *Thaptomys nigrita* and *Marmosops paulensis* were absent only from site 1. Finally, *Kannabateomys amblyonyx*, *Gracilinanus microtarsus*, *Didelphis aurita*, *Euryoryzomys russatus*, *Euryzygomatomys spinosus*, *Phyllomys nigrispinus*, *Drymoreomys albimaculatus* and *Metachirus nudicaudatus* were very uncommon, being captured only once or twice in a single site (see Table 2).

Discussion

Twenty terrestrial small mammal species were captured at the study site, being nine marsupials and 11 rodents. Compared to other Atlantic forest areas, the Limeira quarry area and its surroundings presented higher species richness than several preserved, continuous Atlantic forest areas and also disturbed forest fragments. Actually, the sites that presented similar or higher species richness than our study site (e.g. Parque Nacional do Caparaó, Parque Nacional de Itatiaia, Reserva Florestal do Morro Grande, Parque Estadual Intervales, Parque Estadual Carlos Botelho and Parque Estadual Turístico do Alto Ribeira) usually encompass larger protected areas, higher altitudinal variation and include data collected over several years, by several researchers and including museum information (Bonvicino et al. 1997, Geise et al. 2004, Pardini & Umetsu 2006, Vivo & Gregorin 2001, Hingst-Zaher & Machado 2008, Hingst-Zaher et al. 2010). As discussed by Pardini & Umetsu (2006), in their inventory in Morro Grande Reserve, it is also possible that the use of pitfall traps played a role in the high values of species richness found in Mina Limeira. This method ensures high capture rates because 1) several specimens may be captured in the same trap (Umetsu et al. 2006) and 2) captures are independent of bait attraction and bait preferences (Adler & Lambert 1997, Laurance 1992). Moreover, pitfall traps seem to be quite efficient to capture semifossorial small mammals (Pardini 2004), which are usually absent in communities sampled only with Sherman live traps.

In the study site, non-volant small community presented several intermediary or rare species and only a few dominant ones, which corroborates its high equability. Such pattern is common among natural communities (Magurran 2004), including small mammal assemblages in cerrado and Atlantic Forest areas (Bonvicino et al. 2002, Carmignotto & Aires 2011). Equability values may work as proxies to community conservation status, since disturbed areas usually present low values due to dominance by a few disturbance-tolerant species that manage to proliferate in altered sites (Bonvicino et al. 2002). The high equability estimates at Limeira quarry and surroundings suggests habitat preservation. However, at a smaller spatial scale, we observe a different pattern at site 1, where the community is dominated by few species, especially *O. nigripes*, which presents a high relative abundance, and is considered benefitted by habitat disturbances (Pardini 2004). These results indicate that mining impacts may be distance-dependent, and that although the community as whole is preserved, there are important changes occurring at smaller spatial scales, especially closer to the quarry.

Sampled sites presented differences in species richness and diversity, with a pattern of higher values at sites 3 and 4, which presented habitat resembling mature forests and were located away from the quarry. Such differences corroborate the distance-dependent impact of mining activities in small mammal fauna, although more replicas of each site are necessary. Mining may affect species diversity through reduced availability of food resources (fruits and invertebrates) due to a decrease in plant productivity, reduced litter volume due to soil erosion and changes in plant community composition due to edge effects. Moreover, vibrations caused by blasting of rocks may influence foraging and anti-predator defense of small mammals (Schmidt & Ostfeld 2008, Rabin et al. 2006), thus affecting individual fitness and long-term population persistence. In this way, future tests should evaluate the role of each of these impacts in small mammal assemblages and population dynamics.

Several small mammals are considered resilient to habitat disturbances and changes in vegetation structure (Malcolm 1997), while others are clearly disturbance-intolerant, being associated to mature forests (Pardini et al. 2005). Earlier studies have already demonstrated that *O. nigripes* and scansorial marsupials, such as *M. incanus*, are associated to secondary, fragmented forests (Pardini 2004, Rocha et al. 2011), as we found at Limeira quarry. On the other hand, *T. nigrita*, *Monodelphis* species and *Marmosops paulensis* are usually associated to less-disturbed, preserved sites (Pardini & Umetsu 2006). Although we were unable to clearly evaluate habitat selection, due to the low number of captures, in our study both *T. nigrita* and *M. paulensis* were absent from site 1. The proximity to the quarry may contribute to reduce litter volume, thus decreasing the availability of nest-sites for semi-fossorial species, such as *T. nigrita*, and soil fauna used as food resources by both species.

The captured species at Limeira quarry and surroundings correspond to approximately 24% of the São Paulo state non-volant small mammal fauna (Percequillo & Kierulff 2009). Six of the observed species at our study site are endemic to the Atlantic forest, including *Marmosops paulensis*, which is considered as vulnerable in São Paulo state due to its restricted distribution (Percequillo & Kierulff 2009). Another four marsupial species captured around the Limeira quarry (*Monodelphis americana*, *Monodelphis scalops*, *Metachirus nudicaudatus* and *Marmosops incanus*) are categorized as near threatened in São Paulo state, due to habitat loss and fragmentation (Percequillo & Kierulff 2009). Furthermore, two rodent species found in the area, *Thaptomys nigrita* and *Euryoryzomys russatus*, are also considered as vulnerable in São Paulo state (Percequillo & Kierulff 2009). The high species diversity and the occurrence of several endemic and threatened small mammal species, along with rare and habitat specialist ones, points out to the conservation status of this Atlantic forest remnant and the importance of preserving this site. Moreover, our results demonstrate that mining and its associated habitat disturbances failed to negatively influence small mammal species diversity and composition, although it seems that negative impacts are restricted to sites closer to the quarry. In this way, mining impacts may occur at smaller spatial scales, being distance-dependent, or may occur only at the population level for this small mammal assemblage.

In the future, long-term monitoring plans, usually required as a legislative compliance in mining offsets, should continue to evaluate the impacts of quarrying in small mammal communities. Long-term monitoring should focus on population dynamics and behavioral ecology of species, especially those considered rare and habitat specialists, which are though to be more threatened by mining activities and their consequences. In order to ensure species persistence we suggest the implementation of three different conservation actions: 1) preserve the forest remnant surrounding Limeira quarry through the creation of a protected area, 2) keep noise and vibrations at appropriate levels, in order to reduce disturbance for animals and prevent further soil erosion, 3) implement forest corridors between this remnant and the adjacent state conservation units, once the maintenance of genetic and individual flow between areas may help to prevent population reduction and species extinction.

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Borboletas (Lepidoptera: Papilionoidea e Hesperioidea) de Matas Paludosas e Matas de Restinga da Planície Costeira da região Sul do Brasil

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Abstract: This paper presents a butterfly species list of Swamp and Resting forests in the Coastal Plain of Rio Grande do Sul and Santa Catarina States aiming to contribute to the knowledge of butterflies for these environments in the Atlantic Forest. Data compilation was obtained through inventories carried out in the years 2005 and 2011 with two sampling protocols (bait traps and butterfly nets). After 10.920 trap-hours and 360 net-hours 225 species of butterflies were recorded belonging to six families and 19 subfamilies. Twenty-five species are new records for the Rio Grande do Sul State and 35 species are new records for the Atlantic Forest in Rio Grande do Sul, with six Nymphalidae, ten Hesperiidae, twelve Lycaenidae and seven Riodinidae. The results obtained in the present study are fundamental for the knowledge and conservation of the taxa studied and to their associated habitats.
Keywords: *Atlantic Forest, Itapeva State Park, new records, species richness.*

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Resumo: Este trabalho teve como objetivo elaborar uma lista de espécies de borboletas de Matas Paludosas e de Restingas da Planície Costeira do Rio Grande do Sul e de Santa Catarina contribuindo para o conhecimento da fauna de borboletas da Mata Atlântica. Foram compilados dados obtidos com amostragens realizadas através de duas técnicas de coleta (armadilha com isca atrativa e rede entomológica) nos anos de 2005 e 2011. Com um esforço amostral de 10.920 horas com armadilhas e de 360 horas-rede foram encontradas 225 espécies de borboletas nos dois ambientes, distribuídas em seis famílias e 19 subfamílias. Vinte e cinco espécies são registros novos ainda não publicados para o Rio Grande do Sul e 35 espécies são novos registros para a Mata Atlântica do Rio Grande do Sul, sendo seis Nymphalidae, dez Hesperiidae, doze Lycaenidae e sete Riodinidae. Os resultados gerados no presente estudo são fundamentais para o conhecimento e conservação dos táxons estudados bem como dos ambientes aos quais estão associados.
Palavras-chave: *Mata Atlântica, Parque Estadual de Itapeva, novos registros, riqueza de espécies.*

Introdução

A aceleração do processo de destruição da flora e fauna em diferentes biomas nas últimas décadas tem incrementado a necessidade na conservação de habitats naturais e, principalmente, em maiores esforços para o conhecimento da biodiversidade. Entretanto, o tempo disponível para a geração deste conhecimento é limitado (Daily & Ehrlich 1995, Hughes et al. 2000). Trabalhos de monitoramento e planejamento em conservação são mais efetivos quando são embasados por um conhecimento prévio da ocorrência dos organismos em um determinado local (Colombo et al. 2008). Tais informações são obtidas através da realização de inventários de diversidade (e.g. Freitas et al. 2003, Iserhard & Romanowski 2004), sendo importantes fontes de informação para a restauração, manutenção da composição, estrutura e funcionamento das comunidades naturais (Brown & Freitas 2000a, Freitas et al. 2006, Bond-Buckup 2008, Santos et al. 2008).

Um dos grupos de invertebrados mais conhecidos e que vem aumentando gradativamente seu uso em monitoramento e avaliação ambiental são as borboletas (Brown 1991, New 1997), pois respondem rapidamente às perturbações nos sistemas pela íntima associação com seus microhábitats e por serem especialistas em recursos específicos no ambiente (Brown 1997, Freitas et al. 2003). Além disso, são abundantes na região Neotropical e possuem alta diversidade com cerca de 7800 espécies descritas (Lamas 2004), sendo que no Brasil estima-se que ocorram em torno de 3300 espécies (Brown & Freitas 1999). Para o sul do Brasil, Morais et al. (2007) citam 679 espécies registradas na literatura para o Rio Grande do Sul. Dados atualizados, todavia, indicam a ocorrência de, pelo menos, mil espécies no Estado (Romanowski, dados não publicados).

O bioma Mata Atlântica estava originalmente distribuído em uma extensa área ao longo da região costeira do Brasil. Atualmente, restam em torno de 11 a 16% de sua extensão original, sendo que a maioria de seus remanescentes estão distribuídos em pequenas e isoladas manchas florestais (Ribeiro et al. 2009). As Matas de Restinga fazem parte do bioma Mata Atlântica e são definidas como a faixa de vegetação que ocorre em áreas planas e arenosas localizadas, de uma maneira ampla, entre o oceano e as serras (Waechter 1985). Embora estejam localizadas junto a áreas com alta densidade humana, carecem de informação científica (Rocha et al. 2004) com elevadas taxas de conversão em sistemas antrópicos. As Matas Paludosas (Floresta Ombrófila Densa das Terras Baixas) localizam-se em regiões litorâneas próximas ao mar e caracterizam-se por apresentar alagamento permanente ou temporário com solo lodoso e rico em matéria orgânica vegetal (Rambo 2005). Conservam uma importante biodiversidade e um grande número de espécies ameaçadas (Rio Grande do Sul, 2006). Embora as Matas Paludosas possuam uma distribuição naturalmente fragmentada (Toniato et al. 1998, Paschoal & Cavassan 1999), o intenso impacto de agropecuária e de especulação imobiliária, que só aumentou nos últimos anos, tornou-as limitadas em reduzidos fragmentos com amplas áreas de matriz circundantes, compondo uma conformação amplamente modificada da paisagem original.

Nos últimos doze anos, inventários de borboletas na Mata Atlântica do Rio Grande do Sul foram intensificados, principalmente no que diz respeito à Floresta Ombrófila Densa na encosta do Planalto Basáltico (Iserhard & Romanowski 2004, Iserhard 2009, Santos et al. 2011), na Floresta Ombrófila Mista e nos Campos de Cima da Serra (Teston & Corseuil 1999, 2000, 2002, Corseuil et al. 2004, Romanowski et al. 2009, Iserhard et al. 2010a, Pedrotti et al. 2011, Ritter et al. 2011, Santos et al. 2011). Porém, estudos abrangendo à Mata de Restinga e à Floresta Ombrófila Densa junto à Planície Costeira norte do Estado ainda são escassos. Os trabalhos já publicados neste ecossistema referem-se a (i) um inventário das borboletas da família Nymphalidae em dez municípios no litoral norte (Quadros et al. 2004) e (ii) à ampliação de distribuição da borboleta *Heliconius sara apseudes* (Hübner, 1813) na Mata Atlântica (Iserhard et al. 2010b), relativa a inventários de borboletas realizados na planície, encosta e altitude deste bioma no RS.

O presente trabalho teve como objetivo (i) elaborar uma lista de espécies de borboletas de diferentes ambientes de Mata Paludosa e Mata de Restinga em uma ampla área na Planície Costeira norte do Rio Grande do Sul e uma área entre este Estado com Santa Catarina, visando contribuir para o conhecimento da fauna de borboletas através do registro de novas ocorrências para a Mata Atlântica do Rio Grande do Sul.

Material e Métodos

1. *Área de estudo*

Foram estudados dez fragmentos de Mata Paludosa e três áreas de Mata de Restinga em uma região localizada na Planície Costeira norte do Rio Grande do Sul nos municípios de Torres, Morrinhos do Sul, Mampituba e Dom Pedro de Alcântara e Passo de Torres, em Santa Catarina (Figura 1). As Matas de Restinga localizavam-se junto a dunas fixas com vegetação psamófila arbustiva e arbórea, e as Matas Paludosas caracterizavam-se por serem formadas por processo de sucessão vegetal em lagoas, portanto alagadiças, constituídas tanto por áreas de mata em regeneração quanto por floresta com dossel entre 8-12 m de altura (Colombo et al. 2008). O clima da região é subtropical com verões e invernos relativamente amenos (Maluf 2000). A temperatura anual varia com médias máximas de 29 °C a 18 °C no verão e com médias mínimas de 22 °C a 11 °C no inverno; a precipitação anual fica em torno de 1.600 mm (Agritempo 2012).

2. *Amostragem*

Foram realizadas amostragens através de duas técnicas de coleta: (i) armadilhas com isca atrativa para borboletas frugívoras da família Nymphalidae e (ii) rede entomológica para as borboletas das superfamílias Papilionoidea e Hesperioidea.

Para a primeira técnica foi amostrado um fragmento de Mata Paludosa e três áreas de Mata de Restinga pertencentes ao Parque Estadual de Itapeva (PEVA) em janeiro, maio e novembro de 2005. Posteriormente, foram realizadas duas amostragens (janeiro e março de 2011) em dez fragmentos de Mata Paludosa (incluindo o fragmento do PEVA).

No ano de 2005, em cada área estudada foram colocadas três armadilhas formando uma Unidade Amostral (UA), nas quais, as armadilhas ficavam distantes, aproximadamente, 50 m uma da outra. Estas permaneceram instaladas durante 48 horas na Mata Paludosa e outras 48 horas na Mata de Restinga perfazendo 360 horas de esforço amostral total. Nas amostragens do ano de 2011, em cada fragmento, duas UAs foram delimitadas, sendo uma na borda e uma no interior. Cada UA era constituída por dois grupos de três armadilhas cada, as quais ficavam distantes em torno de cinco metros entre si. Cada grupo de armadilhas foi disposto em duas transecções lineares, cada uma com 50 m de extensão entre a borda e o interior, separadas por 100 m entre si. A isca utilizada foi elaborada através da mistura de banana amassada com caldo de cana fermentada por 48 horas, sendo substituída a cada revisão. As armadilhas foram colocadas na manhã do primeiro dia de amostragem e permaneceram instaladas por mais três dias. O processo de revisão foi realizado a cada 48 horas (totalizando 10.560 horas de esforço amostral).

As amostragens com redes entomológicas foram realizadas em 2005 (nos mesmos meses e nas mesmas ocasiões amostrais descritas

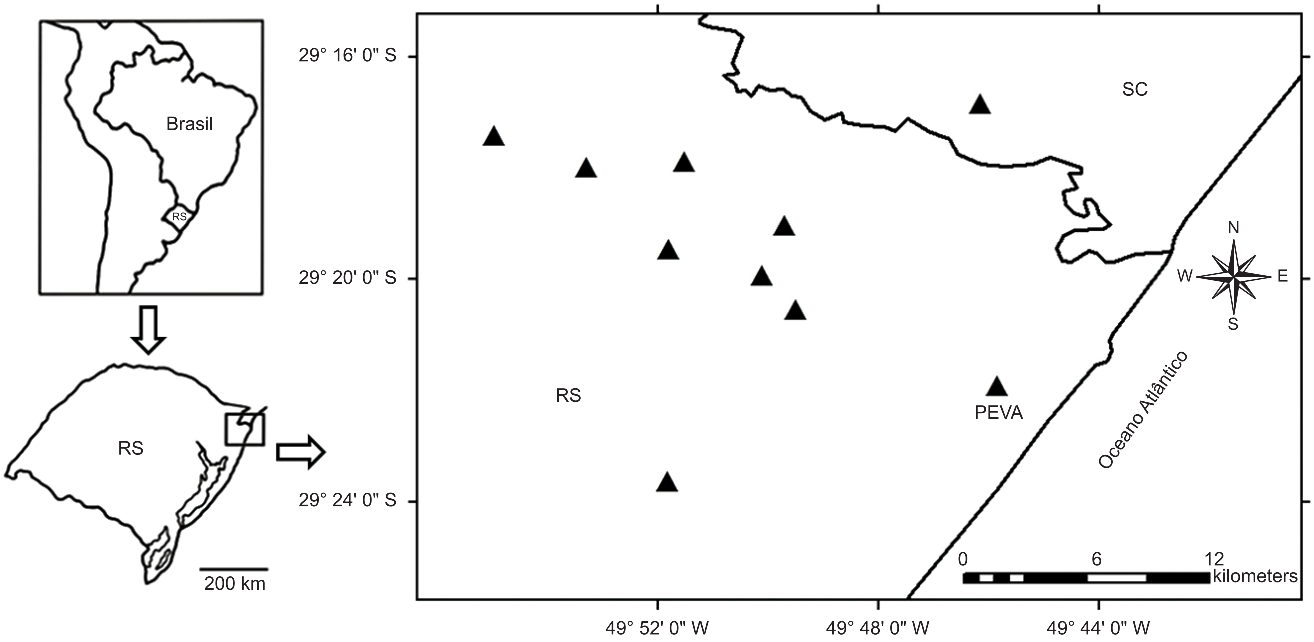

Figura 1. Mapa com a localização dos dez fragmentos de Mata Paludosa amostrados e do Parque Estadual de Itapeva (PEVA) no Rio Grande do Sul (RS) e Santa Catarina (SC).

Figure 1. Map with the location of the ten sampled Swamp forest fragments and Itapeva State Park (PEVA) in Rio Grande do Sul (RS) and Santa Catarina (SC) States.

anteriormente) no interior e nos arredores tanto do fragmento de Mata Paludosa quanto nas áreas de Mata de Restinga no PEVA. Cada ocasião amostral teve duração de cinco dias, com esforço padronizado em três horas/amostrador (totalizando 360 horas-rede), na qual cinco amostradores munidos de rede entomológica percorreram transecções pré-existentes em variados tipos de ambiente em cada área procurando ativamente por borboletas. Quando avistadas eram capturadas e, se possível, identificadas no local (detalhes deste protocolo de amostragem são encontrados em Paz et al. (2008)). Além disso, foram compilados dados de amostragens assistemáticas desenvolvidas na região pelo sétimo autor durante os anos de 1991 a 2012 com a metodologia de redes entomológicas.

Pelo menos dois exemplares de cada espécie foram coletados como material testemunho, assim como os de difícil identificação em campo. Este material encontra-se depositado na Coleção de Lepidoptera do Departamento de Zoologia da Universidade Federal do Rio Grande do Sul. A identificação dos espécimes foi realizada com base na referida coleção, além de consultas a especialistas em determinados grupos de borboletas. A nomenclatura para as famílias, subfamílias e espécies seguiu Lamas (2004) e Mielke (2005), com exceção de Nymphalidae que seguiu determinação taxonômica de Wahlberg et al. (2009).

3. *Elaboração da lista de espécies*

Para a lista de espécies foram incluídos os registros qualitativos das borboletas encontradas nestas formações da Planície Costeira norte do Rio Grande do Sul. Os registros novos para a Mata Atlântica do Rio Grande do Sul foram obtidos por comparação aos trabalhos citados na introdução deste trabalho e as novas ocorrências para o Estado, além de tais citações, através dos trabalhos mencionados em Iserhard & Romanowski (2004) e Iserhard et al. (2010a). Para efeitos de comparação com demais trabalhos desenvolvidos na Mata Atlântica do Rio Grande do Sul, a família Riodinidae está inserida na família Lycaenidae.

Resultados e Discussão

Foram registradas 225 espécies de borboletas nas Matas Paludosas e de Restinga nesta área da Planície Costeira do Sul do Brasil, distribuídas em seis famílias e 19 subfamílias. Deste total, 82 espécies foram compartilhadas entre os dois ambientes; 79 espécies são exclusivas das Matas Paludosas e 64 espécies são exclusivas das Matas de Restinga (Tabela 1). Apesar das Matas Paludosas serem inerentemente ricas, com alta diversidade e neste estudo possuírem mais espécies exclusivas quando comparado com o compartilhado entre os dois ambientes, não se deve deixar de evidenciar o registrado nas Restingas, que apesar de terem possuído um esforço amostral inferior e menos áreas estudadas, também mostraram uma alta quantidade de espécies exclusivas.

Avaliando-se a representatividade de cada família por ambiente e para a região como um todo, o padrão é similar a outros inventários realizados na Mata Atlântica do Rio Grande do Sul: Nymphalidae possui proporcionalmente mais espécies, seguida de Hesperiidae, Lycaenidae+Riodinidae, Pieridae e Papilionidae (Tabela 2). Deve-se levar em consideração o fato de armadilhas atrativas registrarem espécies de borboletas pertencentes somente a Nymphalidae, mesmo assim, apenas com o uso de redes entomológicas, resultados semelhantes foram encontrados para a Floresta Ombrófila Mista e Campos de Cima da Serra (Iserhard et al. 2010a, Ritter et al. 2011) (Tabela 2). A representatividade de borboletas na Floresta Ombrófila Densa apresentou resultados diferentes, nos quais Hesperiidae possuiu maior riqueza quando comparado a Nymphalidae (Tabela 2). Porém, para as áreas de Mata Atlântica, apesar dos esforços amostrais serem os mesmos, as intensidades amostrais são diferentes: Iserhard & Romanowski (2004) e Iserhard (2009) realizaram inventários intensificados da fauna de borboletas com redes entomológicas da Floresta Ombrófila Densa bimestralmente ao longo de três anos e Santos et al. (2011) utilizaram armadilhas atrativas em uma transecção nesta mesma região ao longo de cinco meses, enquanto

Tabela 1. Lista de espécies de borboletas registradas em fragmentos de Mata Paludosa e de Mata de Restinga na Planície Costeira do sul do Brasil.

Table 1. Butterfly species list recorded in fragments of Swamp Forest and Restinga Forest in southern Brazil Coastal Plain.

Famílias/subfamílias	**Tribos**	**Espécies**	**Ambientes**	
			Mata paludosa	**Mata de Restinga**
NYMPHALIDAE (S = 85)				
Heliconiinae (S = 10)	Acraeini	*Actinote mamita* (Burmeister, 1861)	X	X
		Actinote brylla Oberthür, 1917 * #	X	
	Heliconiini	*Agraulis vanillae maculosa* (Stichel, 1908)		X
		Dione juno juno (Cramer, 1779)	X	
		Dryas iulia alcionea (Cramer, 1779)	X	X
		Eueides isabella dianasa (Hübner, 1806)		X
		Heliconius erato phyllis (Fabricius, 1775)	X	X
		Heliconius ethilla narcaea Godart, 1819	X	X
		Heliconius sara apseudes (Hübner, 1813)	X	
		Philaethria wernickei (Röber, 1906)	X	X
Limenitidinae (S = 5)	Limenitidini	*Adelpha hyas* (Doyère, [1840])	X	
		Adelpha lycorias (Godart, 1824)	X	X
		Adelpha mythra (Godart, 1824)		X
		Adelpha syma (Godart, 1824)		X
		Adelpha thessalia indefecta Fruhstorfer, 1913		X
Cyrestinae (S = 3)	Cyrestini	*Marpesia chiron* (Fabricius, 1775)		X
		Marpesia zerynthia zerynthia Hübner, [1823]	X	
		Marpesia petreus (Cramer, 1776)	X	X
Nymphalinae (S = 12)	Victorinini	*Anartia amathea roeselia* (Eschscholtz, 1821)	X	X
		Anartia jatrophae (Linnaeus, 1763)	X	X
	Junoniini	*Junonia evarete* (Cramer, 1779)	X	X
	Melitaeini	*Eresia lansdorfi* (Godart, 1819)	X	X
		Ortilia ithra (Kirby, 1800)	X	X
		Tegosa claudina (Eschscholtz, 1821)	X	X
	Nymphalini	*Colobura dirce dirce* (Linnaeus, 1758)	X	X
		Hypanartia bella (Fabricius, 1793)	X	
		Smyrna blomfildia blomfildia (Fabricius, 1781)	X	
		Vanessa braziliensis (Moore, 1883)		X
		Vanessa myrinna (Doubleday, 1849)	X	
	Coeini	*Historis acheronta acheronta* (Fabricius, 1775)	X	
Biblidinae (S = 8)	Ageroniini	*Hamadryas epinome* (Felder & Felder, 1867)	X	
		Hamadryas februa februa (Hübner, 1823)	X	X
	Callicorini	*Diaethria clymena meridionalis* (H. W. Bates, 1864)	X	
		Haematera pyrame pyrame (Hübner, [1819])	X	
	Epicaliini	*Catonephele numilia penthia* (Hewitson, 1852)	X	X
	Epiphilini	*Epiphile orea orea (*Hübner, 1823)	X	
		Temenis laothoe meridionalis Ebert, 1961	X	X
	Eubagini	*Dynamine myrrhina* (Doubleday, 1849)		X
Charaxinae (S = 7)	Anaeini	*Memphis editha* (Comstock, 1961)	X	
		Memphis moruus stheno (Prittwitz, 1865)	X	X
		Zaretis strigosus (Gmelin, [1790])	X	X
	Preponini	*Archaeoprepona chalciope* (Hübner, 1823)	X	X
		Archaeoprepona demophon thalpius (Hübner, 1814)	X	
		Archaeoprepona demophoon (Hübner, 1814)	X	X
		Consul fabius drurii (Butler, 1874)	X	X
Satyrinae (S = 29)	Satyrini	*Capronnieria galesus* (Godart, 1824)	X	
		Carminda paeon (Godart, 1824)	X	X
		Godartiana muscosa (Butler, 1870)	X	
		Moneuptychia soter (Butler, 1877)	X	
		Yphthimoides celmis (Godart, 1824)		X
		Forsterinaria necys (Godart, 1824)	X	X

S, riqueza de espécies; * indica registros novos para a Mata Atlântica do Rio Grande do Sul; # indica registros novos para o Rio Grande do Sul.

S, species richness; * new records for Rio Grande do Sul Atlantic Forest; # new records for Rio Grande do Sul State.

Tabela 1. Continuação...

Famílias/subfamílias	Tribos	Espécies	Ambientes	
			Mata paludosa	Mata de Restinga
		Guaianaza pronophila (Butler, 1867)		X
		Hermeuptychia atalanta (Butler, 1867) * #	X	X
		Hermeuptychia gisella (Hayward, 1957) * #	X	
		Praepedaliodes phanias (Hewitson, 1862)	X	X
		Paryphthimoides phronius (Godart, 1824)	X	X
		Paryphthimoides poltys (Prittwitz, 1865)	X	
		Paryphthimoides grimon (Godart, 1824)	X	
		Taygetis ypthima Hübner, 1821	X	
	Brassolini	*Blepolenis catharinae* (Stichel, 1902)	X	X
		Blepolenis batea (Hübner, [1821]) * #	X	
		Brassolis sophorae vulpeculus Stichel, 1902 *	X	
		Caligo brasiliensis (C. Felders, 1862)	X	
		Caligo martia (Godart, 1824)	X	X
		Catoblepia amphirhoe (Hübner, 1825)	X	
		Dasyophthalma creusa creusa (Hübner, [1821])	X	X
		Dynastor darius darius (Fabricius, 1775)	X	
		Eryphanis reevesii (Doubleday, 1849)	X	
		Narope cyllastros Doubleday, 1849		X
		Opoptera sulcius (Staudinger, 1887)	X	
		Opsiphanes cassiae (Linnaeus, 1758) * #	X	
		Opsiphanes quiteria quiteria (Stoll, 1780)	X	
		Opsiphanes invirae remoliatus Fruhstorfer, 1907	X	X
	Morphini	*Morpho epistrophus catenaria* (Perry, 1811)	X	
Apaturinae (S = 2)		*Doxocopa kallina* (Staudinger, 1886)	X	X
		Doxocopa laurentia (Godart, [1824])		X
Danainae (S = 9)	Danaini	*Danaus gilippus gilippus* (Cramer, 1775)	X	X
		Danaus erippus (Cramer, 1775)	X	X
		Lycorea halia (Hübner, 1816)	X	
	Ithomiini	*Dircenna dero* (Hübner, 1823)	X	
		Episcada carcinia Schaus, 1902		X
		Episcada hymenaea hymenaea (Prittwitz, 1865)	X	X
		Mechanitis lisymnia lisymnia (Fabricius, 1793)	X	X
		Methona themisto (Hübner, 1818)		X
		Placidina euryanassa C. Felder & R. Felder, 1860		X
PIERIDAE (S = 14)				
Coliadinae (S = 9)		*Eurema albula sinoe* (Godart, 1819)	X	X
		Pyrisitia leuce leuce (Boisduval, 1836)	X	
		Pyrisitia nise tenella (Boisduval, 1836)	X	
		Eurema elathea (Cramer, 1777)	X	X
		Phoebis argante argante (Fabricius, 1775)	X	X
		Phoebis neocypris neocypris (Hübner, [1823])	X	X
		Phoebis philea philea (Linnaeus, 1763)		X
		Phoebis sennae marcellina (Cramer, 1777)		X
		Rhabdodryas trite banksi Breyer, 1939		X
Pierinae (S = 2)	Pierini	*Ascia monuste orseis* (Godart, 1819)	X	
	Antocharidini	*Hesperocharis paranensis* Schaus, 1898		X
Dismorphiinae (S = 3)		*Dismorphia astyocha* Hübner, 1831	X	
		Dismorphia crisia crisia (Drury, 1782)	X	
		Enantia melite (Linnaeus, 1763)		X
PAPILIONIDAE (S = 10)				
Papilioninae (S = 10)	Troidini	*Battus polydamas polydamas* (Linnaeus, 1758)		X
		Parides agavus (Drury, 1782)	X	X
		Parides anchises nephalion (Godart, 1819)	X	
		Parides bunichus perrhebus (Boisduval, 1836)		X

S, riqueza de espécies; * indica registros novos para a Mata Atlântica do Rio Grande do Sul; # indica registros novos para o Rio Grande do Sul.
S, species richness; * new records for Rio Grande do Sul Atlantic Forest; # new records for Rio Grande do Sul State.

Tabela 1. Continuação...

Famílias/subfamílias	Tribos	Espécies	Ambientes	
			Mata paludosa	**Mata de Restinga**
	Papilionini	*Heraclides anchisiades capys* (Hübner, 1809)	X	X
		Heraclides astyalus astyalus (Godart, 1819)		X
		Heraclides hectorides (Esper, 1794)		X
		Heraclides thoas brasiliensis (Rothschild & Jordan, 1906)	X	X
		Pterourus scamander scamander (Boisduval, 1836)	X	X
	Leptocircini	*Protesilaus helios* (Rothschild & Jordan, 1906)	X	X
LYCAENIDAE (S = 35)				
Theclinae (S = 33)	Eumaeini	*Arawacus meliboeus* (Fabricius, 1793)	X	X
		Arawacus separata (Lathy, 1926)	X	X
		Arcas imperialis (Cramer, 1775) * #	X	
		Aubergina vanessoides (Prittwitz, 1865)		X
		Calycopis caulonia (Hewitson, 1877)	X	X
		Chlorostrymon simaethis (Drury, 1773) *	X	X
		Cyanophrys acaste (Prittwitz, 1865)	X	X
		Dicya dicaea (Hewitson, 1874)	X	
		Enos thara (Hewitson, 1867) * #	X	X
		Janthecla aurora (H. H. Druce, 1907) * #	X	
		Janthecla flosculus (H. H. Druce, 1907)	X	
		Ocaria ocrisia (Hewitson, 1868)	X	X
		Ocaria thales (Fabricius, 1793)	X	X
		Ministrymon azia (Hewitson, 1873) * #		X
		Nicolaea sp.	X	
		Nicolaea cupa (Druce, 1907) * #		X
		Ostrinotes empusa (Hewitson, 1867) * #	X	X
		Parrhasius orgia (Hewitson, 1867)		X
		Pseudolycaena marsyas (Linnaeus, 1758)	X	X
		Strephonota tephraeus (Geyer, 1837)	X	
		Rekoa palegon (Cramer, 1780)		X
		Siderus philinna (Hewitson, 1868)	X	X
		Strymon astiocha (Prittwitz, 1865) * #		X
		Strymon bazochii (Godart, 1824)	X	X
		Strymon dindus (Fabricius, 1793)* #		X
		Strymon eurytulus (Hübner, [1819])		X
		Strymon lucena (Hewitson, 1868)	X	X
		Strymon oreala (Hewitson, 1868)		X
		Strymon rana (Schaus, 1902)		X
		Strymon ziba (Hewitson, 1868) *	X	X
		Theritas hemon (Cramer, 1775)		X
		Tmolus echion (Linnaeus, 1767)	X	X
		Ziegleria hesperitis (Butler & Druce, 1872) * #		X
Polyommatinae (S = 2)		*Leptotes cassius* (Cramer, 1775)		X
		Hemiargus hanno (Stoll, 1790) *	X	
RIODINIDAE (S = 15)				
Euselasiinae (S = 3)	Euselasiini	*Euselasia euploea* (Hewitson, 1855)		X
		Euselasia hygenius occulta Stichel, 1919		X
		Euselasia thucydides thucydides (Fabricius, 1793) * #		X
Riodininae (S = 12)	Nymphidiini	*Aricoris constantius* (Fabricius, 1793) * #	X	
		Calospila apotheta (H. W. Bates, 1868)	X	
		Menander menander (Stoll, 1780) * #	X	
		Synargis regulus (Fabricius, 1793) * #	X	X
	Incertae sedis	*Emesis fastidiosa* Ménétriés, 1855 * #		X
	Symmachiini	*Mesene pyrippe* Hewitson, 1874	X	

S, riqueza de espécies; * indica registros novos para a Mata Atlântica do Rio Grande do Sul; # indica registros novos para o Rio Grande do Sul.
S, species richness; * new records for Rio Grande do Sul Atlantic Forest; # new records for Rio Grande do Sul State.

Tabela 1. Continuação...

Famílias/subfamílias	Tribos	Espécies	Ambientes	
			Mata paludosa	**Mata de Restinga**
	Mesosemiini	*Mesosemia odice* (Godart, [1824])	X	X
		Ithomiola nepos (Fabricius, 1793)	X	
		Ionotus alector (Geyer, 1837) * #		X
	Riodinini	*Lasaia agesilas* (Latreille, 1809)		X
		Rhetus periander (Cramer, 1777) * #	X	
		Charis cadytis Hewitson, 1866	X	
HESPERIIDAE (S = 66)				
Pyrginae (S = 32)	Pyrgini	*Achlyodes busirus rioja* Evans, 1953	X	X
		Achlyodes mithridates thraso (Hübner, [1807])	X	X
		Aethilla echina coracina Butler, 1870	X	
		Antigonus liborius areta Evans, 1953		X
		Gesta gesta (Herrich-Schäffer, 1863)		X
		Gorgithion begga begga (Prittwitz, 1868)	X	X
		Gorgythion beggina escalophoides Evans, 1953	X	
		Heliopetes arsalte (Linnaeus, 1758)		X
		Heliopetes omrina (Butler, 1870)	X	
		Milanion leucaspis (Mabille, 1878)	X	X
		Nisoniades bipuncta (Schaus, 1902)	X	X
		Pyrgus orcus (Stoll, 1780)	X	X
		Pythonides lancea (Hewitson, 1868)	X	
		Quadrus cerialis (Stoll, 1782)	X	
		Trina geometrina geometrina (C.Felder & R.Felder, 1867)	X	
		Xenophanes tryxus (Stoll, 1780)	X	
		Zera tetrastigma erisichton (Plötz, 1884) *		X
	Eudamini	*Astraptes aulus* (Plötz, 1881)	X	X
		Astraptes fulgerator fulgerator (Walch, 1775)	X	X
		Autochton zarex (Hübner, 1818)		X
		Celaenorrhinus similis Hayward, 1933	X	X
		Epargyreus exadeus exadeus (Crammer, 1779)	X	
		Nascus phocus (Crammer, 1777)	X	
		Urbanus albimargo (Mabille, 1875)	X	
		Urbanus dorantes (Stoll, 1790)	X	X
		Urbanus esta Evans, 1952	X	X
		Urbanus procne (Plötz, 1880)	X	X
		Urbanus simplicius (Stoll, 1790)		X
		Urbanus teleus (Hübner, 1821)	X	X
	Pyrrhopygini	*Elbella lamprus* (Hopffer, 1874) * #	X	
		Mysoria barcastus barta Evans, 1951*		X
		Pyrrhopyge sp.	X	X
Hesperiinae (S = 34)		*Ancyloxypha nitedula* (Burmeister, 1878)	X	
		Appia appia Evans, 1955	X	
		Arita arita (Schaus, 1902) *	X	
		Callimormus interpunctata (Plötz, 1884)		X
		Callimormus rivera (Plötz, 1882)	X	X
		Chalcone santarus (Bell, 1940)	X	X
		Calpodes ethlius (Stoll, 1782)		X
		Conga chydaea (Butler, 1877)	X	X
		Corticea corticea (Plötz, 1882)	X	
		Cymaenes gisca Evans, 1955		X
		Cymaenes tripunctus theogenis (Capronnier, 1874)		X
		Cymaenes lepta (Hayward, 1939)		X
		Hylephila phyleus (Drury, 1773)	X	
		Lychnuchoides ozias ozias (Hewitson, 1878)	X	X

S, riqueza de espécies; * indica registros novos para a Mata Atlântica do Rio Grande do Sul; # indica registros novos para o Rio Grande do Sul.
S, species richness; * new records for Rio Grande do Sul Atlantic Forest; # new records for Rio Grande do Sul State.

Tabela 1. Continuação...

Famílias/subfamílias	Tribos	Espécies	Ambientes	
			Mata paludosa	**Mata de Restinga**
		Lychnuchus celsus (Fabricius, 1793)		X
		Miltomiges cinnamomea (Herrich-Schäffer, 1869)		X
		Mnasilus allubita (Butler, 1870)	X	
		Morys geisa geisa (Möschler, 1879) * #		X
		Nastra lurida (Herrich-Schäffer, 1869)		X
		Nyctelius nyctelius nyctelius (Latreille, [1824])	X	X
		Panoquina ocola ocola (W. H. Edwards, 1863)	X	
		Parphorus pseudecorus (Hayward, 1934)	X	
		Perichares philetes aurina Evans, 1955	X	
		Polites vibex catilina (Plötz, 1886)		X
		Pompeius dares (Plötz, 1883) * #		X
		Pompeius pompeius (Latreillle, [1824])	X	
		Saliana longirostris (Sepp, [1840])	X	
		Talides riosa Evans, 1955 * #	X	
		Vehilius inca (Scudder, 1872)	X	
		Vehilius stictomenes stictomenes (Butler, 1877)		X
		Vettius phyllus prona Evans, 1955 *	X	X
		Virga austrinus (Hayward, 1934) *	X	
		Zariaspes mys (Hübner, [1808])		X
		Wallengrenia premnas (Wallengren, 1860) *		X
S Total = 225			161	**146**

S, riqueza de espécies; * indica registros novos para a Mata Atlântica do Rio Grande do Sul; # indica registros novos para o Rio Grande do Sul.
S, species richness; * new records for Rio Grande do Sul Atlantic Forest; # new records for Rio Grande do Sul State.

Tabela 2. Representatividade (%) das famílias de borboletas em diferentes fisionomias da Mata Atlântica do Rio Grande do Sul, Brasil.

Table 2. Percentage of composition of butterfly families in different phytophysiognomies of Atlantic Forest in Rio Grande do Sul State, Brazil.

	PCN	**MPA**	**RES**	**FOD**[1,2,3]	**FOM**[3,4,5,6,7]
Nymphalidae	37,8	43,5	34,8	30,0	38,8
Hesperiidae	29,3	28,0	28,1	35,7	28,2
Lycaenidae + Riodinidae	22,3	19,2	24,7	23,6	19,4
Pieridae	6,2	5,6	6,2	7,3	8,7
Papilionidae	4,4	3,7	6,2	3,4	4,9

PCN = Planície Costeira Norte; MPA = Mata Paludosa; RES = Restinga; FOD = Floresta Ombrófila Densa; FOM = Floresta Ombrófila Mista. PCN = North Coastal Plain; MPA = Swamp Forest; RES = Restinga Forest; FOD = Subtropical Atlantic Forest; FOM = Araucaria Moist Forest. [1]Iserhard & Romanwoski (2004); [2]Iserhard (2009); [3]Santos et al. (2011); [4]Iserhard et al. (2010a); [5]Romanowski et al. (2009); [6]Pedrotti et al. (2011); [7]Ritter et al. (2011).

que para a Floresta Ombrófila Mista foram apenas dois anos de amostragem com rede entomológica (Iserhard et al. 2010a) e dois anos de amostragem com armadilhas atrativas (Santos et al. 2011). Em geral, ambientes de Mata Atlântica se aproximam de uma boa representatividade de todos os grupos e famílias de borboletas quando Hesperiidae ultrapassa Nymphalidae em espécies (Brown & Freitas 2000b), como demonstrado na compilação dos trabalhos de Iserhard & Romnowski (2004), Iserhard (2009) e Santos et al. (2011). Este padrão é encontrado, também, em outros inventários na Mata Atlântica brasileira (Brown 1992, Mielke & Casagrande 1998, Brown & Freitas 2000a, b, Santos et al. 2008, Dolibaina et al. 2011, Francini et al. 2011). Mesmo que este inventário tenha obtido um alto esforço amostral com armadilhas para a captura exclusiva de borboletas frugívoras da família Nymphalidae, sugere-se que um aumento no esforço amostral no presente estudo provavelmente levaria a uma maior representatividade de Hesperiidae que superaria Nymphalidae em número de espécies, já que em Hesperiidae o acréscimo de novas espécies é mais lento e constante ao longo do tempo (Iserhard 2009) e a diferença entre tais famílias é de apenas 19 espécies.

Foram encontrados 25 registros não publicados para o Rio Grande do Sul e 35 novos registros de borboletas para o bioma Mata Atlântica neste Estado, sendo seis Nymphalidae, dez Hesperiidae, doze Lycaenidae e sete Riodinidae (Tabela 1), ressaltando a importância da realização de inventários em lacunas de conhecimento como as terras baixas na Planície Costeira do Brasil Meridional. Alguns destes registros chamam a atenção pela forte associação com os hábitats onde foram observadas: *Actinote brylla* Oberthür, 1917 e *Memphis editha* (Comstock, 1961) são espécies características de ambientes de terras baixas mais próximas a Mata Atlântica de faixas litorâneas. *Actinote brylla*, *Memphis editha*, *Aricoris constantius* (Fabricius, 1793) e *Euselasia thucydides thucydides* (Fabricius, 1793) tiveram seus limites sul de distribuição ampliados para a Mata Atlântica brasileira, anteriormente registradas até Santa Catarina (Callaghan 2001, 2010, Dias et al. 2012). É importante ressaltar a quantidade de riodinídeos exclusivos para estas formações de Mata Atlântica, bem como o primeiro registro de *Rethus periander* (Cramer, 1777) e do licenídeo *Arcas imperialis* (Cramer, 1775) para o Rio Grande do Sul. A primeira espécie foi encontrada apenas uma vez e a segunda espécie foi registrada duas vezes, sendo que ambas estavam associadas ao interior da mata paludosa na parte mais preservada do fragmento do Parque Estadual de Itapeva.

Inventários são fundamentais para o conhecimento e para a conservação tanto dos táxons estudados quanto dos ambientes aos quais eles estão associados, pois podem revelar características importantes de comunidades locais, tais como a utilização de recursos e a preferência de habitat, além de contribuir para o conhecimento da fauna regional (Marchiori & Romanowski 2006). Torna-se necessário a divulgação deste tipo de publicação para que estudos ecológicos futuros possam ser adequadamente elaborados e bem conduzidos. A fragmentação e/ou conversão de ambientes nativos em áreas antropizadas pode ser a forma mais destrutiva de perda de habitat (Dunn 2004) e, para Lepidoptera, pode levar à substituição de grupos de espécies especialistas por borboletas generalistas, comuns e adaptadas a ambientes degradados (Brown 1996). As áreas de Mata Paludosa e de Restinga estão fortemente ameaçadas através de duas principais ações antrópicas: agropecuária (cultivo do arroz e manejo de gado) e a construção civil (especulação imobiliária em áreas litorâneas). A paisagem remanescente desses ecossistemas encontra-se restrita a pequenas manchas de floresta e, apesar deste cenário alarmante, são sistemas ainda pouco estudados (Kindel 2002). Em virtude desta devastação, espécies de plantas e animais estão sendo eliminadas, restringindo a diversidade biótica (Maciel 1984), muitas vezes antes de ser conhecida. Este trabalho reforça o direcionamento de esforços de amostragem em regiões pouco conhecidas, visando ampliar as informações sobre a distribuição e a ocorrência de borboletas no Brasil Meridional. O presente estudo pretendeu contribuir com este propósito e sugere que a geração de conhecimento sobre a diversidade de borboletas de uma ampla área na Planície Costeira do sul do Brasil – e em particular, o grande número de novos registros obtidos – contribua para a preservação destes ambientes, ainda tão pobremente representados em Unidades de Conservação e crescentemente ameaçados pela pressão antrópica.

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Diet of the toad *Rhinella icterica* (Anura: Bufonidae) from Atlantic Forest Highlands of southeastern Brazil

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SABAGH, L.T., CARVALHO-E-SILVA, A.M.P.T. & ROCHA, C.F.D. **Diet of the toad *Rhinella icterica* (Anura: Bufonidae) from Atlantic Forest Highlands of southeastern Brazil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?short-communication+bn01612042012

Abstract: In this study, we present some information of the regarding throphic niche from the anuran toad *Rhinella icterica* living in high altitudes above 2000 m a.s.l. from a habitat of the Atlantic Forest Biome – the Altitude Fields in the Itatiaia National Park. We found 150 prey items in toad stomachs, belonging to five prey types, as well as skin remains and some remains of plant material. The index of relative importance indicated that most important prey types were beetles and ants, these last composing 70% of the diet numerically and the trophic niche breadth (B) was 1.81. The relatively low diversity of prey types we recorded in the diet of *R. icterica* of Itatiaia and numerically dominated by ants suggests some preference for this item. We do not found significant relationship between the toad measurements with the preys' measurements. We concluded that *R. icterica* toads at the highlands of Itatiaia feeds on arthropods, mainly ants and coleopterans and that the high consumption of preys with relatively small and similar size as ants in the diet prevents an expected relationship among frog body or mouth size and prey volume and size.
Keywords: *Amphibia, feeding habits, highlands, trophic niche, Yellow Cururu Toad.*

SABAGH, L.T., CARVALHO-E-SILVA, A.M.P.T. & ROCHA, C.F.D. **Dieta do sapo *Rhinella icterica* (Anura: Bufonidae) em altitudes elevadas na Mata Atlântica do sudeste do Brasil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?short-communication+bn01612042012

Resumo: No presente estudo apresentamos informações sobre o nicho trófico de uma espécie de anuro que reside em altitudes elevadas da Mata Atlântica. Descrevemos a dieta do sapo *Rhinella icterica* em altitudes acima de 2000 m em áreas de Campos de Altitude no Parque Nacional do Itatiaia. Encontramos 150 itens nos estômagos analisados de *R. icterica*, divididos em apenas cinco categorias de presa, além de vestígios da própria pele do anuro e restos vegetais. O índice de importância relativa indicou que besouros e formigas foram os itens mais importantes sendo que formigas representam 70% dos itens ingeridos. A amplitude de nicho trófico (B) foi de 1,81. O reduzido número de categorias alimentares, bem como o elevado número de formigas na dieta sugere que *R. icterica* apresente uma preferência por este item. Não encontramos nenhuma relação significativa entre as dimensões do anuro com as dimensões das presas. Concluímos que a população de *R. icterica* que habita os campos de altitude de Itatiaia alimentam-se de artrópodes, principalmente formigas e besouros. O alto consumo de presas com tamanho relativamente semelhante e pequeno como, por exemplo, formigas, impede uma relação esperada entre o tamanho do corpo do anuro ou o tamanho de sua mandíbula e tamanho e volume de presas.
Palavras-chave: *Amphibia, hábitos alimentares, campos de altitude, nicho trófico, sapo Cururu.*

Introduction

Diet is one of the most important dimensions of an animal species niche (Toft 1985). Along the last two decades an increasing number of studies regarding anurans diet has been developed in Brazil in different Biomes, ecosystems and habitats, including the Pantanal (e.g. Sabagh et al. 2010, Sugai et al. 2012), Cerrado (e.g. Batista et al. 2011, Maragno & Souza 2011), Amazon (e.g. Juncá & Eterovick 2007, Sabagh et al. 2012), Caatinga (e.g. Damasceno 2005), and Pampas (e.g. Solé et al. 2002). However, most studies concentrated in the Atlantic Rain Forest (e.g. Siqueira et al. 2006, Santana & Juncá 2007, Sabagh & Carvalho-e-Silva 2008, Ferreira & Teixeira 2009) involved species and populations living in lowland areas (e.g. Boquimpani-Freitas et al. 2002, Siqueira et al. 2006, Almeida-Gomes et al. 2007, Ferreira & Teixeira 2009, Martins et al. 2010, Almeida-Santos et al. 2011), especially in the ombrophilous forest, with a marked lack of information on anurans feeding habits from highlands. Some studies have investigated the relationship and influence of the size of the frog and the size of prey ingested (e.g. Sabagh & Carvalho-e-Silva 2008, Duré et al. 2009, Quiroga et al. 2009, Batista et al. 2011, Maragno & Souza 2011) as an ontogenetic diet shift.

Rhinella icterica (Spix, 1824) has a relatively wide distribution in South America occurring from eastern Paraguay and Misiones, Argentina, along Southern (Rio Grande do Sul) and Southeastern northwards to Bahia in northeastern and Goiás in central Brazil (Frost 2011), occurring in different habitats and altitudes along the Atlantic forest Biome. At the highlands of the National Park of Itatiaia we found one population of *R. icterica* occurring in the "Campos de altitude" (Altitude Fields) ecosystem. Campos de altitude constitutes the southeastern Brazilian highlands above 2,000 m elevation in the Atlantic Forest. The characteristics of this habitat, mainly mediated by low temperatures, also results in a high rate of flora and fauna endemism (Safford 1999, 2007), although relatively little is known in terms of ecology of the species from these mountaintop formations (Safford 1999).

The knowledgement on *R. icterica* feeding habits is considerably restricted and available data for Atlantic Forest indicates that it has a relatively diversified diet including a high number of ants (Sabagh & Carvalho-e-Silva 2008). In the present study, we provide the first information regarding the diet of a population of *R. icterica* living in an area of high elevation (above 2,000 m a.s.l.) in the Itatiaia National Park (Brazil). We aimed to specifically answer the following questions: i) Which food items make up the diet of this *R. icterica* population? ii) Which are the main prey types consumed by this toad?; iii) Which is the niche breadth of this population? iv) There are relationship between the toad body size and the prey size? v) Do the diet of this *R. icterica* population is similar to other populations and other species of the genus?

Materials and Methods

The study was carried out the Itatiaia National Park of (PNI) located between the states of Rio de Janeiro and Minas Gerais (in Serra da Mantiqueira) in southeastern Brazil. Samples were collected specifically in two areas: Brejo da Lapa (22° 21' S and 44° 44' W, 2,000 m a.s.l.), and Abrigo Rebouças (22° 23' S and 44° 40' W, 2,450 m a.s.l.). Abrigo Rebouças is a true Campo de Altitude formation, whereas Brejo da Lapa can be considered as a transition between upper mountain forest and Campos de Altitude (Safford 1999). The mean temperature variation in the area is 7.4-13.6 °C and the annual rainfall ranges from 1,500-3,000 mm (Safford 1999). In terms of vegetation, the "Campos de Altitude" constitutes a mosaic of dispersal shrubs and small copses of short, often stunted trees set within a more continuous matrix of bunchgrasses and bamboo (Safford 1999).

Collections were made at night during August 2005 (dry season). Toads were collected manually, anesthetized with clorethone, and had their stomach flushed (Leclerc & Courtois 1993). The food items obtained from stomach-flushing method were preserved in alcohol 70%. We measured the snout-vent length (SVL), and jaw width (JW) of toads using a caliper (0.1 mm precision). After sampling the stomach contents by flushing and taking biometric variables, the individual toads were kept in captive until recover from anesthesia, and were returned to the exact site of the habitat where they were previously found.

Diet composition was determined based on number (N), volume (V) and occurrence (O) of each prey type in the stomachs. The length and width of each prey item were measured with caliper (0.1 mm precision) and its volume (in mm^3) was estimated using the ellipsoid formulae (Dunham 1983). An index of relative importance (IRI = %O.(%N + %V)) of each prey category in the diet was estimated according Pianka et al. (1971). Food niche breadth was calculated using the formula proposed by Levins (1968) $B = 1/\Sigma pi^2$, where B = niche breadth and pi = proportion of item i in the diet in order to allow comparison with a value of food niche breadth calculated in a previous study for another population of *R. icterica* (Sabagh & Carvalho-e-Silva 2008). The values of niche breadth were standardized (B_A) to a restrict of 0 to 1 using the appropriate formula, $B_A = (B - 1)/(n - 1)$, where B_A = standardized Levins index and n = number of possible resources.

To evaluate if toad snout-vent length or jaw width affects prey size consumed we used a simple linear regression using body variables as independent variables and prey-items size as dependent variables (Zar 1999). We specifically analyzed the relationships SVL × total volume of preys per stomach, JW x the largest prey volume per stomach, and JW × largest prey length per stomach. The values of prey items were ln-transformed for meet normality and homogeneity. We used the value of 0.05 as the cut-off for significance.

We used the individual-based rarefaction method (Gotelli & Colwell 2001) to validate the comparison between the richness of prey (orders) of two *R. icetrica* populations from PNI (data from present study) and Serra dos Órgãos National park – PARNASO (data from Sabagh & Carvalho-e-Silva 2008) even with samples being distinct sizes (Bonansea & Vaira 2007). The rarefaction curves (with standard deviation) and the Jacknife 1 richness estimator were done performing 1,000 randomizations without replacement using the software EstimateS 8.2 (Colwell 2009).

Results and Discussion

We sampled 17 individuals of *Rhinella icterica*, three of which (16.7%) had empty stomachs. We found 150 arthropods items in five prey categories as food items in the stomachs (Table 1). Also, in one stomach (5.9%) we found parts of skin of *R. icterica*. The occurrence of own skin in the stomachs of *R. icterica* has been also found in other studies regarding *Rhinella* species (Evans & Lampo 1996, Teixeira et al. 1999, Sabagh & Carvalho-e-Silva 2008) and it seems to constitutes a common habit among amphibians, which recycle their skin during molting (Weldon et al. 1993). Remains of plant material were found in 10 stomachs (58.8%). We found small stones in the stomach of three individual toads (17.7%). The occurrence of these two last items are common and probably they were ingested accidentally as suggested in many diet studies of *Rhinella* species (e.g. Evans & Lampo 1996, Teixeira et al. 1999, Sabagh & Carvalho-e-Silva 2008, Isaacs & Hoyos 2010).

Table 1. Diet composition of *Rhinella icterica* toad (n = 17) in the highlands of the Itatiaia National Park, Itatiaia Municipality, Rio de Janeiro State, Brazil, with respective absolute and relative values of abundance (N and %N), occurrence (O and %O), volume (V and %V), and index of relative importance (IRI) of each prey categories.

Itens	N	%N	O	%O	V (mm^3)	%V	IRI
Coleoptera	37	24.7	11	64.7	8566.4	60.1	54.84
Hymenoptera (Formicidae)	105	70.0	9	52.9	3197.3	22.4	48.93
Odonata	2	1.3	1	5.9	1561.3	10.9	0.72
Opiliones	3	2.0	2	11.8	462.8	3.2	0.62
Aranae	3	2.0	3	17.7	194.9	1.4	0.59
Unidentified remains	-	-	1	5.9	276.0	1.9	-
Skin remains	-	-	1	5.9	-	-	-
Plant remains	-	-	10	58.8	-	-	-

Formicidae dominated the diet numerically (70.0%), although in terms of volume (60.1%) and occurrence (64.7%) Coleoptera was the most representative item in the *R. icterica* diet (Table 1). Supplementary food items as Opiliones, Araneae and Odonata nymphs were consumed in comparatively lower frequency (Table 1). The data indicated that *R. icterica* population at the highlands of Itatiaia National Park fed on arthropods, mainly on ants and coleopterans, in a similar way to what has been found to the diet of other species in the genus *Rhinella* (Lajmanovich 1994, Isacch & Barg 2002, Sabagh & Carvalho-e-Silva 2008, Duré et al. 2009, Ferreira & Teixeira 2009, Isaacs & Hoyos 2010). These results suggested that toads of the genus *Rhinella* tend to feed predominantly on these arthropods, even living in different ecosystems along the distribution of the species and of the genus. Formicidae usually constitute dominant arthropod organisms among those living in the leaf-litter of the forest floor of the Atlantic forest biome (Lacerda et al. 1998, Santos et al. 1998) and is the most representative item in the diet of other *Rhinella* species (Toft 1980, Evans & Lampo 1996, Teixeira et al. 1999, Isacch & Barg 2002, Sabagh & Carvalho-e-Silva 2008, Duré et al. 2009, Ferreira & Teixeira 2009, Quiroga et al. 2009, Maragno & Souza 2011). However, some species of *Rhinella* have beetles as the most important item in the diet (Lajmanovich 1994, Grant 1996, Duré et al. 2009, Isaacas & Hoyos 2010, Batista et al. 2011). The population of *R. icterica* at Itatiaia highlands follows the pattern of the genus having ants and beetles as the most representative items in your diet (Table 1).

The relatively low number of prey types (only five) in the diet of *R. icterica* in PNI highlands, was comparatively lower than that found for the same species studied in an area about 995 m a.s.l. of PARNASO (Figure 1) to which diet was composed by 21 order of preys (Sabagh & Carvalho-e-Silva 2008). This variation in diet richness found among these studies may reflect differences in food availability between areas, periods of collection or even altitudes. In fact, it is well known that invertebrate availability decreases with an increase in altitude (Leakey & Proctor 1987, Brühl et al. 1999, Almeida-Neto et al. 2006) and thus, we do not know in which extent a supposedly lower availability of arthropods in the highlands of PNI could explain part of these observed differences in number of prey size consumed among *R. icterica* populations. However, the similarities are that ants and beetles showed the most values items in the diet of the species in both localities. Even without showing a confidence interval, *R. icterica* of PNI showed a relative greater standard trophic breadth ($B_A = 0.20$; B = 1.81) when compared with the same species in PARNASO ($B_A = 0.03$) (Sabagh & Carvalho-e-Silva 2008). The Levins index resumes information about consumed preys richness and evenness, thus, we would be expected that *R. icterica* in PNI had a more equitative prey distribution in its diet because had less prey types. We believe that *R. icterica* is a non-selective feeder then dietary differences found between populations may reflect, at list in part, the availability of preys as proposed for other *Rhinella* species (Evans & Lampo 1996) and bufonids (Bonansea & Vaira 2007).

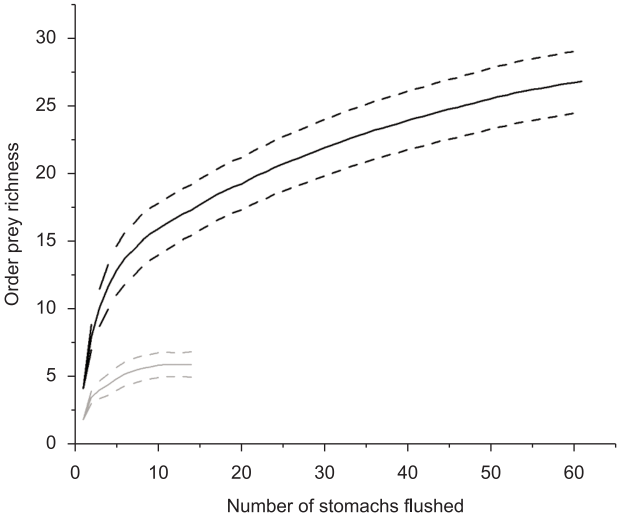

Figure 1. Rarefaction curves with their respective standard deviation for two population of *Rhinella icterica*. Highlands of Itatiaia National Park (gray lines) and Serra dos Órgãos National Park (black lines), southeastern Brazil.

The total volume of preys found in stomachs varied from 160.2 to 4,240.0 mm^3 and the largest prey volume varied from 17.7 (an ant) to 4,021.2 mm^3 (a beetle). In terms of length, the largest prey items in the stomachs varied from 6.0 mm (a spider) to 36.6 mm (a dragonfly nymph). Mean SVL of *R. icterica* sampled measured 114.5 ± 8.1 mm (range = 101.3-128.7 mm) with a mean JW = 41.1 ± 1.9 mm (range = 37.7-44.8 mm). There was no significant relationship between total prey volume and toad SVL ($F = 1.31$; $R^2 = 0.098$; $p = 0.275$), between the largest prey volume and JW ($F = 0.02$; $R^2 = 0.002$; $p = 0.886$), and between largest prey length and toad JW ($F = 0.24$; $R^2 = 0.020$; $p = 0.633$). Amphibians usually ingest their prey whole and as result, mouth dimensions tend to restrict the upper limit of prey size they can consume (Blackburn & Moreau 2006). This relationship is generally reflected in many *Rhinella* species by a positive relationship between mouth size and prey dimensions (e.g. Duré et al. 2009, Quiroga et al. 2009, Batista et al. 2011, Maragno & Souza 2011), which was not observed for *R. icterica* in our study. The absence of a significant relationship between the prey size ingested and *R. icterica* size at Itatiaia National Park may be the result from the high consumption of ants, which are preys of small size and little size variation (which reduces the total prey volume in the toads' diets). This trend has been also found in *Leptodactylus marmoratus*

(Steindachner, 1867) from the Atlantic rainforest of Ilha Grande in Rio de Janeiro (Almeida-Gomes et al. 2007) to which most of diet was composed by ants, and also for the lizard *Cnemidophorus littoralis* Rocha et al. 2000, for which the absence of this relationship seemed to be due to the large consumption of termites (Teixeira-Filho et al. 2003). The difference of 27.4 mm between the highest and lowest toad and 7.1 mm between the highest and lowest jaw may not have been sufficient to establish a relationship with diet. The *R. icterica* population of PARNASO showed a positive and significant relationship between the toad body size and their total prey volume, however the difference between the highest and lowest toad was 92.2 mm, and the low value of r^2 is not enough to prove diet ontegeny (Sabagh & Carvalho-e-Silva 2008).

We concluded that *Rhinella icterica* toads at the highlands of Itatiaia National Park fed a few orders of arthropods, mainly on ants and coleopterans. Last two were also the main preys of PARNASO population and other species of the genus. The high consumption of preys with relatively small and similar size as ants in the diet prevents an expected relationship among frog body or mouth size and mean prey size. Future studies should work with a higher altitude gradient to test the hypothesis of differences in the frogs' diet.

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Morphological differentiation among migratory fish species from the Paraná River basin

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Abstract: This study characterized the morphological differences among migratory fish species from the Paraná River Basin. A total of 177 adult fish of *Leporinus elongatus*, *Leporinus macrocephalus, Prochilodus lineatus, Salminus brasiliensis, Pimelodus maculatus, Pinirampus pirinampu, Pseudoplatystoma corruscans, Pterodoras granulosus*, and *Rhaphiodon vulpinus* were sampled in the Canal da Piracema, a fish passage system at Itaipu Dam, Paraná River. The migratory species were analyzed through 22 morphometric measurements and fineness ratio to identify morphological patterns related to swimming performance. Four species groups were indicated by the Cluster analysis: I) *R. vulpinus*; II) *P. corruscans*; III) *L. macrocephalus*, *L. elongatus*, *P. lineatus*, *P. maculatus*, and *S. brasiliensis* - measurements of head height and anal fin length formed this group; and IV) *P. granulosus* and *P. pirinampu* - measurements of maximum body width and caudal peduncle width contributed to form this group. The morphometric variables that most contributed to the distinction were head length and mouth width for groups I and II. The species R. vulpinus and P. granulosus differed from other species, showing fineness ratios of 9.4 and 3.7, respectively. *Leporinus elongatus, L. macrocephalus, P. lineatus, P. maculatus*, and *S. brasiliensis* showed significant differences from other species, with ratios ranging from 4.57 to 5.19, indicating that these species may be better swimmers. Long-distance migratory species using the Piracema Canal to ascend upstream areas differed morphologically, morphological characteristics such as a narrow caudal peduncle and maximum body length, besides to the values of the fineness ratio, were essential to differentiate the migratory species.

Keywords: *morphology, swimming performance, fineness ratio, migratory fish.*

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Resumo: Este estudo caracterizou as diferenças morfológicas entre espécies de peixes migradores da bacia do rio Paraná. Um total de 117 peixes adultos das espécies *Leporinus elongatus*, *Leporinus macrocephalus*, *Prochilodus lineatus*, *Salminus brasiliensis*, *Pimelodus maculatus*, *Pinirampus pirinampu*, *Pseudoplatystoma corruscans*, *Pterodoras granulosus* e *Rhaphiodon vulpinus* foram capturados no Canal da Piracema, um sistema de transposição para peixes na barragem de Itaipu, rio Paraná. As espécies migradoras foram analisadas através de 22 medidas morfométricas e razão fineza para identificar padrões morfológicos relacionados à capacidade natatória. Quatro grupos de espécies foram evidenciados pela Análise de Cluster: I) *R. vulpinus*; II) *P. corruscans*; III) *L. macrocephalus*, *L. elongatus, P. lineatus*, *P. maculatus* e *S. brasiliensis*, medidas de altura de cabeça e comprimento da nadadeira anal formaram este grupo; e IV) *P. granulosus e P. pirinampu* – medidas de largura máxima do corpo e largura do pedúnculo caudal contribuíram para a formação deste grupo. As variáveis morfométricas que mais contribuíram para distinção dos grupos I e II foram comprimento da cabeça e largura da boca. As espécies *R. vulpinus* e *P. granulosus* diferiram das demais, apresentando razão de fineza de 9,4 e 3,7, respectivamente. *Leporinus elongatus*, *L. macrocephalus*, *P. lineatus*, *P. maculatus*, *S. brasiliensis* diferiram significativamente das demais espécies com valores de razão fineza que variaram entre 4,57 a 5,19, indicando que estas espécies podem apresentar melhor desempenho natatório. As espécies migradoras de longa distância que utilizam o Canal da Piracema para ascender áreas a montante diferiram morfologicamente, características morfológicas como pedúnculo caudal estreito e largura máxima do corpo, bem como os valores de razão de fineza foram determinantes na diferenciação das espécies aqui analisadas.

Palavras-chave: *morfologia, capacidade natatória, razão fineza, peixe migrador.*

Introduction

Morphological and morphometric variations in the fish body structure can lead to functional differences in the performance and locomotion (Breda et al. 2005, Motta & Wilga 1995, Wainwright et al. 2002). The swimming performance depends on a species' morphological characteristics (Lighthill 1969) so many fish morphological characteristics are important to define it, especially those related to production of thrust and drag force as body shape, height of caudal peduncle, length of caudal fin (Webb & Weihs 1986) and fineness ratio (Bainbridge 1960, Landweber 1961, Blake 1983). These characteristics can describe the influence of body shape on the drag in water movement (Ohlberger et al. 2006).

In the conception and implementation of barriers to movement of water flow, as culverts, canals, dikes and dams (Warren & Pardew 1998), the fish swimming performance is an important factor that should be taken into consideration (Beach 1984, Santos et al. 2008), especially for those species that are rheophilic, showing upward migration for reproduction (Agostinho et al. 1992, 2007). However, the swimming performance and morphological characteristics of the Neotropical fish species that may use the fish passages have not been considered in the design criteria.

Studies on morphology of Neotropical freshwater fish are restricted to the comparison between morphology and diet (Piorski et al. 2005, Teixeira & Bennemann 2007), morphological variations under different environmental conditions (Monteiro & Neves 2003), and ecomorphology of fish from streams (Casatti & Castro 2006, Ferreira 2007). However, studies on the morphology associated with swimming performance for the Neotropical fish species are non-existent, with only information available for two migratory species, *Leporinus reinhardti* and *Pimelodus maculatus*, on swimming speeds and determination of swimming performance in the studies conducted by Santos et al. (2007, 2008).

This study characterized the morphological differences among nine long-distance migratory fish species from Paraná River basin, based on morphometric measurements, in order to identify morphological patterns related to the swimming performance, important information to subside the design criteria of the fish passages in the Neotropical region.

Materials and Methods

1. *Samples and collection of morphometric data*

Fish sampling was carried out from April/2004 to May/2005 (April, May, and August to December/2004, and January to May/2005) in the Piracema Canal, a fish-pass system located at the Itaipu Dam, Paraná River, Brazil-Paraguay (Figure 1).

The Piracema Canal is a complex 10-km fish pass system that climbs 120 m to connect the Paraná River to the Itaipu Reservoir along the Brazil-Paraguay border (Makrakis et al. 2011). The canal includes a large section of a natural streambed as well as several fish ladders, artificial lakes and semi-natural channels, and the mean water velocity range from 0.9 to 3.0 m/s (for details see Makrakis et al. 2007).

Fish collections were made in different locations along the Piracema Canal, including in the Paraná River (downstream of the dam) and the Itaipu Reservoir, using several fishing gears: gill nets, casting net, trawl net, and fishing rod.

To analyze the most appropriate morphological patterns for the species' movement related to swimming capacity, morphometric measurements were taken in nine long-distance migratory fish species (Agostinho et al. 2003, Suzuki et al. 2004, Makrakis et al. 2007), totaling 177 individuals (Table 1).

Only adults were analyzed, because they did not show changes in proportion during their growth (allometry) (Gatz Junior 1979a, b). The measurements were taken according to Gatz Junior (1979a), Watson & Balon (1984), totaling 22 morphometrics measurements (Figure 2).

The measurements up to 150 mm were made with a digital caliper of 0.5 mm precision; and above 150 mm, with a metal ruler of 1.0 mm precision. To make the measurements, the live fish were previously anesthetized with clove oil.

2. *Data analysis*

To evaluate the morphological similarities among the species, the residues of linear regressions between the standard length (independent variable) and the morphometric measurements (dependent variables) were used to produce a similarity/dissimilarity matrix (Cone 1989), using Euclidean Distance. These circumstances were classified through grouping analysis (Cluster analysis) applying the Single Link Method, where individual pairs are united, each time, closer to each other (Wilkinson 1987). Non-metric Multidimensional Scaling (MDS), followed by Pearson and Spearman correlations between the retained axes, and the variables that originated them, were applied to complement the patterns of species relationships found, utilizing the clustering procedure, and to illustrate the relationships in a two-dimensional space. The procedure for MDS was calculated with 25 restarts to arrive at a minimum stress value (0.01), in accordance with the procedures suggested by Field et al. (1982) and Clarke (1993). The percentage similarity of routine analysis for the delineation of each group was determined by the SIMPER procedure (Clarke 1993). This procedure indicates the average contribution of each morphometric measurement to the similarity/dissimilarity. The PRIMER v.6 software (Clarke & Gorley 2006) was used in the multivariate analysis.

The fineness ratio (Landweber 1961, Webb 1975, Blake 1983) was calculated for each individual to assess the influence of body shape on swimming performance as follows (Equation 1):

$$\text{Fineness ratio} = \frac{\text{SL}}{\sqrt{\text{MBH} * \text{MBW}}} \tag{1}$$

SL: standard length; MBH: maximum body height; MBW: maximum body width.

Table 1. Number of fish analyzed of the long-distance migratory species.

Tabela 1. Número de peixes analisados das espécies migradoras de longa distância.

Family/species	Number of individuals
Anostomidae	
Leporinus elongatus	15
Leporinus macrocephalus	4
Prochilodontidae	
Prochilodus lineatus	39
Characidae	
Salminus brasiliensis	14
Pimelodidae	
Pimelodus maculatus	39
Pinirampus pirinampu	11
Pseudoplatystoma corruscans	4
Doradidae	
Pterodoras granulosus	5
Cynodontidae	
Rhaphiodon vulpinus	46
Total	117

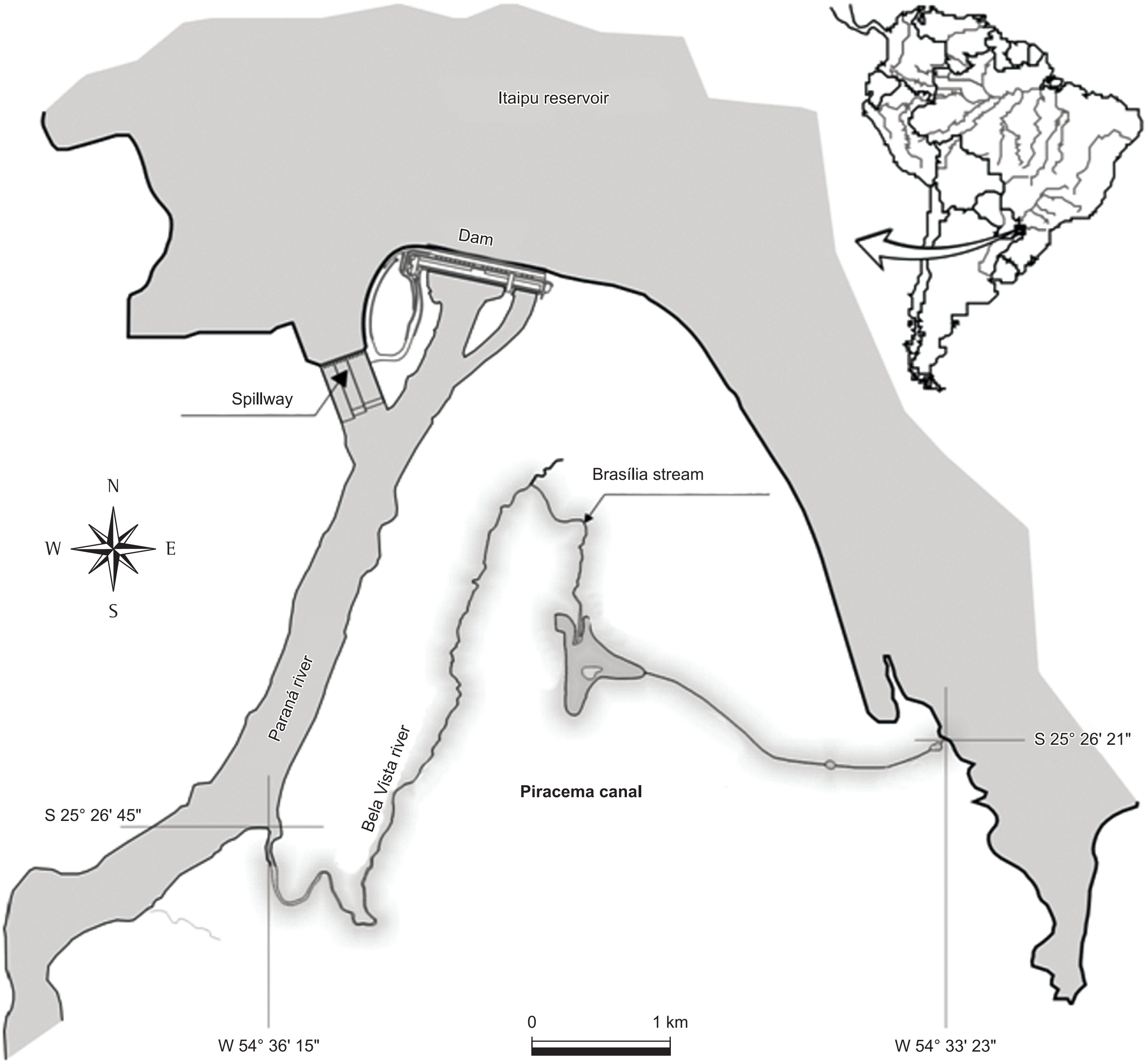

Figure 1. Piracema Canal, connecting the Paraná River and Itaipu Reservoir.

Figura 1. Canal da Piracema, que liga o rio Paraná ao Reservatório de Itaipu.

To assess whether the species showed a different fineness ratio, the variance analysis (ANOVA-One way) was applied, followed by the *a posteriori* Tukey test, both at the 5% level of significance.

Results

From the dendrogram of the species' morphological relationships and the MDS ordination technique (Figure 3), we found that the degree of morphological similarity among the species resulted in four clusters (groups I, II, III, and IV). These groups defined in the dendrogram (level 5.1) are evident in the ordination analysis, non-metric MDS, with a stress of 0.01, indicating that the graphical distances among the species were close to the original similarities. The correlations between the retained axes and the morphometric measurements showed that dimension 1 (MDS 1) was positively related to eye height (EH), anal fin length (AFL), and fineness ratio. In relation to negative values, maximum body width (MBW), caudal peduncle length (CPdL), caudal peduncle width (CPdW), and head width (HW) were prominent. Dimension 2 (MDS 2) showed a positive relationship only to maximum body height (MBH), caudal peduncle height (CPdH), and head height (HH), and negative to mouth height (MoH) (Figure 3, Table 2).

The analysis of similarity percentage (SIMPER procedure) (Table 3) and the dendrogram showed that group I was formed only by *R. vulpinus,* while group II included only *P. corruscans*. Group III was formed by two subgroups, one by *L. macrocephalus,* and the other by *L. elongatus*, *P. lineatus*, *P. maculatus,* and *S. brasiliensis*. Measurements of head height (HH) and anal fin length (AFL) were essential to form the group. Group IV, which showed a similarity of 11.83, was characterized by *P. granulosus* and *P. pirinampu*, and the measurements that contributed most to form this group were maximum body width (MBW) and caudal peduncle width (CPdW).

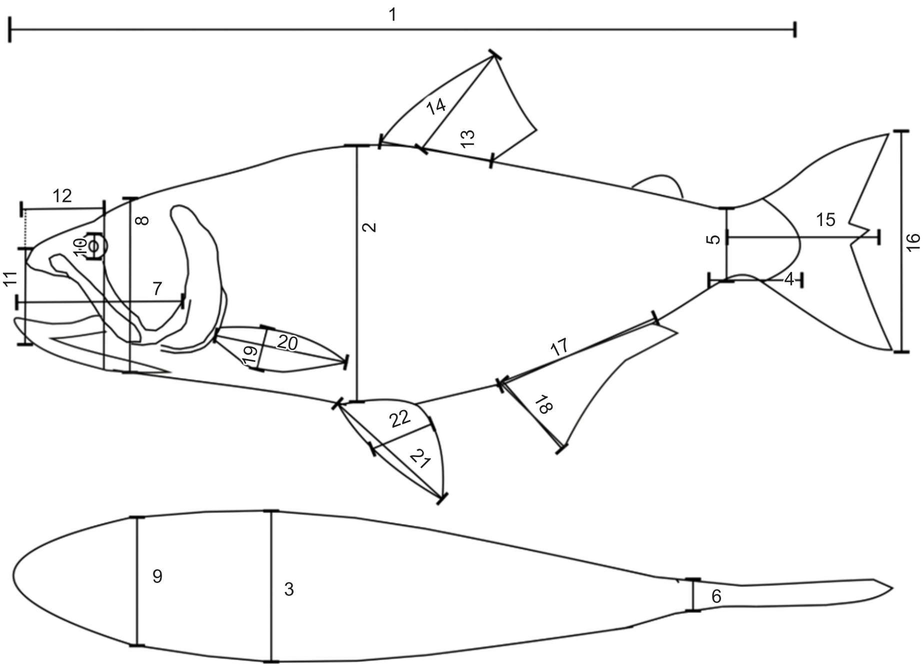

Figure 2. Morphological measurements: 1) standard body length (SBL), 2) maximum body height (MBH), 3) maximum body width (MBW), 4) caudal peduncle length (CPdL), 5) caudal peduncle height (CPdH), 6) caudal peduncle width (CPdW), 7) head length (HL), 8) head height (HH), 9) head width (HW), 10) eye height (EH), 11) mouth height (MoH), 12) mouth width (MoW), 13) dorsal fin length (DFL), 14) dorsal fin height (DFH), 15) caudal fin length (CFL), 16) caudal fin height (CFH), 17) anal fin length (AFH), 18) anal fin height (AFH), 19) pectoral fin length (PtFL), 20) pectoral fin height (PtFH), 21) pelvic fin length (PFL), and 22) pelvic fin height (PFH).

Figura 2. Representação das medidas morfológicas: 1) comprimento padrão do corpo (CP), 2) altura máxima do corpo (ALMCp), 3) largura máxima do corpo (LMCp), 4) comprimento do pedúnculo caudal (CPd), 5) altura do pedúnculo caudal (ALPd), 6) largura do pedúnculo caudal (LPd), 7) comprimento da cabeça (CCa), 8) altura da cabeça (ALCa), 9) largura da cabeça (LCa), 10) altura do olho (ALO), 11) altura da boca (ALBo), 12) largura da boca (LBo), 13) comprimento da nadadeira dorsal (CND), 14) altura da nadadeira dorsal (ALND), 15) comprimento da nadadeira caudal (CNC), 16) altura da nadadeira caudal (ALNC), 17) comprimento da nadadeira anal (CNA), 18) altura da nadadeira anal (ALNA), 19) comprimento da nadadeira peitoral (CNPt), 20) altura da nadadeira peitoral (ALNPt), 21) comprimento da nadadeira pélvica (CNPv) e 22) altura da nadadeira pélvica (ALNPv).

The dissimilarity ranged from 40.28 to 107.23 comparing group to group, and the morphometric variables that most contributed to the distinction were: i) head length (HL) and mouth width (MoW) for groups I and II; ii) head height (HH), dorsal fin length (DFL), and pectoral fin length (PtFL) for groups I and III; iii) maximum body height (MBH), head length (HL), and mouth width (MoW) for groups II and III; iv) pectoral fin height (PtFH), pectoral fin length (PtFL), and caudal peduncle width (CPdW) for groups III and IV; v) pectoral fin height (PtFH), head length (HL), and pectoral fin length (PtFL) for groups II and IV; vi) maximum body width (MBW) and caudal peduncle width (CPdW) for groups I and IV (Table 3).

The mean values of fineness ratio differed significantly among the nine species (ANOVA: F = 510.3; p = 0.001) (Figure 4). The Tukey test showed that *R. vulpinus* and *P. granulosus* differed from other species, displaying the highest (9.41) and lowest (3.77) fineness ratios, respectively. *Leporinus elongatus*, *L. macrocephalus*, *P. lineatus*, *P. maculatus*, and *S. brasiliensis* differed from other species (Figure 4), with intermediate values ranged from 4.57 to 5.19. Similar fineness ratios were verified to *P. corruscans* and *P. pirinampu* (between 6.04 and 6.11, respectively).

Discussion

The swimming performance of fish is not only related to the ecology of organisms that affects prey capture (Rincón et al. 2007) and reproductive success (Videler 1993, Fisher & Bellwood 2003), but also the morphological characteristics of the body, demonstrating that it has a significant effect on aquatic vertebrates (Webb 1984, Blake 2004) and a focus of research in theoretical and applied studies (Hawkins & Quinn 1996, Ojanguren & Brana 2003, Rincón et al. 2007). Morphological characteristics can be used to predict functional differences in the movement and swimming performance, which can result in the incorporation of parameters essential to swimming into ecological studies (Fisher & Hogan 2007).

The morphological patterns identified for the nine long-distance migratory fish species analyzed, which separated them into four distinct morphological groups, may indicate the existence of differences in the swimming capacity and modes of locomotion. Group I was formed exclusively by *R. vulpinus,* a piscivorous species living in the upper layers of the water column, migrator (Ferreira & Caramaschi 2005, Agostinho et al. 2003), and its morphology is adapted to capture prey on the surface or medium depths (Almeida et al. 1997). Therefore, *R. vulpinus* differentiated from other migratory species studied for its body shape, long and laterally compressed body as evidenced by fineness ratio (higher values). In addition, it has a superior-placed mouth, appropriate for predation at the water surface, lateral eyes, short caudal peduncle and large pectoral fins that facilitate fast movements to catch its prey (Freire & Agostinho 2001). On the other hand, the group II, including only *P. corruscans*, showed morphological differences from *R. vulpinus*, with larger mouth opening and higher length of the head.

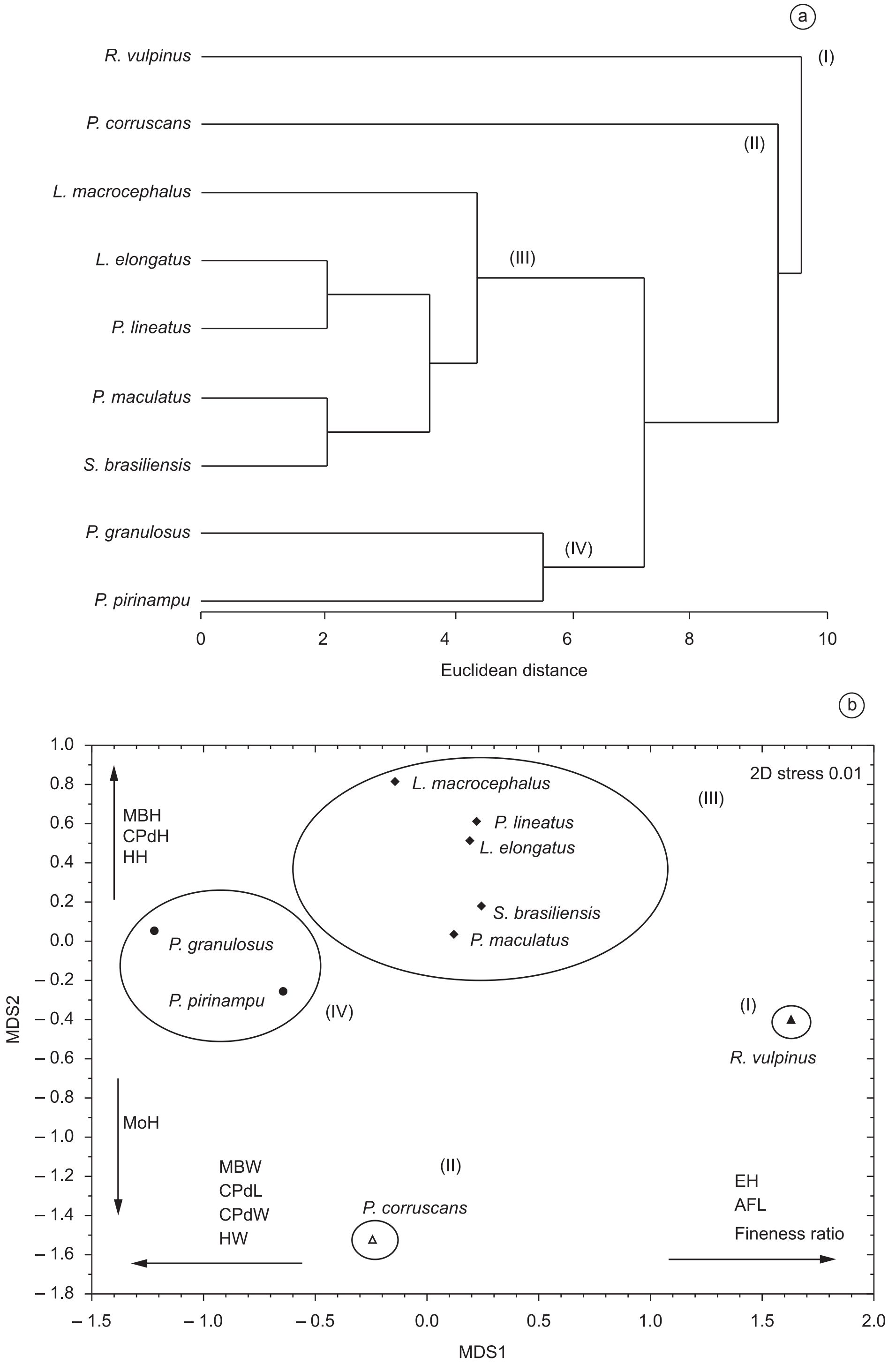

Figure 3. Dendrogram and ordering by the MDS method of morphometric measurements of nine long-distance migratory fish species of the Paraná River. Fish species groups delineated at the 5.1 similarity level on the dendrogram are circled on the ordering graph.

Figura 3. Dendograma e ordenação pelo método MDS das medidas morfométricas de nove espécies de peixes migradores de longa distância do rio Paraná. Grupos de espécies de peixes delineados no nível de 5,1% de similaridade no dendograma estão circundados no gráfico de ordenação.

Morphological characteristics may determine the body shape more efficient (streamlined bodies) to minimize drag and maximize thrust allowing swimming at high speeds for longer time. The shape streamlining considered the most ideal for a more efficient swimming is usually described by the fineness ratio (Scarnecchia 1988), with this attribute can evaluate the swimming performance of fish (Landweber 1961, Blake 1983, Videler & Wardle 1991, Videler 1993, Langerhans & Reznick 2010). The group III was composed by the species *L. macrocephalus*, *L. elongatus*, *P. lineatus*, *P. maculatus* and *S. brasiliensis*, showing lower head height and length of the anal fin. These species exhibit a hydrodynamic body characterized by elongated and fusiform body shape. The fusiform body shape is

Table 2. Pearson and Spearman correlations among the MDS axes.

Tabela 2. Correlação de Pearson e Spearman entre os eixos da MDS.

Variables	Pearson (r)		Spearman (ρ)	
	MDS 1	MDS 2	MDS 1	MDS 2
Fineness ratio	**0.76**	–0.46	0.32	**–0.73**
Eye height (EH)	**0.69**	**0.67**	**0.83**	0.40
Anal fin length (AFL)	**0.67**	0.02	0.52	–0.15
Mouth height (MoH)	0.09	**–0.85**	–0.20	**–0.83**
Caudal peduncle height (CPdH)	0.04	**0.90**	0.25	**0.93**
Pectoral fin length (PtFL)	–0.01	–0.21	–0.08	–0.45
Head height (HH)	–0.07	**0.83**	0.30	**0.93**
Maximum body height (MBH)	–0.09	**0.96**	0.17	**0.98**
Head length (HL)	–0.29	**–0.67**	–0.22	–0.08
Caudal fin height (CFH)	–0.45	**0.75**	–0.17	**0.75**
Dorsal fin length (DFL)	–0.46	**0.75**	0.07	**0.90**
Mouth width (MoW)	–0.56	**–0.78**	**–0.68**	–0.53
Caudal fin length (CFL)	–0.59	0.30	–0.30	0.22
Pectoral fin height (PtFH)	**–0.73**	0.18	–0.63	0.28
Pelvic fin length (PFL)	**–0.75**	0.23	–0.48	0.30
Anal fin height (AFH)	**–0.81**	0.30	–0.43	0.27
Maximum body width (MBW)	**–0.87**	–0.14	**–0.73**	0.17
Caudal peduncle length (CPdL)	**–0.87**	0.20	–0.57	0.40
Dorsal fin height (DFH)	**–0.87**	0.17	–0.62	0.25
Pelvic fin height (PFL)	**–0.88**	–0.17	**–0.87**	–0.18
Caudal peduncle width (CPdW)	**–0.90**	0.12	**–0.78**	0.18
Head width (HW)	**–0.93**	–0.15	**–0.95**	–0.07

Values in bold indicate $p < 0.05$. Valores em negrito indica $p < 0,05$.

Table 3. Contribution of morphometric measurements to the similarity (S) and dissimilarity (D) of the groups (I-IV) of long-distance migratory fish species.

Tabela 3. Contribuição das medidas morfométricas para a similaridade (S) e dissimilaridade (D) dos grupos (I-IV) de espécies de peixes migradores de longa distância.

Mesures	III	IV	III-I	III-II	III-IV	II-I	II-IV	IV-I
	S = 5.70	S = 11.83	D = 59.98	D = 71.48	D = 40.28	D = 107.23	D = 59.48	D = 95.79
MoH	4.53	8.22	3.99	3.83	4.54	-	-	-
HH	**21.81**	7.35	**7.72**	9.92	9.26	-	-	-
MBH	4.25	3.04	5.57	**11.85**	3.43	-	6.20	-
AFH	2.52	2.59	4.39	-	-	-	2.46	5.34
CFH	4.38	0.01	4.83	3.47	-	-	3.18	-
DFH	1.38	0.47	4.72	-	3.19	-	3.62	7.96
PtFH	0.80	1.74	-	-	**10.36**	-	**13.63**	6.57
PFL	1.57	0.16	5.77	-	-	7.33	-	5.76
EH	4.14	0.00	-	10.07	8.34	9.47	-	5.62
CPdH	4.69	1.86	6.23	9.18	5.71	-	2.27	-
HL	3.35	1.07	-	**20.36**	-	**24.84**	**27.99**	-
AFL	**12.32**	0.18	6.3	-	-	7.28	-	4.64
CFL	6.51	3.97	-	-	-	-	-	2.63
DFL	3.32	0.01	**7.44**	2.46	-	-	-	-
PtFL	6.55	0.62	**7.56**	-	**11.27**	6.18	**11.13**	-
PFL	2.71	2.16	6.01	-	-	2.49		5.50
CPdL	0.08	1.46	5.01	-	3.72	-	5.12	8.99
MoW	7.59	0.59	-	**16.53**	7.27	**14.99**	5.45	5.17
HW	4.95	7.95	5.72	2.56	5.44	8.70	-	9.97
MBW	0.41	**29.61**	5.1	-	7.85	8.51	2.96	**10.75**
CPdW	2.15	**26.94**	4.33	-	**10.72**	2.61	6.60	**12.36**

For measure codes see Table 2. Para os códigos das medidas ver Tabela 2.

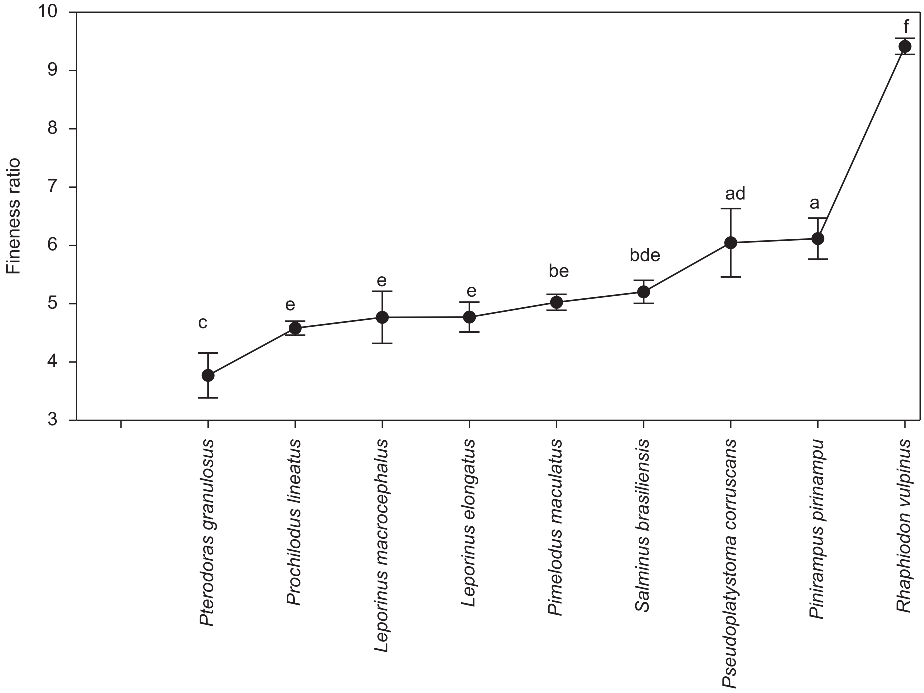

Figure 4. Mean ± 95% standard deviation for the fineness ratios of the nine fish species evaluated. Different letters indicate significant differences in the a posteriori Tukey test.

Figura 4. Média ± 95% de intervalo de confiança para a razão fineza das diversas espécies avaliadas. Letras distintas indicam diferenças significativas pelo teste de Tukey a posteriori.

characterized by the maximum height located at the anterior region of the body; the slender caudal peduncle and high caudal fin soften the opposite forces to the movement (Lagler et al. 1977, Breda et al. 2005). Thus, species from group III may have a higher swimming performance in relation to other species studied, as observed by the values of fineness ratio. Studies conducted in the Piracema Canal by Makrakis et al. (2007) demonstrated that the species *Leporinus elongatus*, *L. obtusidens*, *P. lineatus* and *Salminus brasiliensis*, all species considered good swimmers, pass easier through the Piracema Canal. This feature may also be attributed to the morphological characteristics of these species, because they have been the most hydrodynamic body providing greater performance swimming.

Differences in the shape and length of caudal peduncle are known as important attributes related to swimming ability (Bandyopadhyay et al. 1997), and the propulsive force is related to the width of the caudal peduncle (Gosline 1971). The species *P. granulosus* and *P. pirinampu*, group IV, have higher maximum width of the body and narrower caudal peduncle causing decrease of the waves provoked by the movement of the anterior region of the body associated with a high caudal fin that promote greater thrust (Aleev 1969). Moreover, the swimming performance is related to the development of muscle mass, fineness ratio, and other characteristics associated to morphology that were not addressed in this study as muscle and propulsive ratios (Nanami 2007).

The fineness ratio, a dimensional measure of body fineness, can also provide information about the hydrodynamic shape of the fish body (Blake 2004, Ohlberger et al. 2006, Langerhans & Reznick 2010). The species *R. vulpinus* and *P. granulosus* differ from other species presenting extreme values of fineness ratio. This ratio decreased with increasing fish muscle mass, indicating that *P. granulosus* with ventrally flattened body has higher muscle mass resulting in lower value of fineness ratio. The species has great width caudal peduncle and large pectoral and caudal fins, featuring *P. granulosus* as a great migrator (Freire & Agostinho 2001). Morphologic and behavioral characteristic of Pterodoras granulosus such as depressed ventrally body and staying in areas near background which exhibits high stability, may allow the species take advantage in environments with high speed current (Alexander 1967).

The species *P. corruscans* and *P. pirinampu* inhabiting the lower strata of the water column characterizing bottom species showed similar average fineness ratio (6.0-6.1). Fineness ratios between 2 to 6 result in a drag reduction produced by the animal, and species with ratio of 4.5 have excellent swimming capacity (Von Mises 1945, Blake 1983). The similar fineness ratios found for *L. elongatus*, *L. macrocephalus*, *P. lineatus*, *P. maculatus*, and *S. brasiliensis* (4.57 to 5.19) indicate that these species are all relatively good swimmers. Studies on *Cyprinus carpio* and *Rutilus rutilus* have shown fineness ratios below 4.5; *R. rutilus* showed higher values, characterizing it as a species with an adequate body form for swimming performance (Ohlberger et al. 2006). On the other hand, for *Mugil cephalus cephalus*, Webb (1975) showed that a fineness ratio of 4.5 reduces drag, thus demonstrating that the species may be close to its best swimming performance.

Long-distance migratory species using the Piracema Canal to ascend upstream areas differed morphologically and some morphological characteristics are considered important to relate to the swimming performance: narrow caudal peduncle, maximum width of the body, and fineness ratio were determinant for the differentiation of the four groups of long-distance migratory species. However, beyond these characteristics, studies on swimming performance as swimming speed of the Neotropical migratory fish species can be used to assess the fish passages, linking the environment with the morphological characteristics of species to predict the efficiency in ascending fish passages.

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Home-range and space use by *Didelphis albiventris* (Lund 1840) (Marsupialia, Didelphidae) in Mutum Island, Paraná river, Brazil

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Abstract: Home-range is the area used by an animal in its daily activities. Home-range studies provide data on species mating systems and territorial behavior. Our main goal was to estimate the *Didelphis albiventris* (Lund 1840) home-range in Mutum Island, Paraná River, Brazil. The study was carried out in 2008 from March to October on a 19.20 ha grid. The island is part of the Parana River Islands and Floodlands Federal Environmental Protection Area, with vegetation composed by Alluvial Semideciduous Seasonal Forest in a region of Subtropical Wet climate. The sampling effort was 3,360 traps-night resulting in 152 *Didelphis albiventris* (Lund 1840) captures. Forty-one *Didelphis albiventris* (Lund 1840) individuals were captured in 42 capture stations, composed by a trap placed on the floor and another in understory (2 m high). The animals were mostly terrestrial, independently of age or sex. Four females and five males, which were recaptured at least five times, were used to calculate home-range using the minimum convex polygon method. The mean home-range estimate was 2.33 ± 2.32 ha, similar to previous estimates provided by other methods, suggesting that our capture grid area, that was larger than usually applied for mark-capture studies for this species, have not underestimated the home-ranges. Evidences of the relation between individual home-range area and body mass were observed. Home-range overlaps occurred between males, females and males with females; the average overlap was 33.74%, which may be related to a promiscuous mating system, and suggests female territoriality.

Keywords: *Atlantic Forest, capture-recapture, minimum convex polygon, vertical habitat use, white-eared-opossum.*

SANCHES, V.Q.A., GOMES, M.M.A., PASSOS, F.C., GRACIOLLI, G. & RIBAS, A.C.A. **Área de vida e uso do espaço por *Didelphis albiventris* (Lund 1840) (Marsupialia, Didelphidae) na ilha Mutum, rio Paraná, Brasil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?article+bn00612042012

Resumo: Área de vida é a área usada por um animal em suas atividades diárias. Estudos de área de vida oferecem dados sobre os sistemas reprodutivos e comportamento territorial das espécies. Nosso objetivo foi estimar a área de vida de *Didelphis albiventris* (Lund 1840) na ilha Mutum, no rio Paraná, Brasil. O estudo foi realizado em 2008 de março a outubro em uma grade de 19,20 ha. Esta ilha é parte da área de proteção de ilhas e várzeas do rio Paraná e sua vegetação é composta por floresta estacional semidecidual aluvial sazonal com clima subtropical úmido. O esforço amostral foi de 3.360 armadilhas-noite resultando em 152 capturas de *Didelphis albiventris* (Lund 1840). Foram capturados 41 indivíduos nas 42 estações compostas por uma armadilha no solo e a dois metros de altura. A maioria dos animais foi capturada no solo, independente de idade ou sexo. Quatro fêmeas e cinco machos foram recapturados pelo menos cinco vezes e foram usados para calcular a área de vida mediante método de polígono mínimo convexo. A área de vida média estimada foi de 2,33 ha ± 2,32, similar às estimativas previamente descritas por outros métodos, sugerindo que o tamanho da grade de captura, maior que a usualmente empregada em estudos de marcação-recaptura com esta espécie, não subestimou as áreas de vida. Evidências da relação entre a área de vida e massa corporal dos indivíduos foram observadas. Sobreposição das áreas de vida (média = 33,74%) ocorreu entre machos, entre fêmeas e de machos com fêmeas, o que pode ser relacionado a um sistema de acasalamento promíscuo e territorialidade de fêmeas.

Palavras-chaves: *Mata Atlântica, captura-recaptura, mínimo polígono convexo, uso vertical do hábitat, gambá-de-orelha-branca.*

Introduction

Home-range is the area used by an individual to forage, reproduce, rest and accomplish all its daily activities (Burt 1943). Home-range varies with animal size and food habit: larger animals usually need more food and therefore a larger home-range; specialist animals usually have larger home-ranges than generalists due to difficulties to find food (Krebs & Davies 1996).

Differences between home-ranges of males and females are common, for example, females defend fixed territories, while males searching for females do not defend their territories, which results in females with a higher territoriality than males (Wolf 1993, Loretto & Vieira 2005). This pattern may be explained by increased energy requirements of pregnant and lactating females compared to males, usually observed in breeding seasons (Gentile et al. 1997, Cáceres 2003, Loretto & Vieira 2005).

The home-range overlap provides information on the mating system: the overlap of many females and one male can express a promiscuous behavior; fidelity will be seen as an overlap of only one couple (Madison 1980); and evidences of territorial behavior can be seen in no overlap between individuals in almost all cases (Cáceres 2003). The kangaroo rat, *Dipodomys ingens* (Merriam 1904), only overlaps their home-range intersexually, males with females, showing a sex-biased exclusivity of the home-range (Braun 1985).

Two theories try to explain the occurrence of home-ranges overlap by territorial behavior of small mammal females. The first theory relies on the resources defense, which involves the defense of territories with good quality of limiting resources against all individuals that use the same resources. The second theory is more empirically supported. It is called "pup-defense" and relies on the defense of offspring from unrelated males and females (Wolf 1993).

Female marsupials usually overlap their home-ranges. However during the reproductive season they increase territoriality (Pires & Fernadez 1999, Cárceres & Monteiro-Filho 2001, Cáceres 2003, Martins 2004). Males usually have larger home-range than females (Gentile et al. 1997, Cáceres 2003, Loretto & Vieira 2005). Older, larger and heavier individuals tend to use larger areas than smaller and younger animals (Cáceres 2003). There are also temporal variations in the home-range of marsupials, which in general have larger areas during the breeding season (Gentile et al. 1997, Cáceres 2003, Loretto & Vieira 2005). For the *Didelphis* genus this home-range can still be divided by upper and lower strata, with upper strata mainly operated by younger and smaller individuals as observed for *Didelphis aurita* (Wied-Neuwied 1826) (Pires & Fernandez 1999). Young individuals of this species seem to have a more arboreal life than adults (Cunha & Vieira 2005).

Studies on home-range and use of space with the catch grid technique include rodents, such as *Akodon cursor* (Winge 1887) (Gentile et al. 1997), *Peromyscus boylii* (Baird 1955) and *Peromyscus truei* (Shufedlt 1885) (Ribble et al. 2002) and marsupials, such as *Philander frenata* (Olfers 1818) (Gentile et al. 1997), *Gracilinanus microtarsus* (Wagner 1842) (Martins 2004), *Didelphis aurita* (Wied-Neuwied 1826) (Cáceres 2003) and *Micoureus demerarae* (Thomas 1905) (Moraes-Junior & Chiarello 2005). Studies with the white-eared opossum *Didelphis albiventris* (Lund 1840) became increasingly common, due to the few logistical constraints: high abundance, wide distribution, high synanthropism and preference for living in fragments and disturbed areas (Cáceres & Monteiro-Filho 2006).

D. albiventris (Lund 1840) is the largest Brazilian didelphid, and is considered scansorial (Vieira 2006), solitary, generalist and omnivorous (Cabrera & Yepes 1960). Variations in home-range size according to age, sex, weight, distribution of resources, among other factors have been described (Cáceres 2003, Cáceres & Monteiro-Filho 2006). With increasing deforestation, *D. albiventris* (Lund 1840) has been approaching urban areas and acquired synanthropic habits. They often end up being caught in homes and households, sometimes attacking people which impose a danger for both rural and urban houses acting like diseases carrier, being a rabies or leishmania reservoir, for example (Almeida et al. 2008, Cáceres et al. 2008). Moreover, these animals are well adapted to habitat fragmentation (Fonseca & Robinson 1990, Cáceres 2000, Almeida et al. 2008, Cáceres et al. 2008), which requires management information about landscapes and biomes that have become fragmented (Lambert et al. 2006).

Here we aim to estimate the average home-range of *D. albiventris* (Lund 1840) in Mutum Island to (1) verify whether are differences in the home-range size between males and females, (2) evaluate the influence of the individual body mass in the size of their home-range, (3) describe the home-range overlapping and (4) analyze whether there are differences in the frequency of use of ground or understory by the opossums.

Materials and Methods

1. *Study area*

Samples were collected on "Mutum Island" (22° 45' 58" S and 53° 19' 13" W) which is part of the High Paraná river fluvial archipelago, located on Paraná river, Taquarussu city in the state of Mato Grosso do Sul, border with state of Paraná (Miranda et al. 2007). The island (1050 ha) is part of the Paraná River Islands and Floodlands Federal Environmental Protection Area (Mikich & Bernils 2004). The area is located in a region where the mean annual temperature is 22 °C, the altitude is 250 meters and the climate is humid subtropical climate, Cfa h, according to Köeppen (Maack 1968).

The vegetation is semideciduous alluvial forest composed of primary forest with 30 meters height dossel, riparian, secondary forest (in various stages of succession) and disturbed habitats (Campos & Souza 1997). The island's vegetation complexity was well sampled, since the capture grid crossed the island covering areas with a characteristic vegetation of secondary succession and disturbed areas with several guava trees (*Psidium* sp.), embaúba trees (*Cecropia* sp.), *Brachiaria* sp., bamboo plantation (Bambuseae), tucum palms (*Bactris* sp.) and flooded areas with macrophytes and ingá trees (*Inga* sp.).

2. *Capture procedures*

The survey was carried out from March to October 2008, with five nights per month. Live traps of galvanized wire measuring 45x16x16 cm and with trigger hook were used. The baits used were a mix of a banana slice with sardine oil, cod liver oil and peanut butter.

The grid consisted of seven parallel lines with six traps each. These lines transversally crossed the island from north to south. Lines were 80 meters apart from each other, as well as the trap stations on each line resulting in a 7 × 6 grid with distance between traps and lines determined with tape measures and directions of each line with a compass, resulting in a grid total area of approximately 19.20 ha.

Each capture site was composed of two traps, one on the ground and another about two meters high on the nearest tree to the point determined, totalizing a grid of 84 traps. The traps were set on the trees using a 'L' shaped metal: the shorter part of the "L" bracket was attached to the tree, while the longer part was attached to the trap. Thus the trap is perpendicular to the tree with its entrance facing towards the trunk (Monteiro-Filho & Graipel 2006).

All individuals of *D. albiventris* captured for the first time were marked, weighted, measured, sexed and had their age estimated. The age of the animals was estimated from the number of hatched molars: the animal withtwo molars hatched was classified as young, three molars subadult and four molars an adult (Tyndale-Biscoe & Mackenzie 1976, Cáceres & Monteiro-Filho 1999, Graipel et al. 2006). Capture station and where the trap was placed (floor or understory) were also recorded. The specimens were marked by punching the ears with leather awl. This method allows tracking up to 99 animals in up to two holes per ear. The right ear composes the units while the left ear comprises the dozens. Recaptured animals in the same field campaign were immediately released, while for individuals recaptured in different campaigns the entire procedure was performed, to evaluate changes in size and body mass.

3. *Data analysis*

To estimate home-range we used the minimum convex polygon method (MCP) (Jennrich & Tuner 1969). Since home-range size is related to the number of recaptures (Batzli & Henttonnen 1993), we used the number of recaptures as a covariate in the analysis. We calculated proportional overlap by measuring the area in each home-range (the target animal) that was shared by other animal´s home-range of the same sex (intrasexual overlap) or other animal's home-range of the opposite sex (intersexual overlap), and dividing by the area of the target animal home-range. We assume, as suggested by Batzli & Henttonnen (1993), that home-range overlap significantly lower than random placement indicates that individuals are avoiding one another and it is considered evidence of territorial behavior. We used chi-square with first captures of *D. albiventris* (Lund 1840) individuals to verify the differences in the use of space between males and females and young, subadults and adults. All analyses were carried out using the language R (R Development… 2011) with package adehabitatHR (Calenge 2006).

To assess which factors determine the home-range sizes we applied an analysis of covariance (ancova) using sex (categorical variable), body mass and number of captures as predictor variables. Akaike's Information Criterion (AIC) was used to select the most parsimonious model (see Burnham & Anderson 2002). This criterion may be useful to identify a single model from a particular hypothesis or infer the best solution from a set of competitive models (Johnson & Omland 2004).

Results

The total effort of 3.360 traps-night resulted in 849 small mammals captures, with 146 capture events of 41 individuals of *D. albiventris* (Lund 1840): 17 females (five young, eight subadult, and four adults) and 24 males (six young, four subadults and 14 adults). Only nine individuals (4 females and 5 males) were recaptured at least five times and were used to estimate home-range. The average MCP estimated for all individuals was 2.33ha ± 2.32 SD. For males, the average home-range was 3.20 ± 2.78 ha, while for females the average was 1.47 ± 1.59 ha. The largest home-range estimated was 7.04 ha for a male; the smaller was 0.64 ha for a female (Table 1). The most parsimonious model to predict home-range (Table 2) was dependent of individual body mass and the number of captures (Figure 1).

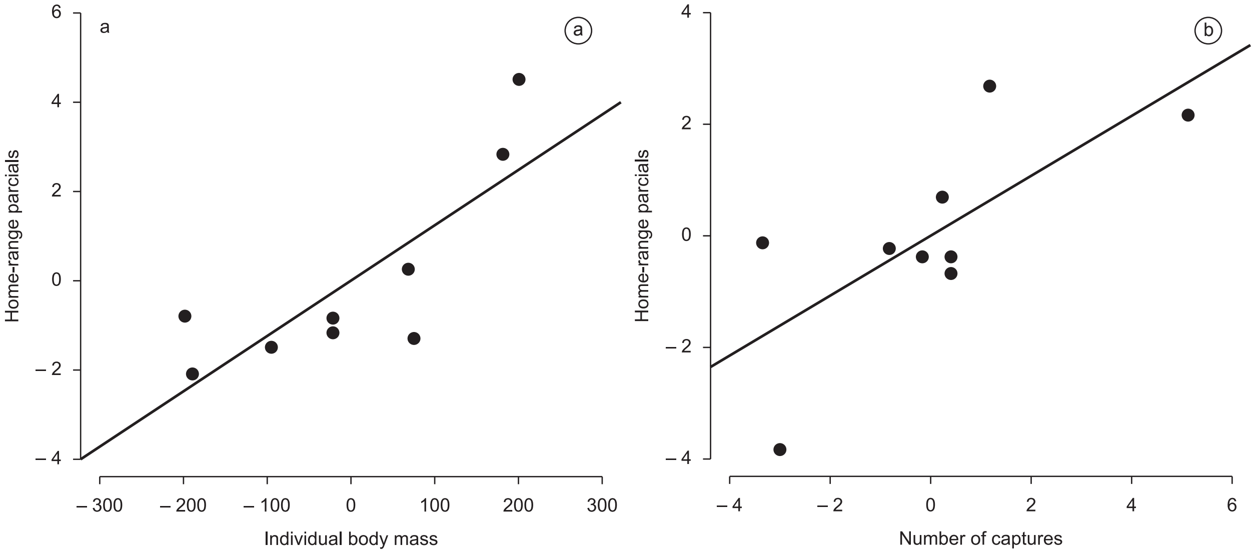

Figure 1. Partial regressions of Home-range with Individuals body mass (a) and Number of captures (b) obtained by a multiple regression model.

Table 1. Sex, mean mass (g), head lenght (mm), home-range (ha) and number of captures per individual.

Individual	Mass	Head heights measure	Home-range	Number of captures	Age
Female 01	700.7	85.2	4.16	15	Adult
Female 02	634.3	91.1	1.28	07	Adult
Female 03	517.0	88.8	0.64	10	Adult
Female 04	661.0	88.3	1.28	10	Adult
Male 01	736.0	90.7	0.32	15	Adult
Male 02	1000.0	96.7	5.12	08	Adult
Male 03	900.0	95.2	1. 60	10	Adult
Male 04	1000.0	101.5	7.04	09	Adult
Male 05	958.0	102.3	1.92	05	Adult

There were intra and intersex home-range overlap. Only one female did not overlap its home-range with any other female and three males. Males overlapped their home range between males and females (Figure 2). The average overlap percentage was 33.74% for all individuals, 33.32% among females and 42.29% among males. From the 72 possible overlaps, 17 were observed among females and 29 among males, with no significant difference ($X^2 = 5$, $p = 0.09$ and GL = 1).

Considering the first captures of the 41 *D. albiventris* (Lund 1840) individuals obtained, 27 were on the floor and 14 occurred in the understory, which suggests that the ground was used more frequently ($X^2 = 4.12$, $p = 0.04$ and GL = 1). Young, subadult and adult specimens showed the same frequency of the use of strata. Eight of the ten young specimens were captured on the ground and two in the understory; nine of 13 subadults were captured on the floor and four in the understory; and 10 of 18 adults were captured in the ground and eight in the understory ($X^2 = 1.86$, $p = 0.39$ and GL = 2). Moreover, females and males did not differ in strata use. Ten females were captured on the ground and seven in the understory (n = 17); 17 males were captured on the ground and seven in the understory (n = 24) ($X^2 = 0.63$, $p = 0.43$ and GL = 1).

Table 2. Initial and most parsimonious regression model (selected by AIC), to predict home-range.

A	Estimate	Standard error	*t*-value	*P*-value
Intercept	–13.39	4.8	–2.79	0.03
Sex male	–1.22	1.73	–0.71	0.51
Mass	0.01	0.01	2.67	0.04
Number of captures	0.52	0.22	2.27	0.07

B	Estimate	Standard error	*t*-value	*P*-value
Intercept	–11.94	4.16	–2.87	0.03
Mass	0.01	0.01	3.35	0.02
Number of captures	0.54	0.22	2.48	0.04

Initial regression model (A): R2 = 0.70, F = 4.01 on 3 and 5 DF, p = 0.08, AIC = 10.95. Most parsimonious regression model (B): R2 = 0.67, F = 2.77 on 2 and 6 DF, p = 0.03, AIC = 9.81.

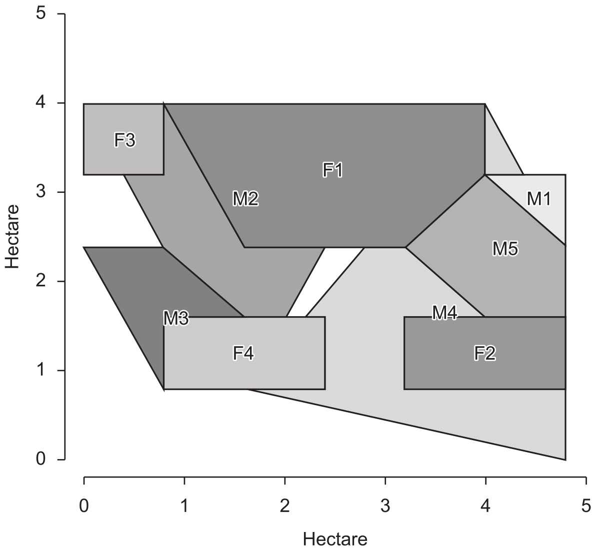

Figure 2. Spatial plot of all home-range estimates (ha). F means Female and M means Male, the numbers follow the order presented in Table 1.

Discussion

This is the first effort in studying home-range of *D. albiventris* (Lund 1840) in an island. In general, populations confined to islands develop the so-called insular syndrome (Adler & Levins 1994), which predicts that populations with this syndrome are usually at higher densities and therefore end up relaxing their intraspecific interactions, reducing the home-range area and increasing the overlap (Adler & Levins 1994, Goltsman et al. 2005). The mean home-range estimated for this population is considerably higher than the previously observed in an urban fragment of araucaria forest in Curitiba city, Paraná State (0.68 ± 0.58 ha with 0.66 ± 0.44 ha for females and 0.69 ± 0, 80ha for males on average; first author unpublished data).

The capture grid used in this study (19.2 ha), as far as we are concerned, is the largest used in studies of home range for Brazilian didelphids (maximum of 5 ha – Cáceres 2003; minimum of 0.36 ha – Martins 2004). The capture success of 5% for *D. albiventris* (Lund 1840) is consistent with other studies: approximately 6% in a semideciduous forest of Minas Gerais State (Almeida et al. 2008) and 5% in an urban fragment of araucaria forest in Curitiba city, Paraná State (Cáceres & Monteiro-Filho 1999).

The difference in the size of capture grids used (19.20 ha versus 3.6 ha), the number of captures (Figure 1b) and the distance between traps (80 m versus 30 m) may lead to underestimated home-ranges (Martins 2004). However, our estimates might not be underestimated when we compare our study to others similar but using other techniques. In the only study conducted using radio-telemetry with *D. albiventris* (Lund 1840), home range area was 3.83 and 6.83 ha for two adult males (Aléssio 2004), similar to values we obtained, showing that the catch grid size used in our study may be adequate for studies of home-range for didelphids. Studies on *D. aurita* (Wied-Neuwied 1826), another species very similar in morphology to *D. alviventris*, have estimated home-ranges varying from 0.20 to 3.0 ha (Cáceres & Monteiro-Filho 2001) and from 0.58 to 2.73 ha (Cáceres 2003). The minimum value we describe for *D. albiventris* (Lund 1840) is approximately the maximum value found in those studies, which may be an influence of the grid size (4.3 ha) and distance between traps (38 m, Cáceres 2003).

Our findings also suggests that body mass is a significant factor determining the size of the home-range for many didelphids (Vieira & Cunha 2008), which is already known for mammals as a primary determinant of home-range for (Ottaviani et al. 2006). The significant relation of home-range size with the body mass of animals is widely reported. Larger animals have larger home-ranges (Mcnab 1963, Krebs & Davies 1996, Cáceres 2003, Martins 2004, Ottaviani et al. 2006). Other Brazilian marsupials also responded directly to this relationship, for example, *G. microtarsus* (Wagner 1842) (Martins 2004) and *D. aurita* (Wied-Neuwied 1826) (Cáceres 2003), both species considered omnivorous (Santori & Moraes 2006).

There was no significant difference in the size of the home-ranges for males and females. These results are similar to those estimated by spool-and-line techniques (Almeida et al. 2008), but differ from the observed for other Brazilian marsupials, for example *D. aurita* (Wied-Neuwied 1826) (Cáceres 2003, Loretto & Vieira 2005), *G. microtarsus* (Wagner 1842) (Martins 2004), *M. demerarae* (Thomas 1905) (Moraes-Junior & Chiarello 2005). The similarity in home-range sizes for males and females of the white-eared opossums may be explained by an apparent lack of sexual dimorphism regarding the mass of males and females of *D. albiventris* (Lund 1840) (Cáceres & Monteiro-Filho 1999).

Overlapping home-range areas among males, between females and between males and females show that *D. albiventris* (Lund 1840) follows a pattern already found for Brazilians didelphids.

This same pattern has been described for *D. aurita* (Wied-Neuwied 1826) (Cáceres 2003), *M. demerarae* (Thomas 1905) (Pires & Fernandez 1999, Moraes-Junior & Chiarello 2005), *G. microtarsus* (Wagner 1842) (Martins 2004), *P. frenata* (Olfers 1818) (Gentile et al. 1997), and is taken as evidence of a promiscuous mating system (Ostfeld 1990, Krebs & Davies 1996, Gentile et al. 1997). The high overlapping home-range suggests an absence of territorial behavior (Sandell 1989), which has been shown for other Brazilians didelphids as *P. frenata* (Olfers 1818) (Gentile et al. 1997). However, *D. aurita* demonstrated evidence of territoriality only during the breeding season (Cáceres 2003). Territoriality in Brazilian marsupials appears to be closely linked to reproduction (Pires & Fernandez 1999, Cáceres 2003). Females showed less overlap than males indicating that females tend to be more territorial.

D. albiventris (Lund 1840) seems to prefer the soil to understory, independent of sex and age, suggesting that these animals forage and find shelter mainly in the soil, similar to *D. aurita* (Wied-Neuwied 1826) which also shows more terrestrial than arboreal tendency in areas of semideciduous Atlantic forest (Vieira 2006), the same vegetation in Mutum Island. Young *D. aurita* (Wied-Neuwied 1826) seem to use more the understory than subadults and adults (Cunha & Vieira 2005), since their feet and claws are relatively larger than those of adult animals and their mass and body size are smaller (Vieira 1997).

Home-range and use of space studies based on catch grids require large areas, are cheaper and allow a perception of the population as a whole, but result in fewer points when compared to radio-telemetry, which can reduce the power of statistical tests and demands more sampling effort (Jones & Sherman 1983, Gurnell & Gipps 1989). Multiple captures grids or a combination with radio-telemetry is suggested to reduce the possibility of underestimating the home-range (Lira & Fernandez 2009) and use of published data as priors for a Bayesian approach.

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Borboletas (Lepidoptera: Papilionoidea e Hesperioidea) de um parque urbano em Belo Horizonte, Minas Gerais, Brasil

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Abstract: Urban forest fragments, such as parks and squares provide food resources, shelter, and favorable conditions for the maintenance of butterflies. This study provides an inventory of butterflies and observations of plants visited by adults in a small urban park, the Américo Renê Giannetti Municipal city park, Belo Horizonte, Minas Gerais State. We sampled an area of 18.2 ha from December 2006 to December 2007 with entomological net and traps baited with fermented fruits. We recorded 165 individuals belonging to 78 species, as follows: 46 spp. of Nymphalidae; 10 spp. of Hesperiidae, seven spp. of Lycaenidae, seven spp. of Pieridae, five spp. of Riodinidae; and three species of Papilionidae. Between the plants visited the more attractive was *Lantana camara* (Verbenaceae), a shrub with flowers of vibrant colors and common source of nectar and pollen. The butterflies recorded show the importance of maintenance of urban green areas, providing favorable conditions for the permanence of butterflies, even in anthropic environments.

Keywords: *inventory, insect-plant interactions, butterfly conservation, urban forest, Lantana camara.*

SOARES, G.R., OLIVEIRA, A.A.P. & SILVA, A.R.M. **Borboletas (Lepidoptera: Papilionoidea e Hesperioidea) de um parque urbano em Belo Horizonte, Minas Gerais, Brasil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?inventory+bn02612042012

Resumo: Fragmentos urbanos de mata, como parques e praças, oferecem recursos alimentares, sobretudo abrigo e condições favoráveis para a permanência de borboletas. Este estudo fornece um inventário de borboletas e também a observação das plantas visitadas por indivíduos adultos em um pequeno parque urbano, Parque Municipal Américo Renê Giannetti, Belo Horizonte, estado de Minas Gerais. Amostrou-se uma área de 18,2 ha no período de dezembro/2006 à dezembro/2007, com o auxilio de rede entomológica e armadilhas com frutos fermentados. Foram registrados 165 indivíduos de 78 espécies, distribuídos nas seguintes famílias: Nymphalidae – 46 spp., Hesperiidae - 10 spp., Lycaenidae – sete spp., Pieridae – sete spp., Riodinidae – cinco spp. e Papilionidae – três spp. Entre as plantas visitadas observou-se que a com maior atratividade foi *Lantana camara* (Verbenaceae), um arbusto com flores de cores vibrantes, destacada como fonte usual de néctar e pólen. As borboletas encontradas indicaram a importância da manutenção de áreas verdes urbanas, proporcionando condições favoráveis para a permanência de borboletas, mesmo em ambientes antrópicos.

Palavras-chave: *inventário, interação inseto-planta, conservação de borboletas, mata urbana, Lantana camara.*

Introdução

Os insetos compreendem cerca de 59% de todos os animais do planeta (751.000 espécies) e desempenham papel chave nos ecossistemas terrestres (Wilson 2003). Além da participação em processos como decomposição, ciclagem de nutrientes, produtividade secundária, fluxo de energia e polinização, eles estão envolvidos na dispersão e predação de sementes (Freitas et al. 2003). Atuam também na regulação de populações de plantas e de outros animais, bem como em diversas interações ecológicas (Leppik 1957, Stebbins 1970, Price 1984, Didham et al. 1996).

O uso de alguns grupos de artrópodes como indicadores biológicos, especialmente os insetos, tem sido útil devido a sua grande diversidade e abundância, facilidade de amostragem e rápidas respostas a alterações ambientais. Segundo Lewinsohn et al. (2005), várias discussões tem ocorrido sobre a utilização de bioindicadores na avaliação e monitoramento de habitats. Os autores ressaltam que diferentes grupos funcionais e/ou taxonômicos fornecem informações relevantes para a efetiva conservação e o uso sustentável dos recursos naturais. Afirmam ainda, que de maneira geral, os invertebrados apresentam respostas demográficas e dispersivas mais rápidas do que organismos com ciclo de vida mais longo. Todas estas características sinalizam que estudos mais refinados podem ser realizados com estes insetos, proporcionando a tomada de decisões mais acertadas em planos de conservação.

Constituída por borboletas e mariposas, a ordem Lepidoptera possui cerca de 146 mil espécies descritas com estimativa de 255.000 espécies a serem descobertas (Heppner 1991). Na região Neotropical, as borboletas são representadas entre 7.100 (Beccaloni & Gaston 1995) e 7.900 espécies (Heppner 1991, Lamas 2004), cujos adultos normalmente são coloridos e de hábito diurno. O Brasil, devido a grande diversidade desses insetos, representa em torno da metade da riqueza neotropical, com 3.300 espécies (Beccaloni & Gaston 1995, Brown & Freitas 1999). Além disso, são utilizadas em monitoramentos por responderem rapidamente a modificações ambientais, serem diversas, relativamente fáceis de amostrar e identificar, e possuírem algumas espécies comuns o ano inteiro (Freitas et al. 2003). Por possuírem reprodução rápida, estreitas associações com habitats e plantas hospedeiras, bem como fatores físicos específicos do habitat, são sensíveis a impactos ambientais de diferentes escalas (New et al. 1995). No Brasil, são objetos de muitos estudos científicos (Brown 1996), podendo ainda ser usadas como indicadoras em inventários de fauna e determinação de prioridades, planejamento e administração de reservas naturais (Brown 1992, Brown & Freitas 2002, Emery et al. 2006, Freitas & Marini-Filho 2011).

Considerando seu modo de alimentação na fase adulta, as borboletas dividem-se em duas guildas: as frugívoras, que se alimentam principalmente de caldo de frutas fermentadas, e as nectarívoras, que se alimentam de néctar de flores (DeVries 1987). As frutas fermentadas atraem as borboletas através de seu forte odor exalado. Já as flores, atraem os lepidópteros adultos através de recursos como cores, odores, pólen e néctar de alto valor nutritivo (Otero 1986, Brown 1992). Além disso, as borboletas também podem sugar seiva fermentada, sais minerais de poças de água, fezes, urina e carcaças de animais em decomposição (Francini 2010). Há ainda aqueles indivíduos que possuem o aparelho bucal atrofiado, como por exemplo *Brassolis sophorae* (Linnaeus, 1758) (Nymphalidae), não se alimentando na fase adulta (Ruszczyk & Carvalho 1993).

A permanência da fauna de borboletas nos habitats, além de ser influenciada pela presença de recursos alimentares, também é explicada por variáveis como sazonalidade, temperatura, perturbação e conectividade entre os fragmentos (Brown & Freitas 2000b). Koh & Sodhi (2004) concluíram que o número de espécies de plantas hospedeiras, somado ao isolamento florestal são alguns dos fatores mais relevantes que afetam a riqueza de borboletas em parques urbanos. Uma estratégia interessante que pode ser aplicada em áreas verdes urbanas é o enriquecimento e recomposição vegetal, garantindo assim, recursos e condições favoráveis para a sobrevivência destes insetos.

Agregado à preservação de muitos habitats remanescentes naturais, a criação e manutenção de parques urbanos promove a permanência de espécies nativas, demonstrando ser uma estratégia viável de conservação nas paisagens mais urbanizadas (Koh & Sodhi 2004). Áreas verdes urbanas promovem a melhora do clima da cidade tornando a temperatura do ambiente agradável, onde grandes arbustos e árvores reduzem a velocidade do vento e a evaporação da umidade do solo (Murphy 1997). Além disto, os parques urbanos possuem o papel de refúgio para as plantas e animais, auxiliando na conservação do ambiente, semelhante à ilhas de habitats margeados por uma matriz inóspita (Primack & Rodrigues 2001).

Este trabalho apresenta um inventário das borboletas registradas no Parque Municipal Américo Renê Giannetti, em Belo Horizonte, somado as observações eventuais de algumas plantas visitadas pelos indivíduos adultos de borboletas, visando contribuir para o conhecimento da fauna de borboletas da capital mineira.

Material e Métodos

O Parque Municipal Américo Renê Giannetti (PMARG), situa-se na região central de Belo Horizonte, Minas Gerais (19° 55’ 22” S e 43° 56’ 01” W), ao lado de sua avenida mais movimentada, a avenida Afonso Pena, (Figura 1). Possui uma área de 18,2 ha, composta por flora diversificada de espécies nativas e exóticas, além de vegetação herbácea, capoeiras, árvores frutíferas, bambuzais, plantas ornamentais e um jardim com flores atrativas para borboletas. A capital é caracterizada por um clima tropical de altitude (Cwa, segundo Köppen) com inverno frio e seco e verão quente e úmido. A temperatura média anual é de 21 °C e a precipitação anual é de aproximadamente 1500 mm (Instituto... 2011).

Para a amostragem foram utilizadas as técnicas de rede entomológica e armadilhas atrativas com frutos fermentados. Diversos estudos recomendam que as coletas com rede devam abranger os períodos da manhã e da tarde (Pollard 1977, Iserhard & Romanowski 2004, Marchiori & Romanowski 2006, Dessuy & Morais 2007, Paz et al. 2008), todavia, optou-se por coletar apenas no período da tarde por questões logísticas. As amostragens com rede foram realizadas semanalmente, entre dezembro/2006 e dezembro/2007, sempre das 13h00 às 15h00, acumulando 104 horas de esforço amostral. Para a coleta das borboletas frugívoras, uma unidade amostral composta por cinco armadilhas (modelo Van Someren-Rydon) foi instalada entre maio e dezembro de 2007. As armadilhas foram posicionadas 1,5 m acima do solo e a 25 m de distância entre si, iscadas com banana amassada, misturada a caldo de cana, fermentada por 96 horas. Estas permaneceram abertas durante sete dias mensais, acumulando um esforço amostral de 6.720 horas.

Após a captura, as borboletas foram coletadas e acondicionadas em envelopes entomológicos, sendo posteriormente montadas e depositadas na coleção de invertebrados do Parque Municipal Américo Renê Giannetti, onde foram identificadas. A identificação das borboletas foi realizada com auxílio de bibliografia especializada (D’Abrera 1981, 1994, 1995, Brown 1992, Canals 2003, Willmott 2003, Tyler et al. 1994), além da consulta a especialistas e a coleção do acervo do Centro Universitário UNA. A nomenclatura taxonômica das borboletas foi atualizada de acordo com Lamas (2004) e Wahlberg et al. (2009).

Figura 1. Imagem de satélite da região metropolitana de Belo Horizonte indicando a localização do Parque Municipal Américo Renê Giannetti.

Figure 1. Satellite image in the metropolitan area of Belo Horizonte indicating the location of Américo Renê Giannetti Municipal city park.

Observou-se ainda, de maneira eventual, a visitação floral por borboletas em espécies vegetais presentes no Parque. Estas observações foram realizadas simultaneamente a amostragem de borboletas onde registrou-se as espécies deste grupo que utilizavam as flores como recurso alimentar. Assim, as plantas consideradas mais atrativas foram aquelas que apresentaram o maior número de registros de diferentes espécies de borboletas utilizando suas flores como alimento. A identificação dos espécimes das plantas foi realizada mediante consulta a Lorenzi & Souza (1995), Souza & Lorenzi (2005) e a coleção de plantas do PMARG. Daquelas não identificadas no campo, um ramo floral foi coletado para consulta posterior ao biólogo especialista na flora do parque e estão depositadas nesta coleção. A nomenclatura dos vegetais esta de acordo com Angiosperm Phylogeny Website (Stevens 2001).

Para a análise dos dados foi plotado a curva de acumulação de espécies, levando em consideração a riqueza acumulada por mês de coleta.

Resultados e Discussão

Foram coletados 165 indivíduos de 78 espécies, pertencentes a seis famílias e 16 subfamílias de borboletas (Tabela 1).

Vários esforços têm sido aplicados atualmente em inventários de borboletas no Brasil, contemplando as mais diversas regiões, como a Mata Atlântica, o Cerrado, o Pantanal e os Campos Sulinos (Santos et al. 2008). Este último, de acordo com Santos et al. (2008) é o bioma mais conhecido, possuindo estudos completos da fauna de borboletas através de informações de registros históricos de coletas provenientes da primeira metade do século XX. Porém, em estudo recente no Pampa da região do extremo oeste do Rio Grande do Sul, Rosa et al. (2011) encontraram um registro novo para o Brasil (o pierídeo *Tatochila mercedis vanvolxemii* (Capronnier, 1874)), evidenciando a necessidade de maiores esforços de amostragem e inventários localizados neste bioma. A Caatinga é totalmente desconhecida nestes inventários, tornando-se o bioma brasileiro mais carente de informação (Santos et al. 2008). Ainda de acordo com Santos et al. (2008), um dos principais motivos da carência de pesquisa deve-se à escassez de estudos de conhecimento básico como diversidade, taxonomia, bionomia e estudo relacionados a níveis populacionais.

Brown & Freitas (2000b) compilaram registros que resultaram em mais de 2.100 espécies de borboletas para a Mata Atlântica. Segundo estes mesmos autores, no Brasil, as famílias Lycaenidae, Hesperiidae e Nymphalidae são, respectivamente, as três mais ricas em espécies (Brown & Freitas 1999). Porém, em alguns inventários realizados no Rio Grande do Sul (Iserhard & Romanowski 2004, Marchiori & Romanowski 2006, Sackis & Morais 2008, Iserhard et al. 2010, Rosa et al. 2011) a ordem se inverte, sendo Nymphalidae a mais rica, seguida de Hesperiidae e Lycaenidae. No presente trabalho, verificaram-se padrões semelhantes a estes estudos, onde a família com maior riqueza foi Nymphalidae (59%), seguida por Hesperiidae (13%), Lycaenidae (9%), Pieridae (9%), Papilionidae (6%) e Riodinidae (4%).

A expressiva riqueza encontrada para Nymphalidae pode ser atribuída ao fato desta família possuir o maior número de espécies, maior diversidade de formas de larvas e utilização de uma ampla gama de plantas hospedeiras (DeVries 1987), além de possuírem uma grande diversidade de hábitos, facilitando sua amostragem. Em ambientes neotropicais, a família Nymphalidae abrange cerca de 25% a 29% do total da comunidade de borboletas de uma área (Brown & Freitas 1999, Freitas et al. 2003, Brown & Freitas 2000b).

Tabela 1. Lista de espécies de borboletas observadas no Parque Municipal Américo Renê Giannetti, de dezembro de 2006 a dezembro de 2007, capturadas com rede entomológica e armadilha de frutas.

Table 1. Species list of butterfly recorded in the Américo Renê Giannetti Municipal City Park between December 2006 to December 2007 captured with entomological net and trap baited.

Família	**Subfamília**	**Espécie**	**Método de coleta**	
			Rede	**Armadilha**
Hesperiidae	Hesperiinae	*Cantha ivea* Evans,1955	X	
	Pyrginae	*Achlyodes busirus rioja* Evans, 1953	X	
		Anastrus sempiternus simplicior (Möschler, 1877)	X	
		Astraptes anaphus anaphus (Cramer, 1777)	X	
		Heliopetes alana (Reakirt, 1868)	X	
		Pyrgus orcus (Stoll, 1780)	X	
		Urbanus dorantes (Stoll, 1790)	X	
		Urbanus proteus proteus (Linnaeus, 1758)	X	
		Urbanus teleus (Hübner, 1821)	X	
		Xenophanes tryxus (Stoll, 1780)	X	
Lycaenidae	Polyommatinae	*Hemiargus hanno* (Stoll, 1790)	X	
		Leptotes cassius (Cramer, 1775)	X	
	Theclinae	*Panthiades hebraeus* (Hewitson, 1867)	X	
		Pseudolycaena marsyas (Linnaeus, 1758)	X	
		Rekoa palegon (Cramer, 1780)	X	
		Rekoa stagira (Hewitson, 1867)	X	
		Theritas hemon (Cramer, 1775)	X	
Nymphalidae	Biblidinae	*Callicore pygas thamyras* (Ménétriés, 1857)	X	X
		Ectima thecla (Fabricius, 1796)	X	X
		Hamadryas amphinome amphinome (Linnaeus, 1767)		X
		Hamadryas epinome (C. Felder & R. Felder, 1867)		X
		Hamadryas februa februa (Hübner, [1823])		X
		Hamadryas feronia feronia (Linnaeus, 1758)		X
		Hamadryas iphthime (Bates, 1864)		X
		Hamadryas laodamia (Cramer, 1777)		X
	Cyrestinae	*Marpesia chiron* (Fabricius, 1775)	X	
		Marpesia petreus (Cramer, 1776)	X	
	Danainae	*Aeria olena* Weymer, 1875	X	
		Brevioleria plisthenes (d'Almeida, 1958)	X	
		Danaus erippus (Cramer, 1775)	X	
		Dircenna dero celtina Burmeister, 1878	X	
		Ithomia drymo Hübner, 1816	X	
		Ithomia agnosia zikani D'Almeida, 1940	X	
		Mechanitis lysimnia lysimnia (Fabricius, 1793)	X	
		Mechanitis polymnia casabranca Haensch, 1905	X	
		Methona themisto (Hübner, 1818)	X	
		Oleria aquata (Weymer, 1875)	X	
		Pteronymia sylvo (Geyer, 1832)	X	

Tabela 1. Continuação...

Família	Subfamília	Espécie	Método de coleta	
			Rede	Armadilha
Nymphalidae	Heliconiinae	*Actinote thalia pyrrha* (Fabricius, 1775)	X	
		Actinote discrepans d'Almeida, 1958	X	
		Agraulis vanillae maculosa (Stichel, [1908])	X	
		Dione juno juno (Cramer, 1779)	X	
		Dryas iulia alcionea (Cramer, 1779)	X	
		Eueides isabella (Stoll, 1781)	X	
		Heliconius erato phyllis (Fabricius, 1775)	X	
		Heliconius ethilla narcaea Godart, 1819	X	
	Limenitidinae	*Adelpha erotia* (Hewitson, 1847)	X	
		Adelpha mythra (Godart, [1824])	X	
	Nymphalinae	*Anartia amathea roeselia* (Eschscholtz, 1821)	X	
		Anartia jatrophae (Linnaeus, 1763)	X	
		Colobura dirce (Linnaeus, 1758)	X	X
		Eresia lansdorfi (Godart, 1819)	X	
		Hypanartia bella (Fabricius, 1793)	X	
		Junonia evarete (Cramer, 1779)	X	
		Ortilia ithra (Kirby, 1900)	X	
		Siproeta stelenes (Linnaeus, 1758)	X	
		Tegosa claudina (Eschscholtz, 1821)	X	
	Satyrinae	*Brassolis sophorae laurentii* Stichel, 1925	X	
		Eteona tisiphone (Boisduval, 1836)		X
		Paryphthimoides phronius (Godart, [1824])	X	X
		Paryphthimoides poltys (Prittwitz, 1865)	X	X
		Yphthimoides affinis (Butler, 1867)	X	X
		Yphthimoides renata (Stoll, 1780)	X	X
Papilionidae	Papilioninae	*Battus polydamas polydamas* (Linnaeus, 1758)	X	
		Heraclides anchisiades capys (Hübner,[1809])	X	
		Parides anchises nephalion (Godart, 1819)	X	
Pieridae	Coliadinae	*Eurema albula albula* (Cramer, 1775)	X	
		Eurema elathea flavescens (Chavannes, 1850)	X	
		Phoebis neocypris (Hübner, [1823])	X	
		Phoebis philea philea (Linnaeus, 1763)	X	
		Phoebis sennae marcellina (Linnaeus, 1758)	X	
		Pyrisitia leuce leuce (Boisduval, 1836)	X	
	Pierinae	*Ascia monuste orseis* (Godart, 1819)	X	
Riodinidae	Euselasiinae	*Euselasia hygenius occulta* (Stichel, 1919)	X	
		Euselasia euploea (Hewitson, [1855])	X	
	Riodininae	*Eurybia pergaea* (Geyer, 1832)	X	
		Lasaia agesilas (Latreille, [1809])	X	
		Synargis sp Hübner, [1819]	X	

Por outro lado, a família Riodinidae caracterizou-se por uma baixa riqueza o que pode estar relacionado à sua suscetibilidade ao ambiente urbano e à associações mutualísticas específicas com formigas (mirmecofilia), além de serem de difícil visualização em campo. Esta última observação pode estar relacionada ao esforço amostral do presente estudo, o qual evidencia uma curva de suficiência amostral (Figura 2) ainda muito ascendente, onde o aumento do esforço poderia acrescentar novos registros da família. Além disto, os riodinídeos, em geral, possuem uma grande proporção de espécies raras em contrapartida à um pequeno número de espécies abundantes (Callaghan 1978).

A utilização de armadilhas na amostragem de borboletas frugívoras resultou na captura de 17% do total, representando 14 espécies (Tabela 1). A disponibilidade de recursos alimentares possivelmente limitou a guilda de borboletas frugívoras no PMARG, onde estão ausentes muitas espécies típicas desta comunidade como espécies de *Prepona*, *Archaeoprepona*, *Memphis*, *Opsiphanes* e *Morpho helenor*, dentre outras. Frutos grandes e carnosos são escassos no interior do Parque, o que provavelmente restringiu a riqueza de espécies dependentes deste recurso. No local, apenas a jaqueira, *Artocarpus heterophyllus* Lam. (Moraceae) possui estas características. Seus frutos são grandes e carnosos, e ao caírem no solo, permanecem na área e fermentam atraindo pássaros, micos e muitos insetos.

Segundo Iserhard & Romanowski (2004), inventários com um longo período amostral possibilitam o aumento do número total de espécies registradas e ampliam a detecção de espécies com tamanhos populacionais baixos (espécies raras) sendo também influenciados pela estrutura da comunidade através da mudança de habitat. De acordo com Freitas et al. (2003), no período de sete dias, um esforço relevante deve contemplar de 12 a 14 horas/pessoa. Brown & Freitas (2000b) afirmam que com esse número de horas, até 50% das espécies presentes no local de estudo podem ser registradas. No presente estudo, observou-se que a curva de acumulação de espécies não atingiu a assíntota (Figura 2), mantendo-se crescente ao longo de todo o período de amostragem, sinalizando que ainda existem espécies a serem amostradas no interior do Parque.

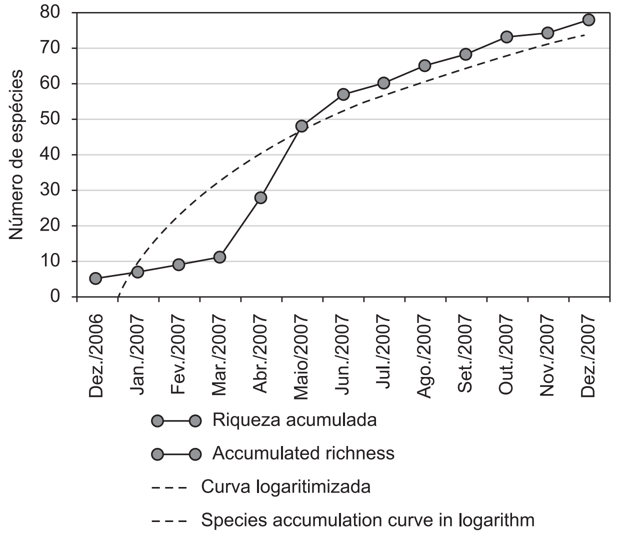

Figura 2. Curva de acúmulo de espécies de borboletas registradas no Parque Municipal Américo Renê Giannetti entre dezembro de 2006 e dezembro de 2007.

Figure 2. Species accumulation curve of butterflies recorded at the the Américo Renê Giannetti City Park between December 2006 and December 2007.

A partir das observações eventuais de visitação floral pelas borboletas adultas, constatou-se que a planta mais atrativa entre as observadas foi *Lantana camara* L. (Verbenaceae) (Tabela 2), observação também realizada por Lemes et al. (2008) ao estudarem visitantes florais no Jardim Botânico da Universidade Federal de Santa Maria, Rio Grande do Sul. Mesmo plantas incomuns em jardins ornamentais, como *Asclepias curassavica* L. (Apocynaceae) e *Heliotropium indicum* L. (Boraginaceae), são eficientes na atração destes insetos. Esta última, de acordo com Freitas et al. (2003), atraem várias borboletas da tribo Ithomiini e ambas atraem borboletas da subfamília Danainae. Devido a esta estreita interação entre borboletas e vegetação, a presença de plantas hospedeiras favorece o aumento da riqueza e abundância de espécies raras de borboletas, podendo ampliar a ocorrência destas espécies e contribuir com a conectividade entre áreas fragmentadas (Jonsen & Lenore 1997).

Apesar de ainda haver poucas pesquisas com borboletas em fragmentos de mata urbanos, os estudos realizados em ambientes mergulhados em uma matriz aparentemente inóspita revelaram dados interessantes. Em Porto Alegre, Ruszczyk (1986a) registrou 43 espécies de borboletas ao longo das principais avenidas da cidade. Bonfantti et al. (2011) registraram 166 espécies em dois parque urbanos na cidade de Curitiba. Já na capital mineira, Silva et al. (2007) realizaram um estudo em uma mata urbana registrando 91 espécies de borboletas, o que corresponde a 18,7% da lepidopterofauna conhecida para Belo Horizonte (Brown & Freitas 2000a). O presente trabalho, com 78 espécies de borboletas coletadas, representa 16% da fauna de Belo Horizonte, sendo que 34 espécies foram comuns entre o PMARG e a mata amostrada por Silva et al. (2007). Todas estas áreas demonstraram possuir condições microclimáticas e nichos ecológicos diversos que possibilitam a conservação e manutenção da riqueza de borboletas em grandes centros urbanos.

Estudos que correlacionam fragmentos de mata urbanos e lepidópteros revelam outros fatores ecológicos, além dos já conhecidos recursos alimentares e perturbações antrópicas, que influenciam a permanência de borboletas nestes ambientes. Ruszczyk (1986b) investigou a distribuição de borboletas ao longo dos gradientes de urbanização bem como a influência do habitat urbano na abundância destes insetos. O autor concluiu que a distância do centro da cidade foi a variável que mais influenciou na abundância e diversidade das espécies. Se confrontarmos a riqueza amostrada por Silva et al. (2007) com os resultados do presente estudo, concluiremos que foram registradas 13 espécies a menos no PMARG. Este localiza-se no centro da cidade de Belo Horizonte, enquanto o estudo de Silva et al. (2007) foi desenvolvido em uma área afastada do centro da capital. Esta comparação corrobora Ruszczyk (1986b), que afirma que a diversidade de borboletas é inversamente proporcional ao crescimento urbano devido à redução de áreas naturais. Esta tendência deve-se ao desaparecimento de espécies não adaptadas à urbanização, possibilitando que espécies colonizadoras dominem o ambiente atingindo densidades populacionais muito altas (Brown & Freitas 1999).

Além de receber influências antrópicas como a poda constante de árvores e a poluição urbana, o PMARG é utilizado como área de lazer pela população. Cerca de 42% das espécies de borboletas deste inventário estão associadas a ambientes antropizados, urbanos e/ou perturbados. Entre as espécies, destacam-se *H. f. februa*, *A. a. roeselia*, *T. claudina*, *J. evarete*, *S. stelenes*, *E. albula*, *B. p. polydamas*, *P. orcus*, *H. e. phyllis*, dentre outras borboletas capazes de permanecer em ambientes muito alterados (Brown 1992, Raimundo 2003). De acordo com Brown & Freitas (2002), embora a maioria dos grupos de borboletas possa sobreviver em matrizes urbanas, muitos grupos são pouco representados ou ausentes em parques muito pequenos ou com vegetação homogênea. Afirmam ainda que famílias como

Tabela 2. Espécies vegetais fornecedoras de néctar observadas no PMARG, entre dezembro de 2006 e dezembro de 2007 e espécies de borboletas que as visitaram.

Table 2. Plant species observed in the supply of nectar in PMARG between December 2006 and December 2007 and species of butterflies that have visited.

Lepidoptera (Família/espécie)	Vegetais (Família/espécie)																				
	Apocynaceae	*Asclepias curassavica* L.	**Asteraceae**	*Cosmos sulphureus* Cav.	*Emilia sonchifolia* (L.) DC.	*Sanvitalia procumbens* Lam.	*Unxia suffruticosa* (Baker) Stuessy	*Zinnia elegans* Jacq.	**Balsaminaceae**	*Impatiens walleriana* Hook. f.	**Lamiaceae**	*Salvia splendens* Sellow ex Wied-Neuw.	**Malvaceae**	*Hibiscus* sp.	**Melastomataceae**	*Heterocentron elegans* (Schltdl.) Kuntze	**Rubiaceae**	*Pentas lanceolata* (Forssk.) Deflers	**Verbenaceae**	*Duranta* sp.	*Lantana camara* L.
Hesperiidae																					
Urbanus dorantes		X																			X
Urbanus proteus proteus												X									X
Lycaenidae																					X
Rekoa palegon																					X
Nymphalidae																					
Agraulis vanillae maculosa		X																			
Anartia jatrophae																					X
Danaus erippus		X																			
Dryas iulia alcionea				X																	
Eresia lansdorfi																					X
Heliconius erato phyllis								X										X			X
Junonia evarete																		X			X
Marpesia petreus																					X
Mechanitis lysimnia lysimnia																		X			
Mechanitis polymnia casabranca										X											X
Methona themisto																					X
Ortilia ithra				X		X										X					X
Siproeta stelenes							X														
Tegosa claudina						X															X
Papilionidae																					
Battus polydamas polydamas																					X
Heraclides anchisiades capys										X											
Parides anchises nephalion												X									
Pieridae																					
Ascia monuste orseis		X		X				X		X											
Eurema albula albula					X			X													
Eurema elathea					X			X													
Phoebis neocypris										X											
Phoebis philea philea										X			X						X		
Phoebis sennae marcellina										X											
Riodinidae																					
Eurybia pergaea		X								X											

Papilionidae, Nymphalidae (Morphinae, Charaxinae, Biblidinae, Satyrinae, Acreinae e Danainae), Pieridae (Pierinae), Hesperiidae e Lycaenidae, necessitam de espaço com vegetação heterogênea, água permanente e outros recursos especiais como formigas mutualísticas. No PMARG não se observou algumas destas subfamílias que necessitam de ambientes mais especializados para se desenvolverem como, por exemplo, Pyrrhopyginae (Hesperiidae). Grupos como estes são especialistas em recursos específicos que possuem fidelidade de microhabitat e respondem de maneira rápida à degradação de habitats (Brown 1991).

Uma das medidas prioritárias para a conservação de borboletas é a preservação das plantas utilizadas na alimentação das larvas e adultos, bem como a manutenção e/ou incorporação de plantas nos locais de ocorrência das borboletas. Fatores como conectividade, presença de corpos d'água permanentes, vegetação, flores, tamanho do fragmento e impactos antrópicos são os que mais influenciam a riqueza de borboletas em remanescentes urbanos e semi-urbanos (Brown & Freitas 2002). Fortunato & Ruszczyk (1997) afirmam que é de suma importância a preservação de fragmentos de vegetação nativa próximo às cidades para a manutenção da diversidade de borboletas em áreas urbanas. Algumas espécies de borboletas dispersam de seu habitat original em áreas florestadas maiores nos períodos de pico de crescimento populacional, parando em manchas de flores ou frutos e em áreas verdes, seguindo cursos de água ou ruas com árvores em linha verde (Brown & Freitas 2002, Marini-Filho & Martins 2010).

O monitoramento das espécies de borboletas se mostra uma ferramenta potencial para o fornecimento de informações relevantes para que medidas acertadas de conservação sejam tomadas antes que os efeitos da perturbação sejam irreversíveis. Preservar parques e áreas verdes urbanas, bem como manter plantas atrativas em seus jardins, como *L. camara*, proporcionam condições favoráveis para a permanência das comunidades de borboletas. Isto demonstra a importância da preservação do Parque Municipal Américo Renê Giannetti, dentro de uma matriz urbana. Do mesmo modo, conectar os fragmentos através do aumento de ruas arborizadas, controlar a poluição, ampliar os cursos d'água e manter o ambiente heterogêneo, se faz necessário para a conservação não apenas de borboletas, mas também de outros grupos animais.

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The harvestmen fauna (Arachnida: Opiliones) of the Parque Estadual Carlos Botelho, and the Floresta Nacional de Ipanema, São Paulo, Brazil

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Abstract: The harvestmen fauna of the Floresta Nacional de Ipanema (FLONA Ipanema) and Parque Estadual Carlos Botelho (PE Carlos Botelho) were inventoried using nocturnal manual collection and sifting of litter. Fourteen species were recorded from the FLONA Ipanema, a richness and diversity higher than those previously reported for other localities in Atlantic Semi-deciduous Forest. The PE Carlos Botelho, with 38 recorded species, is the third richest site for harvestmen in the state of São Paulo. The estimates of species richness place the FLONA Ipanema with a richness of locations near the Coastal Atlantic Rain Forest. A similarity analysis showed that the areas possess only a few species in common, indicated by the very low of similarities indexes, showing the high level of endemism of harvestmen species. The similarities in harvestmen composition were related to the distance between the areas. PE Carlos Botelho showed high similarity with the Parque da Onça Parda (only 5 km away) and with other areas of Coastal Atlantic Rain Forest. The FLONA Ipanema showed low similarity indexes with the other areas analyzed. In a DCA analysis, PE Carlos Botelho forms a group with other areas of Coastal Atlantic Rain Forest and FLONA Ipanema is placed in an intermediate position between the areas of Coastal Atlantic Rain Forest and areas of Atlantic Semi-deciduous Forest and Cerrado.

Keywords: *diversity, Atlantic Semi-deciduous Forest, Coastal Atlantic Rain Forest, conservation units.*

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Resumo: A fauna de opiliões da Floresta Nacional de Ipanema (FLONA Ipanema) e Parque Estadual Carlos Botelho (PE Carlos Botelho) foi inventariada através de coleta manual noturna e triagem de folhiço com peneira. Catorze espécies foram registradas na FLONA Ipanema, a maior riqueza conhecida para áreas de Floresta Atlântica Semidecídua. O PE Carlos Botelho teve 38 espécies registradas, sendo a terceira área mais rica em opiliões no estado de São Paulo. As estimativas de riqueza de espécies colocam a FLONA Ipanema próxima do observado nas localidades de Floresta Atlântica Ombrófila. Uma análise de similaridade mostrou que as diferentes áreas de Mata Atlântica possuem poucas espécies em comum, indicado pelos baixos índices de similaridade, o que demonstra o alto grau de endemismo das espécies de opiliões. A similaridade entre as faunas de opiliões foi relacionada com a distância geográfica entre as áreas. PE Carlos Botelho apresentou alta similaridade com o Parque da Onça Parda (distantes somente 5 quilômetros) e com outras áreas de Mata Atlântica Ombrófila. A FLONA Ipanema apresentou baixos índices de similaridade com as demais áreas analisadas. Na análise de DCA, o PE Carlos Botelho formou um grupo com as demais áreas da Mata Atlântica Ombrófila e a FLONA Ipanema apresentou uma posição intermediária entre as áreas de Mata Atlântica Ombrófila e as de Floresta Atlântica Semidecídua e Cerrado.

Palavras-chave: *diversidade, Floresta Atlântica Semidecídua, Floresta Atlântica Ombrófila, unidades de conservação.*

Introduction

The Atlantic Rain Forest extends over almost the entire Brazilian coast, in a wide latitudinal range (6-30° S), and is divided into two major physiognomic units. The Coastal Atlantic Rain Forest, rises to over 1,000 meters above sea level and features a warm and humid climate, with no marked seasonality. The Atlantic Semi-deciduous Forest spreads inland, away from the coast, with elevations that can exceed 600 meters and seasonal climate, with well marked dry and rainy seasons (Oliveira-Filho & Fontes 2000). Originally this biome covered 1.1 million km^2 of the country, but currently there are only isolated fragments of different sizes that comprise less than 7.6% of the original cover (Morellato & Haddad 2000), and are still under great pressure from human activities.

The order Opiliones, with approximately 6,500 described species (Kury 2011), are especially diverse in the Atlantic Rain Forest, with more than 600 described species, of which approximately 97.5% are found exclusively in this biome (Pinto-da-Rocha et al. 2005). The order is divided into four suborders (Cyphophthalmi, Dyspnoi, Eupnoi and Laniatores), with Laniatores being the most diverse group, with over 4,100 described species worldwide (Kury 2011). Gonyleptidae is the largest family of Laniatores and one of the most diverse groups of the order Opiliones, with more than 823 described species (Kury 2003). The family is endemic from Neotropics and Pinto-da-Rocha et al. (2005), based on the geographical distribution of four subfamilies of Gonyleptidae restricted to Atlantic Rain Forest, divided the biome in 12 areas of endemism. The Atlantic Forest in São Paulo covers two of these areas, the Serra do Mar of São Paulo (SMSP) and the South of São Paulo (SSP), both representing the richest regions in the world for harvestmen, with approximately 220 recorded species (Kury 2003).

Historically, the harvestmen fauna of the state of São Paulo was studied by faunistic surveys conducted on the islands of the coast, such as Alcatrazes (Mello-Leitão 1923), São Sebastião (Luederwaldt 1929), Búzios and Vitoria (Soares 1966), the caves in the Ribeira Valley (Trajano & Gnaspini-Netto 1991, Pinto-da-Rocha 1994), the biological stations of Alto da Serra de Paranapiacaba (Giltay 1928, Soares 1944a, Bragagnolo & Pinto-da-Rocha 2009), and Boracéia (Soares 1942, 1944b). Recent studies were carried out, using standardized collecting protocols, in several areas during the project "Biodiversity of Arachnida and Myriapoda of São Paulo", between 2000 and 2004. Other areas were inventoried later, such as the Estação Ecológica Juréia-Itatins (Brescovit et al. 2004), Reserva Morro Grande (Bragagnolo et al. 2007) and Reserva Particular do Patrimônio Natural da Onça Parda (Resende et al. 2012).

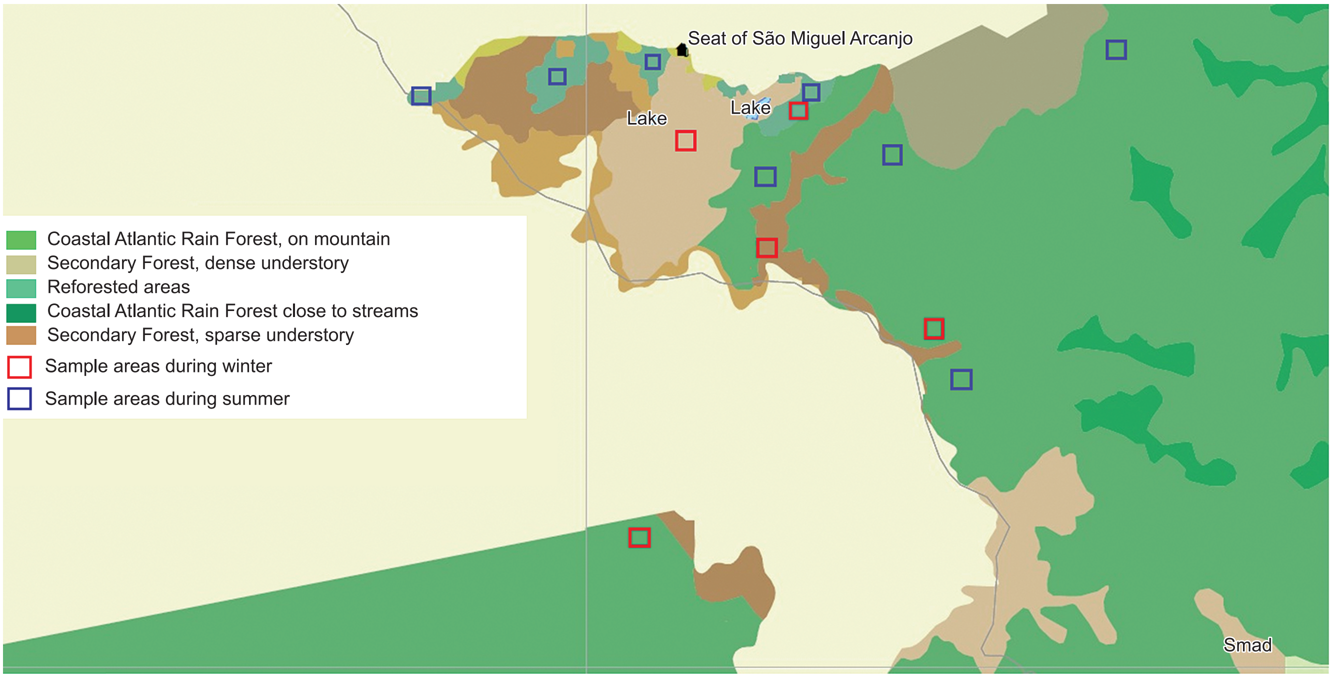
The Parque Estadual Carlos Botelho (PE Carlos Botelho) is an important remnant of Atlantic Rain Forest with 376 km^2 completely covered by primary Coastal Atlantic rain Forest. The Floresta Nacional de Ipanema (FLONA Ipanema) is covered by Atlantic Semi-deciduous Forest, more fragmented and impacted by human action. The two areas represent important preservation areas and faunal inventories are essential for implementing effective management plans. The present study aimed to survey the harvestmen fauna of these two areas, to expand the knowledge on the geographical distribution of the group and better understand the distribution of harvestmen communities in different vegetation types.

Materials and Methods

1. *Study areas*

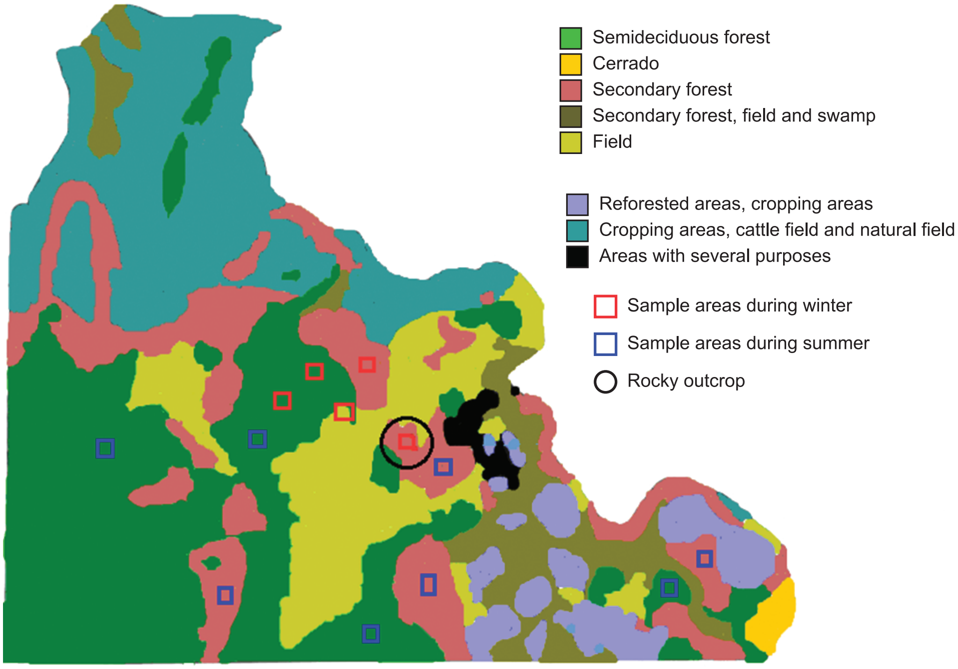
The PE Carlos Botelho (see Figure 1) is a unit of integral protection. It is located between latitudes 24° 06' and 24° 14' S and longitudes 47° 47' and 48° 07' W. It covers an area of 37,644 ha, belonging to four municipalities: São Miguel Arcanjo, Sete Barras, Capão Bonito and Tapiraí. The park is mainly covered by primary Coastal Atlantic Rain Forest. The region has high temperatures and well defined rain in the Summer months, alternating with periods of lower rainfall in Winter. Average rainfall varies from 1,700 to 2,400 mm and average temperatures from 17 to 22 °C (Ab'Saber 1970, 1973).

The FLONA Ipanema (see Figure 2) is a conservation reserve of sustainable use. It is located between latitudes 23° 25' and 23° 28' S and longitudes 47° 33' and 47° 40' W. It covers an area of 5,180 ha,



Fonte: Bases Cartográficas Digitais IBGE e Instituto Florestal Edição: Instituto Ekos Brasil Elaboração: Giorgia Limnios

Figure 1. Sampled sites in the Parque Estadual Carlos Botelho, São Paulo, Brazil.



Fonte: Fávero, et al. 2002

Figure 2. Sampled sites in the Floresta Nacional de Ipanema, São Paulo, Brazil.

belonging to three counties: Iperó, Capela do Alto and Araçoiaba da Serra. According to Fávero (2001), the area of the FLONA Ipanema is covered by fragments of forest vegetation in intermediate and advanced state of regeneration, canopy estimated at 20 m. Vegetation of the area includes Atlantic Semi-deciduous Forest and riparian vegetation, *cerrado* (savannah) areas, *capoeiras* in early stages of regeneration and fields dominated by grasses and herbs. The park also includes areas of swamps and bogs, plantations of *Eucalyptus* and *Pinus* and multiple use areas, with livestock, agriculture and human settlements. There is a significant human influence (the large city of Sorocaba is only 25 km away, and houses are within the buffer zone). The climate shows a more pronounced seasonality, with periods of more intense precipitation in the Summer and a marked dry season in Winter (Albuquerque & Rodrigues 2000). During the dry season an important environmental factor that acts in the area of the FLONA Ipanema is the fire (natural and/or induced), that occurs almost every year (Fávero 2001).

2. *Sampling*

Two field trips were made to each park (18 to 22 July 2011 and 09 to 13 January 2012 at FLONA Ipanema and 25 to 29 July 2011 and 17 to20 January 2012 in PE Carlos Botelho). In July, five environments were sampled in each park. In the FLONA Ipanema, samplings were conducted in areas of riparian forest, secondary forest, forest-field ecotone, scrub vegetation and rocky outcrops, while in the PE Carlos Botelho samplings were carried out in areas of alluvial dense rain forest, reforestation, dense montane rain forest, and secondary forest with different degree of understory density. In each of the five environments, a sampling of four hours (from 18:00 to 22:00 pm) was conducted in 16 points. At each of these points, a transect (10 m × 30 m, 10 m apart from each other) was sampled by one collector. At each transect, harvestmen were collected in litter, leaves and stems to a height of one meter, and fixed in 70% ethanol. At the margin of each transect a square meter of litter was collected for subsequent screening and collection of harvestmen.

In January, samplings were conducted in two environments in each park (capoeira and secondary forest in FLONA Ipanema and reforestation and dense montane rain forest in PE Carlos Botelho). In each area, four independent sampling points, with a distance of at least 200 m between them, were selected,. At each of these points, sampling was carried out along eight transects (10 m × 30 m, 10 m apart from each other) sampled by four collectors in two hours of active night searching (four transects from 19:00 to 21:00 and four transects from 22:00 to 0:00 pm), totalizing eight subsamples per area. Four square meters of litter were removed around each area for subsequent sampling of harvestmen in winkler sifting.

Temperature and humidity were measured just before beginning each subsample in two sampling seasons. The material collected was deposited in the Museu de Zoologia da Universidade de São Paulo (MZUSP, curator: Ricardo Pinto-da-Rocha).

3. *Statistic analysis*

To determine the alpha diversity of harvestmen, the effective number of species (value representing the number of species in a given community with all the species present in equal abundance) was used, using the formula: $\mathbf{exp\ (\sum pi\ ln\ pi)}$ (Jost 2006), which is the same as $\mathbf{exp\ (H')}$ where **exp** is the natural log **ln** raised to power **H'**, and **H'** is the Shannon index ($\mathbf{H' = \sum pi\ ln\ pi}$), where **pi** is the proportion of species in relation to the total number of individuals in the community and **ln** is the neperian log (≈2,72) (Magurran 1988). To calculate the beta diversity, a similarity analysis , using the Jaccard index ($\mathbf{S= a/(a + b + c)}$) (Magurran 1988, Table 3), and a detrend correspondent analysis (DCA), between 22 sites in the State of São Paulo based on occurrence of species from Bragagnolo (2005), Pinto-da-Rocha et al. (2005) and Resende et al. (2012), were used. A Mantel test was performed to analyze the correlation between the similarity (Jaccard) and geographic distance (Euclidian) matrices. The analyses were conducted using computer program PAST – Paleontological Statistic (Hamer et al. 2001). The species richness was estimated with *Jackknife 1*, *Jackknife 2*, *Chao 1* and *Chao 2* for both parks using computer program EstimateS 8.2.0 (Colwell 2006), which also produced species accumulation curves with data randomized 200 times.

Results

1. *Environmental parameters*

In Winter, the average temperature at FLONA Ipanema was 16.4 °C (SD = 2.321) and the average relative humidity 66.2% (SD = 6.976). In Summer, the average temperature was 21.1 °C (SD = 1.635) and relative humidity 69.9% (SD = 7.099). In PE Carlos Botelho, average temperatures were 16.3 °C (SD = 1.505) in Winter and 20.1 °C (SD = 1.739) in Summer, and average relative humidity was 69% (SD = 6.486) in Winter and 85% (SD = 5.151) in Summer. The data shows that the average temperatures at both locations are very similar, in contrast to the mean relative humidity, which is much higher in PE Carlos Botelho.

2. *Richness and abundance*

A total of 387 harvestmen were collected in FLONA Ipanema (171 in Winter and 200 in Summer, with manual collection, and 15 in Winter and one in Summer sifting leaf litter) representing 14 species (Table 1). Two species were dominant, *Mischonyx squalidus* Bertkau (91 specimens) and *Discocyrtus* sp.1 (88 specimens), both corresponding to 46.25% of the total abundance (Figure 3). The species accumulation curve (Figure 5) showed a tendency towards stability, with 80% of the observed richness obtained before 40% of individuals had been added. Although the diversity estimates were

Table 1. Harvestmen of the Floresta Nacional de Ipanema, collected with two methos in two seasons (Winter, July 2011 and Summer January 2012) Captions: Man. Col: Manual Collection; Lf: Leaflitter.

Species	July-11		Jan.-12		Total
	M.C	Lf.	M.C	Lf.	
Gonyleptidae					
Gonyleptinae					
Acanthogonyleptes sp	0	0	2	0	**2**
Mischonyx squalidus Bertkau, 1880	34	0	57	0	**91**
Mischonyx sp1	0	0	25	0	**25**
Goniosomatinae					
Acutisoma longipes Roewer, 1913	17	0	0	0	**17**
Mitobatinae					
Promitobates ornatus (Mello-Leitão, 1922)	39	0	0	0	**39**
Longiperna cancellata (Roewer, 1913)	1	0	0	0	**1**
Promitobates intermedius (Mello-Leitão, 1935)	0	0	19	0	**19**
Promitobates trapista Bragagnolo & Pinto-da-Rocha, 2012	1	0	0	0	**1**
Pachylinae					
Discocyrtus invalidus Piza, 1938	10	0	35	0	**45**
Discocyrtus sp1	69	0	19	0	**88**
Discocyrtus sp2	0	0	15	0	**15**
Parapachyloides armatus (Mello-Leitão, 1931)	0	0	27	0	**27**
Pucrolia sp	0	15	0	0	**15**
Tricommatinae					
Pseudopachylus longipes Roewer, 1912	0	0	1	1	**2**
	171	**15**	**200**	**1**	**387**

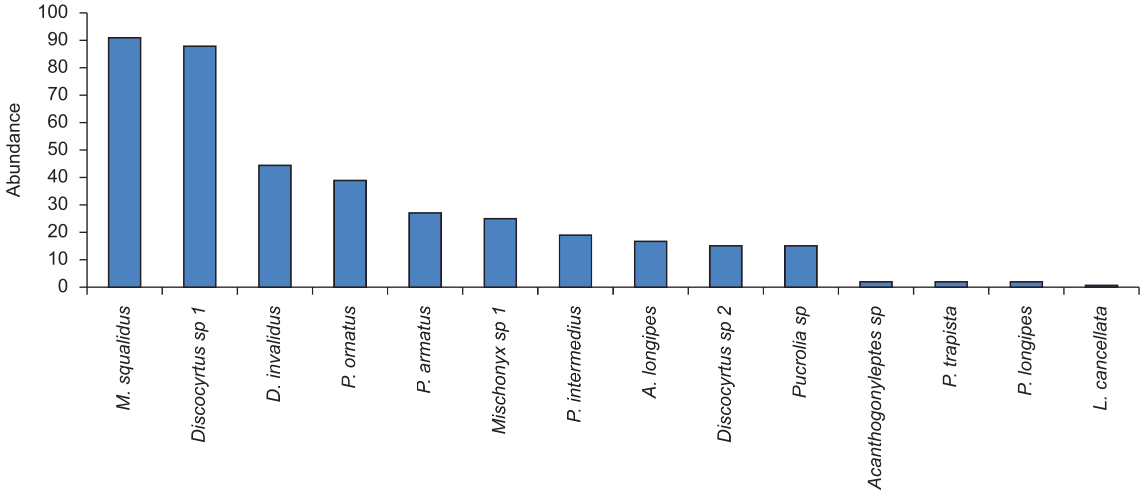


Figure 3. Distribution of harvestmen species abundance in Floresta Nacional de Ipanema, Iperó, São Paulo, Brazil.

very similar, Chao 1 and Chao 2 had the lowest, approximately 16 species. Jackknife 1 showed an average estimate of 17 species, and Jakknife 2 showed the highest with 19 species.

In PE Carlos Botelho, 1763 individuals were collected (594 in Winter and 1,091 in Summer with manual collecting and 36 in Winter and 42 in Summer sifting leaf litter) representing 38 species, 36 of which belong to Laniatores and two to Eupnoi (Table 2). The dominant species were *Holcobunus nigripalpis* Roewer (445 specimens), *Neosadocus maximus* (Giltay) (296 specimens) and *Munequita* sp. (261 specimens), corresponding to 56.83% of the total abundance (Figure 4). The species accumulation curve (Figure 6) showed a tendency to stabilize, with 80% of the richness obtained by addition of approximately 30% of the specimens. The behavior of the estimators (Figure 6) was similar to that observed for the FLONA Ipanema, with Chao 1 and 2 showing the lowest values (40 species), Jackknife an intermediate value (43 species) and Jackknife 2 the highest (44 species).

Manual collecting was responsible for most of the observed abundance and also for most of the richness found in both parks. In FLONA Ipanema, manual collecting yielded 13 of the 14 collected species. Only *Pucrolia* sp. was obtained exclusively by sifting litter. In PE Carlos Botelho the manual collecting was responsible for 36 of the 38 collected species. The sorting of litter added to the list the species *Pucrolia* sp.and Tricommatinae gen.nov..

3. *Alfa and beta diversity*

The alpha diversity, measured by the effective number of species was 8.61 for the FLONA Ipanema and 11.634 for the PE Carlos Botelho. The table of similarity showed the areas possess only a few species in common, generating very low indices of similarities (Table 3). Similarity indexes higher than 0.5 were found only between sites extremely close together (PE Carlos Botelho and Onça Parda – 5 km, Morro Grande and Miracatu – 70 km or Porto Cabral and Morro do Diabo – 40 km). The Mantel test indicated that the similarities of harvestmen fauna between areas were correlated to the geographical distances between them (r = 0.407; p < 0.0001). FLONA Ipanema showed low similarity indexes with the other areas

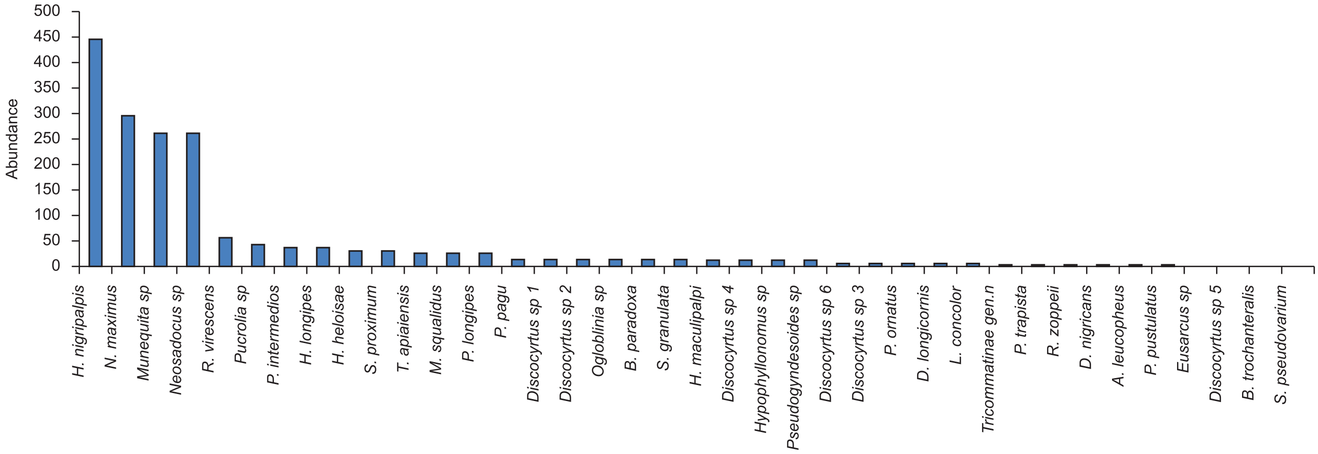


Figure 4. Distribution of harvestmen species abundance in Parque Estadual Carlos Botelho, São Miguel Arcanjo, São Paulo, Brazil.

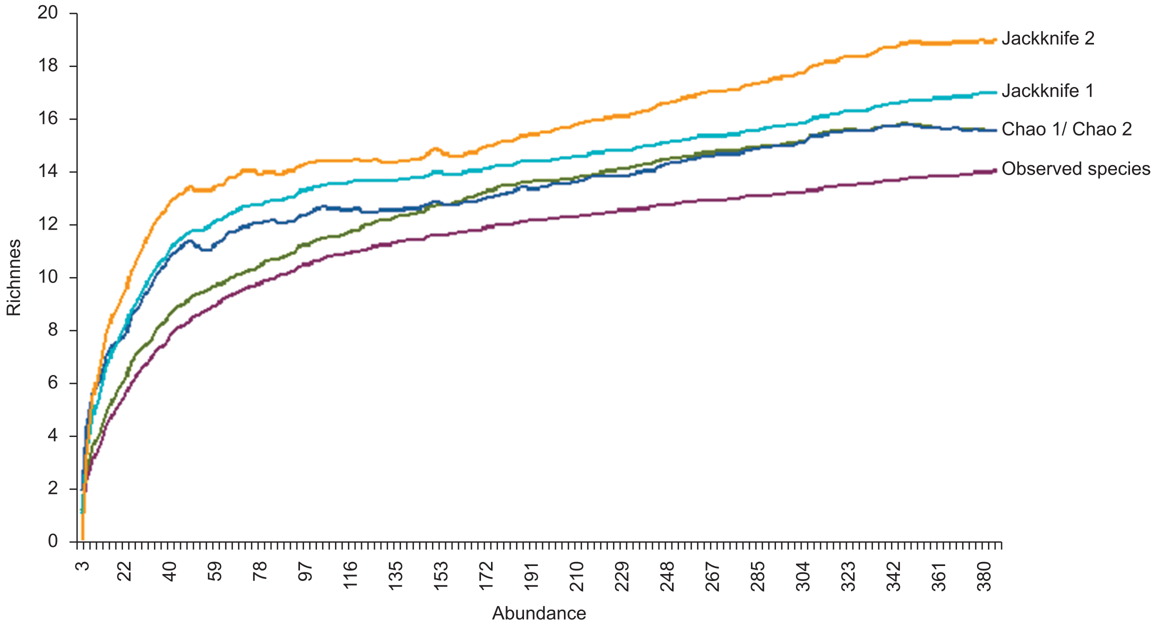


Figure 5. Accumulation curve and estimates for harvestmen species for Floresta Nacional de Ipanema, Iperó, São Paulo, Brazil.

Table 2. Harvestmen of the Parque Estadual Carlos Botelho, collected with two methos in two seasons (Winter, July 2011 and Summer January 2012) Captions: Man. Col: Manual Collection; Lf: Leaflitter.

Species	**Jul-11**		**Jan-12**		**Total**
	M.C	**Lf.**	**M.C**	**Lf.**	
Gonyleptidae					
Bourguyiinae					
Bourguyia trochanteralis (Roewer, 1930)	1	0	0	0	**1**
Caelopyginae					
Ampheres leucopheus (Mello-Leitão, 1922)	2	0	0	0	**2**
Pristocnemis pustulatus Kollar in Koch, 1839	2	0	0	0	**2**
Goniosomatinae					
Serracutisoma proximum (Mello-Leitão, 1922)	29	0	1	0	**30**
Serracutisoma pseudovarium Da-Silva & Gnaspini, 2010	1	0	0	0	**1**
Gonyleptinae					
Neosadocus maximus (Giltay, 1928)	296	0	0	0	**296**
Neosadocus sp	0	0	261	0	**261**
Mischonyx squalidus Bertkau, 1880	0	0	27	0	**27**
Hernandariinae					
Hernandaria heloisae (H. Soares, 1945)	6	0	24	1	**31**
Pseudotrogulus pagu DaSilva & Pinto-da-Rocha, 2010	9	1	4	2	**16**
Mitobatinae					
Discocyrtoides nigricans (Mello-Leitão, 1922)	3	0	0	0	**3**
Longiperna concolor (Mello-Leitão, 1923)	5	0	0	0	**5**
Promitobates intermedius (Melo-Leitão, 1935)	36	0	0	0	**36**
Promitobates ornatus (Mello-Leitão, 1922)	2	0	4	0	**6**
Promitobates trapista Bragagnolo & Pinto-da-Rocha, 2012	1	0	3	0	**4**
Pachylinae					
Discocyrtus longicornis (Mello-Leitão, 1922)	2	0	4	0	**6**
Discocyrtus sp1	15	0	1	0	**16**
Discocyrtus sp2	12	0	3	0	**15**
Discocyrtus sp3	6	0	0	0	**6**
Discocyrtus sp4	7	0	4	0	**11**
Discocyrtus sp5	1	0	0	0	**1**
Discocyrtus sp6	7	0	0	0	**7**
Eusarcus sp	0	0	1	0	**1**
Hypophyllonomus longipes Giltay, 1928	8	0	26	1	**35**
*Hypophyllonomus maculipalpi (*Piza, 1938)	0	0	12	0	**12**
Hypophyllonomus sp	0	0	6	5	**11**
Ogloblinia sp	12	3	0	0	**15**
Pseudogyndesoides sp	6	5	0	0	**11**
Pucrolia sp	0	18	0	23	**41**
Rhioxyna zoppeii (Soares, 1948)	1	0	2	0	**3**
Roeweria virescens (Mello-Leitão, 1940)	50	0	8	0	**58**
Triglochinura apiaiensis (Soares & Bauab-Vianna, 1972)	3	1	21	3	**28**
Sodreaninae					
Sodreana granulata (Mello-Leitão, 1937)	8	0	6	0	**14**
Tricommatinae					
Bissula paradoxa Roewer, 1929	7	7	1	0	**15**
Pseudopachylus longipes Roewer, 1912	9	0	13	4	**26**
Tricommatinae gen.n	0	1	0	3	**4**
Sclerosomatidae					
Gagrellinae					
Holcobunus nigripalpis Roewer, 1910	14	0	431	0	**445**
Munequita sp	34	0	228	0	**262**
	594	**36**	**1091**	**42**	**1763**

analysed. The greater faunal similarity was with PE Carlos Botelho (Sj = 0.19, only six species in common) followed by Porto Cabral (Sj = 0.17, two species in common), and the Parque da Onça Parda (Onça Parda) (Sj = 0.14, four species in common). The PE Carlos Botelho showed a greater similarity to the Onça Parda (Sj = 0.69), with the highest similarity index, and a high number of species in common (20 species). The PE Botelho also shows a high similarity with other localities of Serra do Paranapiacaba and other localities close by, with over 10 species in common (Alto do Ribeira = 0.3; Miracatu = 0.31; Paranapiacaba = 0.25; Juréia-Itatins = 0.28; Morro Grande = 0.29). The DCA analysis shows results consistent with the similarity analysis, where the shaft has PE Carlos Botelho nested with other areas of Coastal Atlantic Rain Forest. FLONA Ipanema is placed in an intermediate position between the areas of Coastal Atlantic Rain Forest and areas of Atlantic Semi-deciduous Forest and Cerrado (Figure 7).

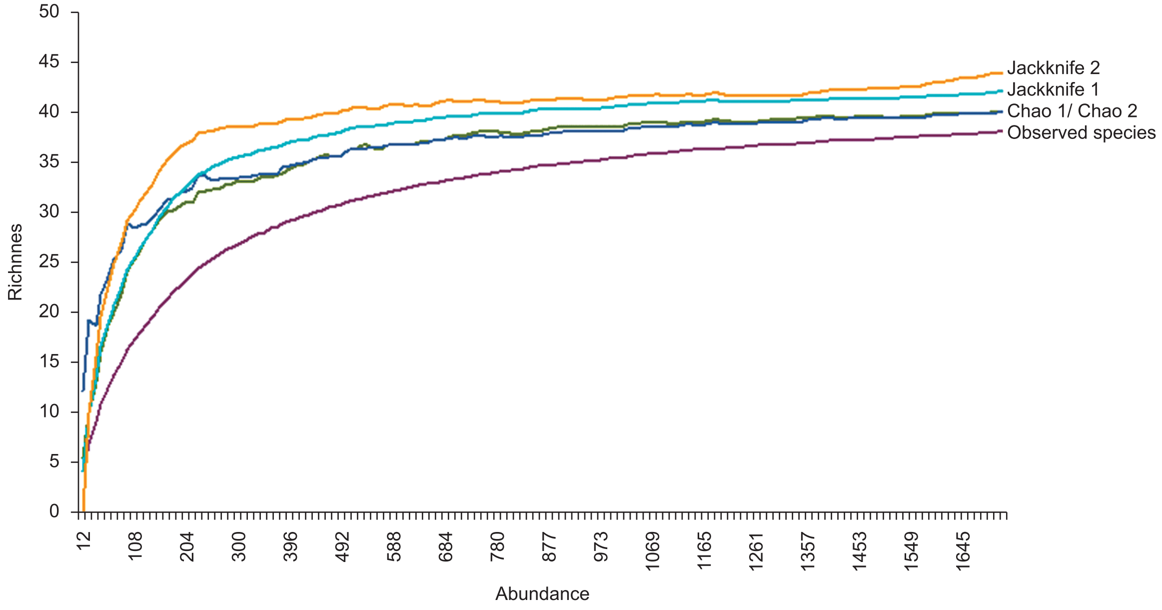


Figure 6. Accumulation curve and estimates for harvestmen species for PE Carlos Botelho, São Miguel Arcanjo, São Paulo, Brazil.

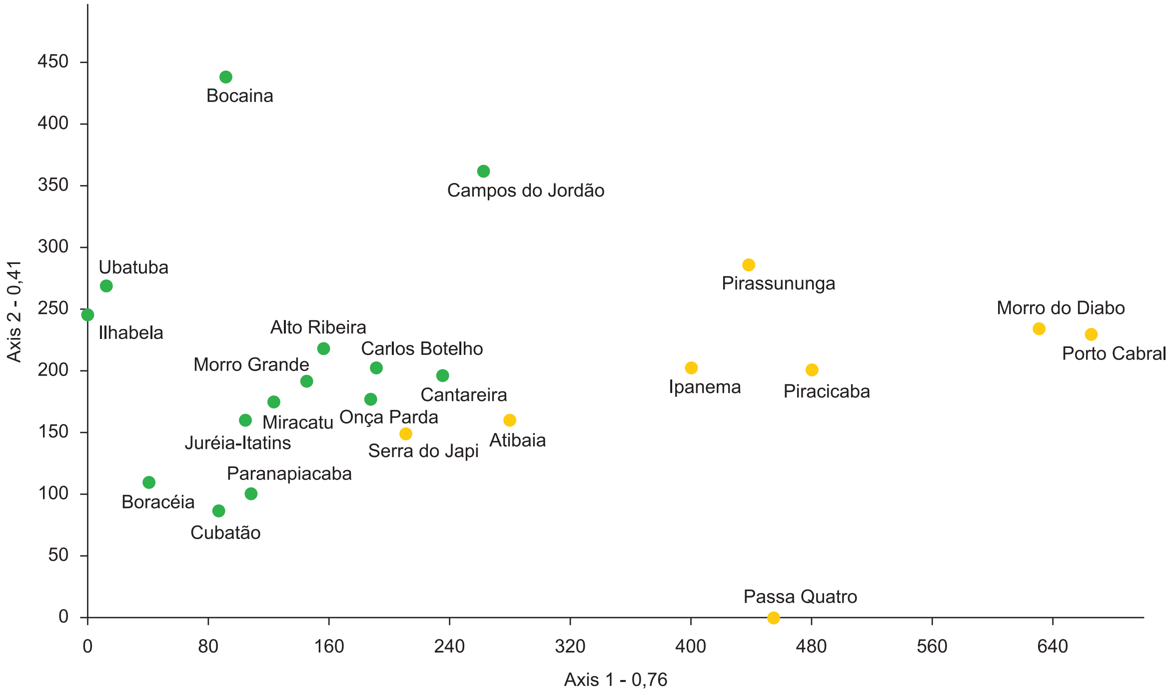


Figure 7. Biplot of axes 1 and 2 from a detrended correspondence analysis (DCA) on the presence of harvestman species in the 22 sites in São Paulo State, Brazil. Green circles represent Coastal Atlantic Rain Forest and yellow circles the Semi-deciduous and cerrado forests.

Table 3. Richness, similarity (Jaccard index), and number of shared species (between parenthesis) between harvestmen faunas of 22 sites from State of São Paulo. Data from Bragagnolo (2005), Bragagnolo et al. (2007); Pinto-da-Rocha et al. (2005) and Resende et al. (2012).

	Richnnes	**Alto Ribeira**	**Atibaia**	**Bocaina**	**Boracéia**	**Campos do Jordão**	**Cantareira**	**Carlos Botelho**	**Cubatão**	**Ilhabela**	**Ipanema**	**Juréia-Itatins**	**Miracatu**	**Morro do Diabo**	**Morro Grande**	**Onça Parda**	**Paranapiacaba**	**Passa Quatro**	**Piracicaba**	**Pirassununga**	**Porto Cabral**	**Serra do Japi**	**Ubatuba**
Alto Ribeira	23	-	(2)	(1)	(5)	(3)	(2)	(10)	(6)	(2)	(1)	(7)	(11)	(1)	(9)	(7)	(7)	(0)	(0)	(0)	(0)	(1)	(4)
Atibaia	13	0.09	-	(1)	(0)	(5)	(7)	(3)	(2)	(0)	(1)	(1)	(3)	(1)	(3)	(4)	(4)	(0)	(1)	(1)	(0)	(5)	(1)
Bocaina	35	0.04	0.05	-	(3)	(5)	(3)	(1)	(1)	(2)	(0)	(2)	(1)	(0)	(2)	(1)	(3)	(0)	(0)	(0)	(0)	(1)	(6)
Boracéia	40	0.12	0	0.07	-	(1)	(3)	(7)	(8)	(7)	(2)	(8)	(9)	(0)	(5)	(7)	(21)	(0)	(0)	(0)	(0)	(1)	(11)
Campos do Jordão	26	0.12	0.31	0.26	0.02	-	(7)	(3)	(0)	(1)	(1)	(1)	(4)	(0)	(2)	(2)	(2)	(0)	(1)	(1)	(0)	(3)	(1)
Cantareira	27	0.06	0.35	0.11	0.06	0.30	-	(6)	(3)	(1)	(2)	(3)	(5)	(0)	(7)	(7)	(9)	(0)	(1)	(1)	(0)	(8)	(2)
Carlos Botelho	38	0.30	0.09	0.03	0.13	0.08	0.15	-	(5)	(5)	(6)	(10)	(13)	(0)	(12)	(20)	(13)	(0)	(1)	(1)	(0)	(2)	(6)
Cubatão	20	0.22	0.08	0.04	0.20	0	0.09	0.13	-	(1)	(1)	(8)	(7)	(0)	(5)	(5)	(13)	(0)	(0)	(0)	(0)	(1)	(6)
Ilhabela	31	0.07	0	0.08	0.17	0.04	0.03	0.13	0.03	-	(1)	(3)	(6)	(0)	(5)	(4)	(4)	(0)	(0)	(0)	(0)	(0)	(7)
Ipanema	14	0.04	0.06	0	0.05	0.05	0.08	0.19	0.04	0.04	-	(2)	(1)	(1)	(2)	(4)	(3)	(0)	(1)	(0)	(2)	(1)	(1)
Juréia-Itatins	30	0.25	0.04	0.07	0.19	0.03	0.09	0.28	0.29	0.09	0.07	-	(14)	(0)	(8)	(7)	(15)	(0)	(0)	(0)	(0)	(0)	(7)
Miracatu	31	0.33	0.09	0.03	0.18	0.11	0.12	0.31	0.18	0.16	0.03	0.42	-	(1)	(19)	(10)	(15)	(0)	(1)	(1)	(0)	(2)	(4)
Morro do Diabo	5	0.05	0.08	0	0	0.07	0.05	0	0	0	0.08	0	0.03	-	(0)	(0)	(0)	(0)	(0)	(0)	(3)	(0)	(0)
Morro Grande	34	0.26	0.09	0.05	0.09	0.05	0.18	0.29	0.13	0.13	0.06	0.21	**0.53**	0	-	(10)	(13)	(0)	(1)	(1)	(0)	(6)	(3)
Onça Parda	26	0.23	0.15	0.03	0.15	0.06	0.21	**0.69**	0.15	0.12	0.14	0.21	0.25	0	0.26	-	(12)	(0)	(1)	(1)	(0)	(3)	(4)
Paranapiacaba	47	0.15	0.09	0.06	0.42	0.04	0.19	0.25	0.30	0.08	0.07	0.35	0.29	0	0.25	0.24	-	(1)	(2)	(1)	(0)	(2)	(7)
Passa Quatro	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	-	(1)	(0)	(0)	(0)	(0)
Piracicaba	4	0	0.08	0	0	0.07	0.05	0.03	0	0	0.08	0	0.03	0	0.03	0.04	0.05	0.25	-	(2)	(1)	(0)	(0)
Pirassununga	7	0	0.10	0	0	0.08	0.05	0.04	0	0	0	0	0.03	0	0.04	0.04	0.03	0	**0.50**	-	(0)	(0)	(0)
Porto Cabral	5	0	0	0	0	0	0	0	0	0	0.17	0	0	**0.60**	0	0	0	0	0.14	0	-	(0)	(0)
Serra do Japi	12	0.04	0.33	0.05	0.02	0.15	0.38	0.06	0.04	0	0.05	0	0.05	0	0.19	0.10	0.04	0	0	0	0	-	(0)
Ubatuba	36	0.12	0.03	0.21	0.26	0.03	0.05	0.14	0.18	0.27	0.03	0.21	0.09	0	0.07	0.10	0.13	0	0	0	0	0.03	-

Discussion

1. Richness and abundance

Data from this survey corroborate that obtained by Pinto-da-Rocha et al. (2005), since the PE Carlos Botelho was 2.7 times richer than FLONA Ipanema. The PE Carlos Botelho, with 38 recorded species, is the third richest locality in the state of São Paulo and stands as the sixth richest area in species of harvestmen of Brazil, surpassed only by the Parque Nacional da Serra dos Órgãos (64 species), Parque Nacional Itatiaia (48 species), Estação Biológica do Alto da Serra de Paranapiacaba (46 species), Petrópolis (45 species), and the Estação Biológica de Boracéia (39 species) (Pinto-da-Rocha et al. 2005). The comparison of the effective number of species of the PE Carlos Botelho with other areas of Coastal Atlantic Rain Forest previously analyzed by Resende et al. (2012) also places the park as an area of great diversity in the country (Resende et al. 2012).

The FLONA Ipanema, with 14 recorded harvestmen species, is the richest area of Atlantic Semi-deciduous Forest compared to other sites with the same vegetation type that have been inventoried (Porto Cabral with five, Serra do Japi with 11; Atibaia with 12 and Morro do Diabo with five species, see Pinto-da-Rocha et al. 2005). Besides the higher richness, the effective number of species of FLONA Ipanema was also higher than that of the Serra do Japi (effective number : 6.1, see Resende et al. 2012) and the Morro do Diabo (3.098).

The nonparametric estimators generated maximum estimates of 19 species of harvestmen for the FLONA Ipanema. This estimated richness is the highest for areas of Atlantic Semi-deciduous Forest and is close to some areas of Coastal Atlantic Rain Forest such as Parque Estadual de Ilhabela (21 spp); Parque Estadual Turístico Alto do Ribeira (PETAR) and Cubatão (both with 19 spp) (Bragagnolo 2005). It should be noted that such comparisons, even considering the higher estimates, only equaled the poorest regions in collected species (not estimated) of the Coastal Atlantic Rain Forest. Furthermore, these regions have not been extensively collected, such as the Parque Estadual de Ilhabela and PETAR, or suffered strong environmental degradation such as Cubatão.

Besides the differences between the richness, the expected pattern due to physiognomic differences in park area and quality between the two parks, the distribution patterns of species abundance of harvestmen were markedly different between the two areas (Figures 3 and 4). In FLONA Ipanema, *Mischonyx squalidus* was the dominat species, representing 23.6% of individuals collected, while the PE Carlos Botelho, this species represented only 1.5% of the total. *Mischonyx* is recognized a species of harvestmen associated to human disturbance in the environment (Mestre & Pinto-da-Rocha 2004). The difference between the abundances of the species may reflect the environmental conditions of the parks. Moreover, in PE Carlos Botelho, there was a high dominance of Eupnoi *H. nigripalpis*, representing more than 25% of the collected individuals. According to Bragagnolo et al. (2007), the high dominance of few species of Eupnoi seems to be associated to human disturbance in the environment. This same pattern of dominance was recorded in Onça Parda (only 5 km from PE Carlos Botelho) by Resende et al. (2012). According Resende et al. (2012), the exploitation of wood for charcoal production in that region may have been responsible for the disturbances in that environment. Due to the close proximity between the areas, it is possible that the logging that occurred in the region of Onça Parda also reached the park area that was studied.

According to Pinto-da-Rocha et al. (2005), the Coastal Atlantic Rain Forest sites have a higher richness of harvestmen when compared to the locations of Atlantic Semi-deciduous Forest. One reason for this high diversity is that the Atlantic Coast receives the largest part of the moisture from the ocean, causing a rain shadow over the inland areas, which in turn end up getting only a third of the moisture (Behling & Lichte 1997). Moreover, historically, Coastal Atlantic Rain Forest vegetation suffered events of expansion and retraction during glaciation, causing speciation in moments of isolation and increased diversity in times of expansion (Behling & Lichte 1997). The vegetation of the Coastal Atlantic Rain Forest is also more diverse than that present in the interior regions and vegetation structure itself is more complex, creating a greater number of microhabitats and resources to be occupied (Oliveira-Filho & Fontes 2000).

2. Beta diversity

The faunistic similarities respected the distance between sites, probably due to the low vagility of harvestmen and historical factors. However, natural barriers such as the Serra do Mar itself also provided a great influence on the isolation of these areas (Pinto-da-Rocha et al. 2005). High similarity indexes (greater than 0.5) were found only between sites belonging to the same type of vegetation and extremely close together, for example, PE Carlos Botelho and Onça Parda (5 km), Morro Grande and Miracatu (70km) or Porto Cabral and Morro do Diabo (40km) (Table 3). The distance between the areas seems to be a determinant of beta diversity among groups with low dispersal ability such as harvestmen (Curtis & Machado 2007). Furthermore, the vegetational formation seems to have a strong influence on the diversity of harvestmen. According to Ivanauskas et al. (2000) and Oliveira-Filho & Fontes (2000), there is a clear floristic separation between Coastal Atlantic Rain Forest of São Paulo (a regime characterized by extremely high rainfall and no dry season) and the Atlantic Semi-deciduous Forest of the interior of the state (characterized by a lower rainfall regime and the presence of marked dry season). This separation is mainly caused by the presence of mountain ranges on the coast of the state, which keep the moisture in the Coastal part extremely high (Ivanauskas et al. 2000, Scudeller 2002). Apparently, the seasonality of rainfall is more important than the total annual precipitation in the distinction between Coastal Atlantic Rain Forest and Atlantic Semi-deciduous Forest areas (Oliveira-Filho & Fontes 2000). This separation between the different types of vegetation can be detected in the first DCA axis (Figure 7), where there is a clear longitudinal gradient in harvestmen species distribution . The Coastal Atlantic Rain Forest areas were grouped on the left edge and savannah and semi-deciduous areas at the right end of the gradient.

A DCA analysis (Figure 7) and observation on similarity values among localities (Table 3) showed that opilionids of Atlantic Semi-deciduous Forests have lower alfa diversity and higher beta diversity than those observed for Atlantic Coastal forests. According to Salis et al. (1995), the vegetation of the interior of the state of São Paulo shows heterogeneous floras, with high alfa and beta diversity. High diversity of fitocenosis could be associated with a complex composition of climate and edaphic characteristics of the interior of the state of São Paulo (Salis et al. 1995).

Finally, besides the importance of distance and of the vegetation, the results obtained by similarity analysis indicate that other factors may be responsible for the distribution of harvestmen species, such as historical ones. According to Pinto-da-Rocha et al. (2005), the PE Carlos Botelho belongs to the area of endemism named South São Paulo situated on the slopes of the Serra Paranapiacaba, between the plateau and the Ribeira do Iguape river valley (DaSilva & Pinto-da-Rocha. 2011).

In their study, Pinto-da-Rocha et al. (2005) and DaSilva & Pinto-da-Rocha (2011) did not recognized semi-deciduous region as area(s) of endemism in the state of Sao Paulo, which makes an understanding in regard to the historical processes related to FLONA Ipanema still unknown. However, large differences in climate at these locations caused by the increasing distance from the coast and consequent changes in rainfall, may have to justify their isolation of harvestmen fauna from the other areas.

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Reproductive aspects of *Harttia carvalhoi* Miranda Ribeiro, 1939, a small loricariid from streams of serra da Mantiqueira eastern, SP, Brazil

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BIAGIOTTO, R.H., RONDINELI, G., CARMASSI, A.L. & BRAGA, F.M.S. **Reproductive aspects of *Harttia carvalhoi* Miranda Ribeiro, 1939, a small loricariid from streams of serra da Mantiqueira eastern, SP, Brazil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?short-communication+bn01512042012

Abstract: The aim of this work was to present the reproductive aspects of *Harttia carvalhoi* Miranda Ribeiro, 1939, a small loricariid whose distribution is restricted to the area of drainage basin of the Paraíba do Sul river. A total of 110 specimens of *H. carvalhoi* were captured. The reproductive period happens from September to February. A total spawning type was identified and fecundity rate ranged from 16 to 106 oocytes. This type of study is important, since fecundity is a specific feature and is adapted to the conditions of the life cycle, varying with growth, population density, food availability and mortality rate. We also emphasize the importance of this study, since there are no previous studies about the reproduction of this species.
Keywords: *Loricariinae, sex ratio, reproductive period, fecundity, Brazil.*

BIAGIOTTO, R.H., RONDINELI, G., CARMASSI, A.L. & BRAGA, F.M.S. **Aspectos reprodutivos de *Harttia carvalhoi* Miranda Ribeiro, 1939, um pequeno loricariídeo de riachos do leste da serra da Mantiqueira, SP, Brasil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?short-communication+bn01512042012

Resumo: O objetivo deste trabalho foi apresentar os aspectos reprodutivos de *Harttia carvalhoi*, Miranda Ribeiro, 1939, um pequeno loricariídeo cuja distribuição é restrita a área de drenagem do rio Paraíba do Sul. Um total de 110 exemplares de *H. carvalhoi* foi obtido. O período reprodutivo acontece desde Setembro até Fevereiro. O tipo de desova foi identificado como total e a taxa de fecundidade variou de 16 a 106 ovócitos. Este tipo de estudo é importante, visto que fecundidade é uma característica específica e é uma adaptação às condições do ciclo de vida, variando com o crescimento, densidade populacional, alimentos disponíveis e taxa de mortalidade. Nós também enfatizamos a importância deste estudo, pois não há estudos prévios sobre a reprodução desta espécie.
Palavras-chave: *Loricariinae, proporção de sexos, período reprodutivo, fecundidade, Brasil.*

Introduction

The serra da Mantiqueira system is a mountain range consisting of crystalline rocks located to the southeast of Brazil, being a watershed between the basins of the Grande river (MG) and the Paraíba do Sul river (SP). This in turn was formed, together with the Serra do Mar, by reactivation of a system of Precambrian rocks failures during the Oligocene-Miocene (Petri & Fúlfaro 1983).

The eastern portion of the serra da Mantiqueira is steeper and scalloped, and from its slopes, numerous creeks descend form micro basins separated from each other by prominent ridges (Braga 2004). This is the context in which lies the watershed of the Piracuama river, a hydrographic network which descends the slope of this portion of the sierra and will disembogue in the left bank of the Paraíba do Sul river, being located in the municipality of Pindamonhangaba, São Paulo.

These drainage networks exhibit a rich fish fauna (Braga & Andrade 2005, Rondineli 2010). However, very little is known about the biology of their species. For example we have the Loricariidae, which is a very diverse group of fish, but there are very few studies concerning its most representative family, the Loricariinae (Menezes et al. 1998). This family shows about 32 genera and 190 species, distributed among four tribes (Isbrücker 1980). Among these, we have the *Harttia* genus, which occurs and is abundant in the watershed of the River Piracuama. According to Menezes et al. (1998), there are five species concerning the *Harttia* genus, being four of them in Brazilian territory and one in Suriname.

The target species of this study is *H. carvalhoi*, a small loricariid (Figure 1), whose distribution is restricted to the area of drainage basin of the Paraíba do Sul river (Reis et al. 2003). Our aim in this work is the study of reproductive aspects, fecundity and spawning type of this species, which has never been addressed before.

Even though there are no such studies concerning the reproductive aspects of this species, there is previous study concerning the genus *Harttia*. Menezes et al. (1998) conducted a study with the species *Harttia loricariformis* Steindachner, 1876, whose distribution is also restricted to the Paraíba do Sul river basin. In this study the reproductive aspects were explored. His studies pointed to a multiple spawning strategy for the species, which contrasts with our results for *H. carvalhoi*. His results also pointed to a reproductive period that extends from September to February, which is in agreement with the species in the present study.

Materials and Methods

Samples were obtained in streams of Piracuama watershed during the months of April, July and October of 2009 and February of 2010. The collection points are located on the slope and piedmont: point 1 – 45° 35' 32" W and 22° 49' 43" S, point 2 – 45° 31' 33" W and 22° 48' 29" S, point 3 – 45° 32' 21" W and 22° 48' 50" S (Figure 2).

Fish was captured by electric fishing equipment with passages of 50 m for twice, without a contention net. All collected fish specimens were immediately preserved in 10% formalin, later transferred to 70% ethanol. Voucher specimens were deposited in icththyological collection of the Universidade Estadual Paulista, in Rio Claro, SP.

Standard length (Ls, mm) and total weight (Wt, g) were taken from each specimen. Sex and gonadal maturity stages were identified considering texture, consistency, coloration, size and surface vascularization of gonads (Vazzoler 1996), through direct macroscopic observation. Four different gonadal mature states were considered: A, immature; B, in maturation or resting; C, mature; and D, spent. For degree of fat accumulated in the visceral cavity were assigned following values: "1" for the visceral cavity that did not present fat, "2" for the visceral cavity partially filled with fat and "3" for the visceral cavity full of fat (Braga 1999).

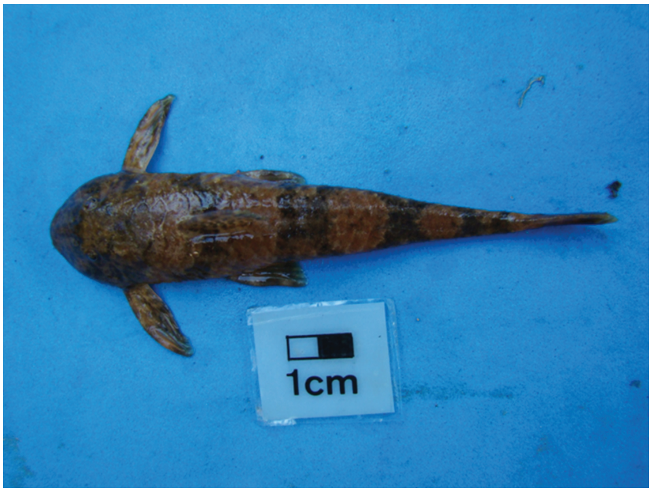

Figure 1. *Harttia carvalhoi* specimen captured on the streams of the Piracuama river micro basin.

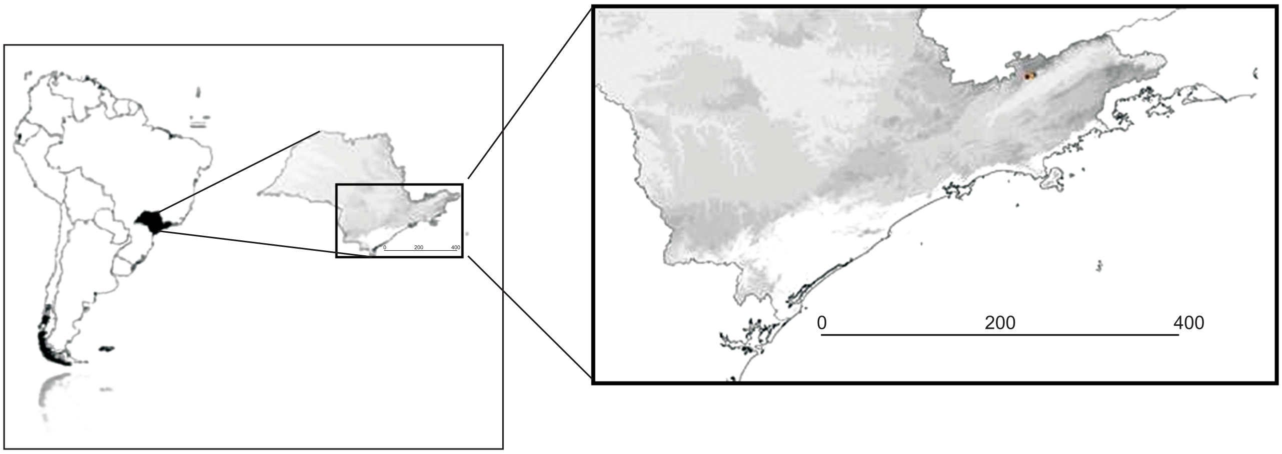

Figure 2. Map showing the three collection points: Point 1 (in red color), Point 2 (in green color) and Point 3 (in yellow color).

To verify if the proportion between males and females of this species was different from the expected (1:1), the test of χ^2 (Siegel 1975) was used, considering $\alpha = 0.05$.

On account of the close relationship between the maturation progress of oocytes and the increase of volume, which implies an increase of the weight of the ovaries, the gonadossomatic relationship (RGS), that shows the percentage of gonads on individual's total weight, is an efficient indicator of the ovaries functional state (Vazzoler 1996). Also, temporary variation of RGS supplies information about the reproductive period of species or population. Therefore, inferences on the reproductive period of species were made through the frequency of individuals with gonads in different stages of maturity and the temporal variation in gonadossomatic relationship (RGS).

Female fecundity was estimated as the total number of vitelogenic oocytes produced during the reproductive period. Mature ovaries were removed, immersed in Gilson solution (Vazzoler 1996) for the complete detachment of ovarian membranes, washed and preserved in 70% alcohol. The type of spawning was determined by the frequency distribution of the oocyte diameter classes (1 D. O. M = 61.2 µm) taken randomly from 100 oocytes of each female (N = 14) (Vazzoler 1996).

Results

A total of 110 specimens of *H. carvalhoi* were captured. The population structure of the species concerning sex ratio was 40 females, 29 males and 41 immatures. The proportion between males and females did not differ from expected ($\chi^2 = 1.754$; gl = 1; p = 0.185). The smaller specimen presented 22 mm of standard length (was an immature) and the largest was a male with 91 mm of standard length (Figure 3). Males and females did not show different standard length (t = 0.68; gl = 1; p = 0.49; $CP_{average}$ for males = 62.69 mm; $CP_{average}$ for females = 64.55 mm). Relationship between standard length and total weight of males and females captured was presented by following equation $Wt = 0.00006Ls^{2.6587}$ (r = 0.98, n = 29) and $Wt = 0.00005Ls^{2.7148}$ (r = 0.98, n = 40), respectively.

Considering each sampling, the most expressive value of relative frequency of mature individuals occurred on sample 3 (Figure 4) and the gonadossomatic relationship presented growing values from sample 1 to sample 2, with subsequent slightly decreasing value in sample 3, following the tendency to sample 4 (Figure 5). Females with spent gonad (D) presented an amount of immature oocytes as well as some residual yolky oocytes. Those remaining yolky oocytes represent a parcel of oocytes that weren't expelled during reproduction, being reabsorbed by the female in time.

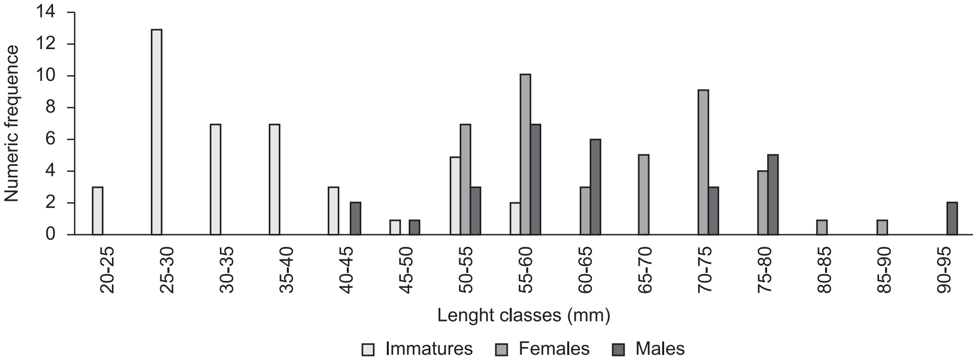

Figure 3. Numeric distribution of immature, females and males of *Harttia carvalhoi* according to class of standard length (mm).

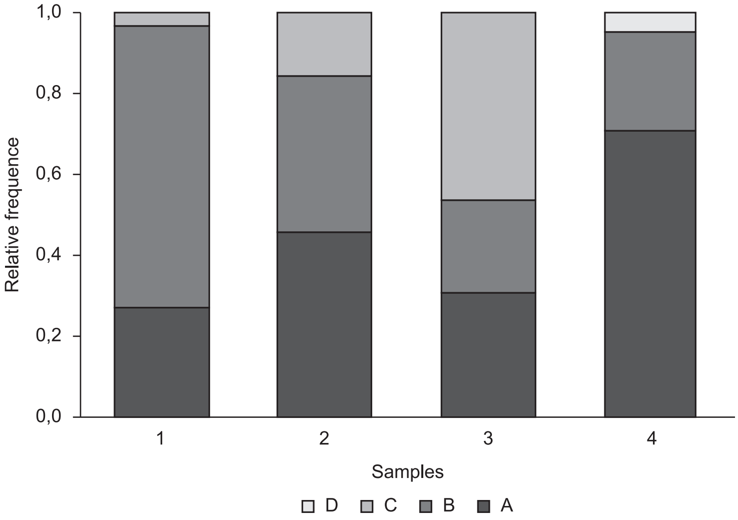

Figure 4. Relative frequency of *Harttia carvalhoi* individuals in different states of gonadal development in each samples (A, immature; B, in maturation or resting; C, mature; and D, spent).

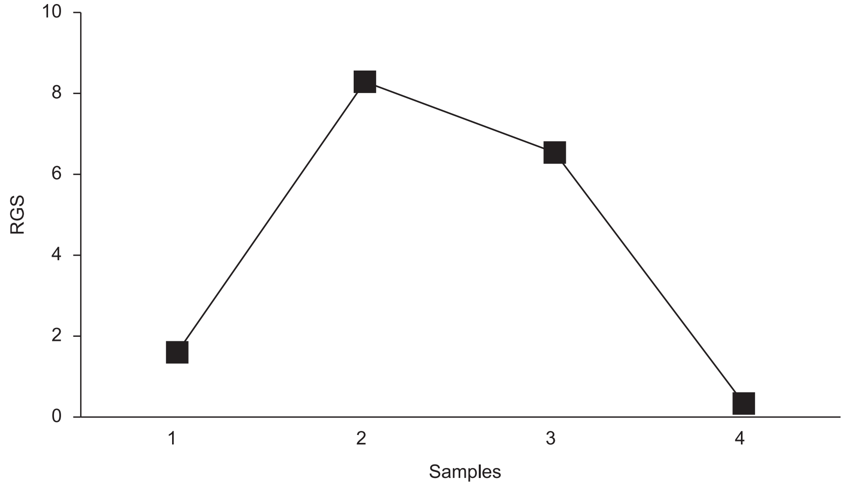

Figure 5. Gonadossomatic relationship (RGS) for mature females of *Harttia carvalhoi* in each samples.

When the distributions of diameter frequency of yolky oocytes were analysed, five groups were defined with two modes, being the first one corresponding to the immature oocytes, and the second one, which progresses in development among the groups, corresponding to the occytes in maturing process (Figure 6). The existence of two modes, being the greatest one corresponding to developing oocytes, suggests a total spawning type (synchronous in two groups).

The oocytes diameter varied from 61.2 µm to 3,427.2 µm, being 1,652.4 µm the measure from which we considered mature oocytes. The total number of oocytes ranged from 68 to 461 and the number of mature oocytes considered (N = fecundity) ranged from 3 to 106. Group I shows an ovary that has not yet started the process of development; groups II and III, shows developing ovaries; group IV, mature ovaries and group V shows ovaries in the process of depletion. Considering group IV, with mature oocytes, the fecundity rate ranged from 16 to 106 oocytes.

Discussion

According to Nikolsky (1963), the variation in body size is a widespread occurrence of sexual dimorphism between fishes, with a predominance of females in larger size classes. Being the fecundity directly linked to the reproductive potential, and knowing the positive relationship between the size and fecundity of the female, a higher frequency of females distributed in classes of larger standard length is justified.

However, we also have significant frequency of males among the classes of higher default length, being the highest measures pertaining to them. This is also justified, because the male tends to be bigger in species which defend the offspring in the nest, assigning reproductive advantages for bigger male individuals (Shine 1990). The same justification serves to the work done by Menezes et al. (1998), with *H. loricariformis* species, whose highest measures and amplitude of standard length were attributed to males.

The proportion of males and females went as expected (1:1) for the total sample, similar to the finding made for the reproductive biology of *H. loricariformis* (Menezes et al. 1998). Still, despite the proportion 1:1 being common in fish studies, variations in prevalence of males and females in the various classes of length may be related to different seasons of study (Vazzoler 1996).

Analyzing the graph of the relative frequency of different states of gonadal maturation of *H. carvalhoi* per sample, it's possible to note a very subtle expression of mature gonads in the first sampling (in April). In the second sampling, in July, a growing number of mature gonads is evident, being a sign of closeness to the reproductive season. In the third sample, in October, the greatest proportion of mature gonads of all samples was found. The dominance of mature gonads in the third sample indicates that the species is already in the reproductive period. And finally, the fourth sample (in February) doesn't present mature gonads, but it does present immature gonads, maturing or resting gonads and the exclusive presence of depleted gonads, characterizing the end of the reproductive cycle, which indicates that the reproductive season happens from around September to February.

The relation of the RGS values also follows the same trend according to the reproductive cycle. An intense feeding during non-reproductive periods may represent a strategy for allocating energy for reproduction, when those energy reserves will be used in the oocytes maturating process (Nikolsky 1963), leading the RGS value to its lowest value (as seen in the 4th sample). Thus, the low value of RGS for the first sample, followed by growing values in the second sample (close to the reproductive period) and the decline of RGS values during the reproductive period, indicates that there's a relation between the trends of both graphs. The decline is due to the spawning, which reduces the RGS values.

We can then relate the data to a reproductive period that probably stretches from September to February for *H. carvalhoi*. The data corresponds to a tendency seen in other representatives of the Loricariidae family, including different genus, such as *Hypostomus luetkeni* Lacèpéde, 1803, whose reproduction also corresponds to an extended spawning period, also lasting from September to February (Mazzoni & Caramaschi 1997).

The evidences are not only found for different genus among the family Loricariidae, but also for the *Harttia* genus. Our result corresponds to another work done about the reproductive biology of the genus, with the species *H. loricariformis* (Menezes et al. 1998) which occurs in the same basin and presents a reproductive season that also goes from September to February. According to this same study, this species has shown reproductive activity in the same period as for most of the other species that occurs in the lower part of the Paraíba do Sul river basin, coinciding with higher temperatures and precipitation levels. This feature maybe connected to a seasonal reproductive strategy linked to favorable environmental factors.

An interesting point is that there are different spawning strategies reported for the *Harttia* genus, since *H. loricariformis* is reported to be a multiple spawning species (Menezes et al. 1998) and our

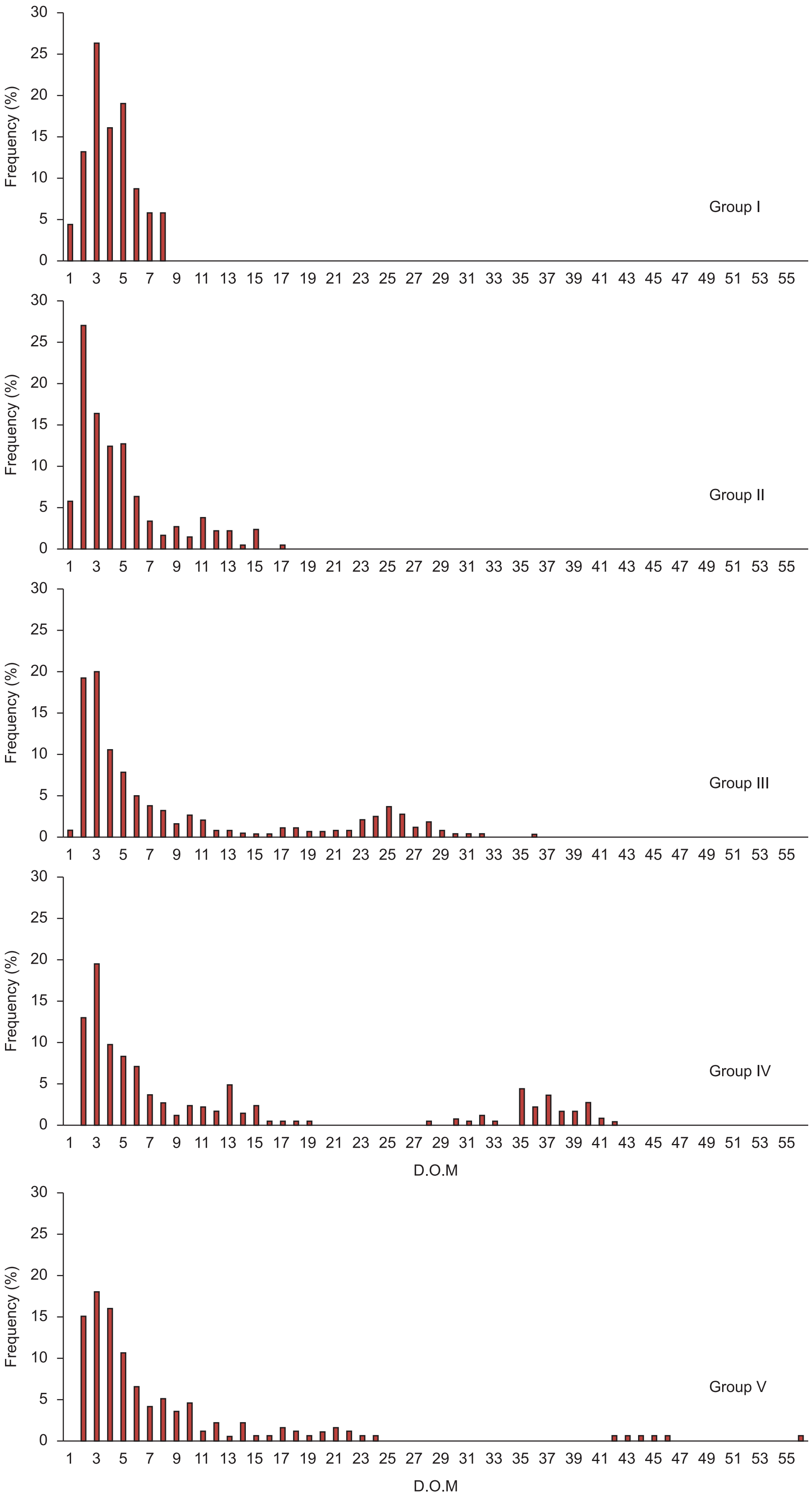

Figure 6. Oocyte size distribution of mature female *H. carvalhoi* showing five groups (GI-GV) of egg distribution (1 d. o. m. = 61.2 µm).

conclusion in this study indicates that *H. carvalhoi* is a total spawning species. Not only for the genus, but the result also differ for *H. luetkeni*. The study done by Mazzoni & Caramaschi (1997) with *H. luetkeni* mentioned before also indicated a multiple spawning strategy. This indicates that the Loricariidae is a diversified family regarding reproduction.

The gonadossomatic relationship increases among females with immature ovaries to females with mature ovaries and then decreases with the ovaries in the process of depletion, indicating that the mature occytes were released.

The knowledge about reproductive aspects of the species is essential for a better understanding and handling of fish populations, as well as their conservation. Thus, the results of our work are of direct application, which allows us to infer interpretations regarding the reproductive biology of *H. carvalhoi*.

In this context, with a pretty low fecundity, large oocytes, the prolonged and total spawning type presented by *H. carvalhoi* may reflect the ability to better adjust to the environment, since the streams are unstable environments, and larger oocytes give rise to larger larvae that may present greater chance of survival.

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Four new species of *Euphyllodromia* (Ectobiidae, Pseudophyllodromiinae) from the Amazon region (Brazil) and description of the genitalia of *E. amazonensis* Rocha e Silva, 1984

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LOPES, S.M. & SILVA, L.O.C. **Four new species of *Euphyllodromia* (Ectobiidae, Pseudophyllodromiinae) from the Amazon region (Brazil) and description of the genitalia of *E. amazonensis* Rocha e Silva, 1984.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?article+bn00212042012

Abstract: Four new species of *Euphyllodromia* Shelford, 1908 (*E. spathulata*, *E. nigromaculata, E. neoelegans* and *E. spiculata*) are described. Their male genitalia are illustrated. The female genitalia of *E. spiculata* and *E. nigromaculata* are also illustrated. Diagnostic characters of the head, thorax and abdomen of *E. amazonensis* Rocha e Silva, 1984 are reiterated, illustrated and combined with the description of the male and female genitalia for the first time. A key is provided to include the species treated here.
Keywords: *Amazonas, Blattaria, key, taxonomy.*

LOPES, S.M. & SILVA, L.O.C. **Quatro novas espécies de *Euphyllodromia* (Ectobiidae, Pseudophyllodromiinae) da região amazônica (Brasil) e descrição da genitália de *E. amazonensis* Rocha e Silva, 1984.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?article+bn00212042012

Resumo: Quatro novas espécies de *Euphyllodromia* Shelford, 1908 (*E. spathulata, E. nigromaculata, E. neoelegans* e *E. spiculata)* são descritas. As genitálias do macho das mesmas são ilustradas. A genitália da fêmea de *E. spiculata* e *E. nigromaculata* são também ilustradas. Caracteres diagnósticos de cabeça, tórax e abdomen de *E. amazonensis* Rocha e Silva, 1984 são redescritos, ilustrados e associados com a descrição da genitália do macho e da fêmea descritos pela primeira vez. Uma chave inclui as espécies aqui mencionadas.
Palavras-chave: *Amazonas, Blattaria, chave, taxonomia.*

Introduction

Shelford (1908) described *Euphyllodromia* and considered it as a subgenus of *Pseudophyllodromia* Brunner, 1865, based on the morphology of the tegmen and the geographical distribution of the group. Hebard (1920) confirmed the validity of the genus and designated the type species *E. angustata* (Latreille, 1807).

Princis (1951) described six new species for Venezuela, among which was included *Euphyllodromia venezuelica* and in 1969 cited a total of 29 species for the genus in the Neotropical region, from the southwestern United States to Bolivia, with the highest incidence in the Amazon basin.

Rocha e Silva (1956) redescribed *E. peruana* (Saussure, 1864) and added other species to the genus (*E. travassosi*) making it similar to *E. albomaculata* (Shelford, 1909) and drawing on the coloration of the head, pronotum, legs and abdomen as well as the arrangement of the veins in the tegmen.

Bonfils (1975) distinguished ten species within the genus, four of which were recorded from French Guiana [*E. atropos* Rehn, 1928, *E. aurora* Rehn, 1932, *E. elegans* (Shelford, 1907) and *E. pavonacea* (Rehn, 1903)].

Rocha e Silva (1984) revised the genus and described three more species (*E. amazonensis, E. jutai* and *E. maturaca*). She also reported new occurrences of members of the genus in Peru and the Brazilian Amazon basin.

Ramirez Pérez (1993), in a revision of the genera of Venezuelan cockroaches, presented a key to the known species and described three new species: *E. fernandezi*, *E. osunai* and *E. cerdai*.

Lopes et al. (2007) described a new species (*E. rondonensis*) and reported a new occurrence for *E. jugata* Rehn, 1928, collected in a wasp nest in the state of Acre, Brazil.

Anisyutkin (2011) reviewed the genus *Euphyllodromia* and described three new species (*E. propinqua* sp. nov., *E. rasnitsyni* sp. nov. and *E. tingomariensis* sp. nov.) and a first fossil representative from the Colombian Copal (Pleistocene-Holocene) (*E.* cf. *angustata*).

Beccaloni (2012) listed thirty-four species for the genus in his catalog on the internet.

Currently, the genus includes thirty-seven species. It is a neotropical genus and in Brazil was only occurrency in the Amazon region.

Euphyllodromia is included in the family Ectobiidae, subfamily Pseudophyllodromiinae, characterized by having the phallomere hooked on the right side in dorsal view. The genus is characterized as being small in size (11 to 19 mm) having a remarkable pigmentation. Triangular head with salient eyes and small ocelli; a transverse pronotum, little-deflected lateral margins; little marked oblique groves on the disk. Developed tegmina and wings. Legs with anteroventral margin of front femur showing few spines, being stronger on the basal half, followed by a thick row of minor spines and having three strong and elongated spines on the apex; pulvilli are present only on the fourth tarsal article; simple arolia and nails.

The present paper describes and illustrates the male genitalia of five species and the female of one of these, as well as three new species from the state of Amazonas. The genitalia and some morphological characters not shown in the original description of *E. amazonensis* Rocha e Silva, 1984 are described and illustrated.

Materials and Methods

The morphology of the specimens was analyzed according to the standard techniques as described by Lopes & Oliveira (2000). The terms for the genital parts, the basic literature and the taxonomic classification were based on the concepts proposed by Roth (2003) and Beccaloni & Eggleton (2011), and the phylogenetic position referring to the subfamily Pseudophyllodromiinae drew upon Klass & Meier (2006). After analysis, the plates and the genital parts were stored in a microvial containing glycerin and together with their respective pinned specimen, a method developed by Gurney et al. (1964). They were analyzed based on the literature, and the material was deposited in the Blattaria collection of the Museu Nacional from Rio de Janeiro. The text was translated by Professor Solange Garrido and edited by Dr. Janet W. Reid.

1. *Euphyllodromia neoelegans sp. nov. (Figures 1-10)*

Etymology: From Latin "neo", new. The name refers to the similarity to *E. elegans*.

Comparison: The species is closest to *E. elegans* (Shelford, 1907), *E. jugata* Rehn, 1928 and *E. atropos* Rehn, 1928, differing from them in the coloration of the spot on the pronotum and the configuration of the styles and subgenital plate.

Description: General coloration glossy brown. Head ferruginous, lightening toward clypeus (Figure 1). Antennae dark with beige base. Palpi with slightly darker ventral region. Pronotum light-colored with blackened spot on central disk (Figure 2). Tegmina and wings with dark-brown veins. Legs yellowish brown, insertion of spines dark brown.

Dimensions (mm). Holotype ♂. Total length 13.0; pronotum length 2.5, width 4.0; tegmen length 10.0, width 2.0.

Head elongated and triangular. The vertex is shown beneath the pronotum in dorsal view. Interocular space ample, measuring about three-quarters of area between antennal sockets. Antennae long, overreaching edge of abdomen. Maxillary palpi with first and second articles small, third article equal to interocular space in size; fourth article equal to area between antennal sockets in size; fifth article dilated and tomentose, shorter than third article.

Thorax with short wide pronotum, ample lateral edges with circular outline laterally. Legs long and acute. Anteroventral margin of fore femur with three irregular spines on basal half, followed by median spine and row of small stout spines on apical half, ending in three long robust apical spines. Posteroventral margin with robust spine on apical half. Tibia spiny. Tarsus with only fourth segment showing an evident pulvillus. Nails long and simple ariolum present but little developed. Tegmen long, overreaching apex of abdomen. Marginal field slightly concave, short and well marked; slightly convex scapular field, discoidal field with longitudinal veins.

Abdomen with tergal modification on sixth segment medially concentrated in the form of a tuft of bristles (Figure 3). Supraanal plate narrow with bristles on apical edge; cerci short and tomentose (Figure 4). Subgenital plate oblong with small, slightly asymmetrical laminate styles, inserted medially on apical edge with bristles, and between the two styles is a projection with small sclerotized spines (Figure 5); left phallomere with two asymmetrical projections, one of these reduced and rounded (Figure 6); sclerite with ciliated apex (Figure 7); median sclerite acute with rounded apex (Figures 8 and 9); right phallomere hooklike (Figure 10).

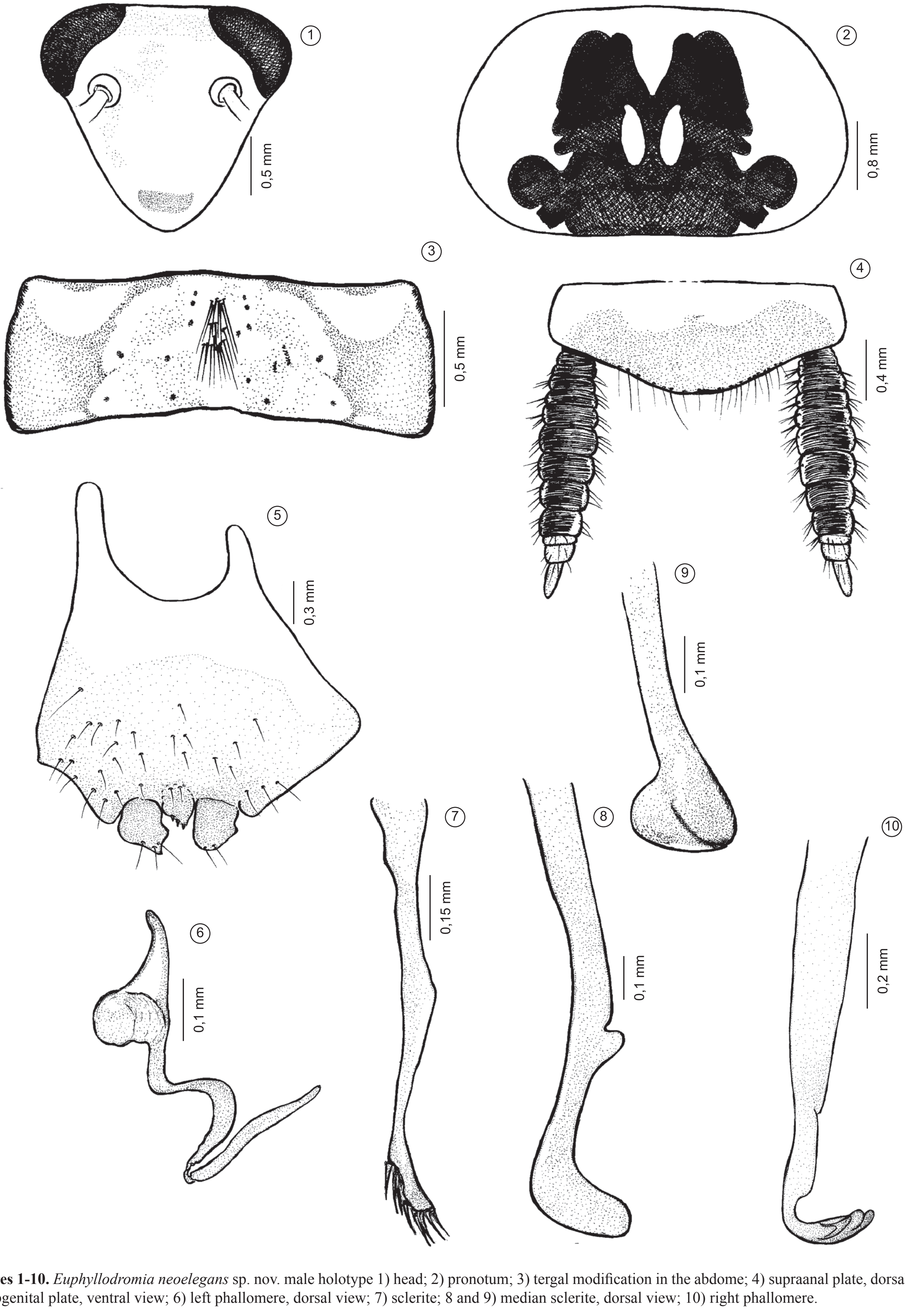
Type material: Holotype ♂. Brazil: Amazonas, Guajara, Ipixuna River, 7° 06' 39 "S and 73° 05' 25" W, 13-19/VI/1995 (in a malaise trap), P. Burnheim and N. O. Aguiar cols.

2. *Euphyllodromia nigromaculata sp. nov. (Figures 11-20)*

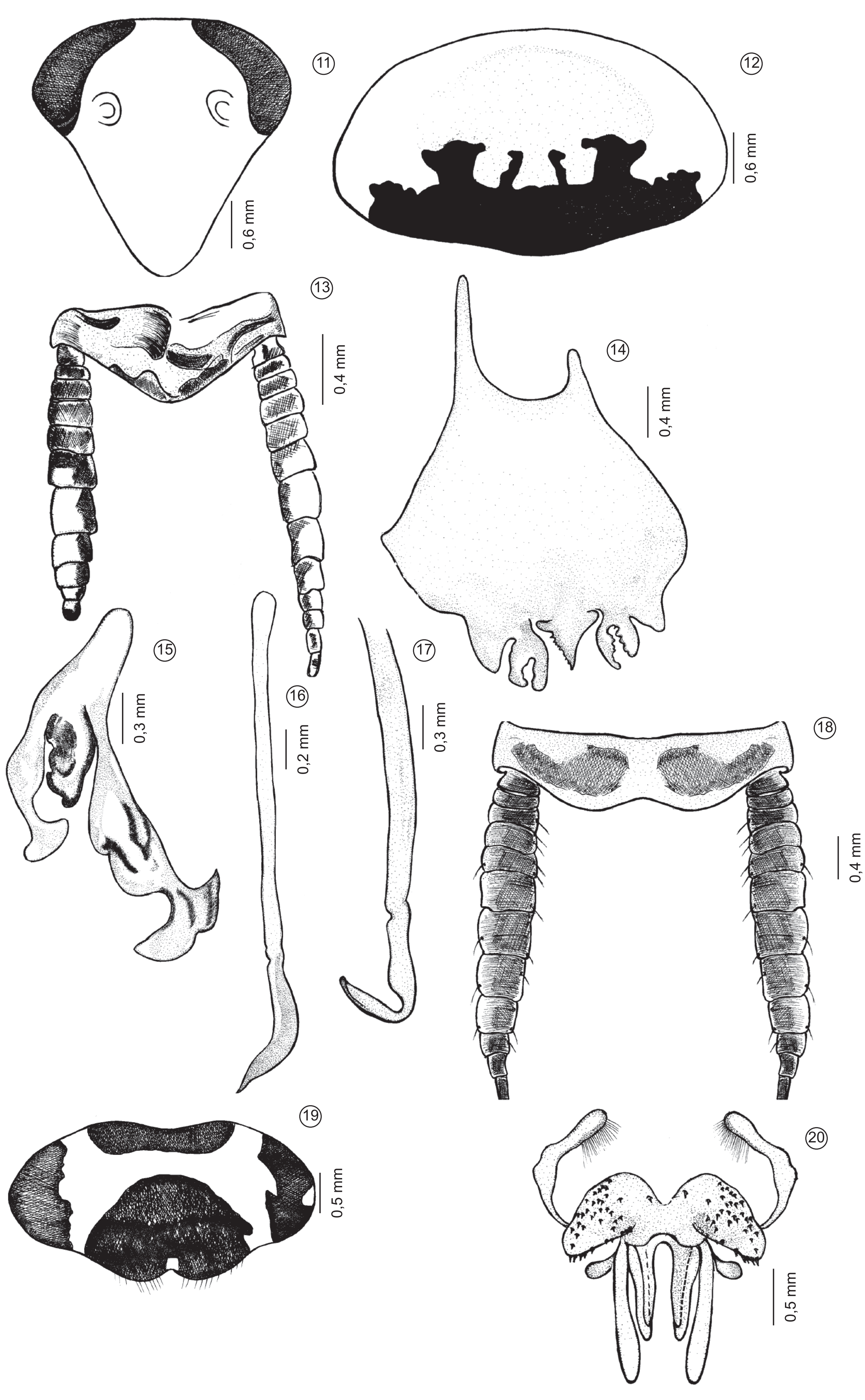
Etymology: From Latin "nigro", black; and "maculata", spot. The name refers to the coloration of the pronotum.

Comparison: Concerning the coloration of the pronotum, the species is similar to *E. chopardi* Hebard, 1921, differing from it in the configuration of the styles on the male subgenital plate.

Description: General coloration glossy brown. Head dark brown (Figure 11), lightening toward clypeus. Dark antennae with beige



Figures 1-10. *Euphyllodromia neoelegans* sp. nov. male holotype 1) head; 2) pronotum; 3) tergal modification in the abdome; 4) supraanal plate, dorsal view; 5) subgenital plate, ventral view; 6) left phallomere, dorsal view; 7) sclerite; 8 and 9) median sclerite, dorsal view; 10) right phallomere.



Figures 11-20. *Euphyllodromia nigromaculata* sp. nov.: male holotype 11) head; 12) pronotum; 13) supraanal plate, dorsal view; 14) subgenital plate, ventral view; 15) left phallomere, dorsal view; 16) median sclerite, dorsal view; 17) right phallomere, dorsal view; female paratype 18) supraanal plate, dorsal view; 19) subgenital plate, ventral view; 20) valves, dorsal view.

base. Pronotum with compact darkened spot on basal half (Figure 12). Tegmina and wings with dark-brown veins. Yellowish-brown legs, with insertion of spines dark brown.

Dimensions (mm). Holotype: ♂. Total length 15.0; pronotum length 2.5, width 4.5; tegmen length 13.0, width 3.2

Head triangular and elongated. The vertex is shown beneath the pronotum in dorsal view. Interocular space measures about half distance between base of antennal sockets. Antennae long, overreaching edge of abdomen. Maxillary palpi with first and second articles small, third article equal to interocular space in size, fourth article equal to area between antennal sockets in size; fifth article dilated and tomentose, shorter than third article.

Thorax with short elongated pronotum, ample with lateral edge having circular lateral outline. Legs long and acute. Fore femur displays three irregular spines on basal half of anteroventral margin, followed by row of small and stout spines on apical half, ending in three long robust apical spines that increase in length. Posteroventral margin with robust spine on apical half. Tibia spiny. Tarsus with only fourth segment showing an evident pulvillus. Long and simple nails with present, but little-developed arolium. Tegmen long, overreaching apex of abdomen. Marginal field slightly concave, short and well marked; slightly convex scapular field, discoidal field with longitudinal veins.

Abdomen with tergal modification on sixth segment, medially concentrated in the form of a row of symmetrical bristles. Supraanal plate narrow, triangular and projecting between the cerci (Figure 13); oblong subgenital plate bearing lateral projections externally to styles, and median projections between triangular styles, tapering apically with row of 10-11 small spines on left margin, styles spatular and cleaved medio-apically (Figure 14); left phallomere with two apically differentiated, wide arms with sclerotized median structure (Figure 15); median sclerite acute, apically, in the form of a spiniform sickle (Figure 16); right phallomere hook-shaped with preapical incisions (Figure 17).

Dimensions (mm): Paratype: ♀. Total length 19.0; pronotum length 3.0, width 4.0; tegmen length 12.5, width 3.0.

Female – Differs from male in having narrow supra-anal plate with slight medial incision apically between the cerci. Cerci long and wide (Figure 18). Subgenital plate ample, with slight medial incision apically (Figure 19). Valve complex developed, first pair of valves well developed, second and third pairs differing little in size and shape (Figure 20).

Type Material: Holotype ♂. Brazil: Amazonas, Coari, Urucu River LUC-18, 4° 53’ 53” S/ 65° 11’ 58” W, 19/II-01/III/1993, P. Bührnheim et al. col.; Paratype ♂, same data, RUC-36, 4° 55’ 53” S/ 65° 18’ 13” W, 25/II-10/III/1995, P. Bührnheim et al. col.; Paratype ♂, same data, Petrobrás RUC-29, 5-10/II/1992, P. Bührnheim, N.O. Aguiar & N. Fé cols.; Paratype ♂, same data, LUC-09, 4° 51’ 56” S/65° 04’ 56” W, 25/I-10/II/1995, P. Bührnheim et al. col.; paratype: ♀, same data, IMT-1, 4° 49’ 33” S/65° 01’ 49” W, 17-29/IX/1995, P. Bührnheim & N.O. Aguiar cols. (in a Shannon trap).

3. *Euphyllodromia spathulata sp. nov. (Figures 21-28)*

Etymology: From Latin “spatha”, spatula and “latum”, wide. The name refers to the configuration of the styles on the subgenital plate.

Comparison: The species is closest to *E. elegans,* differing from the latter in the coloration on the pronotum and the configuration of the styles and subgenital plate.

Description: General coloration glossy brown. Head ferruginous, lightening toward clypeus (Figure 21). Eyes grayish with brown border. Antenna dark with whitish base. Palpi with darker ventral region. Pronotum with blackened spots on central disk (Figure 22). Tegmina and wings with dark-brown veins. Legs yellowish brown with brown insertion of spines.

Dimensions (mm). Holotype ♂. Total length 11.0; pronotum length 2.0, width 3.5; tegmen length 9.0, width 2.2.

Head elongated and triangular. The vertex is shown beneath the pronotum in dorsal view. Interocular space ample, measuring about three-quarters of area between antennal sockets. Antennae long, overreaching edge of abdomen. Maxillary palpi with first and second articles small; third article three-quarters as large as interocular space; fourth article three-quarters as large as area between antennal sockets; fifth article dilated and tomentose, shorter than third segment.

Thorax with short wide pronotum, lateral margins ample with circular lateral outline. Tegmen long, overreaching apex of abdomen. Marginal field slightly concave, short and well marked; slightly convex scapular field; discoidal field with longitudinal veins. Legs long and acute. Fore femur with three spines on basal half of anteroventral margin, followed by row of small stout spines on apical half, ending in three increasingly long and robust apical spines. Posteroventral margin with one robust spine on apical half. Tibia spiny. Tarsus with only fourth segment showing pulvilli. Nails long and simple, with little-developed arolium.

Abdomen with tergal modification on sixth segment medially concentrated in the form of a row of symmetrical bristles (Figure 23). Supraanal plate subtriangular with slight median apical projection (Figure 24). Subgenital plate oblong with short spatular styles, showing between the styles a large projection on the base which tapers toward the apex and has seven spines on the left margin (Figure 25). Left phallomere with arms differing in size and shape, (Figure 26). Sclerite apically acute, with spinelike bristles (Figure 27). Median sclerite tapering, spatulate apically (Figure 28).

Type Material: Holotype ♂. Brazil: Amazonas, Manaus, Estrada AM 010, Km 64, 29/VII/1970, A. Faustino col.; Paratype ♀. Rondônia, Ouro Preto, X/1980, A. C. Domingos col.

4. *Euphyllodromia spiculata sp. nov. (Figures 29-41)*

Etymology: From Latin “spicula”, spine. The name refers to the apical spinelike bristles on the sclerite.

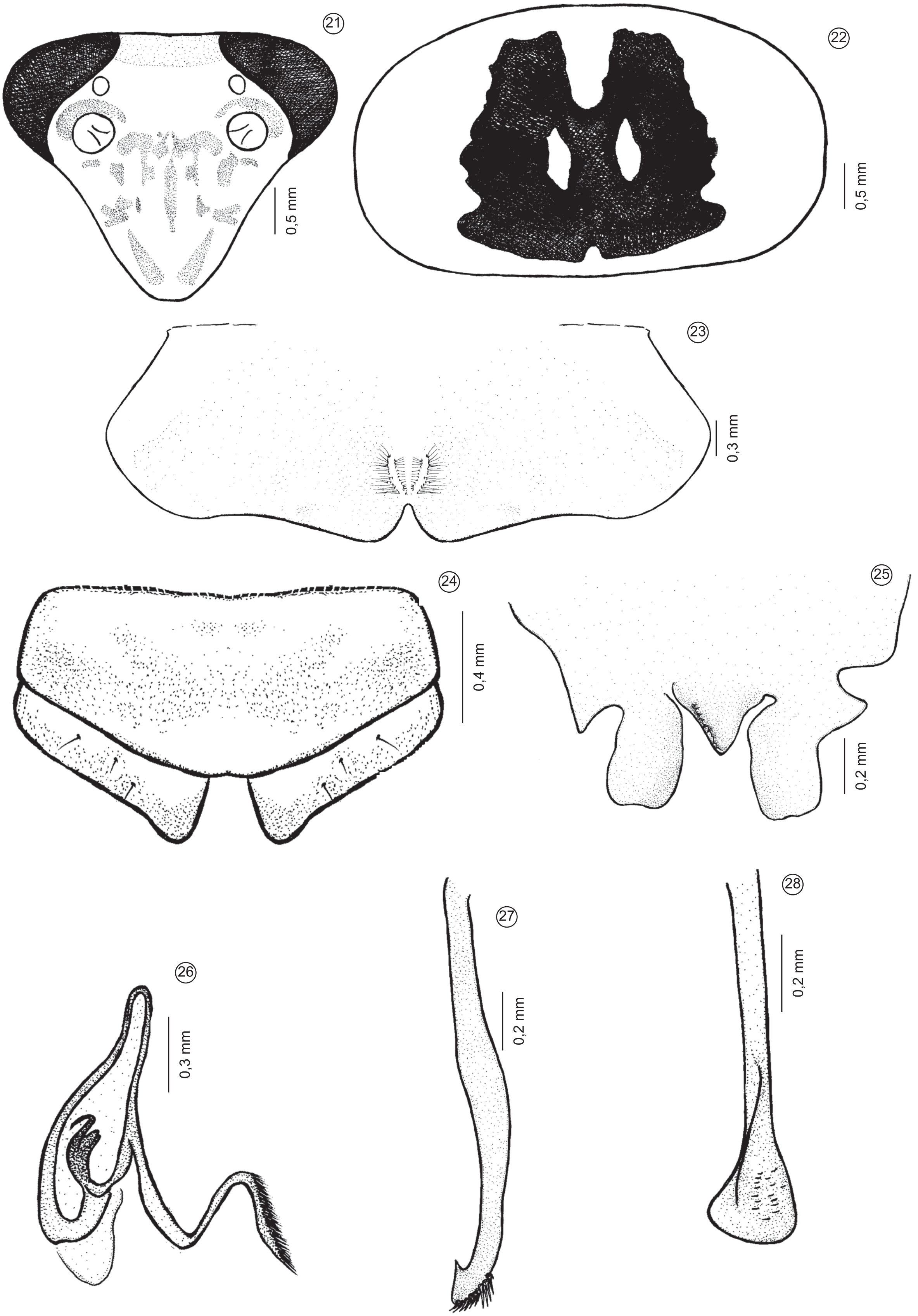
Comparison: The species is similar to *E. variegata* (Walker, 1868) in the coloration of the pronotum, differing from it in the configuration of the supra-anal and subgenital plates and the styles.

Description: General coloration glossy brown. Head brown, yellowish-light brown vertex with four dark-brown, narrow longitudinal stripes (Figure 29). Dark-brown pronotum with two white, longitudinal stripes converging toward apex (Figure 30). Dark eyes with brown outline. Dark-brown antenna with brown base. Yellowish-brown palpi. Tegmina and wings with dark-brown veins and white stripes. Brown legs with dark-brown insertion of spines.

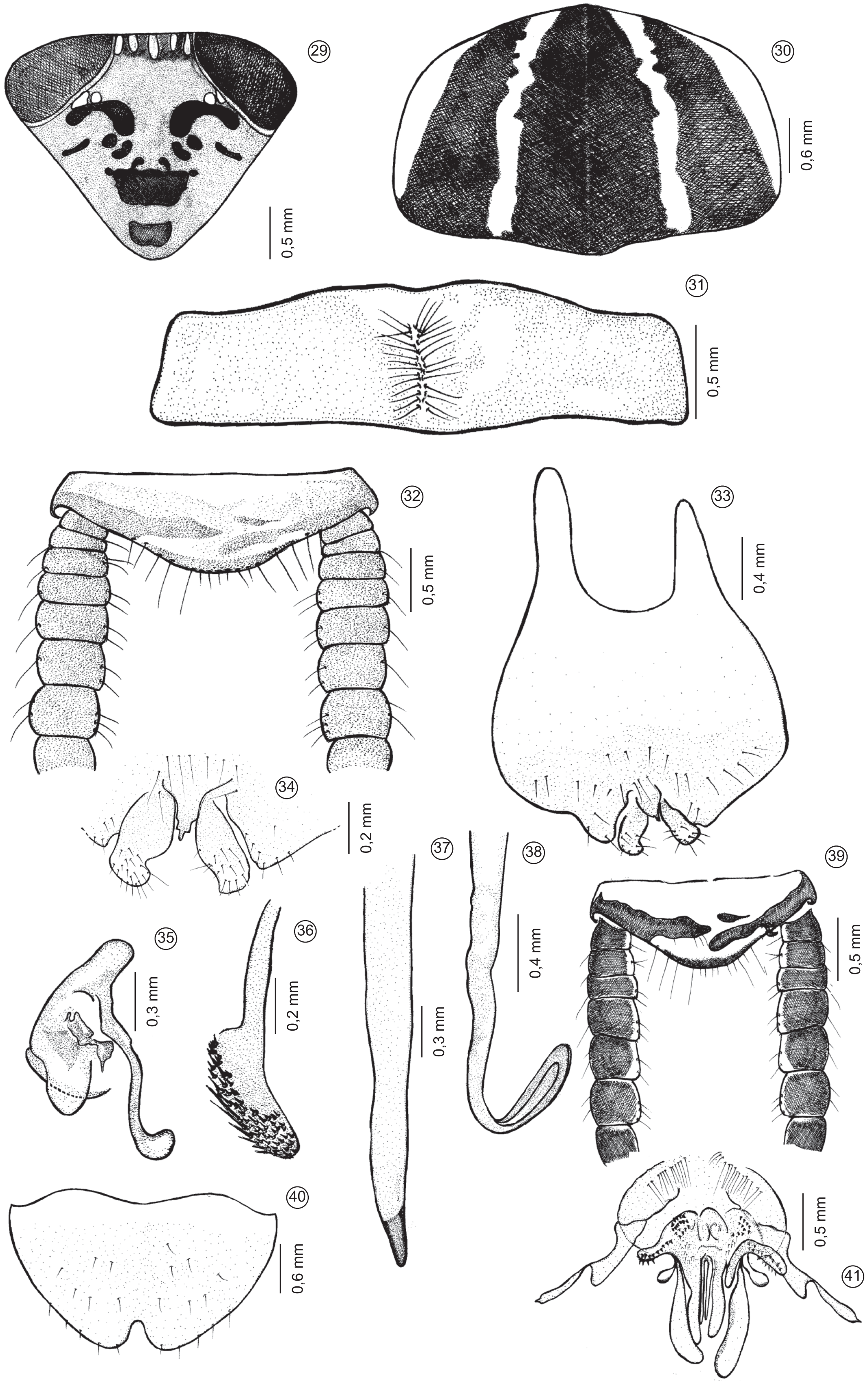
Dimensions (mm). Holotype ♂. Total length 12.0; pronotum length 2.3, width 3.8; tegmen length 9.5, width 2.5.

Head triangular and elongated. The vertex is shown beneath the pronotum in dorsal view. Interocular space ample, measuring about four-fifths of area between antennal sockets. Maxillary palpi with first and second articles small; third and fourth article tomentose and equal to three-quarters of interocular space in size; fifth article dilated and tomentose, shorter than third article.

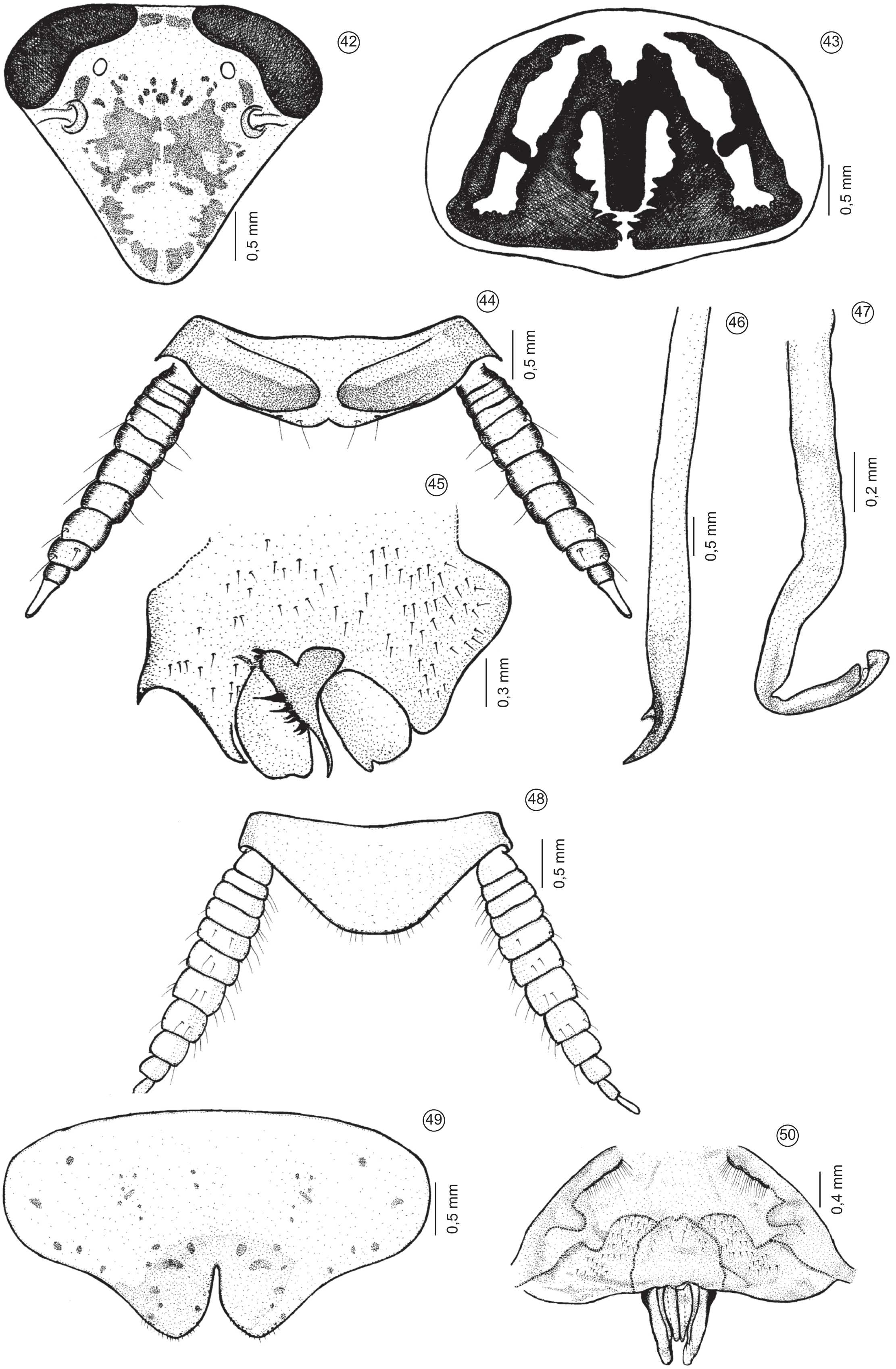
Thorax with short wide pronotum, lateral edges ample with circular lateral outline. Tegmen long, overreaching apex of abdomen. Marginal field slightly concave, short and well-marked; slightly convex scapular field; discoidal field with longitudinal veins. Legs long and acute. Fore femur with about three irregular spines on basal half of anteroventral margin, followed by three spines and a row of small stout spines on apical half, ending in three increasingly long and robust spines on apex. Posteroventral margin with robust spine on apical half. Tibia spiny. Tarsus with only fourth segment showing tiny pulvilli. Nails long and simple with little-developed arolium.



Figures 21-28. *Euphyllodromia spathulata* sp. nov. male holotype 21) head; 22) pronotum; 23) tergal modification in the abdomen; 24) supraanal, plate, dorsal view; 25) subgenital plate, ventral view; 26) left phallomere, dorsal view; 27) sclerite, dorsal view; 28) median sclerite, dorsal view.



Figures 29-41. *Euphyllodromia spiculata* sp. nov. male holotype 29) head; 30) pronotum; 31) tergal modification in the abdomen; 32) supraanal plate, dorsal view; 33) subgenital plate, ventral view; 34) styles on subgenital plate, ventral view; 35) left phallomere, dorsal view; 36) sclerite, dorsal view; 37) median sclerite, dorsal view; 38) right phallomere, dorsal view; paratype female 39) supra-anal plate, dorsal view; 40) subgenital plate, ventral view; 41) valves, dorsal view.



Figures 42-50. *Euphyllodromia amazonensis* Rocha e Silva, 1984: male holotype 42) head; 43) pronotum; 44) supraanal plate, dorsal view; 45) subgenital plate, ventral view; 46) median sclerite, dorsal view; 47) right phallomere, dorsal view; female paratype 48) supra anal plate, dorsal view; 49) subgenital plate, dorsal view; 50) valves, dorsal view.

Abdomen with tergal modification on sixth segment, medially concentrated in the form of a row of symmetrical bristles (Figure 31). Supraanal plate triangular, slightly projecting between cerci, which are tomentose and widened (Figure 32). Subgenital plate with small laminar styles, between them a small and acute projection toward the apex and with strongly sclerotized spines on left margin (Figures 33 and 34). Left phallomere with two asymmetrical arms, one of them larger and rounded and the other reduced; sclerotized median structure (Figure 35); sclerite acute, its apex with several rows of bristles along margin (Figure 36); median sclerite acute, with a more evident spine-like apex (Figure 37); right phallomere hook-shaped with prominent preapical incision (Figure 38).

Dimensions (mm): Paratype ♀. Total length 12.4; pronotum length 2.64, width 3.65; tegmen length 9.2, width 2.58.

Female with triangular supraanal plate with apex projecting between cerci, which are wide and long (Figure 39); subgenital plate ample, split median-apically (Figure 40); valve complex developed; first pair of valves larger than other two pairs; second pair of valves larger and wider than third pair (Figure 41).

Type Material: Holotype ♂. Brazil: Amazonas, Manaus, Est. AM 1, Km 134, 10/VIII/1968, collector unnamed; paratype ♂ same data as holotype; paratype ♀ same data as holotype, Km 135, collector unnamed.

5. *Euphyllodromia amazonensis Rocha & Silva, 1984 (Figures 42-50)*

Diagnosis: In this contribution, we provide illustrations of the head (Figure 42), pronotum (Figure 43), supraanal plate (Figure 44) and subgenital plate (Figure 45),

Type information: Holotype ♂, Brazil: Amazonas, Jutaí, no date and collector;

Description: According to Rocha e Silva (1984), *E. amazonensis* is closest to *E. literata* (Burmeister, 1838) in the coloration of the head and pronotum, differing from it in details of coloration and in the male subgenital plate, which has large and spiny styles. We add information on the male and female genitalia to the description.

Male: Median sclerite is sharpened like a spine showing a small pre-apical spine (Figure 46); the right phallomere is hook-shaped with a pre-apical incision (Figure 47).

Female: Supraanal plate well-marked between the cerci. Cerci are long and wide (Figure 48); subgenital plate ample, having a well-marked median-apical incision (Figure 49). First pair of valves is developed, and the second and third pairs are similar in size and shape (Figure 50).

Type Material: Paratype: ♂ Amazonas, Manaus, Parko col., 1941; Paratype: ♀ Reserva Ducke, IV/1966, H. Schubart col.; Paratype: ♀ Laurete, VI/1949, Carvalho col.; Paratype ♀ Manaus, 17/XI/1962, Bechyné col.; Paratype: ♀ Manaus, Reserva Ducke, 03/V/1968 E.V. Silva & A. Faustino cols; Paratype: ♂ Manaus, Reserva Ducke, 15/I/1978, O. Rodrigues & A. Soares cols.

Key for the males of the species included here:

1.Pronotum with longitudinal stripes converging toward the apex (Figure 43) 2

Pronotum with spot on the basal half (Figure 12)........................... 3

2(1).Ferruginous head; spines present on the left interstylar projection; interstylar projection with spines; interstylar formation subequal in size to the styles (Figure 45)..........*E. amazonensis* Rocha e Silva, 1984

Brown to dark-brown head; spines present on the interstylar projection; interstylar formation smaller than the styles (Figures 33 and 34)..*E. spiculata* sp. nov.

3(1).Ferruginous head; extended styles 4

Brown to dark-brown head; forked styles (Figure 14)......*E. nigromaculata* sp. nov.

4(3).Round interstylar projection (Figure 5).......*E. neoelegans* sp. nov.

Acute interstylar projection (Figure 25)..............*E. spathulata* sp. nov.

Conclusion

For correct identification of the genus *Euphyllodromia* is necessary to identify the structures of the male genitalia, and colours characters are unreliable, because they may indicate intraspecific variation.

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Reproductive biology of *Synallaxis albescens* (Aves: Furnariidae) in the cerrado of central Brazil

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Abstract: Understanding the causes and consequences of variation in reproductive strategies is a central theme in studies of avian life history evolution. This study describes the reproductive biology of *Synallaxis albescens* (Furnariidae) in the cerrado biome of central Brazil. We monitored 35 nests during the 2003 to 2011 breeding seasons, visiting them every 2-4 days. *Synallaxis albescens* breeds from mid-September to mid-January, builds a retort-shaped nest, and generally lays three immaculate white eggs. Eggs weighed 1.75 g and measured 19.7 by 14.4 mm. Most nests studied were in open cerrado or shrub grassland at an average height above the ground of 0.3 m, with a preference for *Davilla elliptica* (Dilleniaceae) shrubs as a nesting substrate. Incubation period averaged 18.1 days, while the nestling period averaged 13.6 days. Of 16 closely monitored nests, four were successful (25%), 11 were depredated (69%), and one was abandoned. Predation was similar during incubation (45%) and nestling (55%) phases. In general, the breeding biology of *S. albescens* was similar to that described previously for this species and for related Furnariidae.
Keywords: *nests, eggs, reproduction, reproductive success.*

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Resumo: Um tema central em estudos acerca da evolução da história de vida de aves é o entendimento das causas e conseqüências da variação em estratégias reprodutivas. O presente estudo descreve a biologia reprodutiva de *Synallaxis albescens* (Furnariidae) no bioma cerrado do Brasil central. Nós monitoramos 35 ninhos durantes as estações reprodutivas de 2003 a 2011, visitando-os a cada 2-4 dias. *Synallaxis albescens* se reproduz da metade de setembro a metade de janeiro, constrói ninho em forma de retorta e geralmente coloca três ovos brancos. Os ovos apresentaram peso de 1,75g e medidas de 19,7 por 14,4 mm. A maior parte dos ninhos estudados estava em Campo sujo e Cerrado ralo a uma altura média, em relação ao solo, de 0.3 m, com uma preferência por arbustos de *Davilla elliptica* (Dilleniaceae) como substrato para os ninhos. O período de incubação durou em média 18,1 dias, enquanto o período de permanência dos ninhegos durou em média 13,6 dias. Dos 16 ninhos monitorados, quatro obtiveram sucesso (25%), 11 foram predados (69%) e um foi abandonado. A predação foi semelhante durante a fase de incubação (45%) e durante a fase de cuidado dos ninhegos (55%). Em geral, a biologia reprodutiva de *S. albescens* foi similar ao descrito previamente na literatura para esta espécie, bem como para Furnariidae relacionados.
Palavras-chave: *ninhos, ovos, reprodução, sucesso reprodutivo.*

Introduction

Understanding the evolution of life history strategies is a central theme in ecology (Roff 1992, Stearns 1992, Ricklefs & Wikelski 2002), particularly with birds (Ricklefs 1977, Martin 1987). Yet despite the fact that avian reproductive strategies provide model systems for developing evolutionary hypotheses (Martin 1995, 1996), testing phylogenetic relationships (Sheldon & Winkler 1999, Zyskowski & Prum 1999, Miller & Greeney 2008), and developing sound conservation measures (Boyce 1992, Reed et al. 1998), we still know little about the basic reproductive biology of most tropical birds (Stutchbury & Morton 2001) including Furnariidae (Remsen Junior 2003).

The genus *Synallaxis* includes 35 species of small furnariids (Passeriformes) which are distributed throughout Central and South America (Remsen Junior et al. 2012). *Synallaxis* spp. build large, bulky nests of twigs with an inner chamber lined with various soft materials and entered through a lateral tunnel (Vaurie 1980, Skutch 1996, Zyskowski & Prum 1999, Remsen Junior 2003). *Synallaxis albescens* Temminck, 1823 is one of four *Synallaxis* species found in the Distrito Federal of central Brazil (Negret et al. 1984), where it inhabits open, sunny habitats such as campo cerrado (Vaurie 1980, Sick 1997, Fontana et al. 2003). Despite the fact that it is common within this part of its range (Negret et al. 1984), nothing has been published on its natural history in cerrado habitat, with most information derived from studies in other parts of its' range (Cruz & Andrews 1989, Skutch 1996, Mezquida 2001). Here we describe the reproductive biology of *S. albescens* from the Brazilian cerrado, including seasonality, reproductive success, and nesting habitat.

Materials and Methods

We conducted our studies in the 10,500 ha reserve, Estação Ecológica de Águas Emendadas (ESECAE), Distrito Federal, Brazil (15°29'12"- 15°36'57" S and 47°31'36"- 47°41'19" W). Habitat in the reserve includes several cerrado vegetation types such as cerrado *sensu stricto*, shrub grassland, open cerrado and gallery forest (Silva Junior & Felfili 1996). The Cerrado covers around 22% of Brazil's land surface (approximately 1.8 million km^2 *sensu* Smith 1998), is the second largest biome of South America (Ribeiro & Walter 1998), and is the largest and most threatened tropical savanna in the world (Silva & Bates 2002). It is the third richest Biome in bird species in the country, with 837 species (4.3% endemic) (Cavalcanti 1999).

Data were collected from November 2003 to November 2011 in a demarcated area of 100 ha (1 km × 1 km) and around it. We searched for nests by systematically inspecting the vegetation and by following the adults who showed evidence of reproductive activity (i.e., carrying material or food). After their initial discovery, we visited nests at intervals of 3-4 days, increasing visits to every 2 days during periods of expected laying, hatching, or fledging. At each visit we recorded the status (active, inactive) and contents (empty, eggs, nestlings). If a nest was encountered empty before the expected fledge date we described any evidence of predation or other disturbance. We considered nests successful when at least one of the chicks left the nest. If a nest was found empty after the minimum period for potential fledging and there was no evidence of predation we considered it successful. We considered as depredated those nests found intact but empty well before conclusion of the breeding cycle, those nests totally or partially destroyed on the ground or in situ, and those found with destroyed (or damaged) eggs or chicks killed by physical harm (i.e., not simply abandoned).

At accessible nests we recorded three external measurements (cm) of nest architecture: the diameter of the main chamber, height of the main chamber, and length of the lateral entrance tube. We measured the maximum length and width of eggs to the nearest 0.1 mm using calipers with 0.05 mm precision and weighed them to the nearest 0.1 g using a scale accurate to 0.01 g.

We define the incubation period as that between the last egg laying and hatching of the first, without considering the laying period. This was done since the only evidence of hatching patterns among Furnariidae is that eggs of the Rufous Hornero (*Furnarius rufus* Gmelin, 1788) hatch asynchronously (Remsen Junior 2003). We define the nestling period as the time between hatching of the first egg to fledging of the last chick from the nest (Robinson et al. 2000). All means are reported with ± SD (standard deviation). We did not examine choice of nesting habitat, but only nesting habitat since we did not search equally for this species in all habitats. We considered all active and inactive nests found in the study area, including those found during construction but for which we did not observe a breeding attempt. We included in the analyses inactive nests since this is the only *Synallaxis* breeding in the study area and there is nothing known if *Synallaxis* builds dormitory-nests. At each nest we measured the height of each nest above ground (m) with the aid of measuring tape. Nest plants were identified in the field or by comparison with plants from the herbarium at the Universidade de Brasília. Plant taxonomy follows Silva Junior (2005).

Results and Discussion

We found 35 *S. albescens* nests between 2003 and 2011. Despite year-round observations we recorded reproductive activity from September to January, including both the discovery of active nests and indirect evidence such as brood patches in adults. Extrapolating from these data we estimate that the earliest nesting attempts occurred during the last week of September (n = 2, both during 2009 breeding season) when we registered the first egg laying and we estimate that the latest fledging occurred during the first week of January. We did not observe adults caught with mist-nets in reproductive condition after the last week of January. We captured six juveniles from November to March. In Argentina, *S. albescens* nests from November to March (Narosky et al. 1983, De la Peña 2005) later than at our study site. Strong nesting seasonality correlated with the rainy season has been documented for *S. albescens* in other parts of its range (Venezuela: Cruz & Andrews 1989, Argentina: Mezquida 2001). Not surprisingly, breeding in our area also agrees with a variety of other cerrado species for which data are available (Alves & Cavalcanti 1990, Marini & Durães 2001, Lopes & Marini 2005, Medeiros & Marini 2007, França & Marini 2009, Santos & Marini 2010, Duca & Marini 2011) and follows the general pattern of most neotropical species studied in habitats with strong seasonal shifts in rainfall (Marchant 1960, Ramo & Busto 1984, Cruz & Andrews 1989, Mezquida 2001, 2002).

Agreeing with previous nest descriptions for *S. albescens* (Vaurie 1980, Narosky et al. 1983, Cruz & Andrews 1989, Skutch 1996, Mezquida 2001, Fontana et al. 2003, De la Peña 2005), and following the classification of Simon & Pacheco (2005), all of the nests we observed were closed, retort-shaped masses of interwoven sticks enclosing an egg chamber entered from a lateral horizontal tube. The bottom portion of the inner chambers was lined with softer plant materials which frequently included pieces of snake skin and man-made materials (e.g., pieces of canvas, plastic tape, candy wrappers). We recorded the following measurements (see methods): external diameter 16 cm (n = 7); external height, 17 cm (n = 6); entrance tunnel length, 11 cm (n = 7), which are slightly smaller than the ones reported by De la Peña (2005). Considering the relative uniformity of nest architecture in *Synallaxis* (Zyskowski & Prum 1999, Remsen Junior 2003), it comes as no surprise that the nest of *S. albescens* is similar in form to those of its congeners (Skutch 1969, 1996, Narosky et al. 1983, Bosque & Lentino 1987, De la Peña 1987, Simon & Pacheco 1996, Sick 1997, Simon et al. 1999, Rubio & Pinho 2008, Greeney 2009). At 16 nests mean clutch size was 2.6 ± 0.6 eggs, a result similar to that of Mezquida (2001) (2.7 ± 0.3) but less than the 3 or 4 (Narosky et al. 1983, De la Peña 2005) or even 5 (Zuberbühler 1953) eggs reported for Argentina. We observed clutches of three eggs in 63% of nests (n = 10), two eggs in 31% of nests (n = 5) and found a single egg in only one nest. Eggs were white and long-oval in shape (after Podulka et al. 2004 classification). We were able to closely examine only two eggs (from the same clutch) which weighed, 1.8 ± 0.2 g and had linear measurements of 19.7 ± 0.1 by 14.4 ± 0.1 mm, similar to values reported by De la Peña (2005). However, egg masses were lighter than the ones reported for Argentina which ranged from 2.0 to 2.4 g (Narosky et al. 1983). Though our sample size was low, egg measurements appear to be slightly smaller than previously reported (Haverschmidt 1968, Ffrench 1991), but within the range reported by Narosky et al. (1983). Average incubation period was 18.1 ± 0.6 (n = 5) days and the nestling period lasted 13.6 ± 2.9 (n = 4) days, generally agreeing with other reports for this species (Ffrench 1991). In Argentina, De la Peña (2005) reported a 15-16 days of incubation period and 15 days of nestling period. Skutch (1996) reported that both parents incubate for 15-16 days. There also appears to be some variation in egg coloration within *S. albescens*. Reports from the southern portion of its range (De la Peña 1987, 2005, Mezquida 2001) describe eggs as greenish white, while in other areas they are described as immaculate white (Haverschmidt 1968, Ffrench 1991, this study). It remains to be seen to what extent color varies geographically for this species. A clutch of 2-3 eggs appears normal for the species throughout its range (Haverschmidt 1968, De la Peña 1987, Ffrench 1991, Skutch 1996, Geffen & Yom-Tov 2000, Mezquida 2001), similar to most congeners (Remsen Junior 2003), but smaller than in Argentina (Narosky et al. 1983, De la Peña 2005).

Nests were built at an average height of 0.3 ± 0.2 m (n = 30) above the ground, much lower than in Argentina (Narosky et al. 1983, Mezquida 2001, De la Peña 2005) and elsewhere in its range where it nests from 0.5 to 9 m (Skutch 1996). The shrub *Davilla elliptica* St. Hil. (Dilleniaceae) was the most commonly used substrate (44%; n = 15). Five nests were built in grass clumps, four in different species of shrubs and over 10 in unidentified plant support. There are studies reporting preference of *S. albescens* by certain plants (Mezquida 2001, Fontana et al. 2003) as we found. The relative abundance of *D. elliptica* in our study area is 0.7% (Silva Junior & Felfili, 1996), suggesting that the nests are being built at that plant with much more frequency than predicted by their availability in the environment, suggesting *S. albescens* would be classified as selective in their choice of substrate following the classification of Johnson (1980). We found nests in all four of the available vegetation types: grassland, shrub grassland, open cerrado and sparse savannah park. However, we found most nests in shrub grassland (42.9%) and open cerrado (34.3%), with the remainder in park savannah (14.3%) and grassland (8.6%).

Of 16 nests which were monitored closely, 11 (69%)were depredated, four fledged (25%), and one was abandoned during incubation (6%). Additionally, one nest failed due to interference from the observer and one was collected during incubation. *Synallaxis brachyura* (Lafresnaye, 1843) from Costa Rica also fledged young from only 23% of the nests (Skutch 1996). Predation has been indicated as the main factor in brood loss for several species of tropical regions (Aguilar et al. 1999, Stutchbury & Morton 2001, Rubio & Pinho 2008, Duca & Marini 2011). Of the total nests depredated, 45% were in egg stage and 55% at the nestling stage. Predation rates are often highest during the nestling phase because, in general, at this stage predators are guided by the movement of adults to feed the chicks (Slagsvold 1982). Straneck (1999) suggested that the begging call of *S. albescens* nestlings mimics the mechanical sound of the rattlesnake to avoid predation.

This study is the first to detail several aspects of the reproduction of this species in the cerrado environment. It revealed some different breeding aspects, such as nest size and placement, egg color, compared to other populations. In addition it improves the knowledge of breeding of birds in the cerrado, a region in face of rapid and wide transformation.

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Life history of three catfish species (Siluriformes: Ariidae) from southeastern Brazil

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Abstract: This study evaluated the spatio-temporal distribution, reproduction and diet of the catfishes *Genidens genidens*, *G. barbus* and *Aspistor luniscutis* in Caraguatatuba Bay. Their sizes were recorded and the sex and reproductive stage identified. The abundance was compared between areas (South and North) and among months (August 2003 - October 2004). The species had different spatial distributions, allowing them to coexist. The temporal distribution reflected their tendencies to migrate in the reproductive period, as evidenced by the dominance of small immature individuals in the bay. *G. genidens* tended to reproduce in winter, and *A. luniscutis* in spring. The diet of *G. genidens* consisted of crustaceans, mollusks (shells), fish scales, ostracods, and bivalve siphons. *G. barbus* consumed a high proportion of mysids, followed by fish (bones and scales). For *A. luniscutis*, the diet was based on fish scales and crustaceans. High quantities of particulate organic matter were observed in the diet of all three species, as previously known for estuarine catfishes. The consumption of fish scales may reflect a lepidophagic habit. A small overlap was observed among the diets, reflecting differences in their environments as well as in the proportions of each item ingested.

Keywords: *spatio-temporal distribution, diet, Genidens genidens, Genidens barbus, Aspistor luniscutis, Caraguatatuba Bay.*

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Resumo: Este estudo teve como objetivo avaliar a distribuição espaço-temporal, reprodução e dieta dos bagres *Genidens genidens*, *G. barbus* e *Aspistor luniscutis* na Enseada de Caraguatatuba. Seus tamanhos foram registrados e o sexo e o estágio reprodutivo identificados. A abundância foi comparada entre areas (sul e norte) e entre meses (agosto/2003 a outubro/2004). As espécies tiveram distribuições espaciais distintas, permitindo sua coexistência. A distribuição temporal reflete sua tendência por migrar no períoo reprodutivo, evidenciado pela dominância de indivíduos pequenos e imaturos na enseada. Houve uma tendência de *G. genidens* reproduzir no inverno e *A. luniscutis* na primavera. *G. genidens* teve sua dieta constituida de crustáceos, moluscos (conchas), escamas de peixes, ostrácodes e sifões de bivalves. *G. barbus* revelou uma grande dominância por misidáceos, seguido por peixes (ossos e escamas). Para *A. luniscutis*, a dieta foi baseada em escamas de peixes e crustáceos. Grande quantidade de material orgânico particulado foi observado na dieta das espécies, como já conhecido para bagres estuarinos. O consumo de escamas de peixes pode refletir um hábito lepdofágico. Pequena sobreposição na dieta foi observada entre as espécies, refletindo distinções no ambiente como também nas proporções ingeridas de cada item.

Palavras-chave: *distribuição espaço-temporal, dieta, Genidens genidens, Genidens barbus, Aspistor luniscutis, Enseada de Caraguatatuba.*

Introduction

The family Ariidae includes the catfishes, marine and brackish water leather fishes (Figueiredo & Menezes 1978). The family has a wide distribution in tropical and temperate waters, and its members occur near the coast, in estuaries and inland waters; few are strictly marine (Marceniuk & Menezes 2007). The catfishes seek out river mouths and lagoons during the spawning period (Figueiredo & Menezes 1978). They have a wide feeding spectrum, which may vary during their ontogenetic development, with the diet mostly constituted of detritus, decapods, fish, polychaetes and bivalves (Espírito Santo & Isaac 1999). The reproduction occurs normally, in the warmer months of the year or during the rainy period, when there is a major uptake from rivers (Mazzoni et al. 2000, Gomes & Araújo 2004, Fávaro et al. 2005).

Genidens genidens occurs in South America, from Brazil to Argentina (Marceniuk & Menezes 2007). It is one of the most common catfishes of the Brazilian coast and is found in large numbers in estuaries and lagoons (Figueiredo & Menezes 1978). It may reach 35 cm in total length (Figueiredo & Menezes 1978, Marceniuk & Menezes 2007). Of the three species studied here, G. genidens is the most studied with respect to several aspects, including distribution (Mishima & Tanji 1981, Azevedo et al. 1999), diet (Mishima & Tanji 1982, Araújo 1984, Chaves & Vendel 1996, Rabitto & Abilhôa 1999), reproduction (Barbieri et al. 1992, Gomes et al. 1999, Mazzoni et al. 2000) and fisheries (Reis 1986).

Genidens barbus occurs over the same range as *G. genidens*, in Brazil, Uruguay and Argentina (Marceniuk & Menezes 2007). It is predominantly marine, but may occur also in brackish waters (Marceniuk & Menezes 2007), where it migrates in the period prior to spawning (Figueiredo & Menezes 1978). It is one of the largest (up to 1 m in total length) and most common catfishes of the Brazilian coast and feeds on molluscs, crustaceans and other benthic invertebrates (Figueiredo & Menezes 1978). Very little is known about its biology apart from a few records of its diet (Mishima & Tanji 1982, Araújo 1984), age, growth, reproduction (Reis 1986) and distribution (Azevedo et al. 1999).

Aspistor luniscutis occurs along the eastern coast of South America from the Guianas to Brazil, and may reach a maximum length of 1.2 m (Figueiredo & Menezes 1978). Like the other species, it occupies marine and brackish environments (Marceniuk & Menezes 2007). Knowledge about this species is also very sparse (Mishima & Tanji 1982, Azevedo et al. 1999).

Caraguatatuba Bay is a sheltered area influenced by a small estuary on the Brazilian southeast coast, and little information on its ichthyofauna is available. This bay receives constant continental freshwater input, making it an appropriate environment for catfishes (Figueiredo & Menezes 1978). Besides the three species mentioned here, the madamango sea catfish *Cathorops spixii* is the most numerous species recorded for the area (Santos et al., unpublished data). In view of the great diversity of fishes in the region (Santos et al., unpublished data) and the significant human impacts on this bay, the present study is the result of a pioneer effort to evaluate the fish fauna of this environment, generating a basis for its management in terms of biodiversity and fisheries.

The present study describes the spatio-temporal distribution, size-class distribution, reproductive aspects, and diets of the catfishes *Genidens genidens*, *Genidens barbus* and *Aspistor luniscutis* from Caraguatatuba Bay.

Materials and Methods

1. *Study area*

Caraguatatuba Bay (23° 37’ S to 23° 44’ S and 45° 24’ W to 45° 26’ W) has a total shoreline of about 16 km, with several sandy beaches (Enseada, Flecheiras, Porto Novo, Romance, Palmeiras, Pan-Brasil, Indaiá, Centro and Camaroeiros; Figure 1).

Two areas with 2 × 2 km each, homogeneous but differing from each other, were selected for this study (Figure 1). These areas

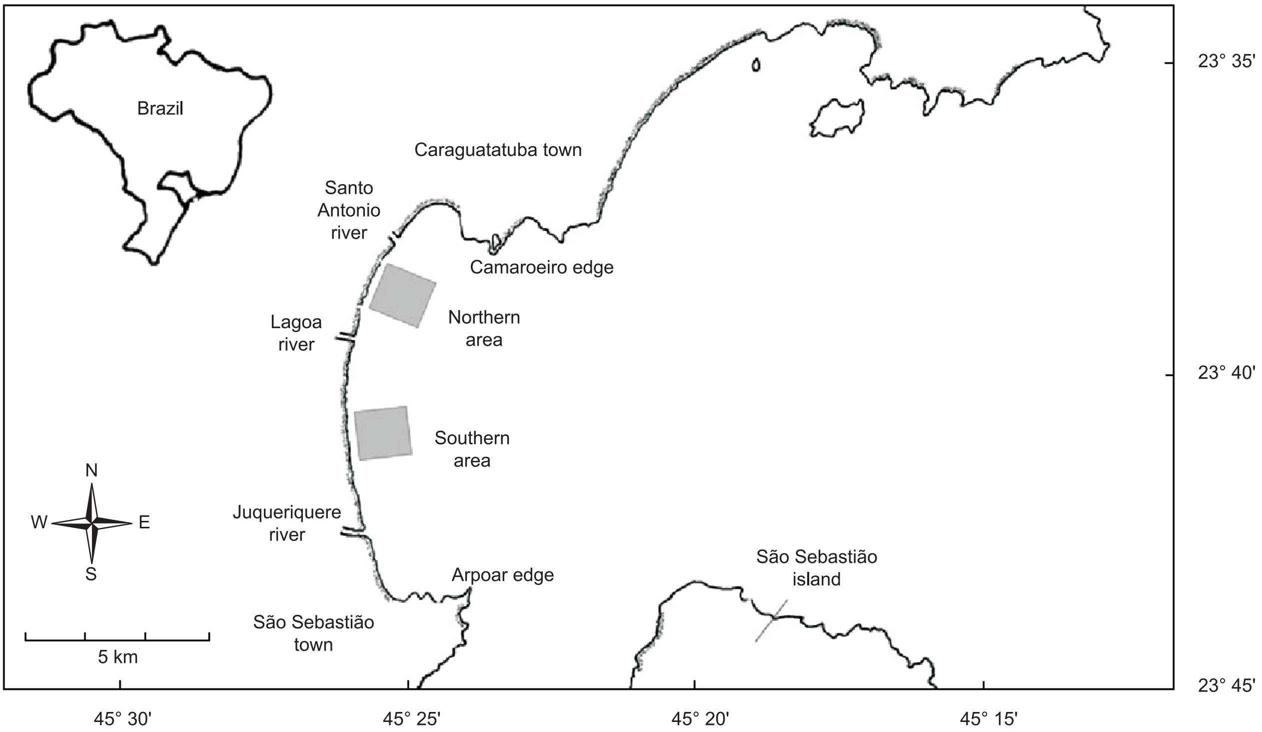

Figure 1. Caraguatatuba Bay. The study areas (South and North) are indicated by gray squares.

were located so as to exclude the strong influence of the local rivers (Juqueriquerê, Lagoa and Santo Antônio). The first (South) area extends from Porto Novo to Palmeiras beaches, and has a gentler slope. It is more exposed to wave activity and is influenced by the presence of the Juqueriquerê River, with the constitution of a small estuary. The North area, extending from Indaiá to Centro beaches, has a steeper slope. It is relatively sheltered from wave energy and is slightly influenced by the smaller rivers (Lagoa and Santo Antônio).

2. *Sampling methods*

Monthly samples were taken between August 2003 and October 2004. Three sampling stations were selected in each area, South and North, among 200 possibilities, *i.e*., the beach length of 2000 m divided into 10-m intervals. The position of each station was stored in a GPS at MLW (mean low water) and then the distance of 800 m was located, in a perpendicular way, using a fishing boat (class G2M, 11 m long, with a 22-HP engine).

At each station an 800-m trawl was performed, from 800 to 1600 m from MLW. This interval is equivalent to a depth from 1 to 4 m. The trawling speed was 1 knot. The trawls were performed using two otter trawls with a 2.0 cm mesh, mouth aperture of 1.6 m in height and 6.0 m in length, bag depth of 3.5 m.

The fish were then removed from the net and immediately preserved in a 10% formalin solution in order to paralyze the enzyme action, preserving the gut contents (Uieda & Castro, 1999). The samples were identified and stored in plastic containers. After identification of species in the laboratory, all specimens were transferred to 70% ethanol.

3. *Population analysis and diet*

All individuals of *G. genidens*, *G. barbus*, and *A. luniscutis* obtained in the samples were measured for standard length (SL), which is the distance between the anterior head edge and the edge of the caudal fin base (Figueiredo & Menezes 1978). No population analysis was performed for *G. barbus*, which had only 20 individuals sampled. *Genidens genidens* had 204 individuals and *A. luniscutis*, 357.

A total of 160 individuals of *G. genidens* and *A. luniscutis* were selected, using a random-digits table, for the diet analysis, while for *G. barbus* all 20 individuals obtained were used. A ventro-sagittal incision was made in the abdomen, from the anal aperture to the pelvic-fin insertions. The gut and gonads were removed. The gonads were analyzed for sex and classified according to the maturation staged suggested by Vazzoler (1996).

The digestive tube length (distance from the beginning of the esophagus to the end of the rectum; DTL) was measured in order to establish the DTL/SL ratio (digestive-tube length/standard length) and to examine a possible relationship to the diet of each species (Knöppel 1970). The digestive tubes were then preserved in 70% ethanol until the diet contents analysis.

The digestive tubes were divided into two portions, the first constituted by pharynx, esophagus and stomach, and the second by the intestine and rectum, due to the different digestive degree found in each portion. Finally, the contents of each digestive tube were identified to the lowest possible taxonomic level. The volume of each item was measured according to methodologies from Bemvenute (1990), in which each food item is compressed between two plastic slides (30x30x1 mm) and the area (mm^3) measured using graph paper.

4. *Data analysis*

The mean number of individuals (+SE) of *G. genidens* and *A. luniscutis* was calculated for the study months and areas (South and North). The sum of the areas was also calculated. Two-way ANOVA was performed to evaluate differences in the spatial (areas) and temporal (months) distribution. Histograms illustrating the relative frequency distribution of the size classes (standard length) of these two species were plotted for the total population. A chi-square test was performed to verify if the sex ratio was equal between males and females, with $\alpha = 0.05$.

The diets of *G. genidens*, *G. barbus*, and *A. luniscutis* were analyzed by the frequency of occurrence (F%), percent volume (V%), and index of alimentary importance (IAi). The F% is the frequency of digestive tubes containing a given food item in relation to the total number of digestive tubes containing any food item; V% is the volume of a given food item in relation to the volume of the total food items in the diet. The index of alimentary importance (IAi) was calculated by the method used by Kawakami & Vazzoler (1980), based on the frequency of occurrence and on the percent volume of each item. Seasonal analysis was possible only for *A. luniscutis*, because the individuals of this species were uniformly distributed in the study period. A similarity index (Krebs, 1989) was calculated to assess the overlap of the diets of the three ariid species.

Results

The three species were not numerous in the bay. In the 15 months, 204 individuals of *G. genidens*, only 20 *G. barbus*, and 357 *A. luniscutis*. *Genidens genidens* occurred during the entire year (Figure 2), and was more abundant in the summer (January to April/2004) (F = 6,774; df = 13; $p < 0.001$), with no significant difference between the North and South areas (F = 0,726; df = 1; p = 0.398). The spatio-temporal distribution (areas × months) did not evidence any interactions between the two variables (F = 1,562; df = 13; p = 0.125). For *G. barbus*, the few individuals obtained showed a tendency to occur preferentially in summer (January to April/2004) and in the South area, although these results were not confirmed by Anova (Months: F = 0,880; df = 13; p = 0.578; Areas: F = 1,984; df = 1; p = 0.164; Months*Areas: F = 0,933; df = 13; p = 0.527). *Aspistor luniscutis* was also present during the entire sampling period, although with a tendency toward higher densities during the autumn (March to June/2004) (F = 2,490; df = 13; p = 0.009), and occurred almost exclusively in the South area (F = 18,066; df = 1; $p < 0.001$). The spatio-temporal distribution (areas × months) indicated a significant interaction between these two variables (F = 2,393; df = 13; p = 0.012).

With respect to the size distribution (Figure 3), *G. genidens* showed standard lengths between 8.3 and 25.7 cm, with a mean SL of 13.00 ± 3.51 cm. Lengths of *G. barbus* ranged from 6.9 to 14.6 cm, with a mean of 11.94 ± 1.82 cm. *Aspistor luniscutis* showed the widest size range, from 4.7 to 30.5 cm, with a mean of 12.12 ± 5.75.

Many individuals of all three catfishes were immature and therefore did not have their sexes identified (Figure 4). The sex ratio of *G. genidens* was 1:1.93 (female: male) in the four seasons ($\chi^2 = 450$; df = 1; $p < 0.001$). The number of maturing individuals tended to increase from spring to winter, when most were sexually mature. In *G. barbus*, 68% of individuals were sexually immature. Considering the adults, males dominated over females during autumn; three males were obtained in the spring and five females in the summer; no individual of this species was collected in the winter. The proportion of *G. barbus* with maturing gonads in relation to immatures, increased gradually from the autumn to the summer. For *A. luniscutis*, sexually immature individuals comprised 68% of the total; among adults, females predominated in the autumn and spring, males in the summer, and the sexes were in equal proportions in winter (χ^2= 144,5; df = 1; $p < 0.001$). The proportion of mature

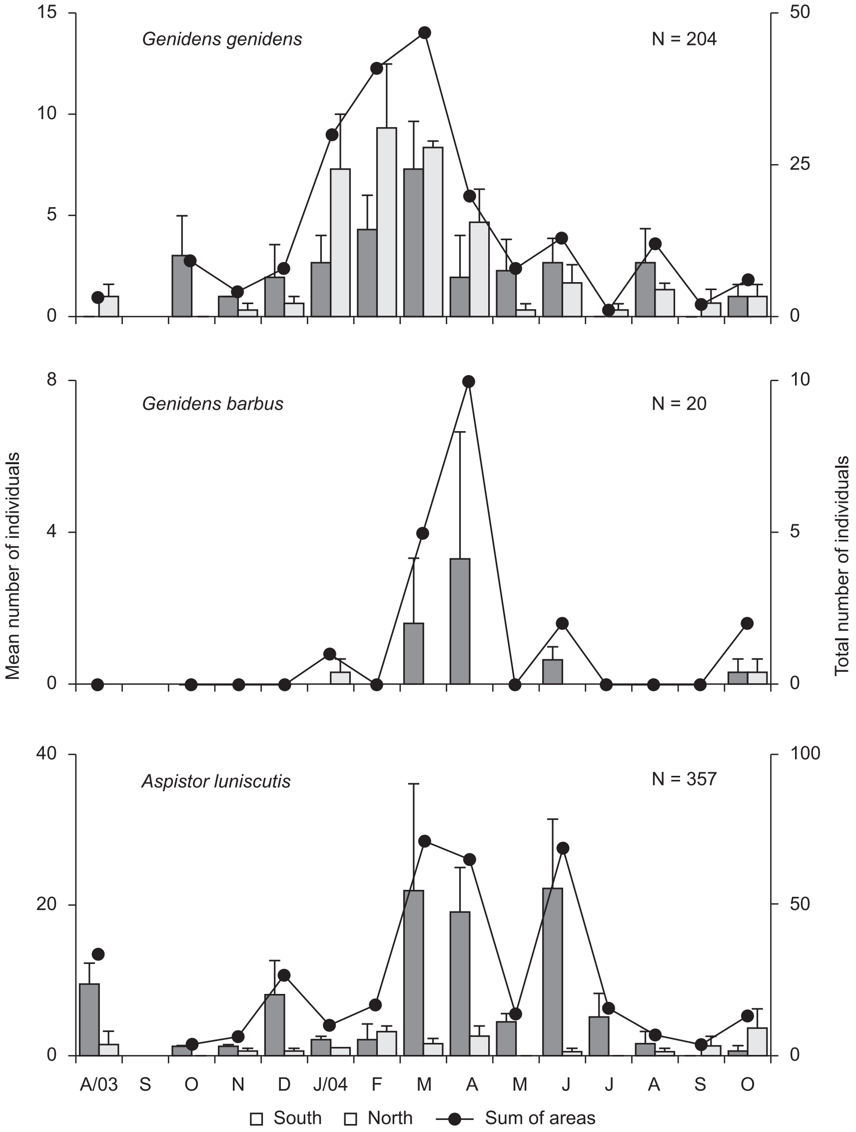

Figure 2. *Genidens genidens*, *Genidens barbus*, and *Aspistor luniscutis*. Monthly mean (+standard error) number of individuals/trawl in each of the two study areas (South and North) and monthly total number of individuals in the two areas.

individuals tended to increase from autumn to spring. In the summer, there were proportionally more maturing individuals, although with a small percentage of individuals with empty gonads, suggesting that spawning occurs in summer.

In relation to the diet (Table 1), *G. genidens* consumed 15 items, including plants (algae, seeds), benthic and planktonic invertebrates, vertebrates, and eggs; *G. barbus* consumed six different items, basically crustaceans, echinoderms, and fish; and *A. luniscutis* contained 12 items in its diet, constituted by algae, benthic and planktonic invertebrates, and fish. The calculated DTL/SL ratios were 1.23, 1.43 and 1.15 respectively, for *G. genidens*, *G. barbus* and *A. luniscutis*.

Comparing the frequency of occurrence of the items ingested in the different portions of the digestive tube, stomach, and intestine, the largest variety of items was observed in the stomach for all three species (Table 1), although with some differences. For *G. genidens*, the items most frequently found in the stomach were unidentified crustacean fragments and fish scales, while in the intestine, fragments of bivalve shells were more frequent. For *G. barbus*, the intestine contained unidentified crustacean fragments and amphipod tubes, but no mysids. For *A. luniscutis*, although the most frequent item in both portions was fish scales, unidentified crustacean fragments were relatively frequent in the stomach but absent in the intestine. Shell fragments were very frequent in the intestine and less frequent in the stomach.

In terms of volume (Table 1), bivalve shells and crustaceans were the most important items in both the stomach and intestine of *G. genidens*, although other items also were relatively important in the stomach. In *G. barbus*, mysids were the most voluminous item in the stomach, while fish scales dominated the intestine volume. For *A. luniscutis*, the most voluminous items in the stomach were crustaceans and fish scales; in the intestine, shell fragments were the most voluminous. A wider variety of voluminous items was observed in the stomachs of these species.

For *G. genidens*, the most important item in the stomach contents was unidentified crustaceans (fragments) (Figure 5), followed by bivalves (shells), fish (scales), ostracods, and bivalve siphons. Ten other items showed relatively important frequencies or volumes, although the calculated relative importance was lower than 5%. The mysids were the absolute item in importance for *G. barbus*, occurring

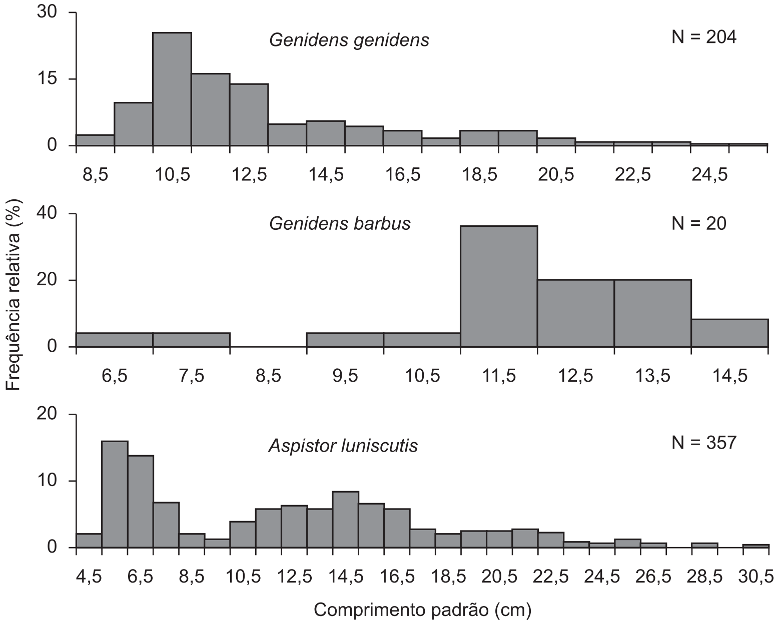

Figure 3. *Genidens genidens*, *Genidens barbus*, and *Aspistor luniscutis*. Size (standard length – cm) frequency distribution of individuals in the study period.

in half of the stomachs and comprising 92% of the total volume of this catfish's diet. Fish (bones and scales) also showed a certain importance in the diet of *G. barbus*. In *A. luniscutis*, fish (scales), followed by crustaceans (fragments) dominated the diet. Bivalves (siphons and shells) and polychaetes were also relatively important in this species' diet.

The only species for which a seasonal analysis of the diet was possible was *A. luniscutis*. In relation to the frequency of occurrence, fish scales were the most frequent item during the entire study period (Figure 6). The second most frequent item was crustacean fragments. In autumn, bivalve siphons also appeared. During winter, polychaetes and mysids were relatively important in frequency. Polychaetes also appeared in spring, when the diversity of items in the diet was highest. In relation to volume (Figure 7), fish scales were the most voluminous item in autumn and summer, while crustaceans (fragments) were prominent in winter and spring. Mysids were also relatively important during winter.

The similarity indexes calculated for the sympatric catfishes in Caraguatatuba Bay revealed, in general, no overlap in the diet of the three species (Gg × Gb = 1.61%; Gg × Al = 37.64%; Gb × Al = 2.37%). Only *G. genidens* and *A. luniscutis* showed a small overlap in the items crustaceans (fragments) and fish scales.

Discussion

The three catfish species had distinct spatial distributions in Caraguatatuba Bay. *Genidens genidens* occurred in both study areas (South and North), with a slightly higher abundance in the North area. *Genidens barbus* and *Aspistor luniscutis* showed highr densities in the South area, which is more frequently influenced by freshwater input. Ribeiro Neto (1993) observed in the Santos and São Vicente bay-estuary complex, that of the three species studied here, *G. barbus* seemed to be more abundant off the beaches, and *G. genidens* and *A. luniscutis* in more-structured environments (biogenic bottoms and parcels). Schmidt et al. (2008) observed a possible preference of the three species for more-protected estuarine environments. Azevedo et al. (1999) suggested that spatial-separation strategies could explain the coexistence of marine catfishes in Sepetiba Bay. *G. genidens* was abundant at all stations in the inner bay, *G. barbus* was abundant near the river mouth, while *A. luniscutis* was widely distributed in the inner and outer bay. In relation to environmental parameters, Mishima & Tanji (1981) observed in the Cananéia estuary, that *G. genidens* and *A. luniscutis* occurred in a wide salinity range (0.1 to 33), while juvenile *G. barbus* concentrated in higher salinities (15 to 33), and suggested that adults of this last species live in the open sea. Thus, the differences in spatial distribution among the three species found here may result from a tendency for *G. genidens* to occur over a wide salinity range, i.e., from the South to the North area. On the other hand, the low numbers of *G. barbus* in Caraguatatuba Bay may be a function of its plasticity in also occupying the open sea, reflecting a possible spatial segregation between the two species as a means of coexistence.

In relation to the temporal distribution, *G. genidens* and *G. barbus* were more abundant in the bay during the summer months, while *A. luniscutis* was observed in larger numbers in autumn. Many species of marine catfishes make seasonal movements in different phases of their life cycles, when they seek out river mouths and lagoons in the spawning period (Figueiredo & Menezes 1978, Mishima & Tanji 1981, Reis 1986, Azevedo et al. 1999). Bento & Bemvenuti (2008) observed a predominance of *G. genidens* in the northern portion of the Lagoa dos Patos estuary, mainly from May to December. According to Mishima & Tanji (1982), *G. genidens* and *A. luniscutis* always live in brackish water, while *G. barbus* is a migratory species that leaves the estuary when it reaches about 20 mm and returns to it as an adult for spawning. Schmidt et al. (2008), on the other hand, found that *G. genidens* and *A. luniscutis* were constant in the inner region of the São Vicente estuary, where they occur in the juvenile pre-maturation phase, and do not reproduce there.

The mean standard lengths obtained for the three species (*G. genidens:* mean = 13.0 cm and max. = 25.7 cm; *G. barbus:* mean = 11.9 cm and max. = 14.6 cm; *A. luniscutis:* mean = 12.1 cm and max. = 30.5 cm) indicate that the study area is dominated by juvenile individuals, because the largest known individuals of the three species measured, respectively, 35 cm, 1.0 m and 1.2 m (Figueiredo & Menezes 1978). Most individuals measured in this study (*G. genidens:* 42%; *G. barbus:* 68%; *A. luniscutis:* 68%) had not yet reached sexual maturity. For *G. genidens*, some lengths at

Table 1. *Genidens genidens*, *Genidens barbus*, and *Aspistor luniscutis*. Frequency of occurrence (F%), percent volume (V%) and index of alimentary importance (IA_i) in the stomach and intestine portions.

	Genidens genidens					
	Stomach			**Intestine**		
	F%	**V%**	**AI_i**	**F%**	**V%**	**AI_i**
Algae	6.90	3.44	1.63	22.22	3.48	2.64
Seed	1.72	8.83	1.04	0.00	0.00	0.00
Nemertine	6.90	1.81	0.86	0.00	0.00	0.00
Polychaeta	13.79	4.77	4.51	0.00	0.00	0.00
Bivalve shells	8.62	23.49	13.88	44.44	37.39	56.67
Bivalve siphon	15.52	7.55	8.03	0.00	0.00	0.00
Crustacean fragments	24.14	28.45	47.08	22.22	48.26	36.57
Amphipod	10.34	2.34	1.66	11.11	2.17	0.82
Copepoda	5.17	0.18	0.06	0.00	0.00	0.00
Ostracoda	15.52	7.95	8.46	11.11	7.39	2.80
Shrimp	10.34	1.63	1.16	0.00	0.00	0.00
Briozoa	1.72	0.18	0.02	0.00	0.00	0.00
Fish scales	20.69	7.90	11.21	11.11	0.87	0.33
Fish bone	3.45	1.19	0.28	0.00	0.00	0.00
Eggs	5.17	0.31	0.11	11.11	0.43	0.16
	Genidens barbus					
	Stomach			**Intestine**		
	F%	**V%**	AI_i	**F%**	**V%**	AI_i
Crustacea	0.00	0.00	0.00	50.00	7.14	7.14
Mysidaceae	50.00	81.93	93.22	0.00	0.00	0.00
Amphipoda tube	0.00	0.00	0.00	50.00	21.43	21.43
Echinodermata	5.56	4.11	0.52	0.00	0.00	0.00
Fish scale	61.11	0.96	1.33	50.00	71.43	71.43
Fish bone	16.67	13.00	4.93	0.00	0.00	0.00
	Aspistor luniscutis					
	Stomach			**Intestine**		
	F%	**V%**	AI_i	**F%**	**V%**	AI_i
Algae	1.05	1.17	0.03	0.00	0.00	0.00
Hidrozoa	1.05	0.53	0.02	0.00	0.00	0.00
Polychaeta	18.95	3.92	2.09	16.67	6.11	2.59
Shell fragm.	8.42	5.37	1.27	44.44	64.15	72.50
Bivalve siphon	11.58	6.96	2.26	5.56	3.38	0.48
Crustacean fragm.	31.58	23.21	20.59	0.00	0.00	0.00
Mysidacea	5.26	5.79	0.86	0.00	0.00	0.00
Amphipoda	1.05	0.09	0.00	0.00	0.00	0.00
Isopoda	1.05	0.42	0.01	0.00	0.00	0.00
Crab	6.32	3.53	0.63	0.00	0.00	0.00
Fish scales	55.79	45.97	72.06	38.89	24.44	24.17
Fish fragm.	2.11	3.03	0.18	5.56	1.93	0.27

Total number of individuals (N = 160, 20, 160, respectively), individuals with empty digestive tube (Ne = 1, 0, 1), mean standard length (SL = 12.33; 11.96; 13.62), digestive-tube length and standard length ratio (DTL/SL = 1.23; 1.43; 1.15).

first maturation found in the literature were 18.0 cm for females in Jacarepaguá Lagoon, Rio de Janeiro (Barbieri et al. 1992); 13.3 and 16.0 cm for females and males, respectively, in Maricá Lagoon, Rio de Janeiro (Mazzoni et al. 2000); for *Aspistor luniscutis*, in the Rio Sergipe estuary, the estimated value of L50 for both sexes was 17.0 cm (Alcântara 1989) and for *G. barbus* the first gonadal maturation for both sexes was estimated at 43.0 cm in Lagoa dos Patos (Reis 1986).

In Caraguatatuba Bay, *G. genidens* showed a higher proportion, although in low numbers, of mature individuals in winter than in the other periods, suggesting that spawning occurs in this season. In *G. barbus*, the number of maturing individuals was higher and the number of immatures lower in summer, although the total number of individuals (20) was too low to infer anything about its reproductive period. For *A. luniscutis*, a small increase in the number of mature individuals was noted in spring, followed by a small number of spent females in summer, indicating that this species spawns in the spring. Barbieri et al. (1992) observed that, for *G. genidens* in Lagoa de Jacarepaguá, the spawning period coincided with the highest surface-water temperatures and lowest salinities (December to January). Mazzoni et al. (2000), also for *G. genidens*, in Lagoa de Maricá (RJ) determined that the species has total spawning and reproduces between December and April, i.e., austral summer. Gomes et al.

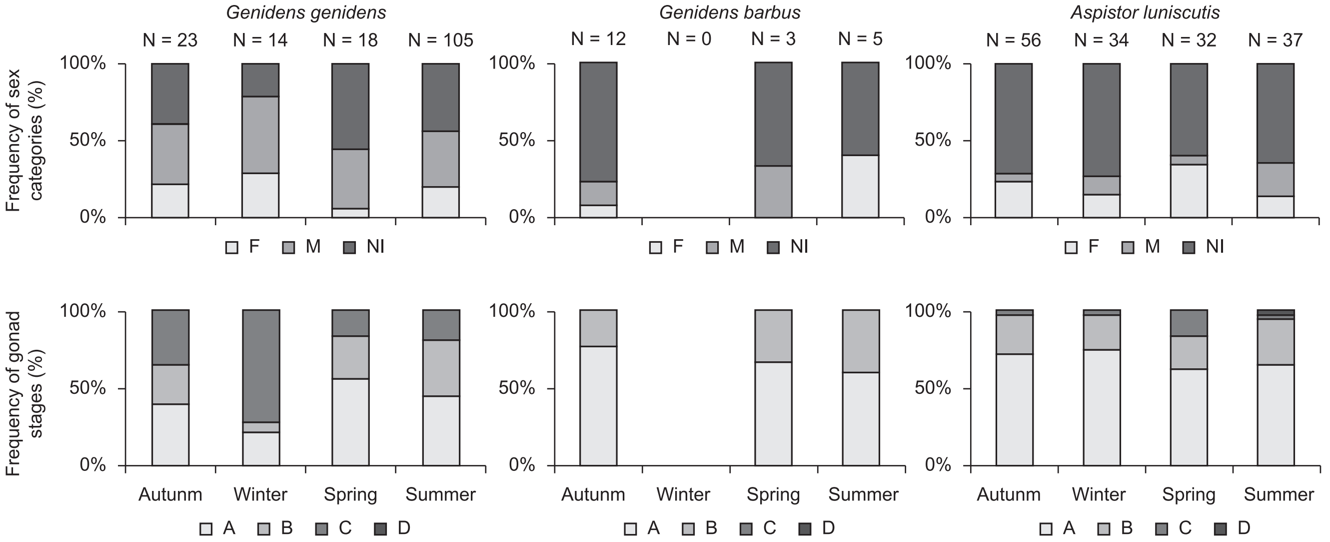

Figure 4. *Genidens genidens*, *Genidens barbus*, and *Aspistor luniscutis*. Frequency of the sexes (M = male; F = female; NI = not identified) and gonad maturation stages (A = immature; B = in maturation; C = mature; D = post-spawning) by season.

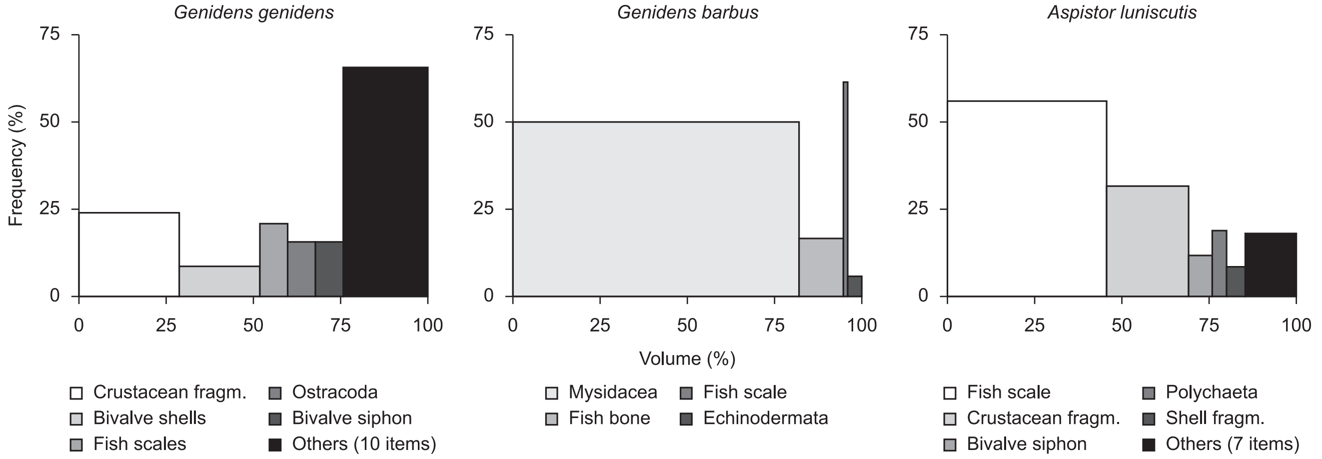

Figure 5. *Genidens genidens*, *Genidens barbus*, and *Aspistor luniscutis*. Relationship between the frequency of occurrence and the percent volume of the food items with higher importance in the stomach.

(1999) observed that *G. genidens* spawns during the summer and beginning of autumn in Sepetiba Bay (RJ) and concluded that the species is a K-strategist, evidenced by the protection given to the eggs and embryos and by their relatively large size. As assessed by Schmidt et al. (2008), the reproductive period of many catfish species is mainly related to the warmer months of the year or to the greatest input of continental fresh waters.

The DTL/SL ratio ranged between 1.15 and 1.43, suggesting that all three species may have omnivorous habits, since the digestive tube is longer than the standard length of the fish (Knöppel 1970). The higher importance of animal items in the diet may be due to an opportunistic habit, in which the fish eat the most available items. Of the three species, *G. genidens* showed the most diverse diet, with crustaceans, represented mainly by fragments, highly important. Other items with high relative importance were molluscs (shells), fish scales, ostracods, and bivalve siphons. The fact that crustacean fragments were the most voluminous item found in the stomach of this catfish seems to be more related to this fish's feeding habit than to the exoskeleton's resistance to digestion, which would result in overestimating the importance of this item, as discussed by Chaves & Vendel (1996). However, crustacean fragments were abundant in the stomach, and less so in the intestine. In contrast, mollusc shells were very highly important in the intestine and much less important in the stomach. These shells were found in the intestine even after the soft parts were completely digested, which did not occur with other items, and led to overestimation of molluscs.

Generally, studies on the diet of *G. genidens* report similar food items as in the individuals analyzed from Caraguatatuba Bay. Variations probably result from local particularities in the availability of the ingested items, in view of the general consensus among researchers that this is a generalist with opportunistic habits, strongly influenced by environmental conditions. According to Chaves & Vendel (1996), the variations in the consumption of certain items may be associated with their availability, but also their exploitation by other predators. Mishima & Tanji (1982) observed that, in the estuarine-lagoon complex of Cananéia, *G. genidens* fed mainly on decapods, molluscs and annelids. Araújo (1984) found that *G. genidens*, in the estuary of Lagoa dos Patos (RS), consumed *Littoridina* sp. (gastropod), *Balanus improvisus* (cirriped), *Cyprideis multidentata* (ostracod), and calanoid copepods. Chaves & Vendel

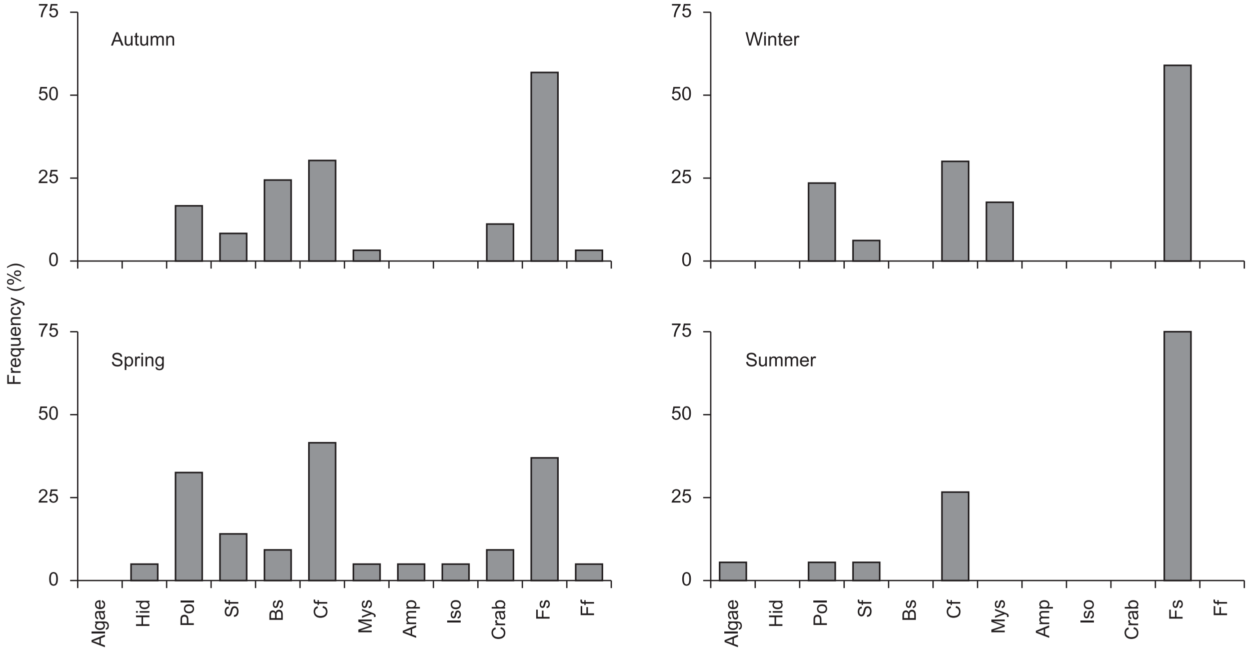

Figure 6. *Aspistor luniscutis*. Frequency of occurrence of the food items in the stomach, by season. (Hid = Hydrozoa; Pol = Polychaeta; Sf = shell fragments; Bs = bivalve siphon; Cf = crustacean fragments; Mys = Mysidacea; Amp = Amphipoda; Iso = Isopoda; Fs = fish scales; Ff = fish fragments).

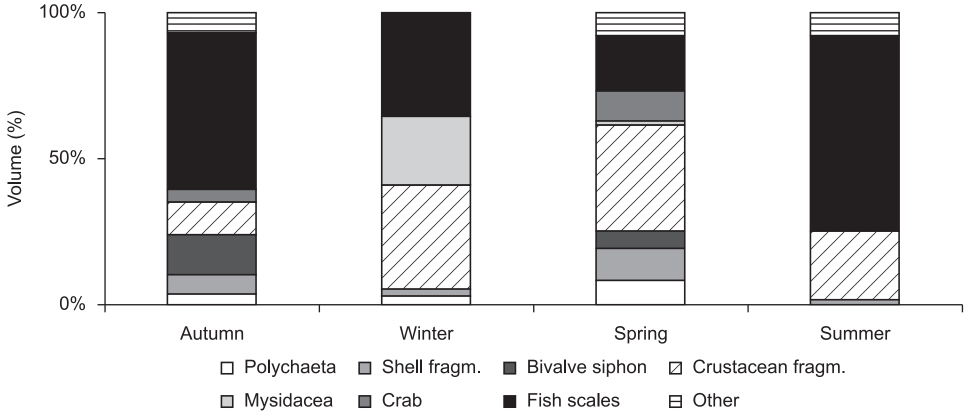

Figure 7. *Aspistor luniscutis*. Percent volume of the most voluminous food items in the stomach, by season.

(1996) observed that the diet of *G. genidens* in Baía de Guaratuba (Paraná) is mainly composed of decapods, followed by polychaetes. Rabitto & Abilhôa (1999) noted that the items of greatest importance in the diet of *G. genidens* on a sandbank of Ilha do Mel (Paraná) were decapod crustaceans (41.72%), unidentified material (42.32%), and polychaetes (1.15%). Pedra et al. (2006) obtained, in order of importance, the following items for *G. genidens*: crustaceans, fish, molluscs, and polychaetes.

Some studies refer to the importance of the strong tooth plates for *G. genidens'* capacity to exploit rigid materials such as crustacean and mollusc shells and skeletons (Araújo 1984, Chaves & Vendel 1996, Pedra et al. 2006). Chaves & Vendel (1996) mentioned additional characteristics of the digestive tract that explain its generalist diet: dead-end stomach, which can store ingested items while digestion proceeds; large mouth opening, which allows prey to be ingested whole; and, to aid in recognizing items on the bottom.

The few individuals of *G. barbus* analyzed here showed a predominance of mysids in their diet. Large amounts of incompletely digested items were also found in the intestine, such as scales and amphipod tubes, probably resulting in an overestimate of the importance of these items. Mishima & Tanji (1982) observed that *G. barbus* fed basically on decapods in the Cananéia lagoon-estuary complex. Reis (1982) found that the diet of adults of *G. barbus* in Lagoa dos Patos was composed of crustaceans of the families Caprellidae, Callianassidae and Callapidae, polychaetes of the family Magellonidae, and fish. Araújo (1984) recorded, in the diet of *G. barbus*, also in Lagoa dos Patos (RS), polychaetes, *Mysidopsis tortonese* (Mysidacea), and eggs of *Micropogonias furnieri* in the coastal areas and in the opening of the lagoon, and even soybeans (from the activities of the Rio Grande Port) and pereiopods of *Callinectes* spp. in the inner part of the lagoon.

Aspistor luniscutis based its diet on fish scales and crustacean fragments in Caraguatatuba Bay. Fragments of mollusc shells had high importance only in the intestine, indicating a possible overestimation of this recalcitrant item. Only Mishima & Tanji (1982), in the lagoon-estuary complex of Cananéia, referred to its diet, which was composed basically of decapods.

Some studies of catfishes' diets refer to large amounts of detritus found in their digestive tubes (Araújo 1984, Chaves & Vendel 1996, Rabitto & Abilhôa 1999, Espírito Santo & Isaac 1999). In Caraguatatuba Bay, practically all the digestive tubes of the three species contained large amounts of unidentifiable organic matter. According to Qasim (1972), the occurrence of detritus in large amounts is a peculiarity of estuarine fishes, and is abundant in their feeding. In addition, the catfishes possess a complex mouth apparatus, which allows them to crush the prey, often making it difficult to identify them.

An item that showed importance in the diet of the catfishes in Caraguatatuba Bay was fish scales. In fact, the consumption of fish scales has been documented for juveniles of the family Ariidae: *Ariopsis felis* (Hoese, 1966), *Neoarius berneyi* (Roberts, 1978) and *Ariopsis seemanni* (Szelistowski, 1989). Two hypotheses have been proposed for the consumption of scales: lepidophagy or saprophagy (ingestion of dead fish). Our findings of fish bones along with scales support the second hypothesis.

The diets of these three species of catfishes in Caraguatatuba Bay showed a slight overlap. Mishima & Tanji (1982) associated differences in diet among the catfishes of the Cananéia lagoon-estuary complex with the fact that *Cathorops spixii*, *G. genidens* and *A. luniscutis* live permanently in brackish waters, and show different feeding preferences and little variation in food composition in relation to their size; whereas migratory species such as *G. barbus* show ontogenetic differences in food composition. In Caraguatatuba Bay, the resource partitioning is better explained by the differences in the subhabitats occupied by the four species, as well as by the different proportions of the same item ingested. The differences in consumption of the most available items in the different seasons of the year, as observed for *A. luniscutis* in Caraguatatuba Bay, are probably another important factor that allows these catfish species to coexist.

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Scarabaeinae (Coleoptera: Scarabaeidae) of a rupestrian field at Cafuringa, Distrito Federal, Brazil: commented list of species

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Abstract: Our aim was to characterize the Scarabaeinae fauna from a rupestrian field formation at APA de Cafuringa, DF, Brazil. We made seven samples between 2007 and 2009 using baited pitfall traps. We collected 602 individuals belonging to 27 species and 13 genera, of which 17 were identified at species level. The majority of species caught has wide geographical distribution in Brazil and South America and do not seem to be specialized in 'campo rupestre' formation. Two species, *Canthidium marseuli* and *Canthon lamproderes* have restricted geographical distribution, being present in the central Brazilian highlands. *C. marseuli* and *C. lamproderes* are probably restricted to rupestrian fields since they have been registered only for this formation in Brazil, which indicates that these species need attention in relation to the conservation of theirs populations and habitats.
Keywords: *altitude, cambisoils, Canthidium marseuli, Canthon lamproderes.*

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Resumo: Nosso objetivo foi caracterizar a fauna de Scarabaeinae de um campo rupestre na APA de Cafuringa, DF, Brasil. Nós realizamos sete amostragens entre os anos de 2007 e 2009 utilizando armadilhas tipo *pitfall* com isca. Coletamos 602 indivíduos pertencentes a 27 espécies, 13 gêneros, das quais 17 delas estão identificadas até nível específico. A maioria das espécies coletadas apresenta ampla distribuição geográfica no Brasil e América do Sul e não parece ser especializada em formações do tipo campo rupestre. Duas espécies, *Canthidium marseuli* e *Canthon lamproderes* tem distribuição geográfica restrita aos campos de altitude do centro-sul do Brasil. *C. marseuli* e *C. lamproderes* são provavelmente habitantes restritas dos campos rupestres, visto que foram registradas apenas nesse tipo de formação no Brasil, o que indica que essas espécies necessitam de atenção em relação à conservação das suas populações e dos seus habitats.
Palavras-chave: *altitude, cambissolos, Canthidium marseuli, Canthon lamproderes.*

Introduction

Rupestrian fields can be found at Brazilian Cerrado and Caatinga usually occurring above 900 meters on mountains associated with pre-Cambrian stones remolded by tectonic movements since Paleocene (Vasconcelos 2011). This formation is mainly associated to quartzite, silicate and iron allurements (Vasconcelos 2011). This physiognomy has a disjunct distribution since Chapada Diamantina, in the state of Bahia, to mountain formations in the south of the state of Minas Gerais (Rapini et al. 2008) also occurring in the states of Goiás and Distrito Federal (Reatto et al. 2002, Vasconcelos 2011). Two features make the rupestrian fields a peculiar formation. First, from biogeographical and historical point of view, rupestrian fields can be understood as islands or archipelagos surrounded by a matrix of low altitude areas. In long term, this isolation can favor speciation processes and thus, the occurrence of an exclusive highland fauna and flora (Safford 1999, Alves et al. 2007, Azevedo et al. 2008, Vasconcelos 2011) Secondly, soil features can be, for some *taxa*, a determinant factor on rupestrian field ecology, modeling the physiognomy and influencing the local biota (Eiten 1972).

Dung beetles of subfamily Scarabaeinae constitute a taxonomic group which distribution and ecology might be affected by those rupestrian field features. This subfamily is worldwide distributed and currently includes about 7000 described species and, securely, more than 1500 at South America (Hanski & Cambefort 1991, Vaz-de-Mello 2000, Davis & Scholtz 2001). Dung beetles have a strong dependence on soil characteristics since many species have the habit to bury feces to build their nests (Halffter & Matthews 1966). Besides, Scarabaeinae clade has a Mesozoic origin, about 200 million years ago (Davis et al. 2002), which, associated with the also ancient origin of rupestrian field (30 million years ago, median tertiary according to Safford (1999)), enable the existence of patterns of endemism on mountain tops (Safford 1999).

A higher knowledge about Scarabaeinae inhabiting Brazilian rupestrian fields will help, *a posteriori*, to understand more about biogeographical and historical aspects of Brazilian Dung beetles – a theme that has been neglected due the low number of publication in this area. Thus, our aim was to characterize taxonomically the Scarabaeinae fauna at a rupestrian field at Cafuringa, DF, Brazil.

Materials and Methods

1. *Study site*

The study was conducted in a rupestrian field area located near road DF 170, at Área de Proteção Ambiental de Cafuringa (APA de Cafuringa), Distrito Federal Brazil (15° 32' S and 42° 02' W, 1200 m over sea level) (Figure 1). APA de Cafuringa has 49.000 ha, it is located in northwest of Distrito Federal and constitutes an important area for conservation of rupestrian fields and dry forests in central Brazil. According to Köppen's climatic classification, the climate in this site can be classified as tropical of altitude (Cwb), which is characterized by two defined stations: one dry station, with lower absolute temperature and precipitation, when occurs between May and September and a humid station with higher absolute temperature and precipitation, when occurs between October and March (Companhia... 1984). Cwb climate types are similar to tropical humid type (Cwa), which also occurs in Distrito Federal. However, Cwb climate type has lower mean temperature and lower mean precipitation than Cwa. Geologically, the study site is characterized by the presence of haplic cambisols with mountainous relief, formation that occurs in 3.1% of Brazilian Cerrado soils (Reatto et al. 2002).

2. *Data sampling*

During December 2007 to April 2008 we made six mensal samples in three sites (A, B, C), each one with one hectare (Figure 1). In each site we installed nine pitfall traps, three baited with rotten banana, three baited with human feces and three baited rotten bovine liver. The traps remained for 48 hours in the study site. Each sampled site consisted of three lines, 50 m apart, with three pitfalls spaced

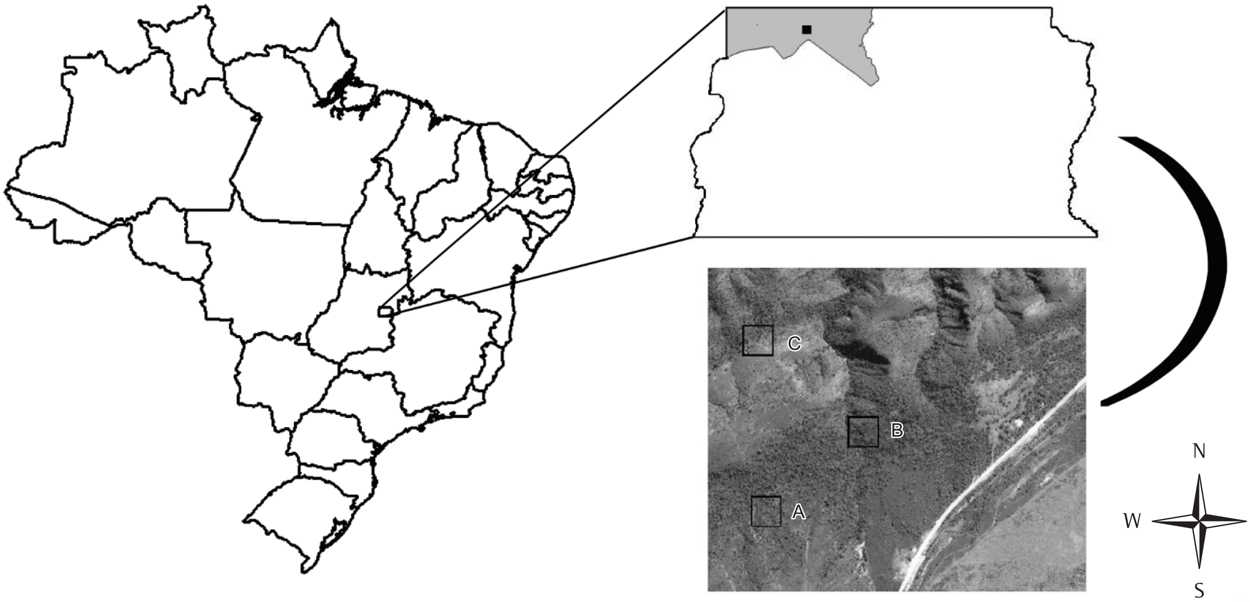

Figure 1. Localization of APA de Cafuringa (grey) in Distrito Federal and Brazil. The black spot on APA de Cafuringa represents the three sampled areas (A, B and C), showed on the satellite image. Font: Google Earth.

Figura 1. Localização da APA de Cafuringa (cinza) no Distrito Federal e Brasil. O ponto preto marcado na APA de Cafuringa representa as três áreas amostradas (A, B e C), mostradas na imagem de satélite. Fonte: Google Earth.

50 m totaling nine pitfalls per month in each area. Additionally, on December 2009, we installed five pitfalls baited with human feces in site "A" (Figure 1).

Dung beetles were identified using taxonomic key for Neotropical Scarabaeinae genera (Vaz-de-Mello et al. 2011), consulting published taxonomic literature and consulting the Entomology Section of Zoological Collection of Universidade Federal de Mato Grosso – CEMT. The identifications were conducted by the third author. The collected beetles are vouchered in CEMT.

Data concerning geographical distribution of species were obtained in published literature and consulting records in CEMT.

Results

A total of 602 beetles from 27 species and 13 genera were collected (Table 1). *Canthidium barbacenicum* was the most abundant species in samples (n = 179) followed by *Dichotomius aff. glaucus* (n = 85). *Agamopus viridis*, *Ontherus carinicollis* and *Trichillum externepunctatum* were collected only in the additional sample done in December 2009. Except for *Dendropaemon* sp., which was collected only in pitfalls baited with rotten banana, all species were collected using human feces bait or rotten bovine liver bait (Table 1).

In rupestrian field of APA de Cafuringa, 15 species have wide geographic distribution while two species have geographic distribution restricted to altitude areas or rupestrian fields (Table 1). For ten species, distribution could not be inferred since they were not identified until species level.

Discussion

Between the species that have a wide geographic distribution, many of them are easily found in Brazilian exotic and natural pastures and are usually associated with human or bovine dung (Köller et al. 2007, Louzada & Carvalho e Silva 2009) case of *Agamopus viridis*, two species of *Ateuchus*, *Canthidium barbacenicum*, *Canthon pilluliforme* and *Dichotomius bos*. *Canthon histrio*, *Trichillum externepunctatum*, *Oxysternon palemo* and *Dichotomius nisus*, also associated with human and bovine dung, are very common in altered environments and the last two occurs also in urban environments in the city of Brasília, DF. *Canthidium decoratum* was collected in the rupestrian fields and Cerrado formations in the states of São Paulo, Minas Gerais, Bahia and Mato Grosso (Pessôa & Lâne 1944, CEMT Records) while *Dichotomius crinicollis* was recorded in "Brejo de Altitude" in the state of Pernambuco (Silva et al. 2007) and in open

Table 1. Identification, author, year, capture method, A(F) abundance on traps baited with human feces, A(B) abundance on traps baited with banana, A(BL) abundance on traps baited with bovine liver and geographic distribution of Scarabaeinae species collected in campo rupestre at APA de Cafuringa between years 2007 and 2009. *species caught only in 2009. (PF) Pitfall baited with human feces, (PB) pitfall baited with rotten banana, (PFB) pitfall baited with rotten bovine liver. (AM) Wide distribution in Brazil and South America, (RE) Restricted distribution to rupestrian and altitudinal fields in Central Brazil.

Tabela 1. Identificação, autor, ano, método de coleta, A(F) abundância em armadilhas iscadas com fezes humanas, A(B) abundância em armadilhas iscadas com banana, A(BL) abundância em armadilhas iscadas com fígado bovino e distribuição geográfica das espécies de Scarabaeinae de campo rupestre na APA de Cafuringa entre os anos de 2007 e 2009. * espécies coletadas apenas em 2009. (PF) pitfall iscado com fezes humanas, (PB) pitfall iscado com banana em decomposição, (PFB) pitfall iscado com fígado bovino em decomposição. (AM) Ampla distribuição no Brasil e América do Sul, (RE) Distribuição restrita a campos de altitude e rupestres do Brasil central.

Species	Method	A (F)	A (B)	A (BL)	Distribution
Agamopus viridis Boucomont, 1928*	PF	19	-	-	AM
Ateuchus striatulus (Preudhomme de Borre, 1886)	PF	1	-	-	AM
Ateuchus vividus (Germar, 1823)	PF	85	-	-	AM
Canthidium barbacenicum Preudhomme de Borre, 1886	PF, PB,PFB	173	2	4	AM
Canthidium decoratum (Perty, 1830)	PF	8	-	-	AM
Canthidium marseuli Harold, 1867	PF, PFB	1	-	1	RE
Canthidium sp.1	PF, PFB	22	-	1	-
Canthidium sp.2	PF, PFB	17	-	-	-
Canthon histrio (Lepelletier de Saint Fargeau & Audinet-Serville, 1828)	PF	4	-	-	AM
Canthon lamproderes (Redtenbacher, 1867)	PF, PFB	41	-	3	RE
Canthon aff. pilluliformis Blanchard, 1845	PF, PFB	26	-	1	-
Canthon sp.1	PF	2	-	-	-
Canthon sp.2	PF	1	-	-	-
Deltochilum sp.1	PF, PB, PFB	4	4	2	-
Dendropaemon sp.	PB	-	1	-	-
Dichotomius bos (Blanchard, 1845)	PF	18	-	-	AM
Dichotomius crinicollis (Germar, 1824)	PF, PFB	5	-	1	AM
Dichotomius nisus (Olivier, 1789)	PF	2	-	-	AM
Dichotomius aff. glaucus (Harold, 1869)	PF, PFB, PB	83	1	7	-
Ontherus carinicollis Luederwaldt, 1931*	PF	5	-	-	AM
Onthophagus sp.1	PF	8	-	-	-
Onthophagus sp.2	PF	6	-	-	-
Onthophagus sp.3	PF	3	-	-	-
Oxysternon palemo Castelnau 1840	PF, PFB, PB	11	2	1	AM
Phanaeus palaeno Blanchard, 1845	PF	5	-	-	AM
Trichillum adjunctum Martínez, 1967	PF	3	-	-	AM
Trichillum externepunctatum Preudhomme de Borre, 1886*	PF	18	-	-	AM

areas and gallery forests at Distrito Federal and Minas Gerais (CEMT Records). *Phanaeus paleno* is distributed along all Brazilian Cerrado (Edmonds 1994).

It is probable that these species are not selective in terms of habitat, what would be a competitive advantage for colonization and establishment in rupestrian field. Rupestrian field soil might limit the occurrence of common species in Cerrado. The variation on humidity as well the type and composition of soils are strong factors that might affect Scarabaeinae community structure (Doube 1983, Davis 2002) and capacity of species in building nests (Barkhouse & Ridssil-Smith 1986).

In this study, two species have restricted geographical distribution: *Canthidium marseuli* and *Canthon lamproderes*. Besides the records provided here, *C. marseuli* is reported only in rupestrian fields in south of state of Minas Gerais (Almeida & Louzada 2009) while *Canthon lamproderes* was registered also in rupestrian fields at Serra da Canastra and Serra do Espinhaço, both on south of the state of Minas Gerais (CEMT Records)

Altitude can be an important biogeographical component that influences the composition of Scarabaeinae fauna in a given region (Lobo & Halffter 2000). As in other *taxa* (Safford 1999, Alves et al. 2007, Azevedo et al. 2008, Vasconcelos 2011) it may also be determinant for Scarabaeinae in Central Brazil rupestrian fields. The isolation of these areas does not constitute only a physical barrier that restrains the transition of species; through the years, the historical persistence of rupestrian fields and altitudinal fields may have favoured the co-evolution of rupestrian biotic components (Safford 1999, Vasconcelos 2008, Vasconcelos & Rodrigues 2010). Since in Distrito Federal rupestrian fields are not much higher than the other environments, the transition of faunal elements between environments is more visible. However is probable that higher and more isolated rupestrian fields have major occurrences of endemic or exclusive species.

As in other studies involving Scarabaeinae community and taxocenosis in Neotropical region, the identity of some *taxa* could not be determined. Between these *taxa*, there are some genera that need urgent taxonomic revision (Vaz-de-Mello 1999) like *Canthon*, *Canthidium*, *Deltochilum* and *Onthophagus*. Other genera are already in revision process like *Dichotomius* and *Dendropaemon*. Higher knowledge of these genera will allow more detailed studies involving biogeographical patterns on rupestrian fields and others environments in Brazilian Cerrado.

Towards the kind of bait used for Scarabaeinae sampling, human feces caught higher richness and abundances than the other baits, results that agree with other studies in Neotropical region (Milhomem et al. 2003). Despite that, is important to emphasize that the using of other sampling methods can collect Scarabaeinae that have other habits beyond the use of feces (different kinds of baited pitfalls) or that do constant dislocation by flight (flight interception traps).

Taxonomic composition of Scarabaeinae in rupestrian field in APA de Cafuringa seems to be influenced by an ecological component related to soil feature, that acts like a selector due its relations to Scarabaeinae nest construction (Halffter & Matthews 1966). This fauna is also influenced by a historical aspect, characterized by the presence of species apparently typical of high altitudes in south-central Brazil. The restriction on geographic distribution and the apparent exclusivity of habitat of *Canthidium marseuli* and *Canthon lamproderes* indicate that these species need attention in relation to its populations and habitat, essential criteria used to access the conservation *status* of species (International... 2010).

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Reproduction of the greater bulldog bat *Noctilio leporinus* (Chiroptera: Noctilionidae) in a mangrove area in southern Brazil

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Abstract: The reproductive pattern of the greater bulldog bat (*Noctilio leporinus*) was studied in southern Brazil from January to December 1999. The morphological characteristics of their reproductive organs were recorded monthly, through histological analysis of testes and ovaries. Those data were correlated with forearm size and body mass, as well as with external reproductive characteristics. The diameter of the seminiferous tubule increased proportionately to testis mass and body weight, and larger males had greater testis mass. Sexually mature males were recorded throughout the year. Ovary histology revealed that females ovulate between July and December. Lactating females were recorded in nearly every month of the year. *Noctilio leporinus* has a bimodal polyestrous pattern, with an increase in the recruitment of juveniles between January and May.
Keywords: *aquatic systems, Neotropics, reproductive cycle, seminiferous tubules, testis mass.*

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Resumo: Entre janeiro e dezembro de 1999 foi estudado o padrão reprodutivo do morcego-pescador (*Noctilio leporinus*) no sul do Brasil. Foram registradas mensalmente as características morfológicas de seus órgãos reprodutivos, através da análise histológica de testículos e ovários. Estes dados foram correlacionados com o tamanho do antebraço e a massa corporal, bem como as características reprodutivas externas. O diâmetro dos túbulos seminíferos dos machos aumentou proporcionalmente à massa dos testículos e à massa corporal, e machos maiores também apresentaram maior massa de testículos. Machos sexualmente maduros foram registrados ao longo de todo o ano. A histologia dos ovários revelou que as fêmeas ovulam entre julho e dezembro. Fêmeas em lactação foram registradas em quase todos os meses do ano. Este estudo revelou que *Noctilio leporinus* tem um padrão reprodutivo poliestral bimodal, com um maior recrutamento de jovens entre janeiro e maio.
Palavras-chave: *sistemas aquáticos, Neotrópico, ciclo reprodutivo, túbulos seminíferos, massa do testículo.*

Introduction

Bats have the most varied mating system of all mammals (Feldhamer et al. 1999). Species from temperate climates are generally monoestrous, but the majority of tropical species are polyestrous (Nowak 1994). In bat species such as *Tonatia bidens* and *Artibeus lituratus*, in which females have two or more breeding cycles per year (Esbérard & Bergallo 2004, Ortêncio Filho et al. 2007), males may remain sexually active longer and, in some cases, throughout the entire year (Duarte & Talamoni 2010).

The greater bulldog bat, *Noctilio leporinus* (Linnaeus, 1758), is widely distributed throughout the Neotropics (Koopman 1982). Although this species is common, some aspects of their biology and ecology are still poorly studied. The social organization of this species is based on polygyny, in which the adult male defends a group of females, with younger males either remaining solitary or in groups far from the female shelters (Brooke 1997). In Mexico, the species was reported to mate in winter, nursing its young in the spring and summer (Hernandez et al. 1985), while in Puerto Rico copulations occurred in September and November, with births occurring only in May (Brooke 1997).

For *N. leporinus*, studies have been limited to feeding ecology (Bordignon & França 2002), on the dimorphism in the color of the fur among males and females (Bordignon & França 2004), and on the species feeding behavior (Schnitzler et al. 1994, Zortéa & Aguiar 2001, Bordignon 2006a). In a semi-arid biome of northeastern Brazil a seasonal monoestrous reproductive pattern was found, with breeding synchronized to the period of greater food supply (insects and fish), which occurs in the rainy season from November to April (Willig 1985). In southern Brazil, the mating behavior of *N. leporinus* was recorded in nature by Marques & Pacheco (1999) and the reproduction in captivity was reported by Silva et al. (2010).

Considering that none of the previously cited studies focused on internal or physiological aspects associated with the reproduction of the species, the aim of the present study was to determine the reproductive pattern of male and female *N. leporinus* in a mangrove ecosystem in the southern Atlantic Forest of Brazil, through histological characterisation of their reproductive organs (cell maturation in testes and ovaries) and external morphological characteristics (testis weight, presence of fetus, lactation).

Materials and Methods

1. Study site

The study was carried out in the municipality of Guaratuba, state of Paraná, on the southern coast of Brazil (25° 50' S and 48° 34' W). The site is a bay with an area of 48.7 km^2, depths ranging from two to 23 m, and is located near the Serra do Mar mountains with typical Atlantic Rainforest vegetation. The bay is widely used by local communities for subsistence and sport fishing. It also serves as a nursery for many marine species, with large amounts of fingerlings (Chaves & Vendel 1997). The climate is humid subtropical (cool winter and warm summer), with precipitation in most months and a greater volume of rainfall in summer (October to March). Annual rainfall ranges from 1250 to 2000 mm. The monthly mean temperature ranges between 14 and 22 °C, with the coldest period between June and August and the warmest between September and May. The salinity of the water rarely surpasses 30.0‰ (Chaves 1995).

2. Bat sampling and histological analysis

Specimens were captured monthly between January and December 1999, from 6:00 PM to 6:00 AM using seven mist nets of 2.6 × 9 m (CH9 model, Avinet Inc. USA) arranged perpendicularly to the margin of the bay and over the surface of the water. The nets were checked every 15 minutes. Captured bats were removed from the net, placed into a black cotton bag (20 × 40 cm) and taken to the laboratory for the recording of the morphometric and biological data. Five nights of capture per month were performed totaling an effort of 9828 m^2.h throughout the year.

The specimens were placed in a recipient containing a cotton ball soaked in anesthetic ether, until sleep. This enabled handling the specimens for five to eight minutes during the recording of the biometric data. Each individual was identified with a tag and placed in a cage at a temperature of 25-32 °C until being released at the original capture site. One hundred and five individuals (54 males and 51 females) were captured and data on forearm length, body mass, sex and reproductive status were recorded. Males with visibly developed extra-abdominal testes and pregnant (determined by abdominal palpation), lactating and post-lactation (large, dark teats with no surrounding hairs) females were classified as adults. In all males ($n = 54$) total length of the right testes were measured (in mm). These measurements served as the estimate for the assessment of sexual maturation and compared to the histological data of the collected males.

Twenty-three males and 15 females were collected for the histological analysis of their reproductive organs. Bats were killed using anesthetic ether inhalation, in compliance with the norms established by the American Society of Mammalogists (Gannon & Sikes 2007).

The right testis of each male was extracted and weighed prior to fixation for the comparison with body mass. The reproductive organs (testes and ovaries) from the right side of the body were fixed in a solution of ethanol, formaldehyde (40%) and acetic acid at a proportion of 85:10:5 for 24 hours. The specimens were then submitted to routine histological methods with 5 µm sections stained with hematoxylin-eosin (Beçak & Paulete 1976, Rose et al. 1997).

Tissue from the region near the epididymis was examined on slides with an optical microscope at a magnification of 450×. The mean seminiferous tubule diameter (20 tubules/testis) of the testis of each male was determined using only tubules with round sections. The stage of spermatogenesis and presence of spermatozoids in the seminiferous tubules were determined (Parreira & Cardoso 1991). Only males with spermatozoids in the lumen of the tubules were considered mature. The histological sections of the ovaries were analyzed for cellular characteristics of the follicle maturation process (Graafian follicles and *corpus luteum*).

A correlation between the histological data of the testes (mass and seminiferous tubule diameter) and the forearm size was tested using Pearson's correlation test. A one-way analysis of variance (ANOVA) was used to compare the mean forearm length between breeding and non-breeding males, as well as the reproductive status of the animals captured in the different months.

Results

Among the fifty-one females captured during the study period about 60% were non-breeding (Figure 1). Non-breeding females were recorded from January to August, whereas pregnant females were recorded only in April, August, November and December. Lactating females were recorded throughout the year.

The number of non-breeding females recorded throughout the year was significantly different from the number of lactating (ANOVA $F = 5.202$; $p = 0.005$) and pregnant females (ANOVA $F = 5.566$; $p = 0.004$). All females captured from September to December (spring) were either lactating or pregnant. Non pregnant females were captured between January and March (summer).

Females with a *corpus luteum* (post-ovulation) were only recorded between July and December (Figure 2). Females with Graafian follicles were recorded in April and May. No females with such breeding characteristics were recorded between January and March.

Among the 23 males histologically examined, nine exhibited spermatogenesis. However, those individuals were distributed among several months throughout the year (Figure 3). Based on the external

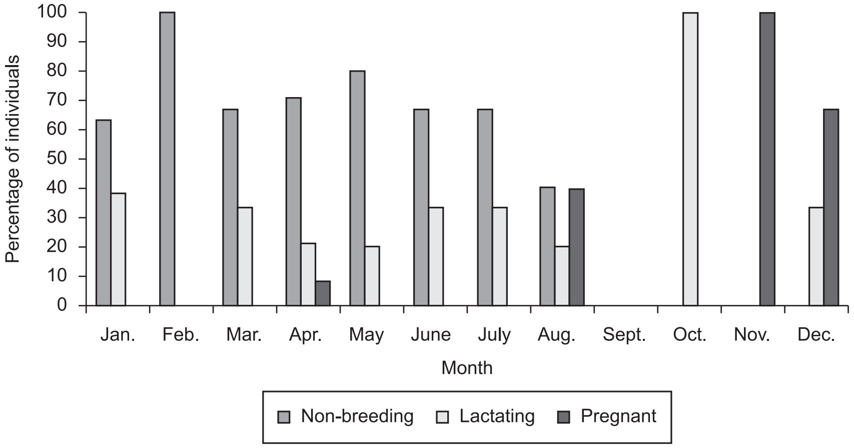

Figure 1. Reproductive pattern of female *N. leporinus* in a mangrove area of southern Brazil, based on external characteristics.

Figura 1. Padrão reprodutivo de fêmeas de *N. leporinus* em uma área de manguezal no sul do Brasil, baseado nas características reprodutivas externas.

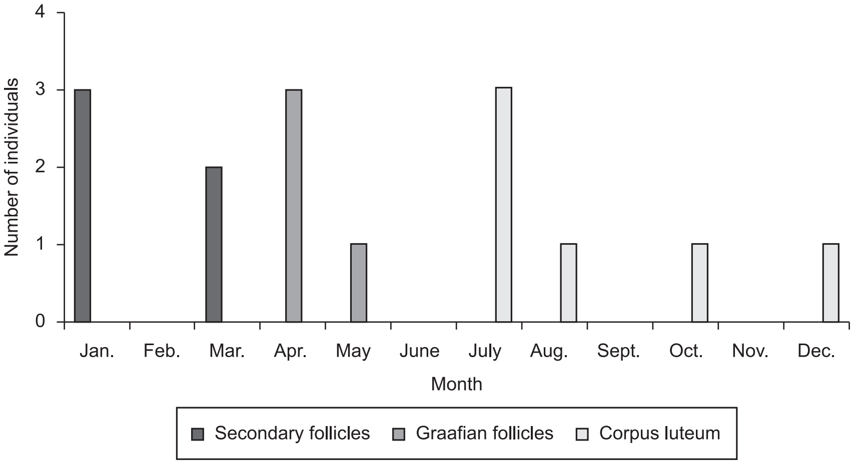

Figure 2. Reproductive pattern of female *N. leporinus* in a mangrove area of southern Brazil based on histological examination of ovaries.

Figura 2. Padrão reprodutivo de fêmeas de *N. leporinus* em uma área de manguezal no sul do Brasil, baseado no exame histológico dos ovários.

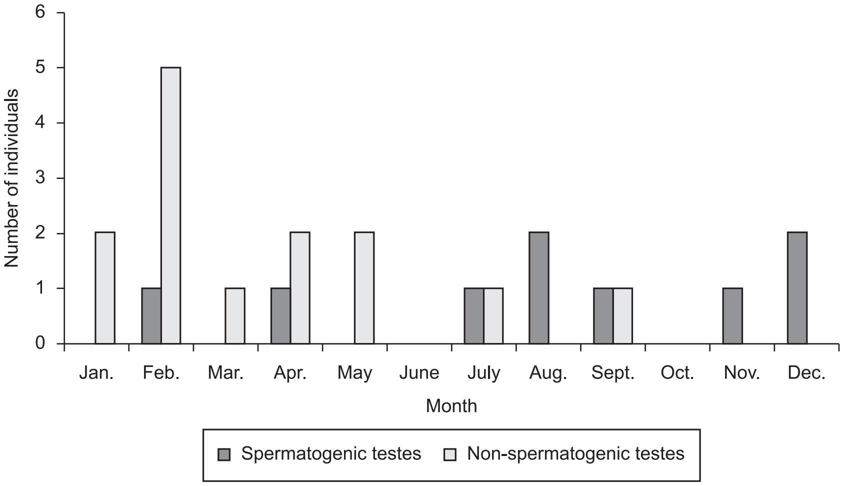

Figure 3. Reproductive pattern of male *N. leporinus* in a mangrove area of southern Brazil based on histological examination of testes.

Figura 3. Padrão reprodutivo de machos de *N. leporinus* em uma área de manguezal no sul do Brasil, baseado no exame histológico dos testículos.

characteristics of the 54 males collected, breeding males (with large testes) accounted for 42% of the sample (n = 23). Few breeding males were recorded from January to March (Figure 4). In this same period, non-breeding males represented 27% of the total catch for the entire year. Although no non-breeding males have been recorded between October and December, there was no statistically significant difference in the distribution of breeding and non-breeding males throughout the year (ANOVA $F = 1.079$; $p = 0.451$).

There was a positive correlation between testis mass and body mass among the 23 males collected for the histological analysis (Pearson $r = 0.774$; $p < 0.001$) (Figure 5a). There was also a positive correlation between testis mass and forearm length (Pearson $r = 0.643$; $p = 0.001$) (Figure 5b).

The majority of males weighing > 90 g had a testis mass ranging from 1.16 to 1.46 g. Among those weighing between 80 and 90 g, testis mass ranged from 0.16 to 1.21 g. For those weighing less than 80 g, testis mass ranged from 0.09 to 0.48 g. There was a positive correlation between mean seminiferous tubule diameter and testis mass among the 23 males submitted to histological analysis (Pearson $r = 0.833$; $p < 0.001$) (Figure 6).

In non-breeding males with a testis weight <1.0 g (0.29 + 0.35; n = 17), the diameter of the seminiferous tubules was <100 µm (59.17 + 25.57), with no spermatozoids in the lumen. In those specimens, only spermatogonia, Sertoli cells and primary spermatocytes were observed.

In males with a testis weight >1.0 g (1.25 + 0.84; n = 6), the diameter of the seminiferous tubules was >100 µm (148.70 + 30.15) and the epithelium exhibited spermatocytes in different degrees of development and spermatozoids in the lumen of the tubule, revealing that these males were sexually mature. Mean forearm length of non-breeding males (97.20 + 1.91 mm; n = 6) was significantly lower (ANOVA $F = 4.390$; $p = 0.046$; Tukey $Q = 2.963$; $p < 0.05$) than that of breeding males (99.00 + 1.22 mm; n = 17).

Discussion

Both the external sex characteristics and histological analysis of the testes revealed that the male greater bulldog bat is capable of mating in any season of the year. Despite living in a polygenic mating system, in which an adult male defends a group of females (harem), fecundation is determined by the fertility status of the females (Feldhamer et al. 1999).

The histological data show that the population analyzed tends to mate after the summer months, with ovulation occurring between early winter (July) and early summer (December). However, the assessment of external genital characteristics of the females showed that lactation occurs in nearly all months of the year. In captive conditions Silva et al. (2010) observed that females of this species showed synchronization of births of pups in October and November, although copulations were observed throughout the year.

We believe that the histological data obtained show just a glimpse of what may be occurring in this species mating. Probably young females start to synchronize their ovulation with other females in the group only after the first ovulation that occurs at puberty. If true, then most data on lactation obtained in our study may derive from females nursing their pups for the first time. This seems logical, since young females do not always have a hierarchy already established in the harem.

The larger number of non-breeding females compared with lactating or pregnant females in April (Figure 1) may indicate a peak recruitment of the juvenile population in this period in the study site, as there was also a high number of non-breeding or sexually immature males in February. The breeding pattern for the *N. leporinus* females in the present study was similar to the bimodal polyestrous pattern reported for other species of tropical bats (Tamsitt & Valdivieso 1963, Reis 1989, Chaverri & Kunz 2006, Duarte & Talamoni 2010).

The positive correlation between testis mass and mean seminiferous tubule diameter in *N. leporinus* males was expected, as spermatogenesis was presumed to be more intense in males with heavier testes. The histological data on spermatogenic activity were similar to those described by Duarte & Talamoni (2010) for *Artibeus lituratus* in southeastern Brazil. However, the mean diameter of the seminiferous tubules in *N. leporinus* was smaller in both breeding and non-breeding males than that described for *A. lituratus* in the study cited. This difference may be related to technical factors, such as the method of fixation of the organs, or the ontogeny and anatomy of the species in question. Although males considered young had underdeveloped testes, it was not possible to ascertain whether the adult males of the greater bulldog bat studied here undergo regression in the spermatogenic activity, as occurs in bats from temperate regions with strong seasonal variations in climate (Racey 1974, Entwistle et al. 1998).

The correlation between testis mass and body size (forearm and weight) indicated that some large males (> 85 g) had a low testis mass (0.29 + 0.35 g). This may be explained by the existence of a size range

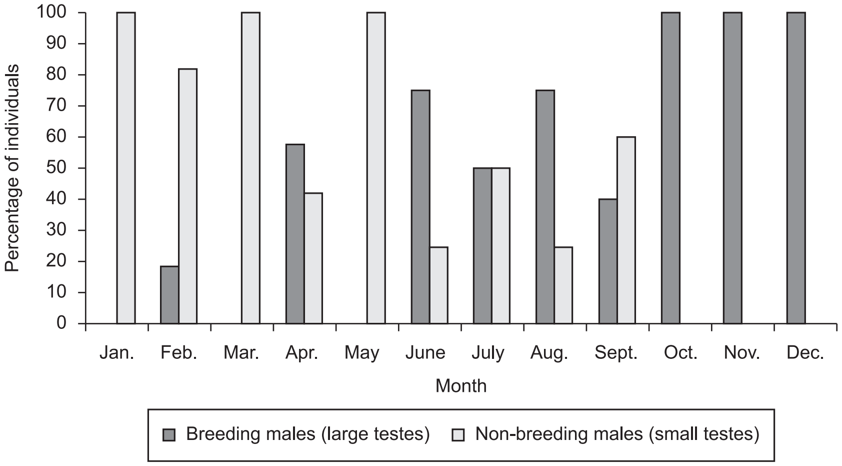

Figure 4. Reproductive pattern of male *N. leporinus* in a mangrove area of southern Brazil based on external testis size.

Figura 4. Padrão reprodutivo de machos de *N. leporinus* em uma área de manguezal no sul do Brasil, baseado nas dimensões externas dos testículos.

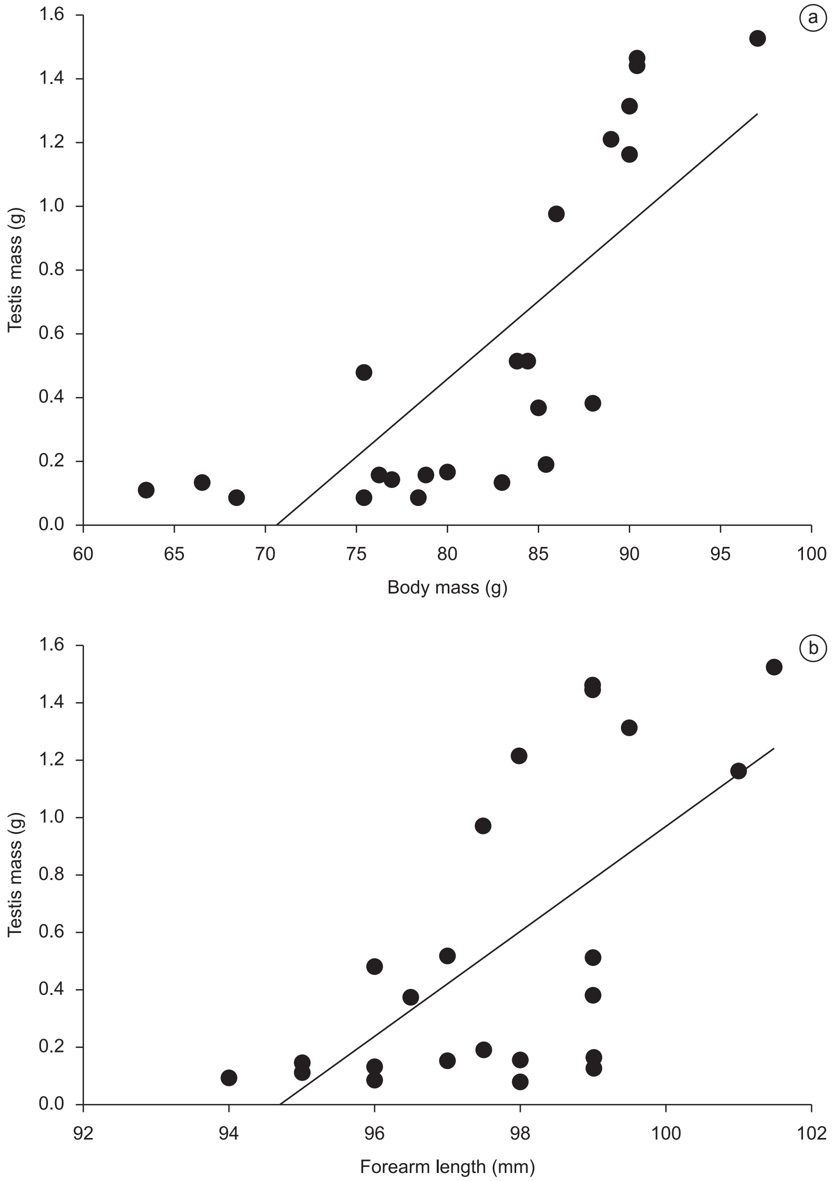

Figure 5. Testis mass correlated with (a) body mass ($r = 0.774$; $p < 0.001$) and (b) forearm length ($r = 0.643$; $p < 0.001$) in *N. leporinus* males (n = 23) from a mangrove area in southern Brazil.

Figura 5. Massa do testículo correlacionada com (a) massa corporal ($r = 0.774$; $p < 0.001$) e (b) comprimento do antebraço ($r = 0.643$; $p < 0.001$) em machos de *N. leporinus* (n = 23) em uma área de manguezal no sul do Brasil.

that indicates adolescence (sexual maturity) in this species. Thus, the correlation graphs (Figure 5) indicate the existence of a size threshold at which males may undergo sexual maturity and become suitable for mating. The size range indicated by our data is 97.5 mm for forearm length and 85 g for body weight. This seems reasonable, as there are no seasonal environmental restrictions, such as food resources availability or a rigorous winter, requiring animals to concentrate their mating or sexual maturity in a single period of the year.

In insectivorous vespertilionid bats, which hibernate during the winter in temperate regions, an increase in testis mass and spermatogenic activity only occurs in spring and summer, when there are favorable conditions for feeding and breeding (Kunz et al. 1998). After this period, there is a regression in testis mass and spermatogenic activity, probably oriented to save energy and ensure survival under unfavorable conditions, such low temperatures and a lack of food sources (Entwistle et al. 1998).

Many species of tropical Phyllostomidae synchronize mating and birth with the rainy season, when there is a greater availability of fruit in the environment (Chaverri & Kunz 2006). For *Artibeus lituratus*, Reis (1989) and Duarte & Talamoni (2010) report that births occur throughout the rainy season, with peaks and the beginning and end of the season, accompanied by synchrony with the greater supply of vegetal food sources. In a previous study on the diet of the greater bulldog bat in Guaratuba Bay, Bordignon (2006b) reported that the most frequently consumed species of fish was the Brazilian silverside (*Atherinella brasiliensis*), which is available throughout the year. Thus, diet is not a limiting factor for the mating period of this species.

The absence of restrictive environmental factors and the polygenic social system in *N. leporinus*, in which the dominant males must be ready to copulate with females ovulating at different times of the year in the harem, may explain the absence of regression in spermatogenic activity in the males of this species. This hypothesis

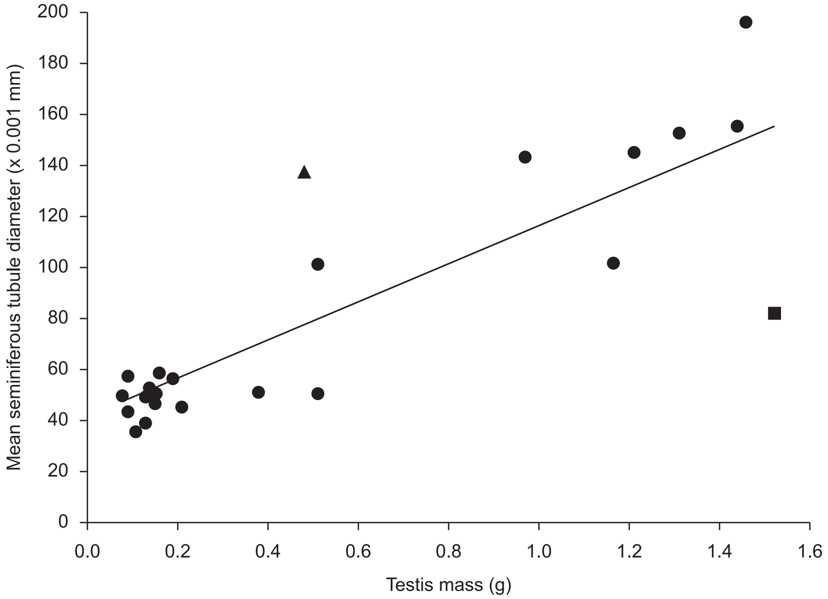

Figure 6. Mean seminiferous tubule diameter (µm) correlated with testis mass ($r = 0.833$; $p < 0.001$) in *N. leporinus* males (n = 23) from a mangrove area in southern Brazil. The solid square represents a senescent adult male without spermatogenic activity and the solid triangle a young male with testes in maturation.

Figura 6. Diâmetro médio dos túbulos seminíferos (µm) correlacionado com a massa dos testículos ($r = 0.833$; $p < 0.001$) em machos de *N. leporinus* (n = 23) em uma área de manguezal no sul do Brasil. O quadrado sólido representa um macho adulto sem atividade espermatogênica e o triângulo sólido um macho jovem com os testículos em maturação.

is supported by the histological and capture data, as adult males exhibiting spermatogenic activity were recorded in the majority of months. Except for the months January, March and April in all other months were captured males with well developed testes and scrotum.

Another fact that makes us think about the lack of regression of the testes in this species is a male that was captured with large testes (1.52 g), large body mass (97 g) and long forearm length (101.5 mm) exhibited seminiferous tubules with a small diameter (82.4 µm) and absence of spermatozoids, thereby suggesting that this male was undergoing an ageing process or andropause.

Recently, Silva et al. (2010) studied this species in captivity. They observed copulations during all months of the year. Though under artificial conditions, these observations corroborate our data, because in our study, all males captured throughout the year showed no decrease in the mass of the testis (testicular regression). Therefore, further long-term histological studies on the copulating behavior of *N. leporinus* in other regions of Brazil are necessary in order to clarify such contradictory data.

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Opportunistic predation of fish by anomuran crabs (Crustacea, Anomura, Aeglidae) in rivers of southern Brazil

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SAVARIS, M., LAMPERT, S., TREVISAN, A. & MASUNARI, S. **Opportunistic predation of fish by anomuran crabs (Crustacea, Anomura, Aeglidae) in rivers of southern Brazil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?short-communication+bn01212042012

Abstract: The opportunistic predation on the fishes *Astyanax fasciatus* and *Crenicichla* sp. entangled in gill net by the aeglid crabs *Aegla grisella* and *Aegla singularis* was observed in rivers of southern Brazil. These events occurred in two rivers located at the National Forest of Passo Fundo, in Mato Castelhano municipality, Rio Grande do Sul State and Tangará municipality, Santa Catarina State. In both places the fish showed similar wound pattern, with eyes and fins being consumed first. However, predation of the whole body was also recorded, probably due to the high number of aeglid crabs feeding on the same individual. This record intended to contribute for understanding the natural diet of these crabs in freshwater environments.
Keywords: *diet, fish, behavior, aeglid crabs.*

SAVARIS, M., LAMPERT, S., TREVISAN, A. & MASUNARI, S. **Predação oportunista de peixes por eglídeos (Crustacea, Anomura, Aeglidae) em rios do Sul do Brasil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?short-communication+bn01212042012

Resumo: A predação oportunista dos peixes *Astyanax fasciatus* e *Crenicichla* sp. emalhados em rede de espera pelos eglídeos *Aegla grisella* e *Aegla singularis* foi observada em rios do Sul do Brasil. Estes eventos ocorreram em dois rios na Floresta Nacional de Passo Fundo, município de Mato Castelhano, RS e no município de Tanguará, SC. Em ambos os locais os peixes apresentavam um padrão de mutilação semelhante, com olhos e nadadeiras sendo consumidos primeiramente. No entanto, a predação de todo o corpo também foi registrada, provavelmente em decorrência do elevado número de eglídeos se alimentando de um mesmo indivíduo. Esse registro visa contribuir para o entendimento da dieta natural dos eglídeos em ambientes de águas continentais.
Palavras-chave: *dieta, peixes, comportamento, eglídeos.*

Introduction

The family Aeglidae Dana, 1852 is the only anomuran crustacean that lives in continental waters. Its species are found in clear and well oxygenated waters of streams, rivers, lakes and stream caves; usually they are hidden under rocks and plant debris (Bond-Buckup & Buckup 1994, Bond-Buckup 2003, Bond-Buckup et al. 2008, Dalosto & Santos 2011).

According to the criteria of the International Union for Conservation of Nature (IUCN), from a total of 70 know species 23 are threatened, mainly due to their endemic distribution and to the visible degradation of freshwater environments. Therefore, these organisms should be a priority for ecological studies aiming the establishment of conservation measures (Bueno & Bond-Buckup 2004).

The feeding habit has been investigated in the following aeglids: *Aegla laevis laevis* Latreille, 1818, *Aegla perobae* Hebling & Rodrigues, 1977, *Aegla platensis* Schmitt, 1942, *Aegla leptodactyla* Buckup & Rossi, 1977, *Aegla camargoi* Buckup & Rossi, 1977, *Aegla lingulata* Bond-Buckup & Buckup, 1994 and *Aegla longirostri* Bond-Buckup & Buckup, 1994. They were characterized as opportunistic omnivorous, feeding on diversified food items such periphyton, organic matter coming from allochthonous plants, aquatic invertebrates, fish scales and fine particulate organic matter (Bahamonde & López 1961, Burns 1972, Arenas 1978, Isler 1988, Magni & Py-Daniel 1989, Lara & Moreno 1995, Medina 1998, Bueno & Bond-Buckup 2004, Castro-Souza & Bond-Buckup 2004, Santos et al. 2008).

Studies based on stomach contents analysis, using more refined statistical methods have been only published recently. Castro-Souza & Bond-Buckup (2004) evaluated the natural diet of *A. camargoi* and *A. leptodactyla* that occur in sympatry at Divisa River, in São José dos Ausentes municipality, Rio Grande do Sul State and Bueno & Bond-Buckup (2004) characterized the diet of *A. plantensis* and *A. lingulata*, from Arroio do Mineiro, southern Brazil. These four species have been considered opportunistic omnivorous, confirming the results of previous authors.

More recently, Santos et al. (2008) recorded plant tissues, organic material in advanced state of digestion, fragments of adults insects, aeglid body parts, clam shells, fish scales, and dipteran larvae in the stomach content of *A. longirostri*, from central region of Rio Grande do Sul State. On the other hand, aeglids constitute an important food item in the diet of the trouts *Oncorhynchus mykiss* (Walbaum, 1792) and *Salmo trutta fario* Linnaeus, 1758 (Burns 1972, Arenas 1978, Isler 1988, Lara & Moreno 1995) and of the otter *Lontra provocax* (Thomas, 1908) (Medina 1998).

The present note is a record of an opportunistic predation on dead or dying fishes that were entangled in nets by two aeglid species in southern Brazil. The events occurred at a stream within the National Forest of Passo Fundo, in Mato Castelhano municipality, Rio Grande do Sul State (28° 19' S and 52° 10' W) in November 2008, and at Azul River, Peixe River Basin, Tangará municipality, Santa Catarina State (27° 06' S and 52° 15' W) in May 2011.

Materials and Methods

The fishes were the target species and the aeglids belong to the by catch. These animals were captured with nets of 20 m length and aperture of 3 cm between opposite knots. These nets were set late in the afternoon and removed in the following morning; they remained about 12 hours in the water. The characid fish *Astyanax fasciatus* (Cuvier, 1819) and the cichlid *Crenicichla* sp. were captured in both sites, however, the aeglid *Aegla grisella* Bond-Buckup & Buckup, 1994 was only recorded in Mato Castelhano, whereas *Aegla singularis* Ringuelet, 1948 only in Tangará.

Pictures of captured fishes were taken and, after that, they were fixed in 10% formalin, preserved in 70% alcohol and identified based on Zaniboni Filho et al. (2004) and Ribeiro et al. (2007), and the aeglids were fixed in 70% alcohol and identified according to Bond-Buckup & Buckup (1994).

Results and Discussion

A total of 37 individuals of *A. fasciatus*, 14 of *Crenicichla* sp. and 21 eglids were obtained from two places. Eleven individuals (29.3%) of *A. fasciatus* showed signs of carnivory by aeglids, while in *Crenicichla* sp. a total of five individuals (35.7%) showed attack by these aeglids. During the net removal from the water only a few aeglids remained attached to it: most of them have loosen from the fishes and fell down back into the water (Figure 1). It is supposed

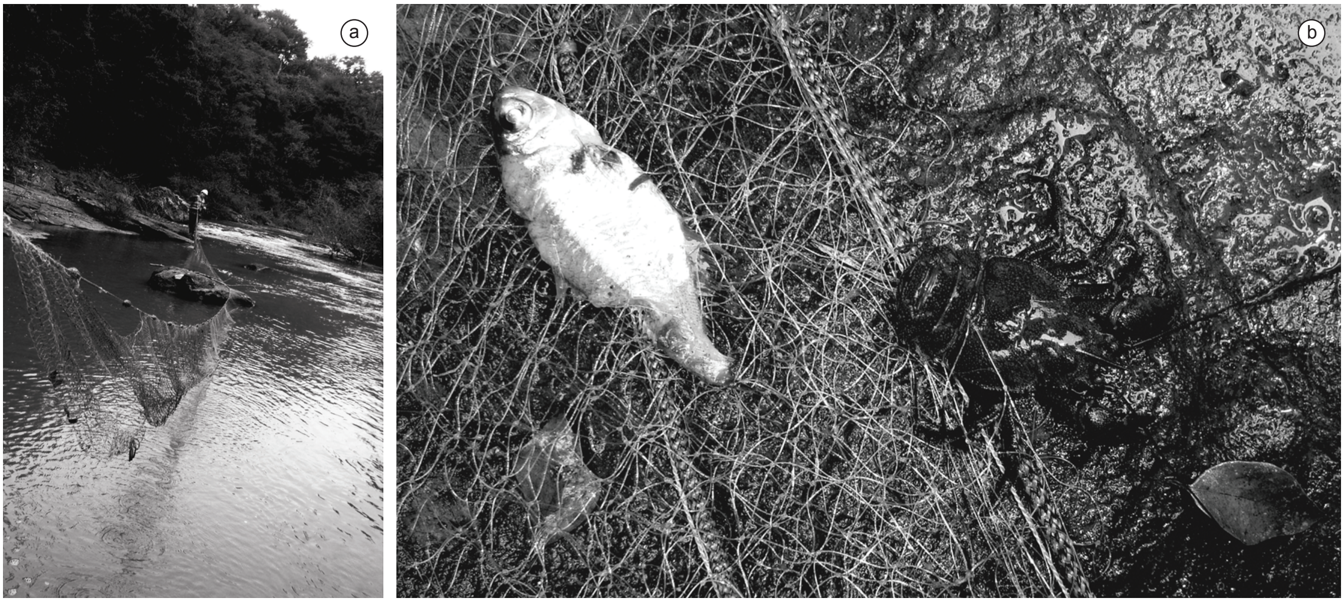

Figure 1. Fish and by catch capture. (a) Gill net pickup. (b) The fish *Astyanax fasciatus* and the aeglid *Aegla singularis* entangled in the gill net. Note that the fish suffered many bites.

that aeglids were attracted to immobilized or dead fishes and were feeding on them.

The carnivory pattern was similar for both aeglids species, regardless of the prey species or sampling site. In all cases, aeglids firstly consumed the soft and protruding parts of the prey, like the eyes and fins (dorsal, caudal, anal, pelvic, and pectoral) (Figure 2a-c). However, a total consumption of the fleshy parts of the fish was also recorded, probably a result of simultaneous attack by many aeglids (Figure 2d).

No record of fish body parts in the aeglid diet is available in the literature, certainly due to the difficulties in identifying them in the stomach content. However the presence of fish scales in it is clear evidence that aeglids can feed on fishes, as showed by Bueno & Bond-Buckup (2004) in 1.0% of individuals of *A. platensis* from Mineiro Brook, in Taquara municipality. Curiously, this food item was absent in *A. lingulata*, a sympatric species of the former. In the same year, Castro-Souza & Bond-Buckup (2004) also recorded fish scales in the sympatric species, *A. camargoi* (5.0% of aeglids had this food item) and *A. leptodactyla* (1.2%) from Divisa River, São José dos Ausentes municipality. Four year later, Santos et al. (2008) also found fish scales in 6.0% of individuals of *A. longirostri* from Itaara municipality. All record sites above mentioned are located in Rio Grande do Sul State. These data and the present communication indicate that fish could constitute an ordinary food item for all species of aeglid crabs.

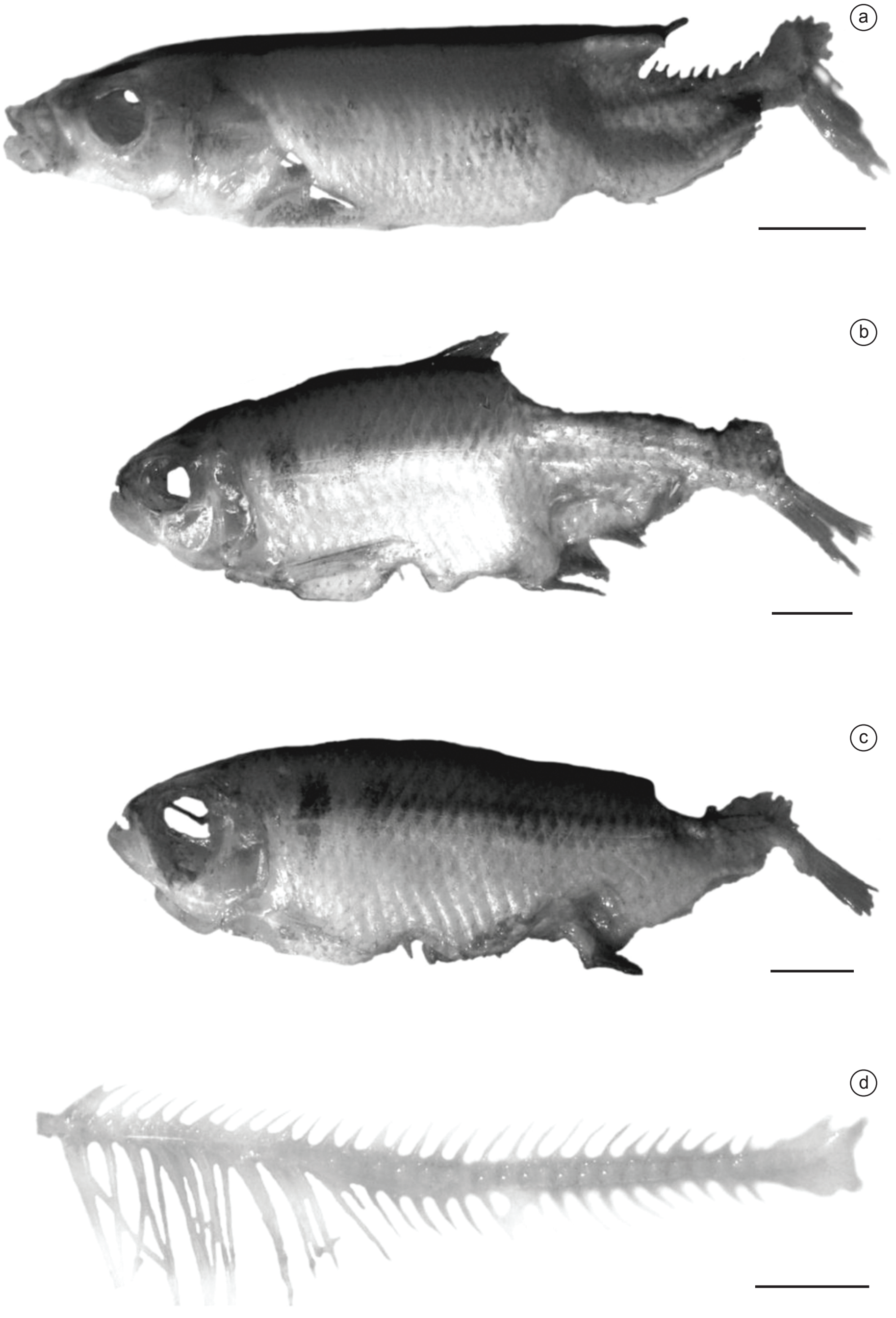

Figure 2. Fish that suffered carnivory by aeglids. (a) *Crenicichla* sp. (b and c) *Astyanax fasciatus*. (d) Fish skeleton. Scale 1 cm.

In this study, the aeglids behave as a perfect opportunistic predator, feeding on immobilized prey attached in a net, but it is possible to deduce that in the natural environments they are able to feed on dead fishes or on pieces of them that have left by other predators. Although the spectrum of food items of *A. grisella* and *A. singularis* is not yet known, it is clear that these aeglids can be carnivorous, which is actually the most efficient way of obtaining energy and proteins of high nutritional value.

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Mamíferos não voadores do Parque Estadual Carlos Botelho, *Continuum* florestal do Paranapiacaba

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BROCARDO, C.R., RODARTE, R., BUENO, R.S., CULOT, L. & GALETTI, M. **Non-volant mammals of Carlos Botelho State Park, Paranapiacaba Forest *Continuum***. Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?inventory+bn02512042012

Abstract: The Atlantic Forest is one of the most studied Brazilian biomes in relation to its mammalian fauna. However, there is still a series of gaps of knowledge about the distribution and persistence of some of these species which prevents taking adequate conservation measures to better protect the mammals. In order to make the inventory of the non-volant mammalian fauna of the Carlos Botelho State Park (SP), we compiled data of camera trapping, diurnal census, track records, pitfall and live trapping collected over 8 years (2004-2012). We registered a total of 53 species, of which 12 are regionally threatened and one is an exotic species (*Lepus europaeus*), including the presence of most mammal species expected for the Paranapiacaba Forest *Continuum*. The high non-volant mammals species richness allied to the presence of threatened species, strengthen the role of this protected area for mammal conservation in the Atlantic Forest. Although, the local extinction of one species, *Tayassu pecari*, alert to the need for effective measures of protection.
Keywords: *Atlantic Forest, conservation, Mammalia, species richness, local extinction.*

BROCARDO, C.R., RODARTE, R., BUENO, R.S., CULOT, L. & GALETTI, M. **Mamíferos não voadores do Parque Estadual Carlos Botelho, *Continuum* florestal do Paranapiacaba.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?inventory+bn02512042012

Resumo: A Mata Atlântica é o bioma melhor conhecido em relação à mastofauna no Brasil, contudo ainda assim apresenta uma série de lacunas de conhecimento sobre a persistência e distribuição de espécies, o que representa um risco adicional à conservação de mamíferos. Neste trabalho, através da coleta de dados por diferentes métodos – armadilhas fotográficas, censos diurnos, registro de vestígios, armadilhas de queda e captura viva – ao longo de oito anos (2004-2012), foi realizado o inventário da mastofauna não voadora do Parque Estadual Carlos Botelho (SP). No total foram registradas 53 espécies, sendo 12 espécies ameaçadas regionalmente e uma exótica (*Lepus europaeus*), com a presença da maioria dos mamíferos esperados para o *Continuum* Florestal da Serra do Paranapiacaba. A comunidade de mamíferos não voadores quase completa, e a presença de espécies ameaçadas reforçam o papel desta área protegida para a conservação de mamíferos na Mata Atlântica. Embora, a extinção local de uma espécie, *Tayassu pecari*, alerte para a necessidade de medidas efetivas de proteção.
Palavras-chave: *Mata Atlântica, conservação, Mammalia, riqueza de espécies, extinção local.*

Introdução

A comunidade de mamíferos está ligada a características ambientais como o tipo de vegetação, a produção primária e o relevo (Peres 2000, Haugaasen & Peres 2005, Galetti et al. 2009). Mas ações antrópicas, como a supressão e fragmentação de habitats, a caça e a perseguição de espécies têm influência marcante na persistência de populações de mamíferos (Chiarello 1999, Cullen-Junior et al. 2000, Peres 2000, Galetti et al. 2009, Brocardo & Cândido-Junior 2012). A riqueza de espécies de mamíferos, por exemplo, parece estar fortemente relacionada ao tamanho da área de habitat remanescente (Chiarello 1999). Dessa forma, a manutenção de grandes áreas protegidas tem sido apontada como fundamental para conservação do grupo, sobretudo para as espécies maiores (Chiarello 2000, Gurd et al. 2001, Ceballos et al. 2005), que estão mais propensas à extinção entre os mamíferos (Cardillo et al. 2005).

Contudo, em ambientes altamente modificados e ocupados por populações humanas, como é o caso da Mata Atlântica (Ribeiro et al. 2009, Tabarelli et al. 2010), grandes remanescentes são uma raridade na paisagem. No bioma, restam apenas sete áreas contínuas com mais de 100.000 ha (Ribeiro et al. 2009), e estes últimos grandes remanescentes constituem as áreas com maior potencial de manutenção de espécies selvagens e de suas interações ecológicas (Tabarelli et al. 2010). E embora a Mata Atlântica seja o bioma com a mastofauna melhor conhecida, a falta de publicações de lista de espécies de mamíferos em forma de artigos (Brito et al. 2009) representa uma lacuna de conhecimento sobre a presença e a distribuição de espécies (Costa et al. 2005, Galetti et al. 2009, De Vivo et al. 2011). Portanto, faz-se necessário conhecer melhor a diversidade dos grandes blocos florestais de Mata Atlântica a fim de direcionar esforços de conservação, e reverter o processo de perda de biodiversidade no bioma (Galetti et al. 2009, Ribeiro et al. 2009).

Diante disso, o objetivo desse trabalho foi inventariar a mastofauna não voadora do Parque Estadual Carlos Botelho, Unidade de Conservação de Proteção Integral localizada no *Continuum* florestal da Serra do Paranapiacaba.

Material e Métodos

1. *Área de estudo*

O estudo foi desenvolvido no Parque Estadual Carlos Botelho (PECB) (24° 08’ S e 47° 58’ W), localizado no sudeste do estado de São Paulo, Brasil (Figura 1). O PECB possui uma área de 37.644 ha formados pela Floresta Ombrófila Densa (FOD) (Mata Atlântica *stricto sensu*), com grande quantidade de lauráceas, mirtáceas e palmito-juçara (*Euterpe edulis* Martius), além de trechos muito pequenos de reflorestamento com pinheiro-do-paraná [*Araucaria angustifolia* (Bertol.) Kuntze] (Brocardo et al. 2010, Lima et al. 2011). O PECB está diretamente ligado ao Parque Estadual Intervales, que por sua vez faz limites com o Parque Estadual Turístico do Alto Ribeira (PETAR) e a Estação Ecológica de Xitué. Estas Unidades de Conservação (UC’s), juntamente com áreas particulares do entorno, formam o *Continuum* Florestal da Serra do Paranapiacaba, uns dos maiores remanescentes de Mata Atlântica, com cerca de 460.000 ha (Figura 1c). O *Continuum* do Paranapiacaba está inserido no grande bloco florestal formado pela Serra do Mar, que tem início no estado do Rio de Janeiro, estende-se pelos estados de São Paulo e Paraná, indo até Santa Catarina, com mais de um milhão de hectares (Figura 1b).

A amplitude altitudinal no PECB vai de 50 a 975 m, sendo a coleta de dados proveniente da parte alta do parque (Base de São Miguel Arcanjo, Figura 1d), com altitude variando de 720 a 850 m. A temperatura média anual na área amostrada varia de 15 a 19 °C, e a precipitação anual 1.700 a 2.000 mm, sem estação seca definida (Instituto... 2008). A área amostrada constitui a parte do PECB com menor atividade de caçadores e palmiteiros (Bueno, R.S. dados não publicados), e possivelmente representa uma das porções menos alteradas e com maior potencial de abrigar a fauna original.

2. *Coleta de dados e análises*

Para o registro de espécies foram utilizados os seguintes métodos: censos diurnos, armadilhamento fotográfico, armadilhas de queda (*pitfall*), armadilhas de captura viva (*live traps*: modelos Sherman – de três tamanhos diferentes: pequeno [23 × 7,5 × 8,5 cm], médio [30 × 7,5 × 9,5cm] e grande [37,5 × 10 × 12 cm], e *Tomahawk* [45 × 16 × 16 cm]), além de registro de vestígios, observações casuais (*ad libitum*) e informações de funcionários do PECB.

A amostragem por meio de censos diurnos foi utilizada para abranger, sobretudo as espécies diurnas de médio e grande porte, mas também pequenas com hábitos arborícolas (e.g. *Guerlinguetus ingrami*) (Peres 1999, Chiarello 2000). Esta amostragem foi realizada em duas etapas, na primeira (outubro/2004 a fevereiro/2006) houve o esforço de 127,6 km percorridos (quatro trilhas, variando de 3,9 a 5,4 km), e na segunda etapa (agosto/2009 a junho/2010) houve o esforço de 430,35 km (em quatro trilhas, que variaram de 1,2 a 5 km). Foram seguidas as metodologias padronizadas para este tipo de amostragem (Peres 1999, Cullen-Junior & Rudran 2006), buscando-se abranger a heterogeneidade ambiental da UC (alto de morros, vales e proximidade a cursos d’água).

Para o registro de espécies noturnas e/ou espécies elusivas foram utilizadas armadilhas fotográficas (Srbek-Araújo & Chiarello 2005). Seis armadilhas fotográficas Reconyx© (modelo RC55 RapideFire, www.reconyx.com) foram instaladas em trilhas e em áreas de interior de mata, a cerca de 30 cm do solo, em pontos distanciados por no mínimo 200 m entre si. Esta metodologia foi dividida em dois esforços distintos: um esforço amostral de 497 armadilhas.dia (número de armadilhas × dias amostrados; dia = 24 horas) realizado entre setembro de 2009 e junho de 2010 (amostragem em todos meses). E outro esforço paralelo realizado com a utilização de atrativos (banana, laranja, sardinha, urina de lince, frutos de *Euterpe edulis*, sementes de *Attalea dubia*), totalizando 112 câmeras.dia (setembro/2009-setembro/2010, esforço mensal).

Em um segundo momento, no período de agosto a outubro 2011, foi realizado o esforço de 166 armadilhas.dia, utilizando quatro armadilhas fotográficas Bushnell Trophy Cam (www.bushnell.com) fora das trilhas e com frutos maduros de *Cryptocarya mandioccana* (Lauraceae) como iscas.

A amostragem de pequenos mamíferos não voadores foi realizada em cinco incursões bimestrais a campo (maio/2011 a janeiro/2012), cada uma com cinco noites de captura, totalizando um esforço amostral de 600 pitfalls.noite e 2.250 *live* traps.noite. Ao todo, foram montados três *grids* de captura somente com *live traps* e seis transectos com *pitfalls*. As *live traps* foram dispostas em forma de grade de 0.6ha (60 m × 100 m) com 24 estações de captura espaçadas 20 m entre si. Cada estação contou com uma armadilha *Sherman* de tamanho distinto e apenas seis dispunham também de uma *Tomahawk.* A distribuição das armadilhas por ponto foi feita de modo aleatório. Portanto, foram iscadas 30 armadilhas *live traps* por grade e um total de 90 armadilhas *live traps* para o PECB. As armadilhas de interceptação e queda constavam de duas linhas paralelas de 50 m de comprimento cada e distantes 30 m entre si. Cada linha consistia em quatro baldes plásticos de 60 L, enterrados a nível do solo, unidos por cerca-guia e distantes 10 m um do outro. Foi usado um total de 24 baldes no estudo. Todo animal capturado foi identificado, individualizado com um brinco numerado (Ear tags, National Band and Tag Co., Newport, Kentucky, USA), teve seus dados biométricos

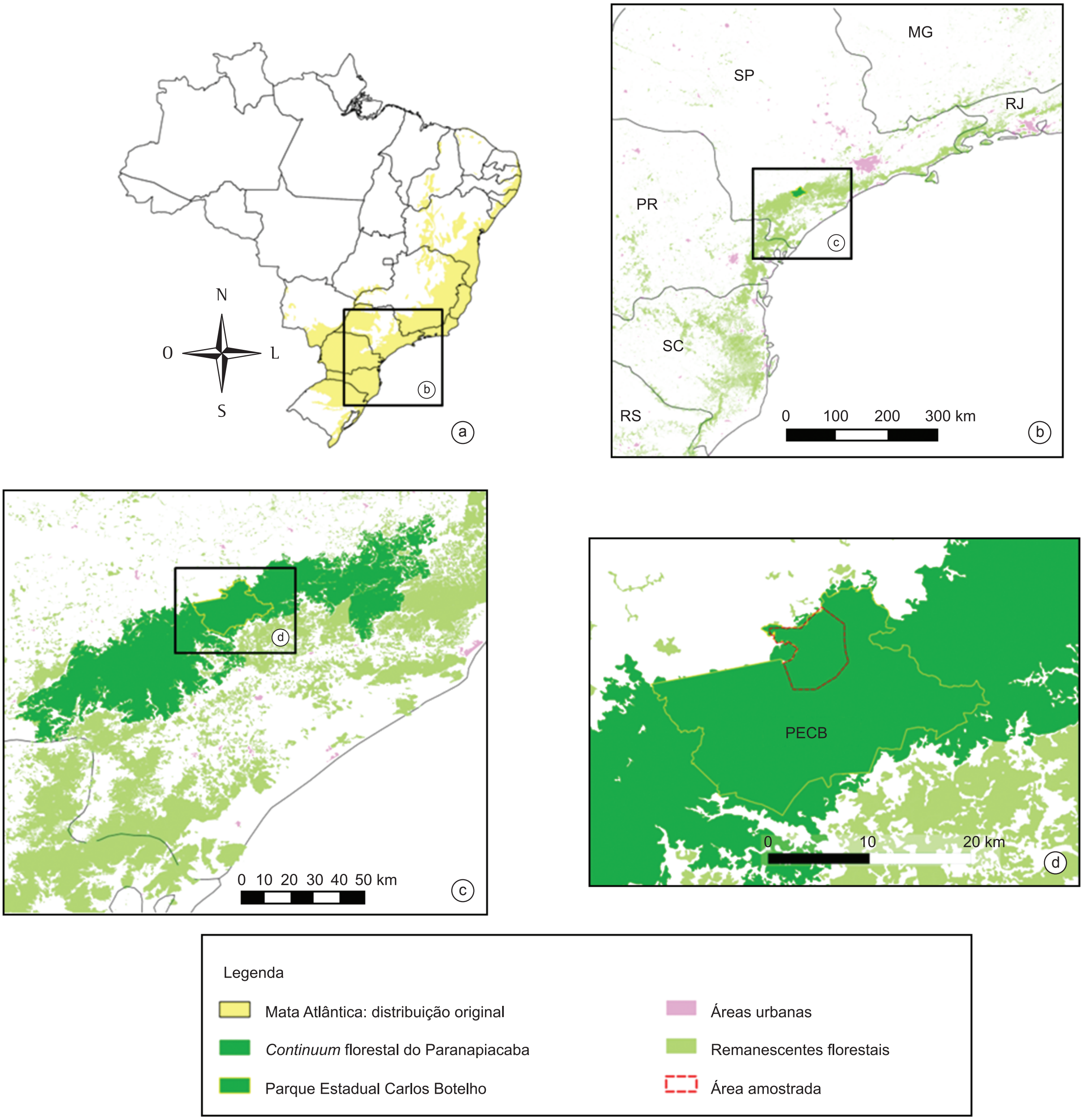

Figura 1. Localização do Parque Estadual Carlos Botelho (PECB) na porção sul da Mata Atlântica brasileira (a, b); destaque para a localização do PECB no *Continuum* Florestal do Paranapiacaba, estado de São Paulo (c); e área amostrada, delimitação pela linha vermelha tracejada (d).

Figure 1. Carlos Botelho State Park (CBSP) in Southern Brazilian Atlantic Forest (a,b); highlighting the CBSP location in Paranapiacaba forest *Continuum*, São Paulo state (c); and sampled area, the red line boundary dashed (d).

registrados e foi liberado no exato local de captura. A fim de auxiliar na identificação de espécies crípticas (ver Apêndice 1), alguns indivíduos foram coletados e enviados para análises citogenéticas no Laboratório de Ecologia e Evolução do Instituto Butantan. Espécies do gênero *Monodelphis* foram identificadas por taxonomista. Todos os espécimes testemunhos foram depositados na Coleção de Mamíferos da Universidade Federal do Espírito Santo (UFES) (Apêndice 1).

Em todo período de trabalho em campo foram realizados registros de espécies por meio de vestígios (pegadas, fezes, carreiros e tocas) sempre que esses eram observados em campo. A identificação dos vestígios foi baseada em literatura técnica de referência (Becker & Dalponte 1991, Borges & Tomás 2004) e em conhecimento prévio. Observações *ad libitum* também foram anotadas durante deslocamento até os locais das amostragens padronizadas.

Para complementar os dados de campo (Voss & Emmons 1996), entrevistas com funcionários do PECB (apenas pessoal com experiência em campo e hábeis na identificação de mamíferos) foram realizadas, solicitando aos entrevistados descrever quais espécies de mamíferos já haviam observado dentro da UC. Ainda para gerar uma lista mais completa, incluímos registros apresentados em bibliografia publicada na forma de artigos científicos. Na lista de espécies foi seguida a nomenclatura apresentada em Paglia et al. (2012).

No programa R (R Development... 2011), com o pacote "vegan" (Oksanen et al. 2011) foram usadas as funções "specaccum" e "specpool", respectivamente, para gerar a curva de acumulação de espécies e estimar o número de espécies. Para padronizar todos os tipos de amostragem, foi gerada uma matriz para cada metodologia com o número de dias de esforço em campo e o número de espécies registradas. Por fim, também foi gerada uma matriz com a combinação de todas as metodologias (esforço em dias × espécies registradas em cada dia) (adaptada de Norris et al. 2012).

Resultados

Foi obtida uma lista com 53 espécies de mamíferos silvestres não voadores para o PECB (Tabela 1).

Apesar de espécies domésticas terem sido observadas no PECB, como gatos (*Felis silvestris catus* Linnaeus, 1758) próximo a sede, cães (*Canis lupus familiaris* Linnaeus, 1758) próximo a sede e

Tabela 1. Lista dos mamíferos não voadores registrados no Parque Estadual Carlos Botelho, entre 2004 e 2012.

Table 1. Non-volant mammals recorded in Carlos Botelho State Park, between 2004 and 2012.

Ordem	Espécie	Forma de registro	Ameaça[1]		
Família			SP	BR	Gl
Artiodactyla					
Cervidae	*Mazama americana* (Erxleben, 1777)	B	VU	LC	DD
	Mazama bororo Duarte, 1996	B*	VU	DD	VU
	Mazama gouazoubira (G. Fisher, 1814)	V, B	LC	LC	LC
Tayassuidae	*Pecari tajacu* (Linnaeus, 1758)	P, F*, B	NT	LC	LC
Carnivora					
Canidae	*Cerdocyon thous* (Linnaeus, 1766)	P, F*, B	LC	LC	LC
	Speothos venaticus (Lund, 1842)	B	DD	DD	NT
Felidae	*Leopardus pardalis* (Linnaeus, 1758)	P, F, F*, B	VU	VU	LC
	Leopardus tigrinus (Schreber, 1775)	B	VU	VU	VU
	Leopardus wiedii (Schinz, 1821)	F*, B	EN	VU	NT
	Panthera onca (Linnaeus, 1758)	P, B	CR	VU	NT
	Puma concolor (Linnaeus, 1771)	P, F, Fe, B	VU	VU	LC
	Puma yagouaroundi (É.Geoffroy, 1803)	B	LC	LC	LC
Mustelidae	*Eira barbara* (Linnaeus, 1758)	C, P, F, F*, B	LC	LC	LC
	Galictis cuja (Molina, 1782)	P, B	DD	LC	LC
	Lontra longicaudis (Olfers, 1818)	P, Fe	NT	LC	DD
Procyonidae	*Nasua nasua* (Linnaeus, 1766)	C, F*, V, B	LC	LC	LC
	Procyon cancrivorus (G. Cuvier, 1798)	P, F, F*, B	LC	LC	LC
Cingulata					
Dasypodidae	*Cabassous tatouay* (Desmarest, 1804)	P, F, B	DD	DD	LC
	Dasypus novemcinctus (Linnaeus, 1758)	B	LC	LC	LC
	Dasypus septemcinctus (Linnaeus, 1758)	V	LC	LC	LC
Didelphimorphia					
Didelphidae	*Didelphis albiventris* Lund, 1840	B	LC	LC	LC
	Didelphis aurita (Wied-Neuwied, 1826)	F, F*, V, Lt, B	LC	LC	LC
	Chironectes minimus (Zimmermann, 1780)	B	NT	LC	LC
	Gracilinanus microtarsus (Wagner, 1842)	Pf	LC	LC	LC
	Marmosops incanus (Lund, 1840) [2]	LC, Pf	NT	LC	LC
	Metachirus nudicaudatus (Desmarest, 1817)	V, F, Lt, B	NT	LC	LC
	Monodelphis americana (Müller, 1776)	Pf	NT	DD	LC
	Monodelphis scalops (Thomas, 1888) [2]	Pf, B	NT	DD	LC
	Philander frenatus (Olfers, 1818) [2]	C, F, B, Lt, Pf, B	LC	LC	LC
Lagomorpha					
Leporidae	*Lepus europaeus* (Pallas, 1778)	B	X	X	LC
	Sylvilagus brasiliensis (Linnaeus, 1758)	Fe	LC	LC	LC

Forma de registro: B = dados bibliográficos a partir de Beisiegel (2009, 2010), onde foi usada unicamente a amostragem com armadilhas fotográficas; B* = fonte Duarte et al. (2012), identificação por meio de DNA fecal (A. Vogliotti com. pess.); C = visual em censo diurno, Ca = carreiro; E = apenas por entrevista, F = armadilha fotográfica sem isca, F* = armadilha fotográfica com isca, Fe = fezes, Lt = *live trap*, P = pegada, Pf = *pitfall* , V = visual fora de censo, Vo = vocalização. [1]Dados regionais (estado de São Paulo – SP) a partir de Bressan et al. (2009). Dados do Brasil (BR) de Chiarello et al. (2008), e dados globais (Gl) a partir de IUCN (International... 2011). CR = Criticamente em Perigo, EN = Em Perigo, VU = Vulnerável, NT = Quase Ameaçada, LC = De Menor Risco, DD = Dados deficientes, X = exótica. [2]Espécies com espécime testemunho depositado na Coleção de Mamíferos da UFES. [3]A espécie é considerada como *Sciurus aestuans* na lista da IUCN (International... 2011).

Tabela 1. Continuação...

Ordem Família	Espécie	Forma de registro	Ameaça[1]		
			SP	BR	Gl
Perissodactyla					
Tapiridae	*Tapirus terrestris* (Linnaeus, 1758)	P, Fe, V, Vo, F, F*, C, Ca, B	VU	LC	VU
Pilosa					
Myrmecophagidae	*Myrmecophaga tridactyla* Linnaeus, 1758	P, B	VU	VU	VU
	Tamandua tetradactyla (Linnaeus, 1758)	E	LC	LC	LC
Primates					
Atelidae	*Alouatta guariba* (Humboldt, 1812)	C, V, Vo	NT	LC	LC
	Brachyteles arachnoides (É.Geoffroy, 1806)	C, V, Vo	EN	EN	EN
Cebidae	*Sapajus nigritus* (Goldfuss, 1809)	C, V, Vo	NT	LC	NT
Rodentia					
Cavidae	*Hydrochoerus hydrochaeris* (Linnaeus, 1766)	E	LC	LC	LC
Cricetidae	*Akodon cursor* (Winge, 1887) [2]	Lt	LC	LC	LC
	Akodon montensis Thomas, 1913 [2]	Lt, Pf	LC	LC	LC
	Brucepattersonius sp. Thomas, 1896 [2]	Pf			
	Delomys sublineatus (Thomas, 1903) [2]	Pf	NT	LC	LC
	Euryoryzomys russatus (Wagner, 1848) [2]	Lt, Pf	VU	LC	LC
	Juliomys sp. González, 2000	Pf			
	Necromys lasiurus (Lund, 1841) [2]	Lt, Pf	LC	LC	LC
	Nectomys squamipes (Brants, 1827)	F*	LC	LC	LC
	Oligoryzomys nigripes (Olfers, 1818) [2]	Pf	LC	LC	LC
	Thaptomys nigrita (Lichtenstein, 1829) [2]	Lt, Pf	VU	LC	LC
Cuniculidae	*Cuniculus paca* (Linnaeus, 1766)	P, F, F*, B	NT	LC	LC
Dasyproctidae	*Dasyprocta azarae* Lichtenstein, 1823	C, V, B	LC	LC	DD
Echimyidae	*Trinomys iheringi* (Thomas, 1911) [2]	F, F*, Lt	LC	LC	LC
Erethizontidae	*Coendou spinosus* (F. Cuvier, 1823)	C	LC	LC	LC
Sciuridae	*Guerlinguetus ingrami* (Thomas, 1901) [3]	V, C, F, F*, B	LC	LC	LC

Forma de registro: B = dados bibliográficos a partir de Beisiegel (2009, 2010), onde foi usada unicamente a amostragem com armadilhas fotográficas; B* = fonte Duarte et al. (2012), identificação por meio de DNA fecal (A. Vogliotti com. pess.); C = visual em censo diurno, Ca = carreiro; E = apenas por entrevista, F = armadilha fotográfica sem isca, F* = armadilha fotográfica com isca, Fe = fezes, Lt = *live trap*, P = pegada, Pf = *pitfall* , V = visual fora de censo, Vo = vocalização. [1]Dados regionais (estado de São Paulo – SP) a partir de Bressan et al. (2009). Dados do Brasil (BR) de Chiarello et al. (2008), e dados globais (Gl) a partir de IUCN (International... 2011). CR = Criticamente em Perigo, EN = Em Perigo, VU = Vulnerável, NT = Quase Ameaçada, LC = De Menor Risco, DD = Dados deficientes, X = exótica. [2]Espécies com espécime testemunho depositado na Coleção de Mamíferos da UFES. [3]A espécie é considerada como *Sciurus aestuans* na lista da IUCN (International... 2011).

em trilhas, e muares (*Equus* sp. Linnaeus, 1758) provenientes de apreensão junto a palmiteiros, não foram contabilizadas na lista de espécies, já que não se tratavam de animais asselvajados. Assim, a única espécie exótica considerada na lista foi a lebre-europeia (*Lepus europaeus*), por se tratar de animais verdadeiramente selvagens.

Das espécies registradas destacam-se predadores de topo como a onça-pintada (*Panthera onca*) e a suçuarana (*Puma concolor*), grandes ungulados como a anta (*Tapirus terrestris*) e o cateto (*Pecari tajacu*), e espécies raras e ameaçadas como o mono-carvoeiro (*Brachyteles arachnoides*) e tamanduá-bandeira (*Myrmecophaga tridactyla*).

A ordem com maior número de registros foi Rodentia com 16, seguida por Carnivora e Didelphimorphia com 13 e nove espécies confirmadas, respectivamente. Para o estado de São Paulo, 12 espécies encontram-se sob algum grau de ameaça, 11 são consideradas quase ameaçadas, e mais três com dados deficientes. Em nível nacional, sete estão classificadas como ameaçadas, e quatro espécies encontram-se com dados deficientes. Globalmente, cinco espécies estão ameaçadas, quatro estão quase ameaçadas e para três espécies constam dados deficientes.

Da lista de espécies obtida, 44 foram registradas em nosso esforço amostral, e nove espécies confirmadas apenas por meio de dados bibliográficos. Das 44 amostradas nesse estudo, 21 já haviam sido registradas (ver Beisiegel 2009, 2010), e 23 são exclusivas. Em nosso esforço, 24 espécies foram detectadas unicamente por meios diretos (visuais *ad libitum*, em censos diurnos, armadilhas fotográficas e capturas), cinco somente por meios indiretos (fezes ou pegadas), e 13 espécies registradas direta e indiretamente. Duas espécies foram registradas somente por entrevistas.

Dos métodos padronizados para amostragem (censos, armadilhas fotográficas, armadilhas de queda e captura viva), houve um maior registro de espécies por meio de armadilhas fotográficas (Tabela 2). Contudo, mais espécies foram contabilizadas utilizando-se vestígios e observações *ad libitum* combinados, e um número maior de espécies obteve registro exclusivamente por estes meios (Tabela 2). Considerando as metodologias mais sensíveis a espécies de pequeno porte (<1 kg), um número muito semelhante de espécies foi detectado, sendo 13 e 11, respectivamente para armadilhas de queda e captura viva, mas com maior número de espécies exclusivas para a primeira metodologia (Tabela 2). De todas as espécies registradas em campo, 17 tiveram registro por uma única metodologia, o que representa 40% do total.

As curvas de acumulação de espécies mostraram haver diferenças na estabilização dos diferentes métodos (Figura 2a-e), indicando

Tabela 2. Número de espécies registradas em campo por este estudo no PECB, através de cada metodologia e número de espécies esperadas.

Table 2. Number of species recorded in field by this study at CBSP, through each method and extrapolated species richness.

Metodologia	Número de espécies		
	Registradas	Exclusivas	Esperadas[1]
Censo diurno	10	1	15,9 ± 2,4
Armadilha fotográfica	18	2	22,9 ± 2,2
Armadilha de queda	13	6	15,9 ± 1,6
Armadilha de captura viva	11	1	12,9 ± 1,3
Vestígios e visual *ad libitum*[2]	24	7	32,9 ± 2,8
Todas técnicas juntas	42	-	47,9 ± 2,4

[1] Baseada em análise *Jackknife* de primeira ordem, [2] Duas espécies registradas unicamente por observações *ad libitum* e cinco por vestígios

que o número de espécies registradas poderia aumentar no censo (Figura 2b), e em registros por meio de vestígios e observações *ad libitum* (Figura 2c). O número de espécies poderia aumentar em média 60% para o censo, e perto de 40% para registros com vestígios e visual *ad libitum* (Tabela 2). A tendência de acumulação apresentou-se mais estável nas demais metodologias (Figura 2a, d, e), havendo um incremento menor para registros de armadilhas fotográficas, de queda e captura viva, com base na extrapolação (Tabela 2). A combinação de todos os métodos mostrou uma curva amostral com maior estabilidade (Figura 2f), havendo a indicação de 48 espécies esperadas (47,9 ± 2,4; Tabela 2).

Discussão

A utilização das diferentes técnicas mostrou-se necessária, havendo quase metade das espécies registradas por uma única metodologia empregada em campo. Também houve maior estabilidade na curva amostral com a combinação das diferentes técnicas em relação esforço em dias (Figura 2f), com a extrapolação para quase 50 espécies esperadas (47,9 ± 2,4), o que fica muito próximo do total confirmado até o momento para o PECB (Tabela 1, dados de campo mais dados bibliográficos e entrevistas). Os dados provenientes de bibliografia também foram importantes, já que mesmo empregando diversas técnicas em campo, e por um longo período de amostragem, espécies raras ou crípticas podem apresentar falhas na sua detecção (González et al. 2009, Beisiegel 2010). Considerando apenas as metodologias mais sensíveis a médios e grandes mamíferos, as armadilhas fotográficas e vestígios foram mais eficientes do que o censo, como já demonstrado (Silveira et al. 2003, Norris et al. 2012), tanto em número de espécies, quanto em espécies com registros exclusivos para cada técnica. Para técnicas de amostragem voltadas para pequenos mamíferos, houve complementaridade entre *pitfall* e *live trap*, com espécies exclusivamente registradas por cada uma, o que reforça a importância da utilização de ambas na amostragem de mamíferos de pequeno porte (Santos-Filho et al. 2006, Caceres et al. 2011).

Os resultados obtidos demonstram o valor regional do PECB na manutenção de espécies silvestres, e preenchem informações sobre a presença de espécies em uma região extremamente importante de Mata Atlântica (Galetti et al. 2009, Ribeiro et al. 2009, Tabarelli et al. 2010, De Vivo et al. 2011). O número de espécies selvagens nativas anotadas dentro da UC (52, excluindo-se *Lepus europaeus*) corresponde a 41% do total de espécies de mamíferos terrestres não voadores encontrados no estado de São Paulo (127 espécies, sendo excluídas as ordens Chiroptera e Cetacea da lista apresentada em De Vivo et al. 2011). A criação de UC's tem sido apontada como uma medida eficiente na manutenção de porções de habitat natural e conservação da biodiversidade, e também como modo de frear as pressões antrópicas (Bruner et al. 2001). Na Mata Atlântica, a importância de áreas protegidas é marcante, já que são as UC's que abrigam os maiores remanescentes (Ribeiro et al. 2009), e constituem áreas essenciais à conservação de diversos grupos (Silvano & Segallo 2005, Bencke et al. 2006, Galetti et al. 2009, Albuquerque et al. 2011). Considerando as recorrentes alterações na legislação ambiental para condições desfavoráveis, e a extensa fragmentação e redução de habitat existente nas áreas fora das UC's, estas adquirem importância ainda maior (Galetti et al. 2010, Tabarelli et al. 2010).

Em pequenos fragmentos (<500 ha) de Mata Atlântica tem sido observada uma redução substancial na riqueza de espécies de mamíferos (Chiarello 1999, Briani et al. 2001, Pardini et al. 2005, Abreu Junior & Köhler 2009, Silva Junior & Pontes 2008, Brocardo & Cândido-Junior 2012), enquanto fragmentos maiores (>500 ha) e áreas com maior conectividade retêm comunidades mastofaunísticas mais intactas (Chiarello 1999, Cullen-Junior et al. 2000, Pardini et al. 2005, Cherem et al. 2011, Brocardo & Cândido-Junior 2012, Norris et al. 2012). Estudos indicam que apenas grandes remanescentes florestais são capazes de manter populações viáveis de boa parte das espécies de mamíferos neste bioma (Chiarello 1999, 2000, Cullen-Junior et al. 2000).

Para espécies de pequeno porte, o número de espécies registradas está próximo do esperado para a formação florestal. Pardini et al. (2005), em estudo realizado em áreas de FOD do estado de São Paulo, registraram sete espécies de marsupiais e 13 de roedores. Para o PECB confirmou-se a ocorrência de nove marsupiais e 12 roedores de pequeno porte. Os pequenos mamíferos não voadores (roedores e marsupiais < 1 kg) constituem o grupo ecológico mais diversificado de mamíferos das florestas Neotropicais, com quase 100 espécies descritas para a Mata Atlântica, das quais mais da metade (62 espécies) é endêmica deste bioma (Paglia et al. 2012). Conhecer a comunidade de marsupiais e pequenos roedores é de extrema importância, uma vez que exercem grande influência na dinâmica florestal além de serem considerados bons indicadores de qualidade de hábitat (Pardini & Umetsu 2006).

Em relação às espécies de médio e grande porte, no PECB praticamente todas cuja ocorrência é esperada para região estão presentes (Tabela 1). Nesse trabalho foram 34 espécies de tamanho médio ou grande (>1 kg), enquanto Norris et al. (2012) registraram 17 espécies, também trabalhando em uma área contínua de FOD (Núcleo de Caraguatatuba – Parque Estadual Serra do Mar, SP). Algumas ausências no PECB, podem ser atribuídas a própria limitação de distribuição natural das espécies, como é o caso da preguiça-de-três-dedos (*Bradypus variegatus*, Linnaeus 1758) e do tatu-canastra (*Priodontes maximus*, Kerr 1792) sem registros recentes no *Continuum* florestal da Serra do Paranapiacaba (Srbek-Araújo et al. 2009, Moraes-Barros et al. 2010), sendo provável que naturalmente não ocorram nas partes mais altas e frias. A falta de registros do tatu-peba (*Euphractus sexcinctus*, Linnaeus 1758) e preá (*Cavia aperea*, Erxleben 1777) dentro do PECB, pode ser atribuída aos hábitos desses animais, que preferem áreas abertas e bordas florestais (Redford & Wetzel 1985, Asher et al. 2004, Pardini et al. 2005). Os esforços amostrais foram realizados, sobretudo, em áreas de mata fechada. Entretanto, mesmo assim registraram-se espécies mais relacionadas a formações abertas, como *Myrmecophaga tridactyla* (grande porte) e *Necromys lasiurus* (pequeno porte). Este último habita formações abertas e florestais do Cerrado (Bonvicino et al. 2008), onde é comumente uma das espécies de roedor mais abundante (Alho & Pereira 1985), mas também pode ser encontrado em regiões de Floresta Amazônica, Caatinga, Chaco e Mata Atlântica (Redford & Fonseca 1986, Bonvicino et al. 2008, este estudo). O tamaduá-

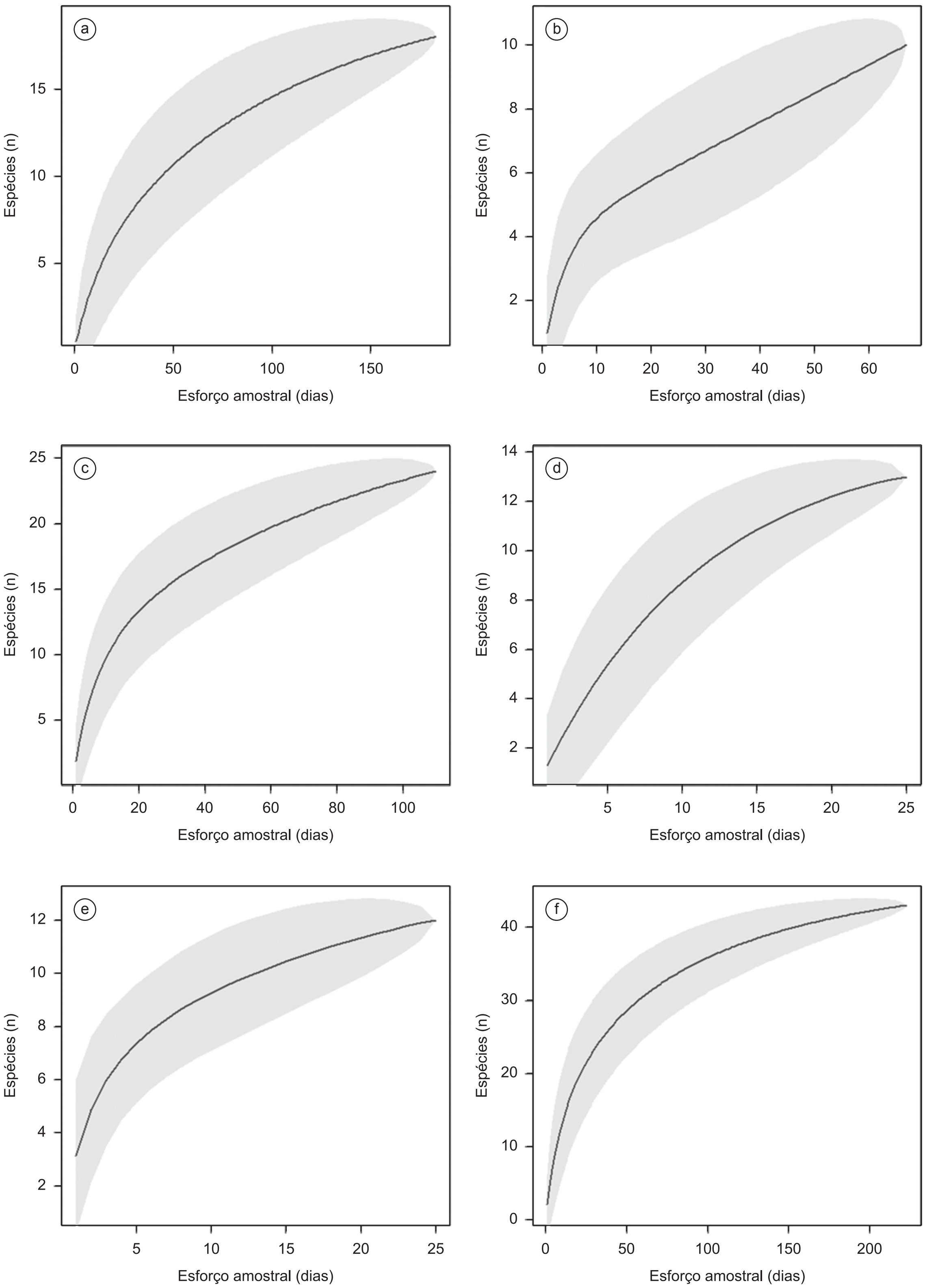

Figura 2. Curva de acumulação de espécies de mamíferos registradas através: a) de armadilhas fotográficas; b) de censos diurnos; c) do registro de vestígios e visualizações ad *libitum*; d) de armadilhas de queda (*pitfall*); e) de armadilhas de captura viva (*livetrap*); e f) da combinação de todas as metodologias de amostragem em campo. A área sombreada representa o intervalo de confiança de 95%.

Figure 2. Species accumulation curve of mammals recorded through: a) camera-traps; b) diurnal census; c) track records and ad *libitum* visualizations; d) pitfalls; e) live traps; and f) combination of all field methods. The shaded area represents the 95% confidence interval.

bandeira (*M. tridactyla*) igualmente conta com registros anteriores na Mata Atlântica (Crespo 1982, Redford & Fonseca 1986, Moreira et al. 2008, Beisiegel 2009, 2010), contudo sua distribuição nesse bioma necessita de maiores informações (Moreira et al. 2008).

A ausência do registro de uma espécie em especial, o queixada (*Tayassu pecari* Link, 1795) é notável, e pode ser considerado indício de uma extinção local. A espécie é apontada como uma das mais vulneráveis no Neotrópico, sendo particularmente susceptível à caça (Peres 1996, Peres & Palacios 2007, Altrichter & Almeida 2002, Altrichter et al. 2012). Embora nossa amostragem se concentre na parte alta do PECB, é pouco provável que a espécie ocorra em outras áreas deste parque, já que a pressão de caça e a extração ilegal de palmito (*Euterpe edulis*) são maiores que no local amostrado. Beisiegel (2009, 2010) em 39 meses de monitoramento (de 2006 a 2009) por meio de armadilhas fotográficas (esforço de 5.715 armadilhas.dia), amostrando 78 pontos distribuídos em todo PECB, não obteve nenhum registro de *T. pecari*. Guardas-parque relataram o desaparecimento do queixada no fim da década 1980 para o PECB (Brocardo, C.R. com. pess.), e o mesmo foi relatado por guardas-parque para o Parque Estadual Intervales (Galetti, M. com. pess.). A espécie também é considerada extinta em outros grandes remanescentes de Mata Atlântica, como o Parque Estadual do Turvo (RS) e o Parque Nacional do Iguaçu (PR) (Kasper et al. 2007, Azevedo & Conforti 2008). A ausência de uma espécie-chave como o queixada (Beck 2005), deixa claro que mesmo grandes remanescentes e UC's podem falhar em manter espécies ameaçadas, se programas efetivos de geração alternativa de renda e fiscalização não forem adotados no entorno, para mitigar ações ilegais dentro das áreas protegidas (Carrillo et al. 2000, Bruner et al. 2001, Galetti et al. 2009, Fragoso et al. 2011).

Efetivamente existe um gradiente de defaunação dentro do PECB que se estende a outros grupos de médios e grandes mamíferos, sendo que na parte baixa (base de Sete Barras) espécies como mono-carvoeiro (*B. arachnoides*) não são avistadas a mais de 15 anos, e ungulados ocorrem em densidades muito inferiores em relação as partes mais altas e próximas a sede de São Miguel Arcanjo (Bueno, R. S. dados não publicados), e não se sabe qual o efeito deste gradiente nos pequenos mamíferos. A provável explicação para esse fato é que nas partes baixas, a maioria dos palmitos adultos (*Euterpe edulis*) já foi retirada, e a ação de caçadores, associados ou não a retirada de palmito, é mais frequente e intensa devido à fiscalização deficitária.

Mas apesar da provável extinção local de um ungulado, o PECB tem papel chave na conservação de outro Artiodactyla extremamente ameaçado, o veado-mateiro-pequeno (*Mazama bororo*), espécie restrita à porção sul da Mata Atlântica brasileira (Vogliotti & Duarte 2009), e recentemente confirmada para a UC (Duarte et al. 2012). Além disso, a presença de outras espécies ameaçadas em níveis regional, nacional e global, como é o caso da onça-pintada (*P. onca*) e do mono-carvoeiro (*B. arachnoides*), reforça o papel do PECB como área prioritária para conservação de mamíferos na Mata Atlântica (Galetti et al. 2009, Albuquerque et al. 2011), Unidade de Conservação de proteção Integral localizada na maior porção remanescente do bioma – o Contínuo florestal do Paranapiacaba.

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Apêndice

Apêndice 1. Espécimes testemunho coletados no Parque Estadual Carlos Botelho, município de São Miguel Arcanjo, estado de São Paulo entre maio de 2011 e janeiro de 2012, e depositados na Coleção de Mamíferos da Universidade Federal do Espírito Santo (UFES).

Nº de tombo UFES	Gênero	Epíteto específico	Coletor	Nº do coletor	Nº cromossômico (Diplóide)	Preparação	Sexo
2214	*Monodelphis*	*scalops*	Raisa Rodarte	58	18	espécime inteiro (ETOH)	F
2215	*Marmosops*	*incanus*	Raisa Rodarte	MARS 27	14	pele; crânio; esqueleto parcial	F
2216	*Philander*	*frenatus*	Raisa Rodarte	MARS 26	22	pele; crânio; esqueleto parcial	F
2217	*Akodon*	*cursor*	Raisa Rodarte	ROD 165	14	pele; crânio; esqueleto parcial	M
2218	*Akodon*	*montensis*	Raisa Rodarte	ROD 169	25	pele; crânio; esqueleto parcial	M
2219	*Akodon*	*montensis*	Raisa Rodarte	ROD 157	24	pele; crânio; esqueleto parcial	F
2220	*Akodon*	*montensis*	Raisa Rodarte	ROD 194	24	pele; crânio; esqueleto parcial	F
2221	*Bruceparttersonius*	sp.	Raisa Rodarte	ROD 155	52	pele; crânio; esqueleto parcial	M
2222	*Delomys*	*sublineatus*	Raisa Rodarte	ROD 168	72	pele; crânio; esqueleto parcial	M
2223	*Delomys*	*sublineatus*	Raisa Rodarte	ROD 162	72	pele; crânio; esqueleto parcial	F
2224	*Euryoryzomys*	*russatus*	Raisa Rodarte	ROD 159	80	pele; crânio; esqueleto parcial	M
2225	*Necromys*	*lasiurus*	Raisa Rodarte	ROD 161	34	pele; crânio; esqueleto parcial	M
2226	*Oligoryzomys*	*nigripes*	Raisa Rodarte	ROD 164	62	pele; crânio; esqueleto parcial	F
2227	*Oligoryzomys*	*nigripes*	Raisa Rodarte	ROD 160	62	pele; crânio; esqueleto parcial	F
2228	*Thaptomys*	*nigrita*	Raisa Rodarte	ROD 158	52	pele; crânio; esqueleto parcial	M
2229	*Thaptomys*	*nigrita*	Raisa Rodarte	ROD 163	52	pele; crânio; esqueleto parcial	F
2230	*Trinomys*	*iheringi*	Raisa Rodarte	ROD 156	63	pele; crânio; esqueleto parcial	M
2231	*Trinomys*	*iheringi*	Raisa Rodarte	ROD 166	64	pele; crânio; esqueleto parcial	M
2232	*Trinomys*	*iheringi*	Raisa Rodarte	37	64	pele; crânio; esqueleto parcial	F
2233	*Trinomys*	*iheringi*	Raisa Rodarte	ROD 167	63	pele; crânio; esqueleto parcial	M

Life cycle of *Scapholeberis armata freyi* Dumont & Pensaert, 1983 (Cladocera, Daphnidae)

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Abstract: Knowledge of the life cycle of zooplankton species can provide information for a better understanding of the role of each species in the community and basic data for secondary production investigations. In this study, some life-cycle traits were measured for *Scapholeberis armata freyi* Dumont & Pensaert, 1983 (Cladocera, Daphnidae), maintained under controlled conditions in laboratory cultures. Experiments were carried out in incubators at a temperature of 23.0 °C, photoperiod of 12 hours light/dark, and food supply (algal suspension of the chlorophycean *Pseudokirchneriela subcapitata* at 10^5 cells.mL^{-1} and mixed suspension of yeast, and fish ration added per organism, at equal proportions) that were kept constant. Observations were made once or twice a day to record individual growth, age and size of primipara, as well as fecundity and longevity. *S. armata freyi* achieved a maximum size of 827 µm, while the primiparous instar measured 542 µm on average, at an age of 5.86 days. The mean fecundity was 8 eggs.female^{-1} and the mean of total number of eggs produced by a female was 47.58. Embryonic development time was 1.9 days and the maximum longevity found was 31 days. In this study, the life cycle parameters of S. *armata freyi* presented are close to those found in other species of Daphnidae, under the same culture conditions of temperature and photoperiod. However, the longevity was greater than other species that received algae as food only. The quality and quantity of food are factors that control secondary production in aquatic ecosystems and an increase of food availability increases longevity and egg production. Thus the greater longevity and egg production observed for *S. armata freyi* can influence its secondary production.
Keywords: *Anomopoda, zooplankton, longevity, fecundity, growth.*

CASTILHO, M.C.A., WISNIEWSKI, C. & SANTOS-WISNIEWSKI, M.J. **Ciclo de vida de *Scapholeberis armata freyi* Dumont & Pensaert, 1983 (Cladocera, Daphnidae)**. Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?article+bn01112042012

Resumo: O conhecimento de parâmetros do ciclo de vida de organismos zooplanctônicos fornece importantes dados para o cálculo da produção secundária da espécie, além de informações sobre sua biologia. Este estudo visou obter informações sobre o ciclo de vida de *Scapholeberis armata freyi* Dumont & Pensaert, 1983 (Cladocera, Daphnidae), cultivada em laboratório. Os experimentos foram mantidos em incubadora com temperatura de 23,0 °C, fotoperíodo de 12 horas luz/12 horas escuro e alimentação (suspensão da alga clorofícea *Pseudokirchneriela subcapitata* na concentração de 10^5 cels.mL^{-1} e uma suspensão mista de fermento e ração de peixes em igual proporção) constantes. As observações foram feitas uma ou duas vezes ao dia para o acompanhamento do crescimento do corpo, idade, comprimento da primipara, fecundidade e longevidade. A primipara da espécie ocorreu com 5,86 dias e comprimento médio de 542 µm. A média do comprimento máximo foi 827 µm. A fecundidade média de *S. armata freyi* foi de 8 ovos fêmea^{-1}.ninhada^{-1} e o número total de ovos produzidos por fêmea durante todo o ciclo de vida foi, em média, 47,58 ovos. O tempo de desenvolvimento embrionário foi de 1,9 dias e a longevidade máxima foi de 31 dias. Os parâmetros do ciclo de vida de *S. armata freyi* obtidos neste estudo são próximos aos encontrados para outras espécies da família Daphnidae cultivadas nas mesmas condições de temperatura e fotoperíodo. No entanto, a longevidade foi maior do que a observada para espécies que receberam apenas alga como alimento. A qualidade e quantidade de alimento são fatores que controlam a produção secundária em ecossistemas aquáticos e um incremento na alimentação aumenta a longevidade, desenvolvimento e produção de ovos. Conclui-se que a maior longevidade e produção de ovos observada para *S. armata freyi* pode influenciar a produção secundária desta espécie.
Palavras-chave: *Anomopoda, zooplâncton, longevidade, fecundidade, crescimento.*

Introduction

Knowledge of the life cycle of zooplankton species can provide information for a better understanding of the role of each species in the community, basic data for secondary production investigations and information on its biology (Santos-Wisniewski et al. 2006).

Environmental factors can influence the growth, reproduction and survival of zooplankton. Among these factors, the quality of food and temperature are the most important. The development time is temperature dependent, while fecundity is related to food availability (Bottrell et al. 1976). Growth and reproduction are species characteristics influenced by environmental conditions, and the parameters of the species' life cycle are used indirectly to know its biology and distribution in specific environments, in addition to observations from the field (Güntzel et al. 2003).

Cladocerans reproduce asexually by parthenogenesis, a process in which unfertilized eggs give rise to amictic females. In unfavorable conditions such as overcrowding, low temperatures and food scarcity, males are produced (Rocha & Güntzel 2000). Because Cladocera reach maturity quickly, the growth of their population and egg production is increased (Melão1999).

Cladocera is typically a freshwater group found in lentic water bodies worldwide. The species found in Brazil are distributed in seven families, and Daphnidae is numerically abundant. Thus, many studies have been done on taxonomy, abundance, morphology, distribution of Daphnidae and some aspects of their biology and ecology (Matsumura-Tundisi 1984, Rocha & Matsumura-Tundisi 1990, Fryer 1991, Fonseca & Rocha 2004, Rietzler et al. 2008).

Scapholeberis armata freyi belongs to the family Daphnidae and subfamily Scapholeberinae (Dumont & Pensaert 1983). The species *Scapholeberis armata* has limited distribution in the United States and Canada; however, the subspecies *S. armata freyi* was found in Paraguay, Mexico (Ciros-Perez & Elias-Gutierrez 1996) and Brazil (Elmoor-Loureiro 2000). Representatives of family Daphnidae usually occur in the limnetic zone of aquatic environments; however, *S. armata* is found in the littoral zone, where they live linked to water surface tension (Rocha & Güntzel 2000).

Studies on the life cycle carried out in Brazil aimed to produce large quantities of these animals for fish food (Sipaúba-Tavares 1988, Sipaúba-Tavares & Rocha 1994) and a few aimed at studying secondary production (Rocha & Matsumura-Tundisi 1984, 1990, Hardy & Duncan 1994, Melão 1997).

In this work data was obtained on the life cycle of the *S. armata freyi*, which may contribute to further studies of secondary production for Brazilian freshwater ecosystems and other countries, where this species or similar species occur. The body dimension, growth, embryonic development time and fecundity obtained from life cycle studies are used in the secondary production calculations.

Materials and Methods

The organisms for starting cultures were collected inside macrophyte stands in the littoral zone of a pond of the Heliodora district (22° 29' 12"S and 45° 36' 68" W) in the southern region of Minas Gerais State, Brazil, by vertical and horizontal hauls using a zooplankton net of 68 μm mesh size. In the laboratory, parthenogenetic females of *S. armata freyi* were isolated and placed in 2 L beakers containing reconstituted water. This culture media had pH 7.6, conductivity 140 μS.cm^{-1} and hardness 46 mg CaCO$_3$L^{-1} in according to ABNT, (Associação... 2009). Experimental cultures were maintained in growing chambers at a constant temperature of 23.0 ± 0.5 °C and 12 hours light.dark^{-1} photoperiod and fed on a suspension of the small chlorophycean *Pseudokirchneriela subcapitata*, cultured in Chu 12 medium and cropped in the exponential phase, at a concentration of 10^5 cells.mL^{-1}, and 0.02 mL of a mixed suspension of yeast and fish ration added per organism (Associação... 2009) at equal proportion.

Individuals were acclimated for about 10 generations (30 days). Ten females were isolated and maintained until the production of neonates. Thirty neonates less than 24 hours old were placed in polypropylene bottles of 50 mL and kept in a germination chamber with the temperature, light and feeding conditions as specified above. Culture media and food suspensions were completely renewed daily with a fresh suspension at the same temperature. Once or twice a day, the animals were observed under the stereomicroscope in order to determine the number of eggs produced per brood and the longevity. The growth of each individual was measured daily under an optical microscope, using a micrometric grid and a 40× magnification.

The cycle life parameters were obtained by nonlinear curve fitting using Chi-square minimization method using a Levenberg-Marquardt algorithm (Moré 1978) by Origin 8.0 software.

Results

The life parameters of *S. armata freyi* are presented in Table 1. Neonates had a mean size of 281 ± 21 μm, reaching maturity after 5.86 ± 1.00 days, with a mean size of 542 ± 44 μm. Mean embryonic development time was 1.90 ± 0.37 days.

During its life cycle, *S. armata freyi* produced a mean of 7.00 ± 1.80 broods with a mean fecundity of 8 ± 3 eggs each. Egg production increased up to advanced-aged organisms as shown in Figure 1. The maximum and mean egg production in the whole life cycle was 98 and 65 eggs per female, respectively.

In the present study, three juvenile stages and 10 instars in the life cycle were recorded for *S. armata freyi*. The maximum longevity of *S. armata freyi* was 31 days and mean longevity was 23 ± 4 days. The mean maximum size was 827 ± 51 μm. Mean individual growth curve of *S. armata freyi* is shown in Figure 2.

Discussion

The results for embryonic development duration (EDD), primiparous age (PA), fecundity (F), longevity (L) and temperature (T) of several Daphnidae are compared to other studies (Table 2).

The primiparous age of *S. armata freyi* was close to those observed for *Simocephalus serrulatus* by Melão (1997). Thus, the maturity of *S. armata freyi* occurred later compared with *Ceriodaphnia silvestrii* (Fonseca & Rocha 2004), *Daphnia laevis* and *Daphnia ambígua*

Table 1. Life cycle parameters of *Scapholeberis armata freyi* (Cladocera, Daphnidae) cultured at 23.0 ± 0.5 °C in a 12 hours light/dark photo period, fed on a mixed suspension of *Pseudokirchneriela subcapitata* (at 10^5 cells.mL^{-1}) and yeast, and fish ration added per organism, at equal proportions.

Life cycle parameters	Values
Adult mean size (μm)	827 ± 21
Neonate mean size (μm)	281 ± 21
Primipara mean size (μm)	542 ± 44
Minimum size of primipara (μm)	400
Number of instars between neonate and primipara	3 ± 0.6
Mean number of instars in the whole life cycle	7 ± 0.69
Mean number of eggs in the whole life cycle	47.58 ± 6.27
Mean fecundity (eggs/female/brood)	8 ± 3
Maximum longevity (days)	31
Mean longevity (days)	23 ± 4
Mean embryonic development times (days)	1.9 ± 0.37
Primipara mean age (days)	5.86 ± 1

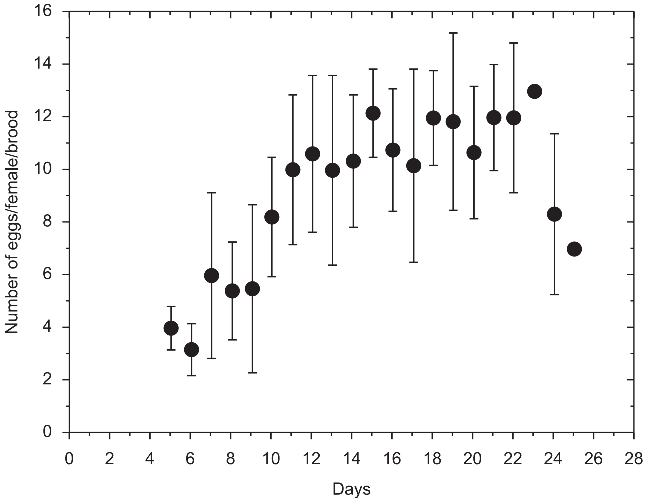

Figure 1. Mean fecundity (number of eggs.female^{-1}.brood^{-1}) of *Scapholeberis armata freyi* (Cladocera, Daphnidae) cultured at 23.0 °C, in the 12 hours light/dark photo period, fed on a mixed suspension of *Pseudokirchneriela subcapitata* (at 10^5 cells.mL^{-1}) and yeast, and fish ration added per organism, at equal proportion.

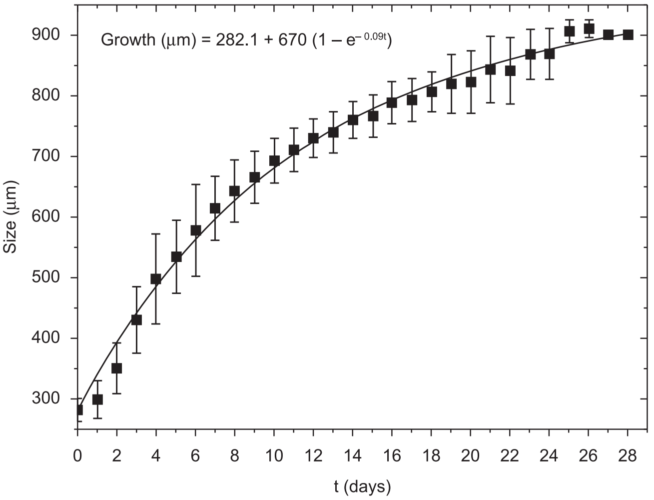

Figure 2. Mean individual growth curve of *Scapholeberis armata freyi* (Cladocera, Daphnidae) grown in the laboratory at 23.0 °C, in the 12 hours light/12 hours dark photo period, fed on a mixed suspension of *Pseudokirchneriela subcapitata* (at 10^5 cells.mL^{-1}) and yeast, and fish ration added per organism, at equal proportion.

Table 2. Comparison of embryonic development duration (EDD), primiparous age (PA), fecundity (F), longevity (L) and temperature (T) from the present study and reported in the literature of several Daphnidae.

Species	DE (days)	PA (days)	F (days)	L (days)	T (°C)	Author
Scapholeberis armata freyi	1,9	5,2	8	23	23	Present study
Scapholeberis kingi				20	28 at 30	Murugan & Sivaramakrishnan (1976)
Ceriodaphnia sivestrii		3 at 4	9,46	29,8	25	Fonseca & Rocha (2004)
Ceriodaphnia cornuta	3,24	4,76	2,2	9,8	20	Melão (1997)
Simocephalus serrulatus	2,58	5,18	22	13,4	20	Melão (1997)
Daphnia laevis	2	4,92	14,3		25	Rocha & Matsumura-Tundisi (1990)
Daphnia gessneri	2	7,38	9,07		22	Hardy & Duncan (1994)
Daphnia ambigua	2	4,25	7,12		25	Rocha & Matsumura-Tundisi (1990)

(Rocha & Matsumura-Tundisi 1990) at a temperature of 25 ± 2 °C. The primiparous age increased as a consequence of the lower experimental temperature in the current study, 23 °C, compared to the 25 °C for the three species mentioned above. However, the age of the first reproduction for *S. armata freyi* was earlier than that observed for *D. gessneri* under the temperature of 22 °C (Hardy & Duncan 1994). As the difference in temperature between the experiments is small, probably the species *C. silvestrii*, *D. ambiguous* and *D. laevis* reach maturity earlier than *S. armata freyi* because these species are typical of the limnetic region, where predation by planktivorous fish is higher, which accelerates the maturity of these organisms. This does not occur with *S. armata freyi*, typical of the littoral region. It can allocate more energy to body growth and, after this, invests in reproduction, since in the littoral region there is greater availability of food (Sarma et al. 2005).

The embryonic development duration of *S. armata freyi* was similar to that found for *S. serrulatus* at 25 °C (Melão 1997). The same author obtained 2.58 days of embryonic development for *S. serrulatus* at 20 °C. Therefore, with an increase in water temperature, the duration of embryonic development decreases. Compared with species from other families of Cladocera, the time of embryonic development of *S. armata freyi* is close to 1.96 days, as recorded for *Chydorus pubescens* (Santos-Wisniewski et al 2006), and greater than 1 day observed for *Moina minuta* (Murugan 1975).

Mean fecundity in some species of this family was higher than that recorded for *S. armata freyi*, such as *S. serrulatus* (Melão 1997). *D. laevis* also showed high fecundity (Rocha & Matsumura-Tundisi 1990). Normally, larger species have a greater number of eggs compared to the smaller species (Melão 1997), such as *S. serrulatus* (22 eggs.female^{-1}.brood^{-1}) and *D. laevis* (14.3 eggs.female^{-1}.brood^{-1}) which are larger than *S. armata freyi*.

During its life cycle, *S. armata freyi* produced a mean of 7.0 ± 1.8 broods with a mean fecundity of 8 ± 3 eggs.female^{-1}.brood^{-1}. The mean fecundity increased as the individual became older, so for the first brood it is, on average, 3 to 4 eggs, while in the third brood, this number increased to 8 eggs, and in the sixth brood it increases to 12 eggs; however, it falls to 9 eggs in the last brood. A similar pattern was observed for *Macrothrix flabelligera*, where the production increased from 5 to 18.5 eggs, starting with the fifth brood (Güntzel et al. 2003). Probably, in the first litters, *S. armata freyi* invests more energy in body growth and produces few eggs. Around the 14th day of life, the rate of body growth decreases and more energy is allocated to reproduction. Near the end of the life cycle, egg production also decreases due to the aging.

The total egg production in the whole life cycle of *S. armata freyi* (98 eggs.female^{-1}) is low compared to that observed for *Scapholeberis kingi* (239 eggs.female^{-1}) with temperatures around 28 to 30 °C (Murugan & Sivaramakrishnan 1976). The *S. kingi* female size ranges from 400 µm to 1000 µm, therefore, the size is larger than *S. armata freyi* (281 µm to 827 µm). The highest temperature of the study was responsible for the high fecundity of *S. Kingi*, because the increase of temperature accelerates the metabolic processes and affects reproduction (Sarma et al. 2005).

During the study, three juvenile instars and seven adult instars were recorded for *S. armata freyi*. The number of juvenile instars is close to that of the *S. kingi*, which showed two juvenile instars and seventeen adult instars (Murugan & Sivaramakrishnan 1976). According to Bottrell (1975) the number of juvenile instars in Cladocera is between three and eight, and is generally constant for each species. For Melão (1999), the number of juvenile instars is between two and four, not exceeding six. However, the number of instars could be higher than recorded, because the animal suffers some seedlings before the first neonate measure (Kotov 1997).

According to Dumont (1987), some species invest energy in a long lifetime and low reproduction, while others invest in reproduction yet their lifetime is lower. In this study, it was observed that body growth is rapid until the sixth day of life, when primiparous occurs. Although they continue to grow after primiparous, the organisms invest more energy in reproduction, and the growth rate is slower.

Compared with other species of Cladocera, the longevity of *S. armata freyi* is similar to that recorded for *Euryalona orientalis* (23.8 days) (Venkataraman 1990) and *Leydigia acanthocercoides*, with a mean longevity of 23.2 days (Murugan & Job 1982). However, the latter two studies were conducted at high temperatures, 28 and 30 °C, respectively.

The parameters of *S. armata freyi* are similar to those found in other species of Daphnidae cultivated under the same conditions (temperature and photoperiod). Primiparous and embryonic development time for *S. armata freyi* were close to those observed for *S. serrulatus*. Although, the longevity of *S. armata freyi* was higher than for *S. serrulatus* and *Ceriodaphnia cornuta* longevity (Melão 1997), because in these experiments the food source was algae, while in the present study, it was algae and a mixed suspension of yeast and fish ration. The quality and quantity of food are factors that control secondary production in aquatic ecosystems (Santos et al. 2010) and an increase of food availability increases longevity and egg production (Santos et al. 2006), thus the greater longevity and egg production observed for *S. armata freyi* can influence its secondary production.

According to Sarma et al. (2005), in tropical regions food availability and water temperature is higher than in temperate regions. Therefore, by offering more food (or richer food) during the experiment and increasing water temperature, the conditions approach those found in the tropics. Thus, under natural conditions, the variation in the water temperature, photoperiod and food availability are responsible for variations in the longevity, duration of the embryonic development and primiparous age.

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Effect of temperature on growth of the threatened annual fish *Austrolebias nigrofasciatus* Costa & Cheffe 2001

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Abstract: This study evaluated the effect of temperature on growth of *Austrolebias nigrofasciatus*, an endemic and threatened annual killifish species of the Patos-Mirim lagoon system in Southern Brazil. In order to verify the effect of temperature on initial growth of *A. nigrofasciatus*, eggs stored in the laboratory were hatched and juveniles reared for eight weeks at 16 and 22 °C. The standard length of newly hatched fishes was 4.67 ± 0.25 mm and after eight weeks they reached 23.68 ± 3.73 and 22.68 ± 5.36 mm, respectively at 16 and 22 °C. However, initial growth of fish reared at 22 °C was faster and they reached sexual dimorphism at an earlier age compared to those reared at 16 °C. Final length of females reared at 22 °C was 23.00 ± 2.83 mm, they were significantly larger than those reared at 16 °C (17.91 ± 2.47 mm). Males were significantly larger than the females at 16 °C, but there was no difference for growth between sexes of fish reared at 22 °C. The sex ratios were 1:0.6 and 1:1.1 (M:F) at 16 °C and 22 °C, respectively, suggesting temperature determination of phenotypic sex. Considering the results, it appears that juveniles to be developed in captivity should be kept at 22 °C during the first six weeks of life, thus ensuring a higher growth rate until puberty.
Keywords: *annual fish, laboratory conditions, Cyprinodontiformes, Rivulidae.*

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Resumo: Este estudo avaliou o efeito da temperatura no crescimento de *Austrolebias nigrofasciatus*, uma espécie de peixe anual endêmica e ameaçada do sistema lagunar Patos-Mirim no extremo sul do Brasil. Para avaliar o efeito da temperatura no crescimento inicial e na diferenciação sexual de *A. nigrofasciatus*, ovos mantidos em laboratório foram eclodidos e os peixes foram mantidos por oito semanas a temperaturas de 16 e 22 °C. O comprimento padrão dos peixes recém eclodidos foi de 4,67 ± 0,25 mm e ao final de oito semanas atingiram 23,68 ± 3,73 e 22,68 ± 5,36 mm, respectivamente para 16 e 22 °C. O crescimento inicial foi maior a 22 °C e os peixes apresentaram precocidade na maturação sexual quando comparados a 16 °C. As fêmeas criadas a 22 °C atingiram maior comprimento (23,00 ± 2,83 mm) em relação aquelas mantidas em 16 °C (17,91 ± 2,47 mm). Machos foram significativamente maiores que as fêmeas a 16 °C, mas não foi constatada diferença de comprimento entre os sexos dos peixes mantidos a 22 °C. A relação sexual foi de 1:0.6 e 1:1.1 (M:F) a 16 °C e 22 °C, respectivamente, sugerindo uma possível influência da temperatura na diferenciação sexual fenotípica. Considerado os resultados obtidos concluímos que juvenis de *A. nigrofasciatus* devem ser criados a 22 °C durante os primeiros meses de idade, garantindo assim uma maior taxa de crescimento até a puberdade.
Palavras-chave: *peixe anual, condições de laboratório, Cyprinodontiformes, Rivulidae.*

Introduction

Most species of Rivulidae are known as annual fish, they complete their life cycle in temporary ponds and as such their lifespan is short (Costa 2006). These fishes grow fast and reach sexual maturity within a short period, about two months after hatching (Walford & Liu 1965, Liu & Walford 1966, Arenzon et al. 1999, Errea & Danulat 2001). They leave their eggs buried in the substrate at depths of up to 15 cm (Vaz-Ferreira et al. 1966). Once these temporary ponds dry off, the entire adult population dies. However, the resting eggs remain on diapause, waiting the next rainy season, when they will hatch and start a new life cycle (Podrabsky & Hand 1999). Annual fish have been used as model organisms for laboratory (Arenzon et al. 2002a, 2003), bioindicators (Arezo et al. 2007), pest control (Fletcher et al. 1992, Frenkel & Goren 2000) and ornamental fish (Costa 2008).

Austrolebias are a genus of annual killifishes distributed in subtropical and temperate Argentina, Southern Brazil, Bolivia, Paraguay and Uruguay (Costa 2010). The most species inhabit seasonal ponds, where the rainy season coincides with winter months, therefore they are usually found in cold water (Costa 2006). *Austrolebias nigrofasciatus* Costa & Cheffe, 2001, are small fish, endemic of the Patos-Mirim lagoon system in Southern Rio Grande do Sul, Brazil. They present marked sexual dimorphism and are characterized by the color pattern of males, which consists of blue strips, parallel to the rays in basal half of dorsal and anal fins and a black spot bordering the posterior end of the dorsal and anal fins (Costa & Cheffe 2001).

This group of fishes requires several adjustments to assure their survival in highly variable environmental conditions such as drought stress, low levels of oxygen and wide fluctuations in temperature (Liu & Walford 1966, 1970, Errea & Danulat 2001). However, the same characteristics that make them able to live in such hostile environments make them dependent on the physical integrity of their biotope. In light of deleterious anthropomorphic activities in their habitat and restricted distribution area, *A. nigrofasciatus* is listed as a threatened species (Reis et al. 2003, Rosa & Lima, 2008, Volcan et al. 2009).

Temperature is considered one of the most crucial factors influencing the early development of fish (Brett & Groves 1979). Temperature has been shown to influence Rivulidae fish in terms of reproduction (Arenzon et al. 1999), time of the embryonic development (Arezo et al. 2007, Arenzon et al. 2002a), growth (Errea & Danulat 2001, Walford & Liu 1965, Liu & Walford 1970), and longevity (Walford & Liu 1965, Liu & Walford 1966, 1970).

The life cycle of *A. nigrofasciatus* is poorly studied. Considering the current threat of extinction for *Austrolebias* species in Brazil, it is important to understand the role of factors regulating its development and thus provide subsidies to improve the management of natural populations and to rear them in captivity (Reis et al. 2003, Rosa & Lima, 2008, Volcan et al. 2009, 2010a, b, 2011a, b, c). As such, this work aimed to study the effects of temperature on their survival, early growth and phenotypic sex differentiation of *A. nigrofasciatus* at laboratory conditions.

Materials and Methods

1. *Production and hatching of eggs*

Were captured 12 pairs of *A. nigrofasciatus* in a freshwater temporary pond located in Southern Brazil (31° 48' 25" S and 52° 25' 11" W) and maintained in laboratory for two months for obtained of fertilized eggs utilized in this study. Eggs were kept in opaque sealed bags buried in wet coconut fiber substrate at room temperature (18-25 °C) for approximately six months, that is considered the approximate time that the biotopes of the species remain dry (M.V. Volcan, unpublished data).

For hatching, the eggs were deposited in Beaker glasses (1 L), buried to a depth of 10 cm in shredded coconut fiber, under 500 mL of water and kept at 18.0 ± 0.9 °C (SD) for 24 hours.

Broodstock fish used in the study were caught under license number 15108-1 issued by the Instituto Brasileiro do Meio Ambiente e dos Rercursos Naturais Renováveis (IBAMA/ICMBio).

2. *Laboratory tests*

Fishes were randomly divided into two 30 L aquaria just after hatching. The stoking density was 1 juvenile/L and they were maintained for eight weeks at two constant temperatures: 16 and 22 °C. This range temperature was tested because it is considered within thermal variation recorded in the habitats of *Austrolebias* species (Walford & Liu 1965) and ideal for their maintenance in captivity (Calviño 2005).

Temperature was controlled by a submersible heater (20 W) coupled to a digital thermostat (Aquaterm®/FullGauge/0.1 °C). Water was kept under constant aeration and photoperiod of 12 hours of light per day. Fish were fed twice daily to satiation, at 12:00 PM and at 8:00 PM, with zooplankton, mainly native copepods and cladocerans, produced in mesocosm with organic fertilizer.

Fish were anesthetized in a benzocaine bath (50 mg/L) prior to standard length (SL) measurement. During the first week length was measured under a stereoscopic microscope equipped with micrometric ocular piece, thereafter a digital caliper was employed, all measurements were made to the nearest 0.01 mm. Fish were measured weekly, except for the second week of life, because a large mortality (25%) was found to be associated to the first biometry. No further mortalities were associated to length measurement. All fish in each tank were measured. The phenotypic sex differentiation and length of 50% individuals attained the sexual dimorphism was detected by development of secondary sexual characters of the species (color pattern and fin morphology) described by Costa & Cheffe (2001).

Temperature, dissolved oxygen, and pH were measured once a day with portable pHmeter Hanna HI9025 (0,01) and oximeter Quimis Q758P (00,1 mg/L). Water exchange was equal to approximately 20 %/day. Average temperature (±SD) was 16.1 ± 0.2 and 22.1 ± 0.2 °C. pH and dissolved oxygen concentration were equal to 7.45 ± 0.04 and 8.04 ± 0.29 mg O_2/L, and 7.52 ± 0.05 and 7.59 ± 0.32 mg O_2/L at 16 and 22 °C, respectively.

3. *Statistical analysis*

Length data and effects of temperature on standard length at the moment of 50% of sexual dimorphism were compared using the Student t-test. The possible bias of the sex ratio of the two temperatures from the expected 1:1 rate were determined by Chi-square test (χ^2). The assumptions of homogeneity of variance and normality distribution were analyzed by Cochran C and Kolmogorov-Smirnov tests, respectively. The significance level of all tests was 95% and they were performed using the software Statistica 8.0. The results are presented as mean ± standard deviation (SD).

Results

With the exception of the accidental mortality of one and five fishes at 16 °C and 22 °C, respectively, during the length measurement after hatching, no further mortalities were observed for both temperatures.

The standard length of newly hatched fishes was 4.67 ± 0.25 mm. Fish kept at 22 °C showed higher initial growth until six weeks of life (t-test; $p < 0.05$). However, at the end of eighth week, there was no more significant difference in length (t-test; $p > 0.05$) of *A. nigrofasciatus* reached 23.68 ± 3.73 and 22.68 ± 5.36 mm, respectively at 16 and 22 °C (Figure 1).

The males responded similarly to temperature with average standard length at the end of eight weeks of 25.61 ± 4.46 and 24.67 ± 4.77 mm, under 16 and 22 °C, respectively (Figure 2). Females reared at 22 °C had significantly higher growth ($p < 0.05$) than those kept at 16 °C in all biometrics, with the average length for the lower and higher temperature of 17.91 ± 2.47 and 23.00 ± 2.83 mm, respectively (Figure 2).

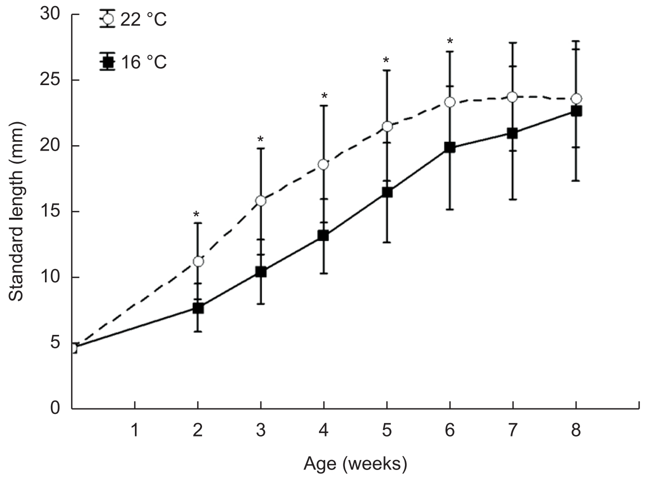

Figure 1. Standard length (mean ± standard deviation) of *Austrolebias nigrofasciatus* kept in the laboratory at 16 and 22 °C during the first eight weeks of life. *Indicates significant difference in standard length between treatments during the first six weeks of study (t-test, $p < 0.05$).

Figura 1. Comprimento padrão (média ± desvio padrão) de *Austrolebias nigrofasciatus* mantido em laboratório a 16 e 22 °C durante as primeiras oito semanas de vida. *Indica diferença significativa em comprimento padrão nas primeiras seis semanas de estudo (teste t, $p < 0.05$).

The males kept at 16 °C attained higher SL than females throughout the entire experimental period in contrast to similarity in size observed between the sexes to 22 °C (Figure 3). In the third week were registered sexual dimorphism in fishes at 22 °C, and the fourth week it was found the sexual maturity of females in this temperature, evidenced by reproductive behavior and egg laying, while at 16 °C the first male and females were identified only in the fifth and sixth weeks, respectively. Only from the eighth week was recorded egg laying for fish kept at 16 °C. In both treatments were recorded juveniles until the sixth week.

The age and standard length that more than 50% of specimens in each treatment reached the sexual dimorphism in females occurs in the seventh week and length of 17.08 ± 2.15 mm at 16 °C and in the fourth week and 21.38 ± 2.15 mm at 22 °C. For males, the dimorphism was reached in the fifth week at 16 °C with 20.45 ± 2.17 mm and the fourth week at 22 °C with 21.31 ± 4.33 mm (Figure 4). The coefficient of variation for male standard length (17.89 ± 2.30%) was significantly higher than females (12.36 ± 2.18%) only at 22 °C (t-test, $p < 0.0001$). The results show that fish kept at 22 °C reached maturity and sexual dimorphism earlier, and at a larger size than those kept at 16 °C.

The sex ratios were 1:0.6 and 1:1.1 (M:F) at 16 and 22 °C, respectively. Although the fish kept at 22 °C showed a tendency to a higher male proportion, there was no significant difference in sex ratio in the two treatments ($\chi^2 = 1.69$; df = 1; $p = 0.193$ for 16 °C; $\chi^2 = 0.04$; df = 1; $p = 0.841$ for 22 °C).

Discussion

In this study there was no mortality related to the rearing temperature, since the reported deaths were due to accidents during measurement of fish. The maximum standard length registered to *A. nigrofasciatus* is 42.7 mm (Costa & Cheffe 2001), considering it as a reference value, the species reaches about 60% of its maximum standard length within two months after hatching in the laboratory, proving the fast initial growth, typical to species of *Austrolebias* (Liu & Walford 1969, Errea & Danulat 2001).

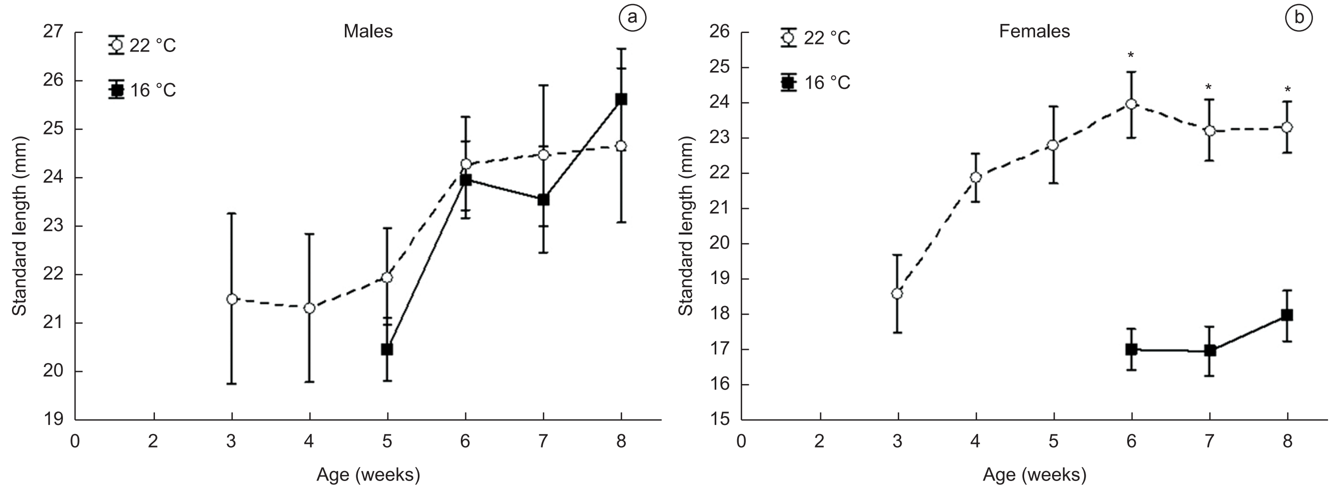

Figure 2. Growth of males (a) and females (b) of *Austrolebias nigrofasciatus* (mean ± standard deviation of SL) reared in laboratory at 16 and 22 °C for eight weeks. Differences at the beginning of the growth curve occurred due to the time of sexual differentiation. In both treatments, females differed later than the males. *Indicates significant difference between the means (t-test, $p < 0.05$).

Figura 2. Crescimento de machos (a) e fêmeas (b) de *Austrolebias nigrofasciatus* (média ± desvio-padrão de CP) mantidos em laboratório a 16 e 22 °C por oito semanas. Diferenças no inicio da curva de crescimento ocorreram devido ao tempo de diferenciação sexual. Em ambos os tratamentos as fêmeas diferenciaram mais tardiamente que os machos. *Indica diferença significativa entre as médias (teste t, $p < 0,05$).

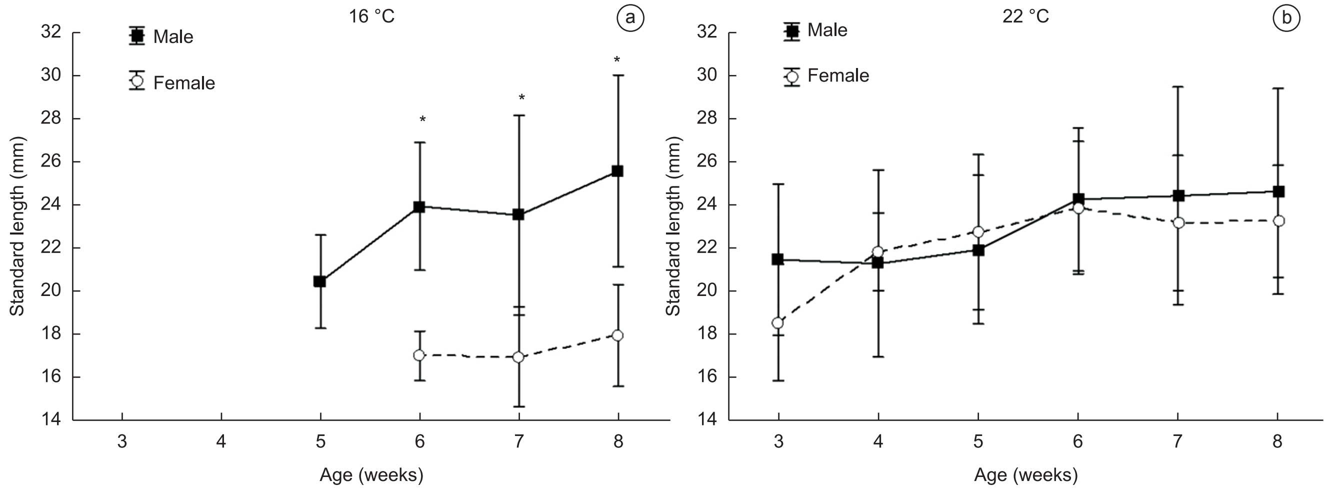

Figure 3. Growth of *Austrolebias nigrofasciatus* in the laboratory at 16 (a) and 22 °C (b) (mean ± standard deviation of SL) for eight weeks from hatching. Differences at the beginning of the growth curve occurred due to the time of sexual differentiation. Fishes of treatment of 16 °C differentiate later than those kept at 22 °C. *Indicates significant difference between the means (t-test, $p < 0.05$).

Figura 3. Crescimento de *Austrolebias nigrofasciatus* em laboratório a 16 (a) e 22 °C (b) (média ± desvio padrão do CP) durante oito semanas após a eclosão. Diferenças no inicio da curva de crescimento ocorreram devido ao tempo de diferenciação sexual. Os peixes do tratamento de 16 °C diferenciaram mais tardiamente que os mantidos a 22 °C. *Indica diferença significativa entre as médias (teste t, $p < 0,05$).

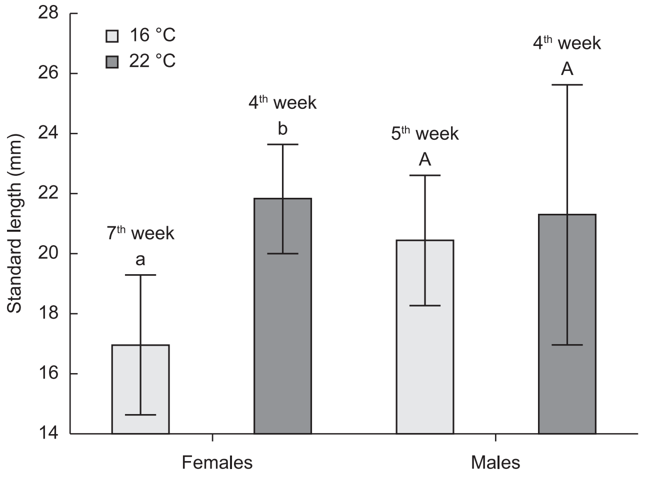

Figure 4. Effect of temperature on age and standard length at the moment of 50% of sexual dimorphism in *Austrolebias nigrofasciatus* (mean ± SD). Different labels indicate significant difference for standard length to females (lowercase) and males (uppercase), respectively (t-test, $p < 0.05$).

Figura 4. Efeito da temperatura na idade e comprimento padrão no momento de 50% de dimorfismo sexual em *Austrolebias nigrofasciatus* (média ± SD). Letras diferentes indicam diferença significativa entre o comprimento de fêmeas (minúscula) e machos (maiúsculas), respectivamente (teste t, $p < 0,05$).

The relationship of temperature with the growth of annual fish was also observed by Errea & Danulat (2001) that in the natural environment of *Austrolebias viarius*, reported the highest growth rates at the beginning and end of life, precisely in the months when the highest temperatures were recorded. These authors, in assessing the effect of temperature on growth of *A. viarius* in the laboratory, found that individuals maintained at 25 °C had higher growth and early sexual maturity when compared with those reared at 15 °C. The results of the present study showed higher initial growth for *A. nigrofasciatus* at 22 °C. This was a contrasting response in relation to sex, since males grow faster than females at 16 °C, but at 22 °C there is no difference in growth rate related to sex. Independently of temperature effect, the higher length of males in rivulids was also observed for several species (*e.g.* Walford & Liu 1965, Liu et al. 1975, Laufer et al. 2009, Arenzon et al. 2001) and is considered a pattern of *Austrolebias* species (Costa 2006).

Annual fishes in general are exposed to marked fluctuations in abiotic conditions in their natural habitat (Errea & Danulat 2001, Arenzon et al. 2002b, Volcan et al. 2011c). Frenkel & Goren (2000) studying the effect of temperature on the growth of killifish, between 18 and 27 °C, showed higher growth of *Aphanius dispar* at 18 and 23 °C. Similarly, studies of effect of temperature on the life cycle of species of *Austrolebias* have shown that they have greater final length at temperatures between 15-16 °C when compared to 20-22 °C (Walford & Liu 1965, Liu & Walford 1970). The influence of temperature on initial growth of *A. nigrofasciatus* recorded in this study suggests that this group of fish present difference effect of the temperature associated with sex and initial growth.

As Liu & Walford (1969), for annual fish, higher temperatures stimulate the growth of the species only in the early stages, while throughout life lower temperatures favor the somatic growth by delaying the development of the gonads. Our study is in agreement with Liu & Walford (1969), where we also observed the effect of temperature in different stages of life. In the first six weeks we noticed a fast growth at 22 °C, however, after the fish reaching sexual maturity and dimorphism, the growth curve tended to stabilize at 22 °C and increased to 16 °C. Liu et al. (1975) reported that the transfer of adult fish from 22 °C to 16 °C results in increasing the growth of *Austrolebias bellotti*.

The early sexual maturity observed for *A. nigrofasciatus* was also recorded for *Austrolebias adloffi* (Walford & Liu 1965) and *Cynopoecilus melanotaenia* (Arenzon et al. 1999). These species reached sexual maturity after 6 (at 22 °C) and 8 (at 17-25 °C) weeks of life, respectively. The precocity of dimorphism in males was also observed for *Austrolebias toba*, the first secondary sexual characteristics were observed at 21 days after hatching, followed by courtship behavior, but still no spawning, since the females in this age were not mature (Calviño 2005).

During the study, territoriality and aggression were observed between males of *A. nigrofasciatus*, which has not occurred within females. According to Belote & Costa (2004) the general pattern of reproductive behavior of *Austrolebias* is similar to most other species of Rivulidae, except for the absence of fights between females. The higher dispersion of mean length of males when compared to females of *A. nigrofasciatus*, in both treatments, probably reflects a phenomenon of social pressure by size/hierarchy imposed over a longer period by the largest males.

Sexual differentiation of *Austrolebias* occurs still in the embryonic stage, as shown by histological analysis (Arezo et al. 2007). It was observed higher proportion of males of *A. nigrofasciatus* reared at 16 °C compared to those reared at 22 °C, suggesting possible role of temperature on the determination of phenotypic sex, a common phenomenon for many teleosts (Devlin & Nagahama 2002). In agreement with this hypothesis, there are 1% of males in natural populations of *Kryptolebias marmoratus* (Rivulidae) in Florida. However, rearing them at 19 °C (lower temperature than in the natural environment) resulted in a 100% male population (Harrington, 1967). Besides, this species presents a higher sex ratio when juveniles are kept at high temperature (30 °C). Harrington (1968) suggests a possible thermo labile sex determination in juveniles of *K. marmoratus* and denotes that the effect of temperature on induction of males differentiation may be a system of sex determination by environmental conditions.

In this work we observed a rapid initial growth of *A. nigrofasciatus*, which resulted in early maturation and sexual dimorphism in the temperature of 22 °C, compared to 16 °C. Despite the satisfactory results, the experimental design of this study did not have replicates for the treatments. An appropriate number of replicas and the exposure of fish to greater thermal amplitude could help to verify these results, mainly on the thermal influence on sex determination of killifishes.

We concluded that newly hatched fish to be developed in captivity should be kept at 22 °C during the first six weeks of life, in favor of more rapid growth until puberty while lower temperatures seems to improve growth after this period. Considering these results, future studies aiming to test the influence of temperature on the life cycle of Rivulidae are key to understanding the biology of these species and to contribute to future studies, mainly those aiming to manage populations in their natural habitat or at laboratory conditions.

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Pollination of *Pagamea duckei* Standl. (Rubiaceae): a functionally dioecious species

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Abstract: The floral biology, pollination and breeding system of *Pagamea duckei* Standl. (Rubiaceae) were studied at the Reserva Biológica da Campina, Manaus, Amazonas, Brazil. Floral morphology suggested that *P. duckei* is a distylous species. However, crossing experiments revealed that it is functionally dioecious. The flowers are actinomorphic, yellowish, produce nectar and a sweet odor, which is more intense in the morning. Anthesis started in the morning between 5.00 and 6.00 AM and extended until dusk, when the corolla tube abscissed. The flowers were visited mostly by bees of the genus *Melipona*. *Pagamea duckei* is not agamospermic and thus needs pollen vectors for effective pollination. The results of this study strengthen the idea that, in *Pagamea*, species with distylous flower morphology are actually functionally dioecious.
Keywords: *floral biology, heterostyly, campinarana forests, Central Amazonia.*

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Resumo: A biologia floral, polinização e o sistema reprodutivo de *Pagamea duckei* Standl. (Rubiaceae) foram estudados na Reserva Biológica da Campina, Manaus, Amazonas, Brasil. A morfologia floral sugere que *P. duckei* é uma espécie distílica. Entretanto, cruzamentos experimentais revelaram que essa espécie é funcionalmente dióica. As flores são actinomorfas, amareladas, produzem néctar e um aroma adocicado que é mais intenso no período da manhã. A antese das flores iniciou de manhã, entre 05h00 e 06h00 e se estendeu até o anoitecer, quando o tubo da corola sofria abscisão. As flores foram visitadas principalmente por abelhas do gênero *Melipona*. *Pagamea duckei* não é agamospérmica e logo necessita de vetores de pólen para que haja polinização efetiva. Os resultados desse estudo fortalecem a hipótese de que muitas espécies de *Pagamea* com flores heterostílicas são na verdade funcionalmente dióicas.
Palavras-chave: *biologia floral, heterostilia, florestas de campinarana, Amazônia Central.*

Introduction

The reproductive biology of most species has been inferred only from the morphology of flowers of herbarium specimens, and subsequent more detailed studies have revealed that morphology alone may be misleading (Barrett & Richards 1990, Owens et al. 1993). Moreover, there may be great intraspecific variation and intermediate flower morphologies in some taxa (Contreras & Ornelas 1999, Faivre & McDade 2001, Wolff & Liede-Schumann 2007). Little is known about the reproductive biology of most species in the Rubiaceae, particularly from tropical regions, and there are still very few phylogenetic studies that would allow the reconstruction of evolutionary transitions between breeding systems in the family.

The genus *Pagamea* (Rubiaceae) comprises approximately 30 species distributed in Tropical South America (Vicentini & Steyermark 2004, Vicentini 2007). It is sister to the paleotropical *Gaertnera*, a relationship supported by morphological, anatomical and molecular data (Malcomber 2002, Vicentini 2007). These two genera form the Gaertnereae, a clade belonging to the supertribe Psychotriidinae, a well-supported clade that includes most of the heterostylous species of Rubiaceae (Robbrecht & Manen 2006). Heterostyly is a breeding system characterized by floral dimorphism with long-styled (LS) and short-styled (SS) flowers and by obligatory xenogamy because of both self and same-morph incompatibility (Coelho & Barbosa 2003). This breeding system evolved independently many times in the Rubiaceae (ibid.), which also include homostylous and dioecious species, making this family particularly suited for studies of breeding system evolution.

The evolution of these reproductive systems has attracted the attention of systematists who aim to understand the ecological and spatial context in which transitions between these systems occur, as well as the relation between these transitions and the diversification of the family (Anderson 1973, Bawa 1980). Naiki & Nagamasu (2004) report, for instance, that the evolution of homostyly from heterostyly in species of *Damnacanthus* is correlated to polyploidy. On the other hand, the evolution of dioecy from heterostyly as seen in many genera, such as *Psychotria*, has been hypothesized to be the result of pollinator change (Bawa 1980). Although various hypotheses have been proposed to explain the evolution of heterostyly in the Rubiaceae (Anderson 1973), the conditions through which these evolutionary transitions happened, and how they may have promoted the diversification of the family, remain largely unknown.

Within Rubiaceae, the genus *Gaertnera* is more diverse than *Pagamea* and includes distylous and dioecious species (Malcomber 2002), while *Pagamea* includes homostylous, dioecious and distylous species (Vicentini 2007). However, dioecious *Pagamea* have distylous flower morphology, and the dioecious breeding system has been inferred by the correlations of lack of fruits in individuals with short-styled flowers, and the presence of reduced anthers with raphids instead of pollen grains in specimens with long-styled flowers (Vicentini 2007). Furthermore, the existence of homostylous species in *Pagamea* may be related to a breakdown in the self-incompatibility system of heterostylous species, as has been reported in *Gaertnera vaginata* Lam. (Pailler & Thompson 1997).

Similarly, a reproductive biology study of *Pagamea capitata* Benth. in the Guyana Shield indicates that the population has homostyled flowers but is dimorphic in the size and quantity of the pollen produced (O. Hokche, personal communication). These patterns suggest that dioecy and homostyly may be derived from heterostyly in *Pagamea*. Although the pattern of breeding system evolution in *Pagamea* remains unclear due to the lack of phylogenetic resolution and ambiguity in the outgroups, the phylogeny of *Pagamea* indicates few transitions, with a clade of dioecious species and a grade of homostylous species (Vicentini 2007). A few exceptions are found in three widespread species of *Pagamea* that present intra-specific variation in breeding system, sometimes at the population level (Vicentini 2007), which are still poorly characterized. These patterns of breeding system variation in *Pagamea* make this clade particularly interesting for studying the evolution of breeding systems. However, it is also clear that flower morphology should be used with caution when characterizing breeding systems (Barrett & Richards 1990, Owens et al. 1993) and, as consequence, additional studies are needed, particularly experimental studies on pollination and a better sampling of population-level intra-specific variation.

Pagamea duckei Standl. is a small tree or shrub found in white-sand *Campinarana* forest and is only known from two disjunct areas: one near Manaus and another close to Benjamin Constant, at the border between Brazil and Colombia (Vicentini 2007). This species is common in open *Campinarana* forests north of Manaus and has been described as characteristic of these forests (Anderson 1981). The floral morphology of *P. duckei* suggests dioecy (flowers with either vestigial stamens or pistils) and this species is sister to the other dioecious species of *Pagamea* (Vicentini 2007). This study aimed to characterize the morphology and floral biology of *P. duckei*, to test the hypothesis that it is really dioecious and to identify its visitors and pollinators.

Methods

1. *Study area*

The study was carried out at the Reserva Biológica da Campina (RBC) between November 2007 and January 2008 with the final season in December of 2008. This reserve belongs to the Instituto Nacional de Pesquisas da Amazônia (INPA) and is located 45 km north of Manaus, (Amazonas state). The climate is humid tropical with temperatures rarely below 18 °C and rains throughout the year. At the Reserve, white-sand, nutrient-poor soils predominate, which determines an open and scleromorphic forest known as *Campinarana* or Amazonian *caatingas* (Anderson 1981, Roberts et al. 1998).

2. *Study species*

The population of *Pagamea duckei* studied comprises small trees or shrubs that reaches 2-3.5 m in height and occur inside the *Campinarana* forest. The species is common at the RBC. The flowering period extended for approximately three months, (from November 2007 to January 2008), and the plants produced fruits in January.

3. *Floral morphology and breeding system*

Observations and experiments were carried out in 10 individuals of *P. duckei* over three consecutive days (November 26th to 29th) with complementary observations on pollinators in December 2008. The individuals were then monitored at 15 day intervals during the flowering and fruiting period.

Marked flowers on each of these individuals were monitored for approximately 14 hours (10 hours in 2007 and 4 hours in 2008) so that we could record color, beginning and duration of anthesis, modification of floral organs during the anthesis, odor emission and visitors behavior over the day.

For anthesis characterization, 20 flowers of each "sex" were monitored at different development stages. The beginning of the anthesis was characterized by the presence of a small opening in the flower apex, stigmatic receptivity (and separation of the stigmatic lobes in pistillate flowers), or open anthers (in staminate flowers) and scent emission. Floral morphology (number, disposition and color of each floral whorl), was characterized in 15 flowers (fresh material) of each plant of each sex with a stereomicroscope.

Stigmatic receptivity was verified with hydrogen peroxide (H_2O_2) 10% in 10 flowers during one day and observed with a pocket folding 20x magnifying glass (Lenzi et al. 2005). Scent emitting regions (osmophores) were detected by immersing flowers in Neutral Red for one hour and then washing them with distilled water; parts dyed in red represent the osmophores (Kearns & Inouye 1993). Nectar was detected by direct visual inspection.

The reproductive system of *Pagamea duckei* was studied by controlled pollinations. To evaluate fruit formation without fertilization (i.e. agamospermy), flowers were bagged before the anthesis. Crossing between morphs (long-styled and short-styled) were impossible to perform because the long-styled flowers did not have pollen in their anthers. Cross breeding between staminate and pistillate flowers were made using pollen from flowers of other trees in the same environment. After treatments flowers were bagged to exclude floral visitors. For the natural pollination treatment (open), inflorescences were marked but not bagged. For each treatment we utilized 50 flowers at random on 10 individuals. To evaluate the reproductive success we compared hand pollination with natural pollination. The behaviors of visiting insects were recorded over 14 hours (10 hours in 2007 and four hours in 2008) and recorded insects were collected for identification at different hours over the day, or through photographs. The bees collected were then washed so as we could analyze their pollinic spectrum.

Results

1. *Floral morphology*

The species present actinomorphic flowers with four petals that were partially fused forming a small tube. The corolla lobes were reflexed at anthesis and had a creamy or greenish-yellow color externally, but were covered by long white hairs inside (Figure 1a, b). These hairs at the mouth of the corolla tube appear to restrict the access of visitors to the interior of the flowers at anthesis. Flowers were strongly dimorphic, with some individuals having very short-styled flowers and others having long-styled flowers. Both floral morphs were similar in size (sepals and petals), and both had a bilocular superous ovary with a single ovule in each locule. The short-styled morph presented a very reduced pistil that, at anthesis, remained inside the corolla tube. The pistil of these flowers had stigmatic lobes that remained closed and that were undifferentiated from the style. Stamens were epipetalous introrsely with a yellowish colored filament and the anthers basifixed with transversal openings. The long-style floral morph had epipetalous stamens with a yellowish-cream colored filament, but the anthers were extremely reduced and no pollen grains were observed. In this morph, the pistil had a long style and a well-developed bifid stigma with papilose lobes that were yellow when receptive. Stigmatic lobes were located above the petals (extrorsely) at anthesis (Figure 1b).

Flowering was diurnal and anthesis lasted one day. In short-styled flowers the anthesis began approximately at 5.00 AM, and by 7.00 AM the flowers had opened, the corolla lobes were reflexed, and the reproductive parts were exposed. When the flowers were completely open, the petal lobes were turgid and had a yellowish color. In long-styled flowers the well-developed stigma had a pale-yellow color. After anthesis the corolla darkened (brown-yellow) and suffered abscission. The long-styled flowers persisted up to 26 hours, when the ovary became reddish-green and the stigma and style yellowish-green. In short-styled flowers, the anthers were already brown-yellow colored at about 3.00 PM when petals and stamens began to fall. After corolla abscission, the sepals became red and subsequently dehydrated.

Flowers were fragrant during the whole anthesis, although this was more intense during the morning. The aroma was sweet and even nauseating. The Neutral Red test revealed areas responsible for scent production on both flower morphs, shown as red spots at the apex of the petal lobes. Nectar was observed inside the corolla tube of both floral morphs.

2. *Reproductive system*

Fruit and seed set in *Pagamea duckei* depended on a pollen vector between flower morphs. The reproductive system experiments indicated that this species is not apomitic. In addition, inflorescences with short-styled flowers did not formed fruits, while long-styled ones had anthers lacking pollen grains. Thus, autogamy can also be ruled out. There was fruit production resulting from hand (inter morph pollination) and natural (control) pollination. Nonetheless, the percentage of formed fruits in natural conditions was lower than on hand pollination (Table 1).

3. *Visitors and pollinators*

Flowers of *Pagamea duckei* were visited mostly by bees and occasionally by butterflies. The first visits to the flowers occurred early in the morning, between 5.00 AM and 5.30 AM, period in which the flowers were starting to open, but were already producing nectar.

Bees were very frequent (Table 2) and always contacted the reproductive organs in their visits. Species of the genus *Melipona* were the most frequent visitors (Figure 1d). These bees landed directly on the corolla lobes and introduced the head into the tube to collect nectar. While doing so, they touched the stigmatic surface with the head and abdomen (sternotrobic pollination). Pollen was also collected as a resource. At landing on the corolla lobes, they used the forelegs to collect pollen and, while still on the flower, they transferred the pollen loads to the corbiculae using the middle legs. Visits for nectar collecting lasted about two to three seconds and most of the times every open flower per inflorescence was visited.

Visits by the solitary bee genus *Centris* were also observed. Both male and female bees visited the flowers of *Pagamea duckei* (Figure 1e, f). These visits were rapid, lasting on average three seconds and male bees stayed longer in the flowers and inflorescences, while females visited flowers rapidly. Males were more frequently observed than females. Bees of the genus *Trigona* were also frequent, but their visits were more restricted to short-styled flowers (Figure 1g).

Butterflies visited the flowers quickly, staying on average for ten seconds in one single flower and their visitation frequency was higher in the morning (Figure 1h).

Additional observations (December 2008) yielded similar results as those of 2007 (Table 2). Meliponini bees, mainly *Melipona compressipes* were the most frequent floral visitors. *M. compressipes* had pollen loads in their corbiculae and their pollinic spectrum reveled pollen of *Pagamea duckei* throughout of their body, suggesting that it may be an important pollen vector for this plant species.

Discussion

1. *Dioecy vs. heterostyly*

The observed floral dimorphism in *Pagamea* species has been traditionally interpreted as indicative of heterostyly (Steyermark 1974), which is a common reproductive system in the Rubiaceae (Coelho & Barbosa 2003, Teixeira & Machado 2004b, Mendonça & Anjos 2006, García-Robledo & Mora 2007, Wolff & Liede-Schumann 2007). The sister group to *Pagamea*, the paleotropical *Gaertnera*, as

Figure 1. Flowers, fruits, and visitors in *Pagamea duckei*. (a) staminate flowers, (b) pistillate flowers showing the exteriorized stigma, (c) immature fruits, (d) *Melipona fulva*, (e) *Centris* sp. ♀, (f) *Centris* sp. ♂, (g) *Trigona williame* (h) Lepidoptera sp. 1.

Figura 1. Flores, frutos e visitantes em *Pagamea duckei*. (a) flores estaminadas, (b) flores pistiladas destacando o estigma exteriorizado, (c) frutos imaturos, (d) *Melipona fulva*, (e) *Centris* sp. ♀, (f) *Centris* sp. ♂, (g) *Trigona williame* (h) Lepidoptera sp. 1.

well as other closely related genera (*Psychotria* “alliance”), include heterostyled, homostyled and dioecious species (Malcomber 2002). Vicentini (2007) reported these three reproductive systems for *Pagamea* but he interpreted the strongly heterostyled flowers of many species of *Pagamea* as functionally unisexual flowers, based on three observed characteristics: a) “short-styled” flowers have, on most dimorphic species, a very reduced pistil with closed stigmatic lobes without papillae; b) “long-styled” flowers have stamens with reduced anthers, which are packed with raphids and lack pollen; c) herbarium samples and field observations on plants with “short-styled” flowers indicate that these never form fruit, suggesting that these flowers are staminate. Bentham (1857) had already recognized that flowers of *Pagamea guianensis* Aubl. ‘*had a tendency to become polygamous due to the abortion of feminine organs in some flowers, and occasionally the anthers in others*’. The present survey confirms, with evidences from floral biology and absence of fruit formation in “short-styled” plants that the strong floral dimorphism observed in *Pagamea duckei* and several other species of *Pagamea*, is indeed indicative of dioecy.

The incorrect inference of heterostyly based only on floral morphology has been reported in several groups of plants such as *Phlox*, *Erythroxylum*, *Eichhornia* and *Mussaenda* (Barrett & Richards 1990, Naiki & Kato 1999), and this may be also true for many more Rubiaceae where heterostyly is considered a common breeding system. Dioecy and homostyly are the most common reproductive systems in *Pagamea*, but some species have morphologies suggestive of true heterostyly (Vicentini 2007). The mapping of these breeding systems on a species-level molecular phylogeny of *Pagamea* indicated that homostylous and dioecious species form separate clades and suggest a single origin for dioecy in this genus (Vicentini 2007). According to this phylogeny, *Pagamea duckei* is sister to the other species with strongly dimorphic flowers suggestive of dioecy and, hence, the functional dioecy confirmed by this study may be inferred to the other putatively dioecious species as well.

There is only one additional study about the biology and pollination of *Pagamea*. In contrast to the dioecious system described here, this study of a population of *Pagamea capitata* Benth. in the Guyana Shield, indicated that this species has homostyled flowers but which are dimorphic in the size and quantity of the pollen produced (O. Hokche, personal communication). This dimorphism is typical of heterostyled plants (distyled; Barrett & Richards 1990), and *Pagamea capitata* presents homostyled and heterostyled populations (Vicentini 2007).

These patterns are in agreement with a model of evolution in which dioecy and homostyly are derived from heterostyly (Barrett & Richards 1990).

2. *Pollination experiments*

Fruit set in *Pagamea duckei* was higher with hand pollination than with open pollination (Figure 1c). In *Psychotria barbiflora* DC. (Rubiaceae), the small number of visitors during the flowering period and the distance between pistillate and staminate plants explained the low rate of fruit production in open pollination when compared to hand pollination (Teixeira & Machado 2004a). However, in the present study, staminate and pistillate plants were in close proximity. Hence, distance was not the limiting factor for pollen transportation. The low rate of fruit production in *P. duckei*, the large size of fruits, and the lack of the ability of selfing or apomixis may be among the causes of the restricted geographic distribution of this species. *Pagamea duckei* has a very restricted distribution, particularly when taking into consideration age estimates for this species (~8 Ma) and the much wider geographic distribution of younger species (~4 Ma), which are also dioecious (Vicentini 2007). In *Pagamea*

Table 1. Results of controlled pollination tests in *Pagamea duckei* at the Reserva Biológica da Campina, Manaus, AM.

Tabela 1. Resultado dos testes de polinização controlada em *Pagamea duckei* na Reserva Biológica da Campina, Manaus, AM.

Treatments	Flowers (n)	Fruits (n)	Success (%)
Agamospermy	50	0	0
Hand pollination	50	22	44
Control	50	5	10

Table 2. Floral visitors and visitation frequency in *Pagamea duckei* at the Reserva Biológica da Campina, Manaus, AM, in 2007 and 2008.

Tabela 2. Visitantes florais e frequência de visitação em *Pagamea duckei* na Reserva Biológica da Campina, Manaus, AM, em 2007 e 2008.

Order	Family	Genus/species	Frequency of visitation on pistillate and staminate flowers			
			2007		2008	
			♀	♂	♀	♂
Lepidoptera						
	Hisperidae					
		sp.1	R	F	-	-
Hymenoptera						
	Apidae	*Centris* sp. ♂	F	VF	-	-
		Centris sp. ♀	R	F	-	-
		Melipona fulva (Lepeletier, 1836)	VF	VF	-	-
		Melipona compressipes (Fabricius, 1804)	-	-	F	F
		Ptilotrigona lurida (Smith, 1854)	F	F	-	-
		Trigona fulviventris (Guérin, 1835)	F	F	LF	LF
		Trigona william (Freise, 1900)	R	R	R	R
		Eufriesea surinamensis (Linnaeus, 1758)	R	R	-	-
		Vespa sp.	-	-	R	R

VF = very frequent (≥4 visits/hour), F = frequent (±3 visits/hour), LF = low frequent (±2 visits/hour), R = rare (≤1 visit/hour).

VF = muito freqüente (≥4 visitas/hora), F = frequente (±3 visitas/hora), LF = pouco frequente (±2 visitas/hora), R = raro (≤1 visita/hora).

there is a correlation between the average number of flowers per inflorescence and geographical area, suggesting the hypothesis that the rate of range expansion may be related to fecundity (i.e. fruit number; Vicentini 2007). Higher number of flowers per inflorescence may indicate higher fecundity but it may also correlate with smaller fruits and larger array of dispersers (Vicentini 2007). Low fecundity in *P. duckei*, at least concerning the number of fruits produced also indicates the importance of these experiments for understanding the processes of diversification.

Pagamea duckei is dioecious and there was no seed formation via apomixis. Therefore, cross-polination is mandatory in this species. Many apomictic plants belong to lineages of plants that have reproductive systems of self-incompatibility, dioecy or heterostyly (Asker & Jerling 1992 apud Bicknell & Koltunow, 2004), and there is an evidence of apomitic formation of seeds in *Coprosma*, another Rubiaceae (Heenan et al. 2002). Apomixis may allow dioecious species to colonize new environments or isolated and small areas and this could be the case for *Pagamea*, which has an island-like distribution because of its habitat specificity (white-sand forests and savannas; Vicentini 2007). However, in *Pagamea duckei* there is no evidence for apomixis, which weakens any relationship with geographical distribution because the most widespread species of *Pagamea* are also dioecious (Vicentini 2007).

3. *Pollinators and visitors*

In *Pagamea duckei*, Meliponini bees (*Melipona* and *Trigona*) are the most frequent floral visitors and thus seem to be the main pollen vectors. Pollination by small bees like the Meliponini is characteristic of most dioecious species of tropical trees and shrubs (Bawa 1980). In addition, dioecious species tend to have one or few seeds per fruit, which are dispersed by birds (ibid.). Such characteristics are clearly present in *P. duckei*. The actinomorphic flowers, the corolla color ranging from white to cream, and shallow tube, presence of nectar and pollen production found in *P. duckei* are traits that fit the Melittophily syndrome. These floral characteristics are also in agreement with descriptions by Richards (1997), Machado et al. (1998) and Goldblatt & Manning (2002) for pollination by small bees.

Melittophily has been mentioned for other Rubiaceae, mainly in *Psychotria* (Coelho & Barbosa 2003, Teixeira & Machado 2004a, Ramos & Santos 2006). Bees seen in *P. duckei* flowers occur in higher frequency in the first part of the morning and this frequency increased in sunny and drier conditions. Such higher visitation rate in the morning seems to be related with higher production of nectar in this period. The synchrony between bee activity and anthesis is another indicative of the involvement of bees in the pollination process of this species (Ando et al. 2001).

Generally, species of Rubiaceae present a wide range of floral visitors (Consolaro et al. 2005). In *Psychotria*, many species of bees, including those of *Trigona* and *Euglossa*, and some wasps, are efficient pollen vectors (Coelho & Barbosa 2003, Teixera & Machado 2004a). In *Amaioua guianensis* Aubl., large bees such as *Bombus atratus* (Franklin, 1913), *Centris* sp., *Epicharis flava* (Friese, 1900) and *Eulema nigrita* (Lepeletier, 1841), are the most efficient pollen vectors (Amorim & Oliveira 2006). Teixeira & Machado (2004b) recorded seven bee species on *Sabicea cinerea* Aubl., pointing out mainly individuals of *Euglossa cordata* (Linnaeus, 1758), *Xylocopa suspecta* (Moore & Camargo, 1988), *Exaerete smaragdina* (Guérin-Méneville, 1844), *Trigona fulviventris* (Guérin, 1835) and a species of *Pseudaugochloropsis*.

Bees of the genus *Centris* also showed high visitation frequency, although lower when compared to *Melipona*. *Centris* females are in general oil collectors in flowers of Krameriaceae, Scrophulariaceae, Solanaceae, Gesneriaceae, Bignoniaceae and Malpighiaceae. The high number of bristles present in the forelegs of these bees makes it possible to allocate and transport oil. Male individuals do not have these bristles in the forelegs. Nevertheless, male bees collect nectar and in some cases visit flowers with the only purpose of attracting females for copulation (Gimenes & Lobão 2006, Silva et al. 2007), and in these cases they are territorial, hardly acting as pollen vectors. The behavior of male *Centris* on the flowers of *P. duckei* suggests that these bees act only as floral visitors and not as pollen vector.

The floral traits of *Pagamea duckei* and that of most species in this genus, like the tubular corolla with free spreading lobes covered with hairs that limits the nectar robbing by small insects, and the nectar production itself, are in agreement with Psycophily (Faegri & Van der Pijl 1979), which has been reported for other Rubiaceae (Castro & Oliveira 2002, Goldblatt & Manning 2002, Fenster et al. 2004). Flies, however, were not observed visiting the flowers of *P. duckei*. Additionally, pollination by Lepidoptera has been documented in *Psychotria* and *Palicourea* (Castro & Oliveira 2002, Coelho & Barbosa 2003), genera phylogenetically close to *Pagamea* (Robbrecht & Manen 2006). Nevertheless, Lepidoptera were rare visitors in *P. duckei*. Small bees, hence, appear to be the main pollinators. The strong and sweet flowers odor also supports this hypothesis.

Final Considerations

This study confirms that the strongly dimorphic flowers of *Pagamea duckei* represent unisexual flowers rather than distylous perfect flowers, and thus the studied population is dioecious. Observations on floral visitors showed that flowers are insect-pollinated, mainly by bees, and that there is no specificity for pollinator type, with nectar as the main reward. The results here obtained suggest that other species of *Pagamea* with similar flower morphology are also dioecious, contributing to the understanding of breeding system variation and evolution within this clade.

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Predation on *Tropidurus hispidus* (Squamata: Tropiduridae) by *Lasiodora klugi* (Aranea: Theraphosidae) in the semiarid caatinga region of northeastern Brazil

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VIEIRA, W.L.S., GONÇALVES, M.B.R. & NÓGREGA, R.P. **Predation on *Tropidurus hispidus* (Squamata: Tropiduridae) by *Lasiodora klugi* (Aranea: Theraphosidae) in the semiarid caatinga region of northeastern Brazil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?short-communication+bn02112042012

Abstract: A predation event on *Tropidurus hispidus* (Tropiduridae) by the crab spider *Lasiodora klugi* (Theraphosidae) was observed in an arboreal caatinga area in northeastern Brazil. Arthropods are potential predators of small vertebrates and researchers have reported predation events involving spiders and herpetofauna in Neotropical regions. As such, the present short communication is the second case of predation of spiders on *Tropidurus* lizards in Brazil, and the first for the semiarid caatinga, reinforcing the argument that large spiders have relevant roles as predators of these animals.
Keywords: *natural history, prey-predator relationships, Lacertilia, Mygalomorphae, semiarid environment.*

VIEIRA, W.L.S., GONÇALVES, M.B.R. & NÓGREGA, R.P. **Predação sobre *Tropidurus hispidus* (Squamata: Tropiduridae) por *Lasiodora klugi* (Aranea: Theraphosidae) na região de caatinga semiárida do nordeste do Brasil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?short-communication+bn02112042012

Resumo: Um evento de predação sobre *Tropidurus hispidus* (Tropiduridae) pela aranha caranguejeira *Lasiodora klugi* (Theraphosidae) foi observado em área de caatinga arbórea no nordeste do Brasil. Artrópodes são potenciais predadores de pequenos vertebrados e pesquisadores têm relatado eventos de predação envolvendo aranhas e herpetofauna em regiões neotropicais. Portanto, a presente comunicação breve é o segundo caso de predação de aranha sobre lagartos do gênero *Tropidurus* no Brasil e o primeiro para as caatingas semiáridas, reforçando a argumentação de que grandes aranhas possuem um papel relevante como predadores desses animais.
Palavras-chave: *história natural, relação presa-predador, Lacertilia, Mygalomorphae, ambiente semiárido.*

Introduction

Predator-prey relationships are one of the main ecological factors structuring vertebrate and invertebrate assemblages (Sandidge 2004, Vitt & Caldwell 2009). These important interactions influence utilization strategies of food resources among different species groups (Toft 1985) and can result in non-random patterns of interspecific relationships between different types of predators (Gotelli & Entsminger 2001).

Vertebrates are the main predators of arthropods, and insects and spiders are the most representative food items in the diet of a large numbers of lizard species (Vitt & Pianka 2005). However, arthropods, especially spiders, are likewise potential predators of small vertebrates (McCormick & Polis 1982). Numerous researchers have reported predation events involving spiders and herpetofauna in Neotropical regions (e.g. Raven 1990, Prado & Borgo 2003, Menin et al. 2005, Pombal Junior 2007, Barbo et al. 2009, Maffei et al. 2010, Bocchiglieri & Mendonça 2010, Maffei et al. 2010, Sousa & Freire 2010a, Moura & Azevedo 2011, Diniz 2011).

Within this context, it must be noted that Armas & Alayón (1987) reported individuals of *Argiope trifasciata* (Forsskål, 1775) (Araneidae) as predators of the arboreal lizards *Anolis porcatus* Gray, 1840 and *A. sagrei* Duméril & Bibron 1837 (Polychrotidae); Schwammer & Baurecht (1988) and Blondheim & Werner (1989) reported predation events of *Latrodectus* spiders (Theridiidae) on *Podarcis melisellensis* (Braun, 1877) and *Mesalina guttulata* (Lichtenstein, 1823) (Lacertidae); Bauer (1990) prepared a review of spiders as predators of lizards of the Gekkonidae family; Armas (2000) published a survey of arachnids as predators of frogs and lizards in the Greater Antilles; Maffei et al. (2010) reported predation events of the wolf-spider *Lycosa erythrognatha* Lucas, 1836 (Lycosidae) on gymnophthalmid species in the Cerrado (savanna) of central Brazil; and Diniz (2011) documented the predation of *Hemidactylus mabouia* (Moreau De Jonnès, 1818) (Gekkonidae) by the giant orb-weaver spider *Nephilengys cruentata* Fabricius, 1775 (Nephilidae). Considering the importance of spiders as predators of lizards, this short communication reports the first recorded event of *Lasiodora klugi* (Koch, 1848) (Theraphosidae) preying on *Tropidurus hispidus* (Spix, 1825) (Tropiduridae) in the semiarid region of northeastern Brazil (Figure 1).

Figure 1. Predation of *Tropidurus hispidus* by the Theraphosid spider *Lasiodora kluge* (50 mm/cephalothorax + abdomen length), observed in an area of arboreal caatinga in the Almas Farm RPPN, in the municipality of São José dos Cordeiros, Paraíba, northeastern Brazil. Photograph: Washington L.S.Vieira.

Materials and Methods

This predation event was observed during fieldwork focusing on the ecology of reptiles and amphibians within the Long-Term Ecological Research Program (PELD – Caatinga: Estrutura e Funcionamento) and the Universal – Edital MCT/CNPQ Nº 14/2011 research project in an area of arboreal caatinga at the Fazenda Almas. This area is included in the Natural Private Reserve (Reserva Particular do Patrimônio Natural–RPPN) and covers an area of 5500 ha in the municipality of São José dos Cordeiros, state of Paraíba, in northeastern Brazil (7° 28’ 15” S and 36° 52’ 51” W).

Results and Discussion

On April 26, 2012 (8:00 AM) an adult female specimen of *Lasiodora klugi* (Koch, 1848) was observed feeding on an adult female specimen of *Tropidurus hispidus* (Spix, 1825) amidst the leaf litter of the dry forest floor (Figure 1). As we approached the animals, the spider began to retreat while carrying the lizard under its body (holding it with its chelicerae and pedipalps) for a distance of approximately 10 m, with short pauses, until finally reaching and entering a small hole in the ground; the entire distance was covered in approximately 10 minutes. Since the spider entered a hole, it was not possible to collect it or its prey for inclusion in a scientific collection. However, photographs taken of this predation event were incorporated into the image and video bank of the Laboratório de Ecofisiologia Animal at the Universidade Federal da Paraíba, Paraíba, Brazil.

Tropidurus hispidus is a small lizard, approximately 140 mm long (SVL), with diurnal habits and a wide distribution range through northeastern South America – predominantly in the caatinga biome of northeastern Brazil, in open areas north of the Amazon River, and in the central Amazon region near the city of Manaus (where it was apparently introduced) (Rodrigues 1987, Vitt et al. 2008). *Lasiodora klugi* is a Theraphosid spider that reaches 50 mm (cephalothorax + abdomen length) (S. Lucas, pers. comm.). This species has an ample geographical distribution, with records in both the caatinga and cerrado (Brazilian savanna) biomes (Bertani 2001).

Individuals of both *T. hispidus* and *L. klugi* are commonly observed co-habiting rock outcrops and crevices and areas with hyperxerophilic vegetation (W. Vieira, pers. obs.) – which suggests that predation of these lizards by Theraphosid spider may be quite common in these environments. Arachnids are some of the principal predators of small animals that inhabit the forest floor in the Neotropical region, and predation of terrestrial vertebrates such as frogs and lizards is probably quite common (Armas 2000, Menin et al. 2005, Barbo et al. 2009). Predation events by arthropods on vertebrate assemblages are quite difficult to record, however, and the observer must be continually attentive while exploring microhabitats where these predators are found to be able to observe them during the short moments when they are capturing and/or devouring their prey (Pombal Junior 2007).

Bocchiglieri & Mendonça (2010) reported a wolf spider (*Lycosa erythrognatha*) feeding on an adult *Tropidurus oreadicus* Rodrigues, 1987 in a pitfall trap in southeastern Brazil – which was the first report of predation on a lizard of this genus by a spider. As such, the present report is the second case of predation of spiders on *Tropidurus* lizards in Brazil, and the first for the semiarid caatinga – reinforcing the argument that spiders of the families Theraphosidae and Lycosidae have important roles as predators of these animals.

The few publications that have examined predator-prey relationships between spiders (and other arthropods) and Brazilian lizards in seasonal environments have recorded events involving *Lycosa erythrognatha* preying on *Micrablepharus atticolus*

Rodrigues, 1996 in an area of Cerrado (Brazilian savanna vegetation) in central Brazil (Maffei et al. 2010), a non-identified theraphosid spider preying on *Micrablepharus maximiliani* (Reinhardt & Lütken, 1862) (Sousa & Freire 2010a) in a restinga (coastal) area, and a large ant of the species *Dinoponera quadriceps* Santschi, 1921 preying on the small lizard *Coleodactylus natalensis* Freire, 1999 (Sousa & Freire 2010b) in a remnant area of semi-deciduous Atlantic Forest (the latter two in northeastern Brazil); Ribeiro et al. (2011) also observed predation events on *Hemidactylus brasilianus* (Amaral, 1935) and *Cnemidophorus ocellifer* (Spix, 1825) by *D. quadriceps* in an area of caatinga.

Within this context, this short communication increases the knowledge of the trophic interactions that occur between arthropods and lizards in the semiarid caatinga regions of northeastern Brazil, which suggest that predation of these lizards by Theraphosid spider may be quite common in these environments.

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A new species of *Notalina* Mosely, 1936 (Trichoptera: Leptoceridae) from Southeastern Brazil

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HENRIQUES-OLIVEIRA, A.L., SPIES, M.R. & DUMAS, L.L. **A new species of *Notalina* Mosely, 1936 (Trichoptera: Leptoceridae) from Southeastern Brazil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?article+bn03012042012

Abstract: The Neotropical subgenus *Notalina* (*Neonotalina*) Holzenthal, 1986 has ten described species in two species groups: *brasiliana,* formed by seven species from Southeastern Brazilian and Goiás State; and *roraima*, represented by three species from the Amazonian and Andes regions. In this paper, a new species of *Notalina* is described and illustrated from specimens collected in the Mantiqueira mountain range, Southeastern Brazil. The new species belongs to the *brasiliana* group and is easily recognized by the poorly developed dorsomesal and ventrolateral processes and the pair of mound-like protuberances located mesolaterally on abdominal segment X, and by the robust, rounded mesoventral processes and long digitate mesodorsal processes of the inferior appendages. A key to the Neotropical species in the genus is provided.

Keywords: *Atlantic Forest, Neotropical, Hudsonemini, new species, identification key.*

HENRIQUES-OLIVEIRA, A.L.; SPIES, M.R. & DUMAS, L.L. **Nova espécie de *Notalina* Mosely, 1936 (Trichoptera: Leptoceridae) do Sudeste do Brasil**. Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?article+bn03012042012

Resumo: O subgênero Neotropical *Notalina* (*Neonotalina*) possui dez espécies descritas em dois grupos: *brasiliana*, formada por sete espécies provenientes do Sudeste brasileiro e do Estado de Goiás; e *roraima*, representado por três espécies das região Amazônica e Andes. Neste trabalho, uma nova espécie de *Notalina* é descrita e ilustrada a partir de espécimes coletados na Serra da Mantiqueira, Sudeste do Brasil. A nova espécie pertence ao grupo *brasiliana* e é facilmente reconhecida por processos dorsomesal e ventrolateral pobremente desenvolvidos e por um par de pequenas protuberâncias localizadas mesolateralmente no segmento X, apêndices inferiores com processo mesoventral arredondado e robusto, e processo mesodorsal longo e digitado. Uma chave de identificação para as espécies neotropicais do gênero é fornecida.

Palavras-chave: *Mata Atlântica, Região Neotropical, Hudsonemini, espécie nova, chave de identificação.*

Introduction

Leptoceridae (or long-horned caddisflies) are among the three largest families of Trichoptera, with about 1,800 described species and 46 extant genera (Malm & Johanson 2011). The family is currently divided into four subfamilies: Leptocerinae Leach, 1815, with cosmopolitan distribution, Triplectidinae Ulmer, 1906 and Grumichellinae Malm & Johanson, 2011, both with primarily Southern Hemisphere distribution in the Neotropics and Australasia, and Leptorussinae Malm & Johanson, 2011, with only the monotypic genus *Leptorussa* Mosely, 1953 from Australia (Holzenthal 1986, Morse & Holzenthal 1987, Malm & Johanson 2011).

The genus *Notalina* Mosely, 1936, which belongs to the subfamily Triplectidinae, tribe Hudsonemini, contains 25 species distributed in two subgenera: *N.* (*Notalina*) Mosely, 1936, with 15 species endemic to Australia and Tasmania, and *N.* (*Neonotalina*) Holzenthal, 1986, with 10 species exclusively South American in distribution (Calor 2008). The genus is especially diverse in Brazil, where there are seven species described: *N. brasiliana* Holzenthal 1986, *N. cipo* Holzenthal 1986, *N. froehlichi* Calor & Holzenthal 2006, *N. goaianensis* Calor, 2008, *N. hamiltoni* Holzenthal 1986, *N. morsei* Holzenthal 1986, and *N. paulista* Calor & Holzenthal 2006 (Holzenthal 1986, Calor et al. 2006, Calor 2008).

Holzenthal (1986) recognized two species groups of Neotropical (*roraima* and *brasiliana* groups). The *roraima* species group occurs in the upper Amazon basin, the Northern Andes, and the Guiana Highlands, while species of the *brasiliana* species group are found in the highlands of Southeastern and Central Brazil (Calor 2008). Herein, a new species of *Notalina* (*Neonotalina*) from the Mantiqueira mountain range, Southeastern Brazil is described and illustrated.

Materials and Methods

The specimens were collected with Pennsylvania light traps (Frost 1957), Malaise traps, and hand net at Parque Estadual de Campos do Jordão (São Paulo State) and the upper portion of the Itatiaia massif, Itamonte municipality (Minas Gerais State), both located in the Mantiqueira mountain range, an Atlantic Forest highland area of Southeastern Brazil.

The material examined was preserved in 80% alcohol. To observe genital structures, the abdomen was removed and cleared in 10% KOH solution. Both stereo- and optical microscopes were used to examine specimens and specimens were illustrated with the aid of a camera lucida. Morphological terminology follows that of Holzenthal (1986). The type specimens are deposited in Museu de Zoologia, Universidade de São Paulo, Brazil (MZSP), and the Coleção Entomológica Prof. José Alfredo Pinheiro Dutra, Departamento de Zoologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (DZRJ).

Taxonomy

***Notalina jordanensis*, new species**

Notalina jordanensis belongs to the *brasiliana* species group as defined by Holzenthal (1986), by sharing the phallobase with paired, lateral, acuminate flanges and the large, well developed phallotremal sclerite. The new species is most similar to *N. brasiliana* and *N. goianensis*, due to the general structure of saddle-like segment X. However, *N. jordanensis* has the dorsomesal and ventrolateral processes poorly developed on abdominal segment X and has a mound-like protuberance mesolaterally, absent in the other species. Furthermore, the robust and rounded mesoventral processes and the long digitate mesodorsal processes of the inferior appendages, are also useful diagnostic characters for the new species.

Adult: Color (in alcohol) brown to dark brown; legs, palps, and antennae brown. Tibial spur formula 2,2,4. Wing venation as in Figure 1; forewing with forks I, and V presents, with small clear area dorsoapically at thyridial cell; hindwing with forks I, III, and V presents. Forewing length 9.2-10.4 mm (n = 8).

Male genitalia: Abdominal segment IX annular, broadest ventrolaterally, with pair of small dorsal expansions and setae on lateral edge (Figures 2, 3). Segment X saddle-shaped, with setose, mound-like protuberance mesolaterally, and bearing pair of small ventrolateral processes apically and pair of poorly developed dorsomesal processes (viewed only in dorsal view) (Figures 2, 3). Preanal appendages elongate, smaller than segment X, setose, digitate, rounded at apex (Figures 2, 3). Inferior appendages broad at base, with apical portion elongate, digitate, setose; basodorsal process short, flat, rounded apically; mesodorsal process digitate, slender, with approximately half-length of apical portion, rounded at apex, dorso-medially directed; basoventral protuberance setose, small as viewed laterally, enlarged in ventral view; mesoventral process enlarged, rounded in lateral view, elongate, digitate, rounded at apex, as viewed ventrally (Figures 2, 4). Phallic apparatus with phallic apodeme and phallobase well developed; phallobase with pair of dorsally directed, acuminate flanges, not laterally directed; phallotremal sclerite moderately developed, roughly U-shaped as viewed dorsally (Figures 5, 6).

Holotype male: BRAZIL: São Paulo: Campos do Jordão, Parque Estadual de Campos do Jordão, afluente do Córrego Galharada, 22° 41’ 30” S, 45° 27’ 36” W, el. 1600 m, 07.×.2007, M.R. Spies leg. (MZSP).

Paratypes: BRAZIL: São Paulo: Campos do Jordão, Parque Estadual de Campos do Jordão, afluente do Córrego Galharada, 22° 41’ 30” S and 45° 27’ 36” W, el. 1515 m, 07.x.2007, M.R. Spies leg. 3 males (DZRJ 3517); same data, 2 males (MZSP); Campos do Jordão, Parque Estadual de Campos do Jordão, Córrego Galharada, 22° 41’ 40.0” S and 45° 27’ 37.0” W, el. 1646 m, 07.x.2007, M. R. Spies leg., 3 males (DZRJ 3518); same data 3 males (MZSP); Campos de Jordão, Parque Estadual de Campos do Jordão, afluente do Rio Sapucaí, 22° 41’ 04” S and 45° 28’ 29” W, el. 1551 m., 22.viii.2006, M.R. Spies leg., 3 males, (DZRJ 3519); Campos de Jordão, Parque Estadual de Campos do Jordão, Córrego do Serrote, 22° 39’ 30” S and 45° 26’ 32” W, el. 1540 m, 20.viii.2006, M.R. Spies leg., 3 males (DZRJ 3520); Campos de Jordão, Parque Estadual de Campos do Jordão, Córrego Galharada, 4ª ordem, 22° 41’ 29” S and 45° 27’ 36” W, 07.x.2007, M. R. Spies leg., 1 male (MZSP); Campos do Jordão, Parque Estadual de Campos do Jordão, Córrego Galharada, 22° 41’ 26” S and 45° 28’ 02” W, el. 1548 m, 10.viii – 06.ix.2005, malaise trap, M.R. Spies leg., 1 male, (DZRJ 3521); Campos do Jordão, Parque Estadual de Campos do Jordão, Córrego Galharada, 22° 41’ 26” S and 45° 28’ 02” W, el. 1548 m, 21.viii – 21.ix.2006, malaise trap, M.R. Spies leg., 1 male, (MZSP); Campos de Jordão, Parque Estadual de Campos do Jordão, Córrego do Serrote, 22° 39’ 30” S and 45° 26’ 32.0” W, el. 1530 m, 20.viii.2006, M. R. Spies leg., 2 males (MZSP); Campos de Jordão, Parque Estadual de Campos do Jordão, Córrego do Campo do Meio, 22° 41’ 56.0” S and 45° 29’ 19.0” W, el. 1547 m, 21.viii.2007, M. R.. Spies leg., 1 male (MZSP); Campos do Jordão, Parque Estadual de Campos do Jordão, Córrego Celestina, 22° 41’ 23” S and 45° 28’ 26” W, el. 1527 m, 19.viii.2006, M.R. Spies, leg. 1 male (DZRJ 3522). **Minas Gerais:** Itamonte, Rio Aiuruoca, 22° 20’ 56.9” S and 44° 41’ 57.9” W, el. 1860 m., 25.x.2002, J. L. Nessimian & A. A. Huamantinco leg., 1 male (DZRJ 1871).

Distribution: Southeastern Brazil (São Paulo and Minas Gerais States).

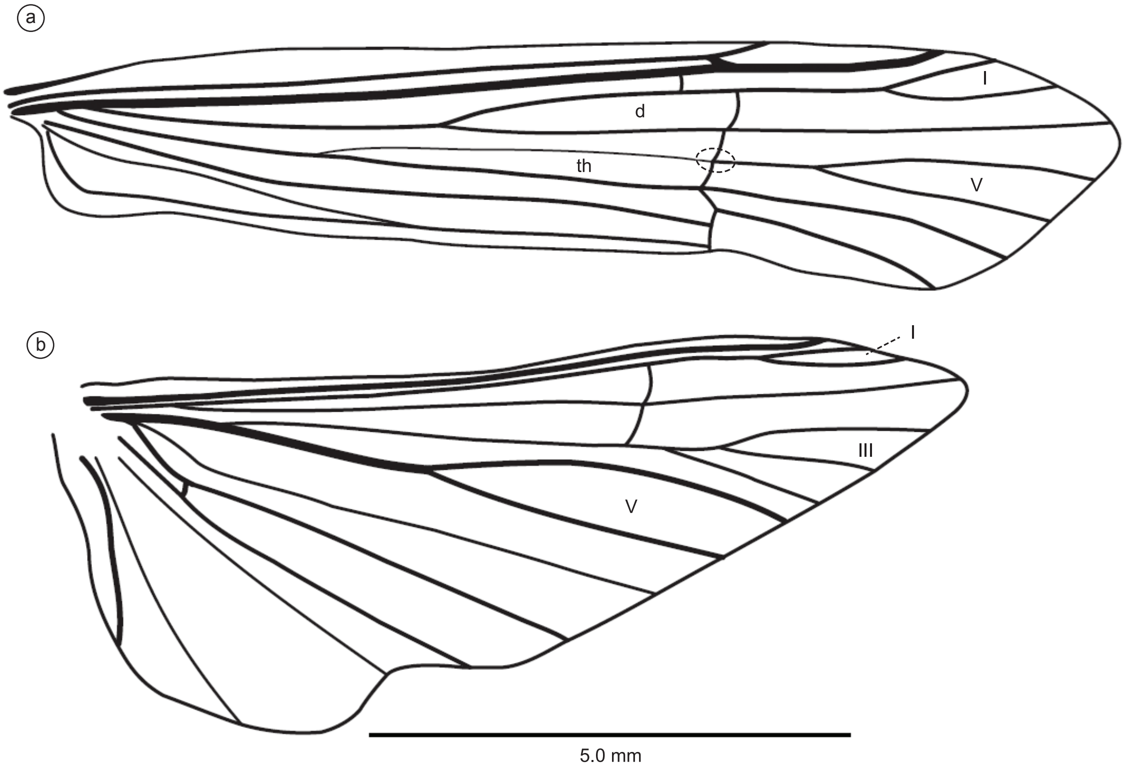


Figure 1. *Notalina jordanensis* Henriques-Oliveira, Spies & Dumas, new species. Male wing: a) Forewing; b) Hindwing.

Figura 1. *Notalina jordanensis* Henriques-Oliveira, Spies & Dumas, espécie nova. Asa masculina: a) Asa anterior; b) Asa posterior.

Etymology: The epithet specific name *jordanensis* refers to the holotype locality, Campos do Jordão municipality, in São Paulo State, Southeastern Brazil.

Key to the males of *Notalina* (*Neonotalina*)

(modified from Holzenthal 1986)

1. Phallobase with paired, acuminate flanges; phallotremal sclerite well developed, large (*see* Figures 3D, E in Holzenthal 1986) *brasiliana* group (2)

1'. Phallobase with paired, spatulate flanges; phallotremal sclerite underdeveloped, small (*see* Figures 9D, E in Holzenthal 1986) *roraima* group (9)

2. Abdominal segment X bearing a single pair of terminal processes (*see* Figures 5A, B in Holzenthal 1986) 3

2'. Abdominal segment X bearing 2 pairs of terminal, finger-like processes (*see* Figures 3A, B in Holzenthal 1986) 6

3. Segment X with dorsolateral processes (*see* Figures 2A, C in Calor, Holzenthal & Amorim 2006). *N.paulista*

3'. Segment X without dorsolateral processes 4

4. Terminal processes of segment X large, quadrate in dorsal view; segment X with pair of lateral protuberances (*see* Figures 5A, B in Holzenthal 1986) 5

4'. Terminal processes of segment X small; segment X without lateral protuberances (*see* Figures 8A, B in Holzenthal 1986) *N. hamiltoni*

5. Segment X saddle-shaped in lateral view; inferior appendage narrow basally and bearing 2 sclerotized points mesoventrally (*see* Figures 5A, C in Holzenthal 1986) *N. morsei*

5'. Segment X not as above; inferior appendage with basal region massive and bearing a lateral ridge (*see* Figures 7A, C in Holzenthal 1986) *N. cipo*

6. Segment X with a setose, mound-like protuberance mesodorsally; inferior appendages with mesoventral process rounded in lateral view (Figures 2, 3, 4) *N. jordanensis*

6'. Segment X without mound-like protuberance; inferior appendages with mesoventral process elongate (*see* Figure 3A in Holzenthal 1986) 7

7. Segment X with phallotremal sclerite greatly enlarged, with anteriorly-directed projection (*see* Figures 3A, B, D, E in Holzenthal 1986) *N. brasiliana*

7'. Segment X with dorsomesal processes not surpassing or with same length of ventrolateral processes; phallotremal sclerite not greatly enlarged, without projection (*see* Figures 2A, E in Calor 2008) 8

8. Phallobase with pair of laterallly directed, acuminate flanges (*see* Figures 1D, E, F in Calor, Holzenthal & Amorim 2006) *N. froehlichi*

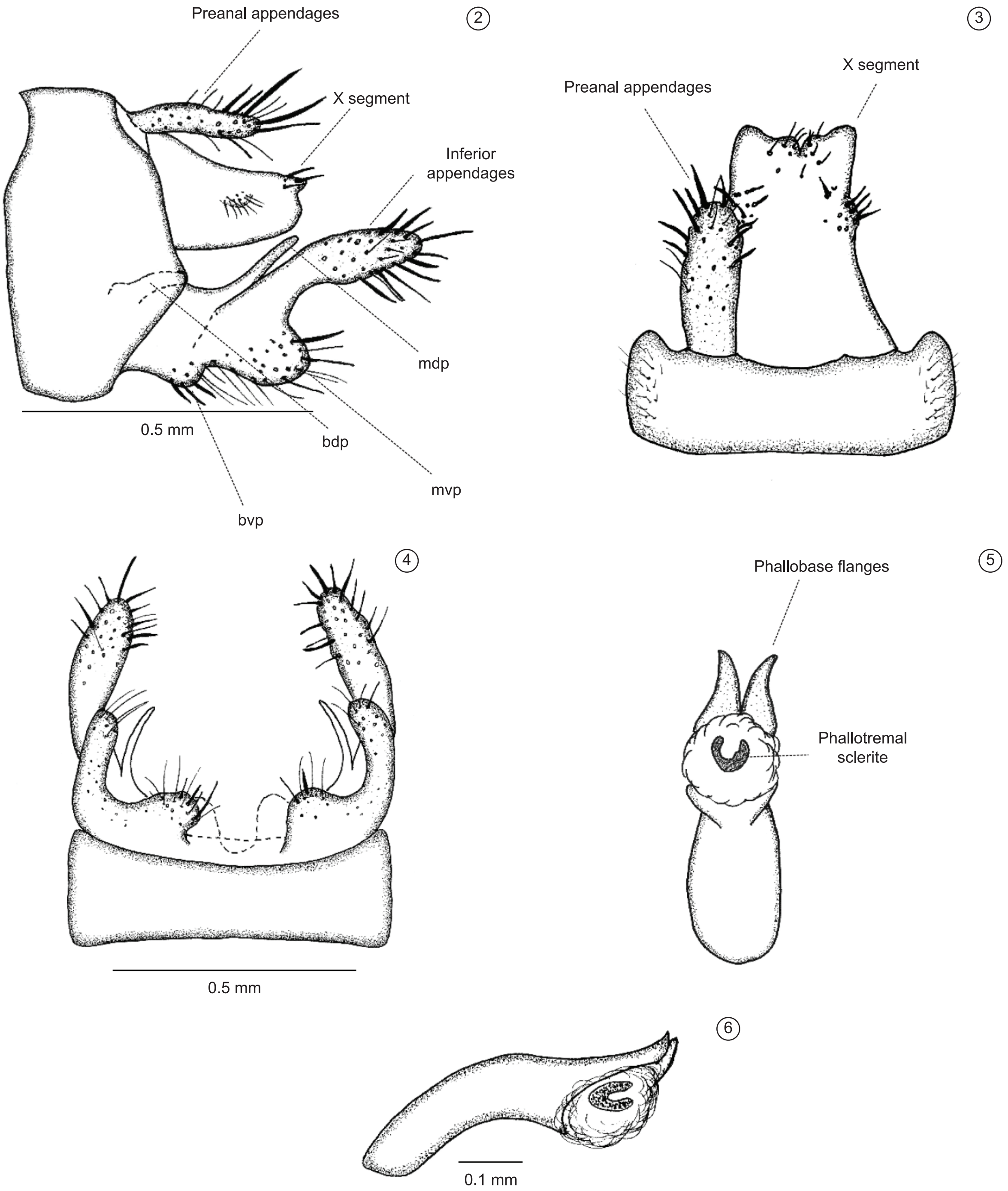
8'. Phallobase with pair of dorsally directed, acuminate flanges (*see* Figures 2B, D, F in Calor 2008) *N. goianensis*

9. Segment X with apex entire or with a very slight mesal cleft; without heavy setae (*see* Figures 9B, 10B in Holzenthal 1986) 10

9'. Segment X with a deep apico-mesal cleft and bearing heavy setae (*see* Figures 11A, B in Holzenthal 1986) *N. matthiasi*

10. Inferior appendages with basal and apical portion long and slender, bearing a sharply pointed mesoventral projection (*see* Figures 9A, C in Holzenthal 1986) *N. roraima*

10'. Inferior appendages with basal portion broad, lacking pointed mesoventral projection (*see* Figures 10 A, C in Holzenthal 1986) *N. nanay*



Figures 2-6. *Notalina jordanensis* Henriques-Oliveira, Spies & Dumas, new species. Male genitalia: 2) Abdominal segments IX and X (lateral view). Abbreviations: bvp-basoventral protuberance, mvp-mesoventral process, bdp-basodorsal process and mdp-mesodorsal process; 3) Abdominal segments IX and X (dorsal view), preanal appendages left omitted; 4) Abdominal segments IX and inferior appendages (ventral view); 5) Phallic apparatus (ventral view); 6) Phallic apparatus (lateral view).

Figuras 2-6. *Notalina jordanensis* Henriques-Oliveira, Spies & Dumas, espécie nova. Genitália masculina: 2) Segmentos abdominais IX e X (vista lateral) Abreviações: bvp-protuberância basoventral, mvp-processo mesoventral, bdp-processo basodorsal e mdp- processo mesodorsal.; 3) Segmentos abdominais IX e X (vista dorsal); 4) Segmento abdominal IX e apêndice inferior (vista ventral); 5) Aparato fálico (vista ventral); 6) Aparato fálico (vista lateral).

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Natural forest regeneration in abandoned sugarcane fields in northeastern Brazil: floristic changes

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Abstract: Surveys were undertaken to examine the floristic changes during secondary succession in three areas of 12 and three of 20-year-old secondary forests in Pernambuco State, Brazil. Two hundred and six species were identified, with 136 being found in the 12-year-old secondary forest and 161 species in the 20-year-old forest. Fabaceae and Myrtaceae were the most important families, increasing in species numbers with regeneration age. Of the 216 species, 115 were trees, 48 shrubs, 16 herbaceous plants, and 24 woody lianas, without significant differences between the two regeneration site ages. NMDS analysis revealed a formation of two floristic groups, distinguishing secondary and mature forests, with a further division within secondary forests in accordance with the time since abandonment. Similarity analysis ANOSIM confirmed the significance of the groups, which had floristic composition significant distinct (R=0.96) and 63% of dissimilarity (SIMPER). However, the sharing of 68 arboreal species between the secondary and mature forests suggests a floristic convergence. DCA analysis of the arboreal component as well as the other plant habits suggested that the separation of the subgroups is correlated with physical and chemical variables of the soils. All of these results indicate that, within the chronosequence analyzed, the velocity and direction of the floristic composition during secondary succession was influenced not only by the time of their abandonment, but also by a wide range of environmental variables.
Keywords: *secondary forests, floristic, secondary succession.*

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Resumo: Com objetivo de detectar mudanças florísticas ao longo da sucessão secundária e subsidiar futuros projetos de recuperação florestal foi realizado levantamento florístico de seis áreas de floresta secundária (capoeira) de 12 e 20 anos em Pernambuco. Foram registradas 206 espécies, sendo 136 nas capoeiras de 12 anos e 161 nas de 20 anos. Fabaceae e Myrtaceae foram as famílias mais importantes, aumentando no número de espécies com a idade de regeneração. Do total de espécies, 115 foram árvores, 48 arbustos, 16 herbáceas e 24 trepadeiras, sem diferença significativa por idade de regeneração. Análise de NMDS indicou a separação dos grupos florísticos das florestas maduras e das capoeiras, assim como a formação de subgrupos de capoeiras (SF1-2-3 e SF4-5-6) com idade de regeneração distinta. A análise de similaridade ANOSIM mostrou que os grupos formados apresentaram composição florística significativamente distintas (R = 0.96) e 63% de dissimilaridade (SIMPER). Entretanto, a presença nas capoeiras de 67 espécies em comum com as florestas maduras indicam uma tendência de convergência florística. A análise de DCA do componente arbóreo e dos outros hábitos sugere que a separação dos subgrupos por idade estaria correlacionada com variáveis edáficas físicas e químicas. Todos esses resultados indicam que, numa análise de cronossequência, não apenas o tempo de abandono, mas todas as variáveis ambientais influenciam a velocidade e direção de formação da composição florística durante a sucessão secundária.
Palavras-chave: *capoeira, flora vascular, sucessão secundária.*

Introduction

The degradation and destruction of natural habitats figure among the principal modern threats to biodiversity (Primack 2008). With the acceleration of the conversion of forests into pasture lands and agricultural fields in recent decades in Latin America (Geist & Lambin 2001) it has come to the point that mature forests altered by anthropogenic actions and regenerating secondary forests now compose approximately half of all remaining forest areas in the tropics (International... 2002). On the other hand, large areas of formerly cleared lands have also been abandoned and are evolving into secondary forests (Wright 2005).

Fragments of mature and secondary forests can be found in many landscapes otherwise dominated by agriculture or pasture lands. This situation can be seen, for example, in the Brazilian Atlantic Forest biome that has suffered negative impacts from a number of economic cycles, resulting in significant landscape modifications and ecosystem destruction (Dean 2002). The conservation of the Atlantic Forest and its biodiversity now presents a significant challenge to conservation efforts, principally due to its advanced state of forest substitution, and depends on the protection of the remaining fragments of mature forest (Tabarelli & Gascon 2005) and the correct management of regenerating forests after abandonment (Dent & Wright 2009). The Atlantic Forest now persists on only between 11% and 16% of its original land area coverage, and even these remnants are extremely fragmented (Ribeiro et al. 2009). This once extensive forest is currently composed of just a few well-preserved mature forest sites with numerous areas of varying ages with diverse use-histories undergoing secondary succession, and these are often surrounded by matrixes of cultivated areas and pasturelands (Ranta et al. 1998, Trindade et al. 2008).

A number of workers have pointed out the importance of secondary forests: as biodiversity reservoirs within fragmented landscapes (Chazdon 1998, 2003, Letcher & Chazdon 2009); as sources of sustenance for wildlife (Parry et al. 2007, Herrera-Montes & Brokaw 2010), providing sites for conservation of rare and endemic species (Liebsch et al. 2008) and wood and non-wood products (Chazdon & Coe 1999); in the accumulation of biomass (Gehring et al. 2004, Grace 2004, Feldpausch et al. 2007); for controlling carbon emissions (Feldpausch et al. 2005); and for diminishing pressure on natural habitats (Wright & Muller-Landau 2006).

The structural attributes of tropical forests such as density, biomass, richness, diversity, and composition can slowly recover after significant natural or anthropogenic disturbances (Brown & Lugo 1990, Guariguata & Ostertag 2001, Chazdon 2003, Finegan & Nasi 2004), but an important question in terms of our understanding of successional processes of secondary forests is if their floristic composition also tends to converge towards that of nearby mature forests or if they maintain their differences. According to Chazdon et al. (2009), convergence seems to be related to the level of anthropogenic disturbance, the duration of the time that the area was used, and the regional landscape context. The interrelations of these parameters make the outcomes of succession less predictable, and measurable differences in the floristic compositions of secondary forests may persist even centuries after they have been abandoned and left to recuperate (Finegan 1996, Aide et al. 2000, Denslow & Guzman 2000, Calvo et al. 2002, Ribas et al. 2003).

Previous researchers (refer to a review by Guariguata & Ostertag 2001) have demonstrated that a number of factors influence the recuperation of the floristic composition after disturbances, although many questions still remain unanswered due, in large part, to the idiosyncratic, non-directional, and largely unpredictable processes of succession in tropical forests (Letcher & Chazdon 2009).

The present work analyzed the floristic composition of 12 and 20-year-old secondary forests (known in northeastern Brazil as capoeiras) growing within a landscape dominated by sugarcane plantations and compared them with mature forest fragments of various sizes and showing varying degrees of disturbance, with the intention of addressing two basic questions: 1) Do 12 and 20-year-old secondary forest tend to floristically converge to resemble neighboring mature forests? 2) Is their time of abandonment/recuperation the principal factor determining this conversion process?

Materials and Methods

Weekly collections were made between June/2006 and July/2009 in six secondary forest fragments (capoeiras) belonging to the Usina São José (USJ) sugar refinery in Igarassu, Pernambuco State (PE), Brazil. The fragments were located between the geographical coordinates 07° 41' 04.9" and 07° 54' 41.6" S and 34° 54' 17.6" and 35° 05' 07.2" W, within a total area of approximately 280 km^2 (Figure 1); 88% of that area was occupied by a monoculture of sugarcane (Trindade et al. 2008). The six forest fragments had sizes that varied from 5 to 11 ha, and they were up to 300 m from mature forest fragments, the latter being considered mature in not having suffered any clear-cutting for at least 60 years.

The local climate is of the type As' (Köppen 1936), characterized as hot and humid, with an average annual rainfall rate of 1687 mm, average temperature of 24.9 °C, and a dry season lasting more than three months (Schessl et al. 2008). The predominant geological formation in the area is the Barreiras Formation of the plio-Pleistocene (the most extensive geologic formation in this region of the coast) that comprises nonconsolidated sandy-clay sediments of continental origin (Companhia... 2003). The landscape is dominated by coastal plateaus 40 to 160 m above sea level that are cut by deep and narrow valleys whose sides have inclinations greater than 30% (Companhia... 2003). The regional vegetation is classified as Dense Ombrophilous Lowland Forest (Veloso et al. 1991).

Site selections considered the approximate ages of the secondary forest (capoeira) remnants based on the vegetational characteristics captured in aerial photographic sequences (CONDEPE/FIDEM) covering the decades of 1960, 1970, and 1980 (at a scale of 1: 30,000), as well as satellite images acquired in 2005 and disturbance histories from the 1990s obtained from interviews with long-time residents in the area.

Of the six secondary forest sites examined, three had been undergoing natural regeneration for approximately 12 years (sites 1, 2 and 6) and three had regenerated for 20 years (sites 3, 4 and 5) after suspending sugarcane cultivation during the 1980s. When they were selected in 2006, the six areas had shrub/arboreal canopy physiognomies varying from 6 to 18 m in height.

Botanical material was collected, using traditional techniques (Mori et al. 1989), crisscrossing the fragment in random walks (Filgueiras et al. 1994) and also examining each plant within one hundred and eighty 10 × 10 m plots installed in the six fragments (30 plots in each fragment). In each fragment, the whole fragment was surveyed, including edge and interior areas. Growth habits examined were arboreal (diameter at breast height, DBH $\geq$ 15 cm), shrub/subshrubs and terrestrial herbs (DBH < 15 cm), epiphytic herbs and woody lianas, all with reproductive parts, whether flowers or fruits. Seedlings or saplings of arboreal species were not included.

Soil samples were collected in each plot from the first 20 centimeters below the surface and analyzed in terms of their soil texture (sand, silt, and clay), pH in water, P, K^+, Ca^{2+}, Mg^{2+}, and extractable Al^{3+}, according to protocols described in the Manual of Soil Analysis Methods (Embrapa 1997).

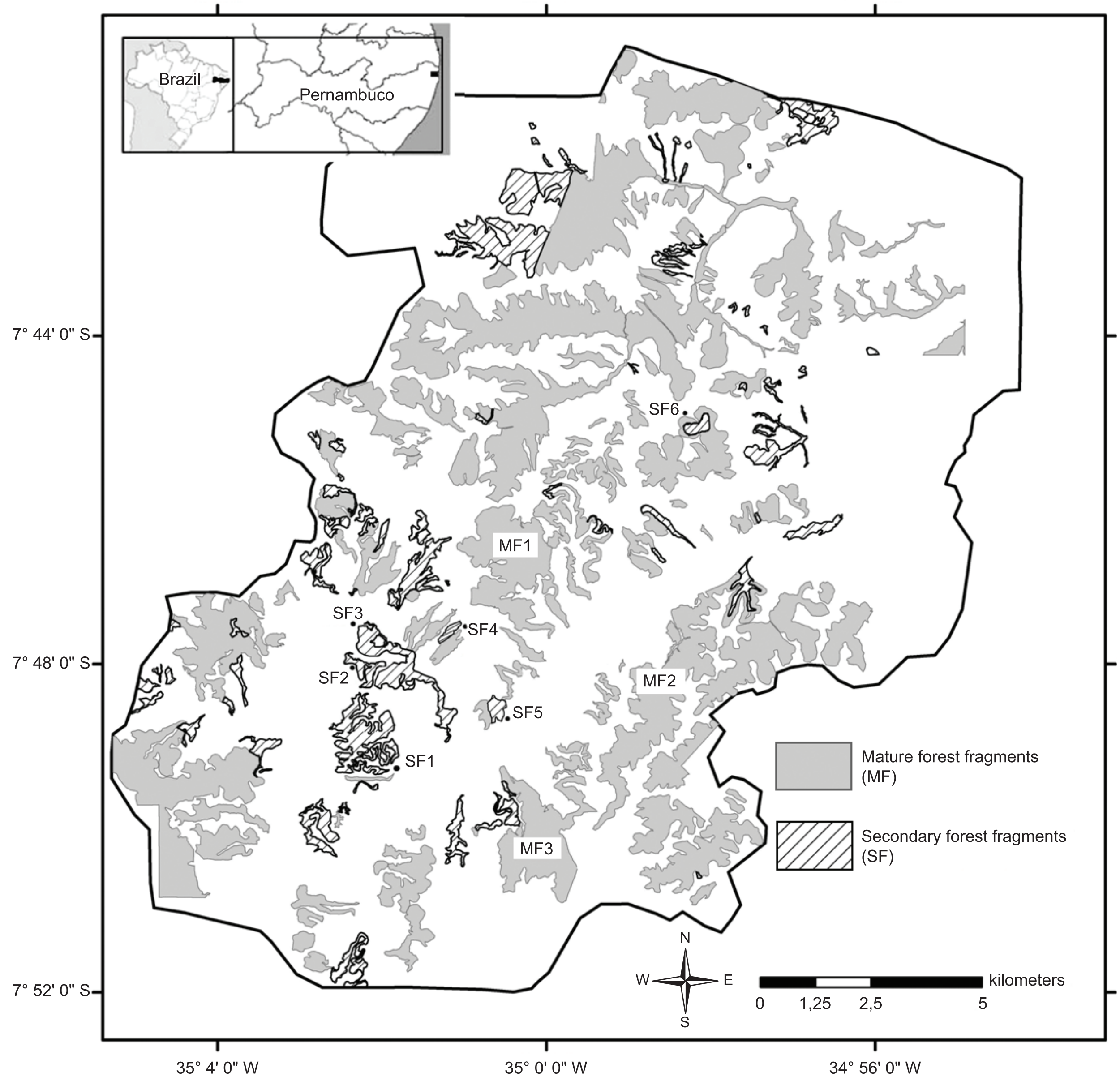

Figure 1. Location of 12-year (SF1, SF2 and SF6) and 20-year secondary forests (SF3, SF4 and SF5) and of mature forests (MF1 = Silva (2004), MF2 = Rocha et al. (2008), MF3 = Silva et al. (2008)) in Usina São José, Igarassu municipality, Pernambuco state, Brazil.

Reference collections were incorporated into the Geraldo Mariz Herbarium (UFP), with duplicates to the Dárdano de Andrade Lima Herbarium (IPA). Species identifications were made by specialists at different Brazilian institutions and by comparisons with collections deposited at the Professor Vasconcelos Sobrinho (PEUFR) and IPA herbaria.

A species list was prepared, listed according to family, with information about plant habits, localities of occurrence, and their herbarium collection numbers. The classification of the angiosperm families followed the recommendations of the APG III (Angiosperm... 2009), and those of the pteridophytes followed Smith & Wolf (2006), with modifications as presented by Smith et al. (2008). The authors' names and scientific names were confirmed using The International Plant Names Index (www.ipni.org) database.

Statistical differences in the soils were tested using one-way ANOVA (Stat Soft 2001). Values were transformed before analysis if they did not exhibit normal distribution or variance homogeneity, following Sokal & Rohlf (1995).

The G test (Sokal & Rohlf 1995) was used to identify changes in the species richness of each plant habit between the 12 and 20-year-old secondary forests.

The floristic compositions of the arboreal component of mature forest fragments in the study area were obtained from the works of Silva (2004), Rocha et al. (2008), and Silva et al. (2008), which included all trees with DBH ≥ 15 cm, similarly to the present study. Four types of analyses were performed to examine the arboreal habit data (NMDS, ANOSIM, SIMPER and DCA-Detrended Correspondence Analysis), utilizing the PAST 2.01 (Hammer et al. 2001) and PC-ORD version 4.0 software program (McCune & Mefford 1999).

The NMDS analysis (Non-metric Multi-dimensional Scaling) was used to analyze the degree of floristic difference between the two secondary forest ages (12 and 20-year-old), and between those and nearby mature forests. To that end, a binary matrix (presence/absence) of the secondary forests (115 species) and the mature forests (171 spp.) was constructed. Infra-specific taxa or those without precise identification to the species level (listed as "sp.", "cf." or "aff."), which occurred in at least two areas, were excluded from analysis, resulting in a matrix of 136 species. In the analysis, the Jaccard (J) index coefficient was applied to generate a graph (Legendre & Legendre 1998).

The non-parametric analyzis ANOSIM (Clarke 1993) was also performed, com 10,000 permutations, aiming at confirming the significance of the groups formed by the NMDS analysis. This method generates a global R-statistic, which is a measure of the distance between groups. An R-value close to 1 indicates strongly dissimilar assemblages, while an R-value close to zero indicates that assemblages are scarcely distinguishable (Clarke 1993). These R-values were used to compare floristic assemblages between secondary vegetation ages. Where ANOSIM revealed significant differences between groups, Similarity percentages (SIMPER) analysis was used to identify those species that contributed most to the observed assemblage distinction (Clarke 1993). Cumulative contributions were cut arbitrarily at 50%. Species with the highest dissimilarity to standard deviation ratios were identified as good discriminators for each comparison (Clarke 1993).

A third analysis (DCA) was applied to determine correlations between the species distributions and environmental variables. Data concerning the presence/absence (0-1) of the arboreal species (115 spp.) and the set of other habits (shrubs, herbs, and woody lianas = 91 spp.) were used to form two primary matrices. A categorical variable matrix was created based of the average values of the chemical (pH, P, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}) and physical (percentages of sand, clay, and silt) analyses of the soils and with the time of vegetation recuperation (12 and 20 years). The Pearson and Kendall correlation was applied to evaluate the representativeness of the variables on the axes; r values ≥ 0.70 were considered high (Cohen 1988, Dancey & Reidy 2006).

Results

Sixty-six families, 120 genera, and 206 species were recorded in the six secondary forests at the USJ. Fifty families and 136 species were identified in the 12-year-old areas, and 57 families and 161 species were encountered in the 20-year-old areas (Table 1), which represented an approximately 15% increase in the number of species. Of the 206 species encountered, 115 were trees (56%), 48 shrubs (23%), 16 herbs (8%), 24 woody lianas (12%), and three were epiphytes (1.5%) (Table 2). In spite of the fact that there was a 20% increase in the number of arboreal species in the 20-year-old

Table 1. Species recorded in six secondary forests (three 12-year and three 20-year old regeneration forests) and mature forests (Silva 2004, Rocha et al. 2008, Silva et al. 2008) in Usina São José, Igarassu municipality.

Species	Growth form	12 years	20 years	Mature
Alliaceae				
Hippeastrum stylosum Herb.	herb		x	
Anacardiaceae				
Mangifera indica L.	tree		x	x
Tapirira guianensis Aubl.	tree	x	x	x
Thyrsodium spruceanum Benth.	tree	x	x	x
Annonaceae				
Anaxagorea dolichocarpa Sprague & Sandwith	tree	x	x	x
Annona montana Macfad.	tree	x		
Guatteria pogonopus Mart.	tree		x	x
Guatteria schomburgkiana Mart.	tree	x	x	x
Guatteria sp.	tree		x	
Xylopia frutescens Aubl.	tree	x	x	x
Apocynaceae				
Allamanda cathartica L.	woody liana	x	x	
Allamanda sp.	woody liana	x		
Aspidospema discolor A.DC.	tree			x
Himathanthus phagedaenicus (Mart.) Woodson	tree	x	x	x
Rauvolfia grandiflora Mart. ex A.DC.	shrub	x	x	x
Rauvolfia ligustrina Willd. ex Roem. & Schult.	shrub	x		
Tabernaemontana salzmannii A.DC.	tree			x
Araliaceae				
Schefflera morototoni (Aubl.) Maguire, Steyerm. & Frodim	tree	x	x	x
Arecaceae				
Acrocomia sclerocarpa Mart.	palm tree	x	x	
Bactris ferruginea Burret	palm tree			x
Desmoncus polyacanthos Mart.	woody liana	x		
Elaeis guineensis A.Chev.	palm tree	x	x	
Aspleniaceae				
Asplenium sp.	herb	x		

Table 1. Continued...

Species	Growth form	12 years	20 years	Mature
Asteraceae				
Chromlaena sp.	shrub	x		
Conocliniopsis prassifolia (DC.) R.M.King & H.Rob.	shrub	x		
Conyza sumatrensis (Retz.) E. Walker	shrub	x		
Tilesia baccata (L.) Pruski	shrub		x	
Verbesina macrantha A.Rich.	shrub	x		
Vernonia brasiliana (L.) Druce	shrub		x	
Bignoniaceae				
Adenocalymma sp.	woody liana	x		
Lundia cordata (Vell.) DC.	woody liana		x	
Boraginaceae				
Cordia multispicata Cham.	shrub		x	
Cordia nodosa Lam.	shrub	x	x	
Cordia polycephala (Lam.) I.M. Johnst.	tree	x		
Cordia sellowiana Cham.	tree	x	x	
Cordia superba Cham.	tree		x	x
Tournefortia candidula (Miers) I.M. Johnst.	shrub	x		
Boraginaceae 1	shrub		x	
Burseraceae				
Protium arachouchini (Aubl.) Marchand	tree			x
Protium giganteum Engl.	tree		x	x
Protium heptaphyllum L. Marchand	tree	x	x	x
Tetragastris catuaba Soares da Cunha	tree			x
Canabaceae				
Trema micrantha (L.) Blume	tree	x	x	x
Celastraceae				
Maytenus distichophylla Mart. ex Reissek	tree	x	x	x
Maytenus obtusifolia Mart.	tree		x	
Chrysobalanaceae				
Hirtella racemosa Ruiz & Pav.	shrub	x	x	
Clusiaceae				
Clusia nemorosa G.Mey.	tree			x
Symphonia globulifera L.f.	tree	x		
Vismia guianensis (Aubl.) Pers.	tree	x	x	x
Coclospermaceae				
Cochlospermum vitifolium Spreng.	tree		x	
Convolvulaceae				
Ipomoea alba L.	woody liana	x	x	
Cyperaceae				
Cyperus rotundus L.	herb	x	x	
Dilleniaceae				
Davilla aspera (Aubl.) Benoist	woody liana	x		
Doliocarpus dentatus (Aubl.) Standl.	woody liana		x	
Tetracera breyniana Schltdl.	woody liana	x	x	
Dryopteridaceae				
Cystopteris sp.	herb		x	
Erythroxylaceae				
Erythroxylum citrifolium A. St.-Hil.	shrub		x	x
Erythroxylum mucronatum Sw.	shrub	x		x
Euphorbiaceae				
Croton floribundus Spreng.	tree		x	
Pera ferruginea (schott) Mull. Arg.	tree	x	x	x
Pogonophora schomburgkiana Miers ex Benth.	tree	x	x	x
Sapium glandulosum (L.) Morong	tree	x		

Table 1. Continued...

Species	Growth form	12 years	20 years	Mature
Fabaceae-Caesalpinoideae				
Chamaecrista ensiformis (Vell.) H.S.Irwin & Barneby	tree			x
Apuleia leiocarpa (Vogel) J.F. Macbr.	tree	x		
Dialium guianense (Aubl.) Sandwith	tree	x		x
Sclerolobium densiflorum	tree			x
Senna georgica H.S. Irwin & Barneby	shrub	x	x	
Senna quinquangulata (L.C.Rich.) H.S.Irwin & Barneby	woody liana	x	x	
Swartzia pickelii Killip ex Ducke	tree	x	x	x
Fabaceae-Caesalpinoideae 1	tree	x		
Fabaceae-Mimosoideae				
Albizia polycephala (Benth.) Killip.	tree	x	x	
Albizia saman (Jacq.) F. Muell.	tree	x	x	
Inga blanchetiana Benth.	tree			x
Inga capitata Desv.	tree			x
Inga cayennensis Sagot ex Benth.	tree	x	x	
Inga flagelliformis (Vell.) Mart.	tree	x	x	x
Inga ingoides (Rich.) Willd.	tree	x	x	
Inga laurina (Sw.) Willd.	tree		x	
Inga thibaudiana DC.	tree	x	x	x
Inga striata Benth.	tree			x
Parkia pendula (Willd.) Benth. ex Walp.	tree			x
Plathymenia foliolosa Benth.	tree			x
Plathymenia reticulata Benth.	tree		x	x
Fabaceae-Mimosoideae 1	woody liana	x	x	
Fabaceae-Mimosoideae 2	tree		x	
Fabaceae-Papilionoideae				
Andira fraxinifolia Benth.	tree	x	x	x
Andira nitida Mart. ex Benth.	tree	x		x
Bauhinia microstachya (Raddi) J.F. Macbr.	shrub		x	
Bowdichia virgilioides Kunth	tree	x	x	x
Desmodium axillare (Sw.) DC.	herb		x	
Dioclea virgata (L.C.Rich.) Amshoff	woody liana		x	
Dioclea sp.	woody liana	x		
Diplotropis purpurea (Rich.) Amshoff.	tree			x
Indigofera suffruticosa Mill.	shrub		x	
Machaerium hirtum (Vell.) Stellfeld	tree	x	x	
Machaerium salzmannii Benth.	tree	x	x	
Phanera outimouta (Aubl.) L.P. Queiroz	woody liana		x	
Pterocarpus rohrii Vahl	tree		x	
Stylosanthes guianensis (Aubl.) Sw.	shrub		x	
Fabaceae-Papilionoideae 1	shrub	x		
Fabaceae-Papilionoideae 2	tree	x		
Fabaceae-Papilionoideae 3	tree		x	
Fabaceae-Papilionoideae 4	shrub		x	
Heliconiaceae				
Heliconia sp.	herb	x	x	
Hernandiaceae				
Sparattanthelium botocudorum Mart.	shrub	x	x	x
Lauraceae				
Ocotea gardneri Mez	tree		x	
Ocotea glomerata (Nees) Mez	tree	x	x	x
Ocotea limae Vattimo	tree		x	x
Lecythidaceae				
Lecythis pisonis	tree			x

Table 1. Continued...

Species	Growth form	12 years	20 years	Mature
Eschweilera ovata (Cambess.) Miers.	tree	x	x	x
Gustavia augusta L.	tree	x	x	x
Loganiaceae				
Strychnos bahiensis Krukoff & Barneby	shrub	x	x	
Loranthaceae				
Struthanthus sp. 1	shrub		x	
Struthanthus sp. 2	shrub		x	
Malpighiaceae				
Byrsonima sericea DC.	tree	x	x	x
Malpighiaceae 1	woody liana		x	
Malvaceae				
Apeiba tibourbou Aubl.	tree	x	x	x
Eriotheca crenulaticalyx A.Robyns	tree			x
Guazuma ulmifolia Pers.	tree	x	x	x
Luehea paniculata Mart.	tree		x	x
Luehea ochrophylla	tree			x
Triumfetta semitriloba Jacq.	shrub	x	x	
Melastomataceae				
Clidemia capitellata (Bonpl.) D.Don.	shrub	x	x	
Clidemia hirta Cong.	shrub	x		
Henriettea succosa (Aubl.) DC.	tree	x		x
Miconia albicans (Benth.) Triana	shrub	x	x	x
Miconia ciliata (Rich.) DC.	shrub	x	x	x
Miconia minultiflora (Bonpl.) DC.	tree	x	x	x
Miconia prasina (Sw.) DC.	tree	x	x	x
Meliaceae				
Trichilia lepidota Mart.	tree		x	x
Monimiaceae				
Siparuna guianensis Aubl.	tree	x	x	
Moraceae				
Artocarpus heterophyllus Lam	tree	x	x	x
Brosimum guianense (Aubl.) Huber	tree	x	x	x
Brosimum rubescens Taub.	tree			x
Sorocea hilarii Gaudich.	tree		x	x
Myrsinaceae				
Rapanea guianensis Aubl.	tree		x	x
Myrtaceae				
Calyptranthes brasiliensis (Aubl.) DC.	tree		x	x
Campomanesia dichotoma (O. Berg.) Mattos	tree	x	x	
Eugenia candolleana (O. Berg) Kiaersk.	tree	x	x	
Eugenia florida DC.	tree		x	
Eugenia punicifolia (Kunth) DC.	tree		x	
Eugenia sp.	tree	x	x	
Myrcia bergiana O. Berg.	tree		x	
Myrcia guianensis (Aubl.) DC.	tree		x	x
Myrcia racemosa Barb. Rodr.	tree	x	x	x
Myrcia splendens (Sw.) DC.	tree			x
Myrcia sylvatica (G. Mey.) DC.	tree	x	x	x
Myrcia tomentosa (Aubl.) DC.	tree	x	x	
Psidium araca Raddi	tree	x		
Psidium guineense Sw.	tree	x	x	
Psidium guajava L.	tree		x	
Nyctaginaceae				
Guapira laxa (Netto) Furlan	tree	x	x	x
Guapira nitida (Schmidt) Lundell	tree	x	x	

Table 1. Continued...

Species	Growth form	12 years	20 years	Mature
Guapira opposita (Vell.) Reitz	tree		x	x
Neea sp.	tree		x	
Ochnaceae				
Ouratea hexasperma (A.St.-Hil.) Baill.	tree			x
Ouratea polygyna Engl.	tree	x		
Olacaceae				
Schoepfia brasiliensis A. DC	shrub	x		
Orchidaceae				
Orchidaceae 1	herb		x	
Orchidaceae 2	herb		x	
Passifloraceae				
Passiflora alata Curtis	woody liana		x	
Peraceae				
Chaetocarpus myrsinites Baill.	tree			x
Piperaceae				
Piper arboreum Aubl.	shrub	x	x	
Piper colubrinum (Link ex Kunth) Link ex C. DC.	shrub		x	
Piper marginatum Jacq.	shrub	x	x	
Phyllanthaceae				
Margaritaria nobilis L.f.	tree			x
Poaceae				
Lasiacis sorghoidea (Ham.) Hitchc. & Chase	herb		x	
Urochloa fusca (Sw.) B.F. Hansen & Wunderlin	herb	x	x	
Poaceae 1	herb		x	
Poaceae 2	herb	x		
Poaceae 3	herb	x		
Poaceae 4	herb	x		
Poaceae 5	herb		x	
Polygalaceae				
Bredemeyera sp.	woody liana	x		
Polygonaceae				
Coccoloba laevis Casar.	tree		x	
Coccoloba mollis Casar.	tree	x	x	x
Pteridaceae				
Pellaea sp.	herb		x	
Rhamnaceae				
Colubrina glandulosa Perkins	tree		x	
Rubiaceae				
Alseis floribunda Schott	tree	x	x	x
Alseis pickelii Pilg. & Schmale.	tree			x
Genipa americana L.	tree	x		
Palicourea crocea (Sw.) Roem. & Schult.	shrub	x	x	
Posoqueria sp.	tree		x	
Psychotria barbiflora DC.	shrub	x	x	
Psychotria bracteocardia (DC.) Mull. Arg.	shrub	x		
Psychotria capitata Ruiz & Pav.	shrub	x	x	
Psychotria carthagenensis Jacq.	tree			x
Psychotria hoffmannseggiana (Willd. ex Roem. & Schult.)	shrub	x	x	
Sabicea grisea Cham. & Schltdl.	woody liana		x	
Rubiaceae 1	shrub	x		
Rubiaceae 2	shrub		x	
Rubiaceae 3	shrub	x		
Rubiaceae 4	shrub		x	
Rutaceae				
Hortia arborea Engl.	tree			x

Table 1. Continued...

Species	Growth form	12 years	20 years	Mature
Zanthoxylum rhoifolium Lam.	tree		x	x
Salicaceae				
Banara brasiliensis (Schott) Benth.	tree	x	x	
Banara guianensis Aubl.	tree		x	
Casearia arborea (Rich.) Urb.	tree			x
Casearia hirsuta Sw.	tree	x	x	
Casearia javitensis Kunth	tree	x	x	x
Casearia sylvestris Sw.	tree	x	x	x
Sapindaceae				
Allophylus edulis (A.St.-Hil., Cambess. & A.Juss.) Radlk.	tree	x	x	x
Cupania oblongifolia Mart.	tree	x	x	
Cupania paniculata Cambess.	tree	x	x	
Cupania racemosa (Vell.) Radlk.	tree	x	x	x
Cupania revoluta Radlk.	tree	x	x	x
Paullinia pallida L.	woody liana	x		
Paullinia pinnata L.	woody liana	x	x	
Paullinia trigona Vell.	woody liana	x	x	
Serjania salzmanniana Seem.	woody liana		x	
Talisia elephantipes Sandwith	tree			x
Talisia esculenta (A. St.-Hil) Radlk.	tree	x		
Sapindaceae 1	woody liana	x	x	
Sapotaceae				
Diploon cuspidatum (Hoehne) Cronquist	tree			x
Pouteria bangii (Rusby) T.D.Penn.	tree			x
Pouteria gardneri (Mart. & Miq.) Baehni	tree	x	x	x
Pouteria grandiflora (A.DC.) Baehni	tree			x
Pouteria peduncularis (Mart. & Eichler ex Miq.) Baehni	tree			x
Pouteria reticulata (Engl.) Eyma	tree		x	
Pradosia lactescens (Vell.) Radlk.	tree			x
Sapotaceae 1	tree	x	x	
Sapotaceae 2	tree		x	
Scrophulariaceae				
Scrophulariaceae 1	shrub	x		
Simaroubaceae				
Simarouba amara Aubl.	tree	x	x	x
Smilaccaceae				
Smilax sp.	woody liana	x		
Solanaceae				
Solanum asperum Rich.	shrub	x	x	
Solanum paludosum Moric.	shrub	x		
Solanum sp.	shrub		x	
Solanaceae 1	shrub	x		
Trigoniaceae				
Trigonia nivea Cambess.	woody liana		x	
Urticaceae				
Cecropia pachystachya Trécul	tree	x	x	x
Verbenaceae				
Aegiphila pernambucensis Moldenke	shrub	x	x	
Aegiphila vitelliniflora Walpers.	shrub	x	x	
Lantana camara L.	shrub		x	
Violaceae				
Amphirrhox longifolia (A.St.-Hil.) Spreng.	tree	x	x	
Paypayrola blanchetiana Tul.	tree	x		x
Family undetermined				
Undetermined	tree		x	

secondary forest, there were no significant overall differences in terms of the habits of the plants in the two regeneration ages (G test, p = 0.55, Table 2).

The NMDS analysis, applied for all arboreal species of secondary forests (12 and 20 years) and mature forests, revealed the formation of three groups, with stress of 0.093 (Figure 2). The first group was composed by the 12-year secondary forests (SF 1, 2 and 3), the second by the 20-year secondary forests (SF 4, 5 and 6), and the third, by mature forests (Silva 2004, Rocha et al. 2008, Silva et al. 2008).

When the ANOSIM was performed, the three groups previously formed by NMDS were found to be significant (R = 0.983, p = 0.0036), with dissimilarity (SIMPER) of 63%. The two groups composed by secondary forests (SF 1-2-3 and SF4-5-6) differed in floristic composition, with dissimilarity of 57%. Floristic differences were larger when 12-year secondary forest group was compared to mature forests (MF 1-2-3), with R = 1 and dissimilarity of 78% (Table 3). The high dissimilarity on floristic composition between mature and secondary forests was shaped by the presence of tree species exclusive to mature forests, such as: *Aspidosperma discolor*, *Chamaecrista ensiformis*, *Parkia pendula*, *Inga blanchetiana*, *I. capitata*, *Pouteria bangii*, *P. peduncularis*.

The physical and chemical parameters of soil varied significantly between the secondary forest ($p < 0.05$), regardless of age. The secondary forests differed significantly ($p < 0.05$) in their soil physical and chemical parameters and the differences were not related to the forest age. SF1, SF2, and SF3 (20-years) had similar values differing from SF6 (12-years), SF4, and SF5 (Table 4).

This separation of the secondary forests independent of their times of recuperation as observed in the grouping analysis (sub-groups A and B) was confirmed by the DCA analysis, indicating on axis I (eigenvalue = 0.43) that the concentrations of K^+ (r = 0.92), Ca^{2+} (r = 0.64), Mg^{2+} (r = 0.83), and the percentages of clay (r = 0.89) and silt (r = 0.96) were responsible for the formation of the secondary forest groups 1-2-3, while pH (r = –0.74) and sand (r = –0.93) were responsible for the formation of the secondary forest groups 4-5-6 (Table 4; Figure 3a).

The DCA analysis for the other plant habits indicated the formation of two groups with distinct ages (Figure 3b). On axis 1 (eigenvalues = 0.82) there was a correlation of the first group (SF 1-3) with variables K^+ (r = 0.57), clay (r = 0.68), and silt (r = 0.69) and of the second group (SF 2-4-5-6) with pH (r = –0.97) and sand (r = –0.69), Table 4.

Discussion

The difference in the numbers of families between the two regenerating forest ages may seem small, although the presence of families typical of mature forests (such as Aspleniaceae, Dryopteridaceae, Orchidaceae, and Pteridaceae) in the oldest sites and the increases in the numbers of species of Fabaceae, Myrtaceae, Annonaceae, and Sapotaceae indicated that there was a significant floristic enrichment over the years – even though this was not as notable when considering the plant habits.

The occurrence of a large number of species (206) in secondary forests with different times since abandonment within the same landscape, experiencing the same climate, geology and history, could be attributed to spatial heterogeneity, which allows that a high number of plant species persists due to the high resource supply (Tilman & Pacala 1993). According to Connell (1978), different successional stages can be seen as moderately disturbed scenarios, in which disturbance occurs with moderate frequency, duration and intensity, enabling that pioneer and secondary species cohabit the same area, resulting in larger species richness, when compared to less disturbed sites (Castillo-Campos et al. 2008).

The low level of floristic similarity between the secondary and mature forests indicates that they are in distinct successional stages and corroborates with the hypothesis that the recuperation of the floristic composition of secondary forests occurs only slowly (Chazdon 2003, Chazdon et al. 2009, Piotto et al. 2009, Powers et al. 2009). However, the sharing of 68 arboreal species between the secondary and mature forests suggests that the flora of the secondary forests at the USJ tends to convergence to that of the mature forests – as has been observed

Table 2. Number of families and species of different growth habits in six secondary forests (three 12-year and three 20-year old regeneration forests) in Usina São José, Igarassu municipality, Pernambuco state, Brazil (G test, 2.09, p = 0.55, non-significant).

Habit	12 years		20 years	
	Families	Species	Families	Species
Tree	31	78 (57,4%)	34	98 (60,8%)
Shrub	16	35 (25,7%)	15	35 (20,5%)
Herb	4	7 (5,1%)	9	13 (8,1%)
Woody liana	9	16 (11,8%)	10	17 (10,5%)
Total	50	136	57	161

Table 3. Values of R obtained in the similarity analysis (ANOSIM, upper diagonal) and percentages of dissimilarity (SIMPER, lower diagonal) between areas, using binary data of the arboreal component of of 12-year (SF1, SF2 and SF6) and 20-year secondary forests (SF3, SF4 and SF5) and mature forests (MF1= Silva (2004), MF2 = Rocha et al. (2008), MF3 = Silva et al. (2008)) in Usina São José, Igarassu, Pernambuco, Brazil.

Group	SF 1-2-3	SF 4-5-6	MF 1-2-3
SF 1-2-3	0	0.963	1
SF 4-5-6	57%	0	1
MF 1-2-3	78%	53%	0

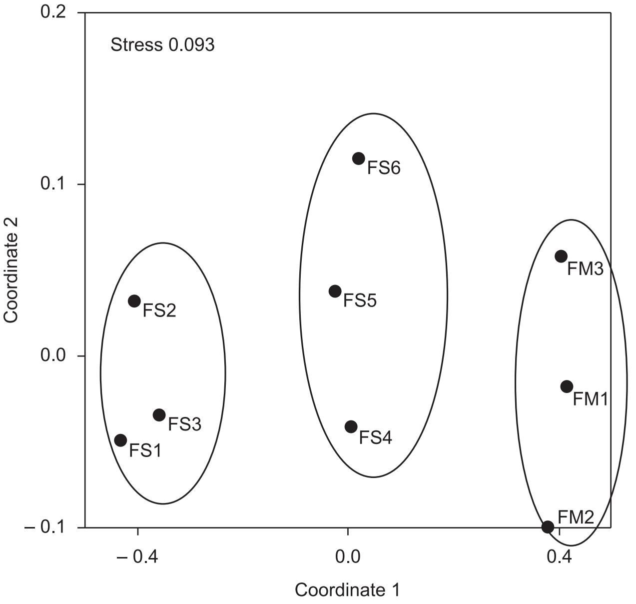

Figure 2. NMDS analysis, using the index of Jaccard, of 12-year (SF1, SF2 and SF6) and 20-year secondary forests (SF3, SF4 and SF5) and mature forests (MF1= Silva (2004), MF2 = Rocha et al. (2008), MF3 = Silva et al. (2008)) in Usina São José, Igarassu municipality, Pernambuco state, Brazil.

Table 4. Means and standard deviations of soil chemical and physical variables of 12- and 20-year secondary forests in Usina São José, Igarassu municipality, Pernambuco state, Brazil and their Pearson and Kendall correlation coefficients with the first two axes of detrended correspondence analysis (DCA) for trees and shrubs, herbs and woody lianas. Different letters in rows, in each forest age, indicate significantly different means (ANOVA, $p < 0.05$).

Soil variables	12 years			20 years			Trees		Schrubs, herbs and woody lianas	
	SF1	SF2	SF6	SF3	SF4	SF5	Eigenvalue 1	Eigenvalue 2	Eigenvalue 1	Eigenvalue 2
pH	4.86 ± 0.35^a	4.97 ± 0.27^a	5.08 ± 0.19^b	4.64 ± 0.16^a	5.14 ± 0.25^b	5.01 ± 0.52^b	–0.74	0.24	–0.94	–0.50
P (mg.dm^{-3})	5.07 ± 1.59^a	4.07 ± 1.43^b	2.80 ± 1.35^b	3.63 ± 1.32^b	3.23 ± 1.04^b	4.37 ± 1.85^a	0.80	0.22	0.59	–0.41
K$^+$(mg.dm^{-3})	0.27 ± 0.11^a	0.20 ± 0.07^a	0.08 ± 0.06^b	0.14 ± 0.05^c	0.07 ± 0.05^b	0.09 ± 0.08^b	0.92	0.32	0.65	–0.27
Al^{3+}(cmolc.dm^{-3})	0.41 ± 0.31^a	0.32 ± 0.25^a	0.46 ± 0.29^b	0.66 ± 0.26^c	0.42 ± 0.23^b	0.25 ± 0.24^a	0.10	–0.61	0.46	0.59
Ca^{2+}(cmolc.dm^{-3})	1.79 ± 0.89^a	1.69 ± 0.66^a	0.95 ± 0.63^b	0.77 ± 0.36^b	0.96 ± 0.54^b	1.14 ± 1.01^c	0.65	0.63	0.21	–0.54
Mg^{2+}(cmolc.dm^{-3})	1.62 ± 0.54^a	1.65 ± 0.45^a	0.83 ± 0.29^b	1.06 ± 0.29^b	0.74 ± 0.18^b	1.31 ± 1.31^c	0.83	0.63	0.50	–0.25
% Sand (g.cm^{-1})	53.95 ± 7.96^a	55.81 ± 6.00^a	76.32 ± 6.52^b	63.34 ± 6.21^c	79.49 ± 5.23^b	75.94 ± 5.69^b	–0.93	–0.41	–0.73	–0.02
% Clay (g.cm^{-1})	32.61 ± 8.30^a	32.38 ± 5.89^a	18.78 ± 6.01^b	27.48 ± 5.16^c	15.77 ± 4.97^b	16.17 ± 4.60^b	0.89	0.40	0.71	0.09
% Silt (g.cm^{-1})	13.44 ± 4.70^a	11.81 ± 2.43^a	4.90 ± 2.93^b	9.18 ± 2.78^c	4.75 ± 1.65^b	7.89 ± 1.89^b	0.96	0.40	0.74	–0.13

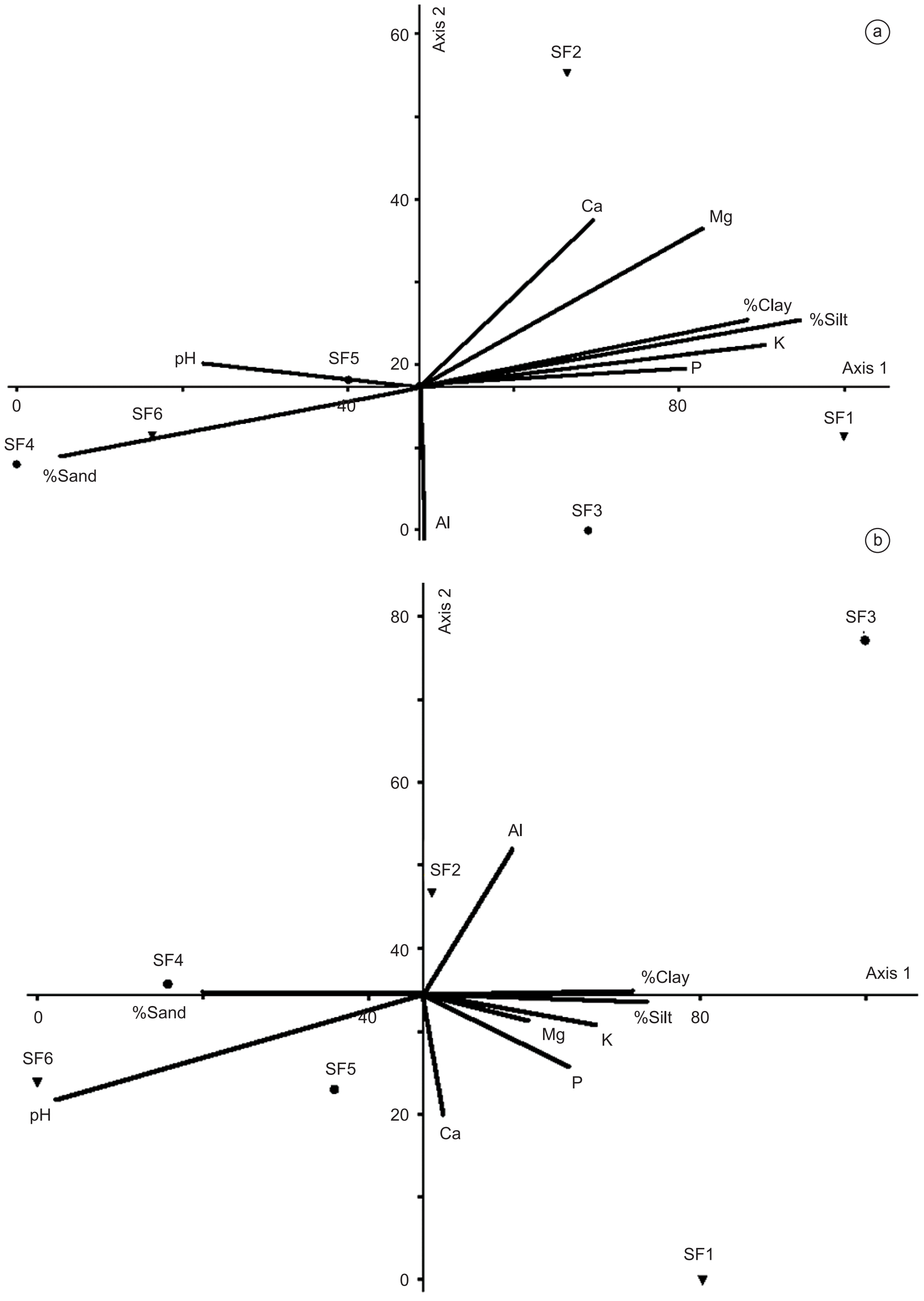

Figure 3. Ordination diagrams (DCA) of trees (a, eigenvalue = 0.43, 0.12) and shrubs, herbs and woody lianas (b, eigenvalue = 0.82, 0.24) of 12-year (SF1, SF2 and SF6) and 20-year secondary forests (SF3, SF4 and SF5) in Usina São José, Igarassu municipality, Pernambuco state, Brazil.

in other tropical forests (Guariguata et al. 1997, Peña-Claros 2003, Capers et al. 2005, Carim et al. 2007, Chazdon et al. 2007, 2009, Liebsch et al. 2007, Castillo-Campos et al. 2008, Norden et al. 2009, Lebrija-Trejos et al. 2010).

The formation of secondary forest groups composed of distinct regeneration ages, as observed in the grouping analysis and ordinations of the arboreal habit, can be justified by the similarities of the soil characteristics within the groups (which is often a consequence of the close proximity of these areas). In terms of the other plant habits, there is also a high correlation within the groups that were formed, principally due to the similarities of soil textures (with the exception of SF 2).

All of these results indicate that not just recuperation times, but many other environmental variables influence the velocity and direction of the formation of floristic composition during secondary succession. Our results corroborate those reported for secondary forests in Costa Rica (Chazdon et al. 2009), Mexico (Powers et al. 2009), and the Brazilian Amazon (Prata et al. 2010) – which also did not encounter any significant correlation between the forest ages and their floristic compositions – with each locality following a distinct and idiosyncratic path of species accumulation driven by edaphic factors (Guariguata & Ostertag 2001), colonizing species (Chazdon 2003, Junqueira et al. 2010), and the landscape matrix (Bierregaard et al. 1992, Nascimento & Laurance 2006). Together these results indicate that the preservation of conserved forest fragments near areas undergoing regeneration permits genetic flux and the continuity of successional processes.

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Folk taxonomy of fishes of artisanal fishermen of Ilhabela (São Paulo/Brazil)

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Abstract: This article investigates the folk taxonomy of four artisanal fisheries communities in Ilhabela/SP. The local folk taxonomy shows how these fishermen identify, name and classify fish resources in the environment exploited by them. Forty-two fishermen from four different local communities of Ilhabela were interviewed through a structured questionnaire and photographs of fish species with occurrence for the southeast region of Brazil. Respondents identified the 24 species listed as 50 generic names and 27 binominal specific names, mainly related to aspects of fish species morphology such as color, shape and size. These fish were classified into eight groups according to local criteria related to the morphology, ecology and fishing forms associated with the capture of species. The morphological aspect was identified as the most used feature by respondents to name and classify local fish, followed by ecological aspects such as behavior, diet and habitat. The comparison of local criteria used for the groups was similar to the scientific taxonomy criteria, showing a detailed local ecological knowledge by this group of fishers.
Keywords: *ichthyofauna, biodiversity, biological classification, human ecology, ethnoecology, fisheries resources.*

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Resumo: Este artigo investiga a etnotaxonomia de quatro comunidades de pescadores artesanais de Ilhabela/SP. A etnotaxonomia mostra como esses pescadores, identificam, nomeam e classificam os recursos pesqueiros no ambiente explorado por eles. Quarenta e dois pescadores de quatro diferentes comunidades locais de Ilhabela foram entrevistados através de um questionário estruturado e fotografias de espécies de peixes de ocorrência para a região sudeste do Brasil. Os entrevistados identificaram as 24 espécies listadas através de 50 nomes genéricos e 27 nomes específicos binomiais, principalmente relacionados com aspectos morfológicos como forma, cor e tamanho. Estes peixes foram classificados em oito grupos de acordo com critérios locais relacionados com a morfologia, ecologia e técnicas de pesca associados à captura de tais espécies. O aspecto morfológico foi identificado como o fator mais utilizado pelos entrevistados para nomear e classificar as espécies de peixes, seguidos por critérios relacionados à ecologia das espécies tais como, dieta, comportamento e habitat. A comparação dos critérios locais utilizados para os grupos foi semelhante aos critérios científicos de taxonomia, mostrando um detalhado conhecimento ecológico local deste grupo de pescadores.
Palavras-chave: *ictiofauna, biodiversidade, classificação biológica, ecologia humana, etnoecologia, recursos pesqueiros.*

Introduction

Artisanal fishing is an important economic activity in rural or native communities which often include broad systems of knowledge about the fish existing in the environments exploited. Berlin (1992), based on studies of ethnobiology, emphasizes that local communities dominate the three steps of systematic detail when folk ecological knowledge about identification, naming and classification of local species. When investigated these steps show the classification system popular in the studied community that may be similar in different environments, reflecting the universal principles of classification of nature in different cultures (Marques 1991, Berlin 1992).

The interactions of human populations with nature can be investigated through the study of fishing practices and use of marine resources from the perspective of ethnoicthiology that, according to Marques (1991), is the branch of ethnobiology that specifically addresses the interactions between humans and fish. In this interaction, human populations establish their criteria for identification and naming of natural resources they use, forming their own rating systems of nature, which can be investigated through studies of folk biology. Local knowledge of human populations on nature has various denominations in the literature such as: "*indigenous knowledge*", "*local ecological knowledge*-LEK", "*traditional ecological knowledge*-TEK" or "*folk knowledge*" (Posey 1986, Berlin 1992, Berkes & Folke 1998, Berkes 1999, Begossi 2004, Drew 2005).

It is considered appropriate in this article using the terminology "local ecological knowledge" to deal with the knowledge of local fishermen about the nature and the folk taxonomic term to speak of local knowledge expressed by fishermen on the nomenclature and classification of fish.

The local ecological knowledge is itself a cultural context in a given environment. Learning this kind of knowledge takes place, overall, by direct observation of natural phenomena and experience from the activity of natural resources exploitation. According to Diegues (1995), local knowledge about nature is a set of knowledge and know-how. From this perspective, studying human populations' knowledge about the natural world is to understand the relationship between knowledge and action of local populations ahead the natural resources exploited and managed by them.

Studies comparing the classical and folk taxonomies, describing the criteria used by both for classifying organisms, have being developed especially in recent decades and reveal principles of organization and classification of nature in different cultures (Berlin 1992, Faulkner & Silvano 2003). Among these studies, we can mention Marques (1991, 2001) in estuarine-lagoon complex Mundaú-Manguaba (Alagoas); Begossi & Garavello (1990) in the Tocantins River (Amazon); Begossi & Figueiredo (1995) in Búzios Island (SP) and Sepetiba Bay (RJ); Paz & Begossi (1996) in the Bay of Sepetiba (RJ), Costa Neto & Marques (2000) with fishermen of Siribinha (BA); Seixas & Begossi (2001) on the Ilha Grande, Coastal southeastern Brazil; Mourão & Nordi (2002a, b) in the estuary Mamanguape (PB); Clauzet et al. (2007) in Guaibim (BA) and Begossi et al. (2008) on the Atlantic coast of Brazil and Amazon.

The local ecological knowledge comprises many ecological, behavioral and classification of fish species that implies in how fishermen manage fisheries resources. Overall, the knowledge acquired by fishing communities is deep and rich in details, often consistent with scientific observations. The plurality of knowledge permeating the practices of fish populations can contribute to the construction of scientific knowledge and strategies for conservation of natural resources based on new local information for biological research. Silvano & Valbo-Jorgensen (2008) propose hypothesis testing of local ecological knowledge in order to be added to scientific knowledge, when local knowledge is compatible ("high-probability hypothesis") to the existing scientific research, or even when indicates new directions for the same.

The comparison between the two forms of knowledge and the importance of the sum of local ecological knowledge to scientific knowledge for the conservation of social and ecological resources of environment are highlighted in the works of Acheson (1988), Johannes (2002) and Ruddle & Hickey (2008), among others.

Other approaches relate the local ecological knowledge and use of natural resources to management ways and conservation. Lopes et al. (2011a, b), for example, show how is possible using ecological models as tool to understand the use of natural resources and behavior of human populations and, in an even broader context, the article of Begossi et al. (2011) is the interface between human ecology and economic ecology, discussing economic and technical alternatives to co-management for artisanal fishermen in areas of environmental protection and industrial fisheries, considering the success of initiatives of payment for environmental services (PES) in forest areas and fisheries agreements (FAs) in the Brazilian Amazon.

This study aimed at conducting a study on the local folk taxonomy focused on the identification and classification of fish by fishermen who know and use marine resources in their traditional fishing practices in the region of Ilhabela/SP.

Materials and Methods

Ilhabela is a archipelagic municipality of 12 small islands, two slabs and the inhabited islands of São Sebastião, Búzios and Vitoria. It is located on the northern coast of São Paulo, 220 km from the capital (São Paulo). According to the IBGE Census (Instituto... 2011), the population of Ilhabela municipality is 28,196 inhabitants. The city has some special features about geography and biological richness, source of livelihood for those who live from its fauna and flora and for those who exploit the tourism (Merlo 2000, Maldonado 2004).

The São Sebastião Island is the largest island in the municipality, 348 km² and has its face towards the São Sebastião channel, an urbanized area with characteristics common to a small town: small industries, commerce, services and concentration a greater number of inhabitants. It is also the area where tourism is developed, with large numbers of vacation residences, hotels, hostels, campsites, etc. (Maldonado 1997, Calvente 1997). It is covered for the most part by the hillside rainforest, the Atlantic Forest, with plenty of small watersheds in steep relief, with more than 400 streams rapids, features that give it a great tourist potential (Calvente 1997).

In the municipality of Ilhabela is located the Ilhabela State Park, created in 1977 with 27,025 hectares, covering about 80% of the municipal area. The park covers much of the São Sebastião Island, whose limits are defined by altitudes (100m and 200m) and marine areas, including small islands and slabs that make up the archipelago (Maldonado 1997).

Native families remaining in the most urbanized part of the São Sebastião Island have their lives transformed by changes from the technical progress and cultural values assimilated through tourism and media. Other communities still live in relative isolation in some beaches distant from the central region of the island. So-called "isolated communities" are so considered by the urban population due to the precariousness of access, either by land or sea, in relation to the urban center.

In this research we conducted interviews on folk taxonomy with artisanal fishermen from beaches Bonete, Fome, Jabaquara and Serraria. The beach Jabaquara (north of Ilhabela) is connected by land road of difficult transportation to the urban center; Bonete (to the south), linked by roads that in the last 9 km become in trail of difficult access; Praia da Fome and Praia da Serraria are accessible only by sea (Figure 1).

We analyzed the fishermen who developed fishing activity for 10 years or more. Fishermen were interviewed using questionnaires and photographic material. This material consisted of a kit, consisting of photos of 24 fish species, which often represent the main species present in the composition of fish caught by fishermen from the north coast of São Paulo. Fish species that were part of the kit had already been pre-determined by the researchers since this research was part of a major research project in the area coordinated by one of the authors (AB). Fish pictures used in this project were done by R. A. M. Silvano, from FIFO and UFRGS, Porto Alegre, Brazil and was described in Begossi et al. (2008). In this technique, already used successfully in previous studies (Marques 1991, Paz & Begossi 1996, Silvano 2001, Silvano & Begossi 2002, Silvano et al. 2006), fish photographs were given to fishermen in the same order for all respondents, being it determined by draw. While viewing photos, fishermen answered the following questions: 1) What is this fish? 2) What is its name? 3) Which of these fish are relatives or in the same family? 4) What is a relative? Subsequently, fisherman was asked to group the photos according to his knowledge of the "kinship" of fish.

Data were analyzed qualitatively and quantitatively. Seeking to represent the consensus among informants interviewed, responses were analyzed as a percentage of quotes about every aspect addressed. Most of the answers or the most frequently mentioned aspects were considered as most relevant information on the local ecological knowledge (Paz & Begossi 1996, Silvano & Begossi 2005). The local information was compared with the scientific literature on compared

Figure 1. Communities of fishermen studied in the Ilhabela/SP.

cognition tables, according to Marques (1991), through literature reviews on fish species addressed in this research and discussed with the theoretical framework of folk systematic, especially developed in the work of Berlin (1992). Data on folk taxonomy detailed in this article have been shown more widely in the study of Begossi et al. (2008) who made a comparison between taxonomy of fishers from southeast of Sao Paulo and Amazon; therefore, the results of data analysis collected in Ilhabela can be understood as a deepening of the analysis performed earlier by these authors.

Results and Discussion

The twenty-four species presented to the fishermen belong to19 genera and 11 families. The nomenclature of fishermen for fish species mostly was carried out by generic names and for some fish has been given binominal names, resulting in 50 generic names and 27 binominal specific names (Table 1).

Most of species was named by fishermen with monotypic generic names, the main ones: *corvina/Micropogonias furnieri*

Table 1. Fish Nomenclature according to the fishermen of Ilhabela. Values correspond to the number of citations in interviews (N = 42 fishermen interviewed).

Fish scientific name	Generic name	N	%	Binominal	N	%	Non-recognized fish
1. *Bodianus rufus* (Linnaeus, 1758)	*godião*	22	52.4	*godião-batata*	8	19	5
	caranha	1	2.4	*godião-fogueira*	1	2.4	
	vermelho	1	2.4	*godião-papagaio*	3	7.1	
				vermelho-caranha	1	2.4	
2. *Epinephelus marginatus* (Lowe, 1834)	*garoupa*	39	92.8	*garoupa-legitima*	1	2.4	0
				garoupa-preta	1	2.4	
				garoupa-São-Tomé	1	2.4	
3. *Epinephelus morio* (Valenciennes, 1828)	*garoupa*	8	19	*garoupa-São-Tomé*	18	42.8	1
	badejo	6	14.3	*garoupa-banana*	8	19	
				garoupa-legitima	1	2.4	
				garoupa-vermelha	1	2.4	
4. *Caranx latus* Agassiz, 1831	*xaréu*	35	83.3	*xaréu-olhudo*	1	2.4	1
	xarelete	1	2.4	*xaréu-cacundo*	1	2.4	
	piranga	1	2.4				
	betara	1	2.4				
5. *Umbrina coroides* Cuvier, 1830	*betara*	30	71.4	*corvina-da-areia*	5	11.9	0
	corvina	5	11.9				
	maria-luisa	3	7.1				
	badejo	1	2.4				
	xarelete	1	2.4				
6. *Mycteroperca bonaci* (Poey, 1860)	*badejo*	23	54.8	*badejo-branco*	1	2.4	1
	miracelo	13	33.3				
	badejote	2	4.8				
	água-fria	1	2.4				
	badejinho	1	2.4				
	cherne	1	2.4				
7. *Mugil curema* Valenciennes, 1836	*parati*	31	73.8	*parati-guaçú*	1	2.4	0
	tainha	11	26.2				
8. *Seriola lalandi* Valenciennes, 1833)	*olhete*	32	76.2	*olhete-verde*	3	7.1	0
	olho-de-boi	8	19				
9. *Bodianus pulchellus* (Poey, 1860)	*godião*	19	45.2	*godião-fogueira*	6	14.3	3
	vermelho	2	4.8	*godião-batata*	4	9.5	
	sabonete	2	4.8	*godião-vermelho*	4	9.5	
	trilha	1	2.4	*godião-papagaio*	1	2.4	
10. *Oligoplites saliens* (Bloch, 1793)	*guaivira*	40	95.2				0
	salteira	2	4.8				
11. *Pomatomus saltatrix* (Linnaeus, 1766)	*anchova*	42	100				0
12. *Caranx crysos* (Mitchill, 1815)	*carapau*	23	54.8	*xaréu-amarelo*	2	4.8	0
	xarelete	20	46.6				
13. *Micropogonias furnieri* (Desmarest, 1823)	*corvina*	42	100				
14. *Cynoscion jamaicensis* (Vaillant & Bocourt, 1883)	*goete*	29	69	*goete-da-pedra*	1	2.4	3
	pescada	3	7.1	*goete-cascudo*	1	2.4	
	maria-mole	2	4.8	*pescada-branca*	1	2.4	
	betara	1	2.4	*pescada-cascuda*	1	2.4	
	robalo	1	2.4				

Table 1. Continued...

Fish scientific name	Generic name	N	%	Binominal	N	%	Non-recognized fish
15. Stegastes fuscus (Cuvier, 1830)	*café-torrado*	20	46.6				8
	tiniuna	12	28.6				
	corintiano	1	2.4				
	paru	1	2.4				
	peixe-frade	1	2.4				
	sargo	1	2.4				
	gudião	1	2.4				
16. Scomberomorus brasiliensis Collette, Russo & Zavala-Camin	*sororoca*	25	59.5	*cavalinha-do-norte*	2	4.8	0
	cavala	11	26.2				
	olhete	1	2.4				
	olho-de-boi	1	2.4				
	olhudo	1	2.4				
	robalo	1	2.4				
17. Centropomus parallelus Poey, 1860	*robalo*	41	98				1
18. Mycteroperca acutirostris (Valenciennes, 188)	*miracelo*	29	69				0
	badejo	14	33.3				
19. Abudefduf saxatilis (Linnaeus, 1758)	*tiniuna*	39	92.8				1
	corintiano	5	11.9				
	paulistinha	3	7.1				
	porquinho	1	2.4				
20. Euthynnus alleteratus (Rafinesque, 1810)	*bonito*	34	80.9	*bonito-pintado*	4	9.5	0
	olhete	1	2.4	*bonito-pulador*	2	4.8	
	bacoria	1	2.4				
21. Trichiurus lepturus Linnaeus, 1758	*espada*	42	100				0
22. Mugil platanus Gunther, 1880	*tainha*	33	78.6				0
	parati	11	26.2				
23. Menticirrhus americanus (Linnaeus, 1758)	*betara*	22	52.4	*betara-roliça*	5	11.9	2
	perna-de-moça	13	30.9	*betara-preta*	1	2.4	
	pau-de-fumo	5	11.9				
	papa-terra	1	2.4				
	maria-luiza	1	2.4				
24. Lutjanus synagris (Linnaeus, 1758)	*vermelho*	30	71.4	*vermelho-cioba*	6	14.3	2
	corcoroca	3	7.1				
	pargo	1	2.4				
Totais:	*50*	-		*27*	-		-

(Desmarest, 1823), *anchova/Pomatomus saltatrix* (Linnaeus, 1766) and *espada/Trichiurus lepturus* Linnaeus, 1758, which were called for 100% of fishermen and showed no specific associated, as well as the *robalo/Centropomus parallelus* Poey, 1860 cited by 98% of fishermen. According to Berlin (1992) names that represent the generic taxa are always more numerous in any folk classification system and can be divided into monotypic and polytypic. When the generic taxon is the terminal hierarchical level perceived by fishermen, it is called monotypic.

Among the monotypic generic names mentioned by fishermen of Ilhabela, 19 of them were also presented by Freire & Carvalho Filho (2009). This work the authors present an important assessment of the richness of Brazilian common names for reef and reef-associated fish species, and provide an initial list of unique common names for species studied.

Clauzet et al. (2007) conducted a study on folk taxonomy in Guaibim/BA, using 21 fish species common to this work and found a variety of generic names even greater than this study, being cited 122 generic and only 16 binomial names. The emphasis on generic names found between fishermen of Ilhabela/SP and Guaibim/BA has also been demonstrated by Begossi & Figueiredo (1995), who found about 20% binomial names among fishermen from Búzios Island (SP) and Sepetiba Bay (RJ) and Seixas & Begossi (2001) at Ilha Grande (RJ), who found 97 generic and 25 binomial names for 123 scientific species. According to Berlin (1992), semantic terms as simple as monotypic generic names found in Ilhabela could be related to ease of learning language among human populations.

In addition to monotypic names, polytypic generic names (or binomial) were also mentioned which, according to Berlin (1992), are those subdivided into specific and invariably refer to those classes of culturally important organisms. The polytypic most frequently cited were: *garoupa-são-tomé/Epinephelus morio* (Valenciennes, 1828), 42.8%; *garoupa-banana/Epinephelus morio* (Valenciennes, 1828), 19%; *godião-batata*/*Bodianus rufus* (Linnaeus, 1758), 19% and *Bodianus pulchellus* (Poey, 1860), 9.5%; *godião- fogueira/Bodianus pulchellus* (Poey, 1860), 14.3%, *vermelho-cioba*/*Lutjanus synagris* (Linnaeus, 1758), 14.3% and *corvina-da-areia/Umbrina coroides* Cuvier, 1830, 11.9% respectively related to the monotypic: *garoupa*, *godião*, *vermelho* and *corvina*.

Mourão & Nordi (2002a) conducted a review of Brazilian ethnoichtyological works by checking the proportionality monotypic/polytypic existing in naming species and found that the same generic polytypic may represent one or more species. According to these authors, the specific folk taxa recorded in studies on folk taxonomy are fewer than those on generic, which was also observed in the nomenclature of fishermen of Ilhabela (SP), generic monotypic were majority.

Among the generic names, fishermen of Ilhabela identify fish by simple generic (*Peroá*, *betara*, etc) and compound names (eg, *peixe-porco*, *peixe-folha*, *peixe-gato*). Some of most frequently generic compound names cited were: *café-torrado*/*Stegastes fuscus* (Cuvier, 1830), 46.6%; *perna-de-moça*/*Menticirrhus americanus* (Linnaeus, 1758), 30.9%; olho-de-boi/*Seriola lalandi* Valenciennes, 1833, 19%; *pau-de-fumo/Menticirrhus americanus* (Linnaeus, 1758), 11.9% and *Maria-Luisa/Umbrina coroides* Cuvier, 1830, 7.1%.

The binomiality is given in the case of generic modifiers, ie, when some generic name is added of a supplement name that makes it specific. Among the binomial cited by fishermen of Ilhabela, it was possible to identified references to as morphological such as color (*godião-fogueira*, *garoupa-preta*, *garoupa-vermelha*, *badejo-branco*, *godião-vermelho*, *xaréu-amarelo*, *bonito-pintado* and *betara-preta*) and format (*xaréu-olhudo*) ecological aspects such as habitat (*corvina-da-areia*, *goete-da-pedra* e *cavalinha-do-norte*) and analogies with terrestrial organisms (*godião-batata* e *godião-papagaio*). Among the fishermen of the River Estuary Mamanguape (PA), Mourão & Nordi (2002a) found that the popular nomenclature of some fish results from analogies made in relation to domestic animals or objects. Some examples include: *peixe-gato*, *peixe-galo* and *peixe-agulha*, among others; however, they are not characterized as a binomial, but as compound generic names.

According to Berlin (1992), organisms categorized into generic taxa are identified by several morphological marked and distinguishable features. However, organisms included in specific categories require a more detailed observation of the morphological aspects. Living organisms of generic taxa are usually included in the category of life forms such as fish, trees etc. For Brown (1984), "life forms" are sets of living beings easily or naturally recognized in different cultures by their discontinuity in nature, generally recognized by morphological characters. From this perspective, trees are "life forms"; wherever the local knowledge about nature is investigated, organisms perceived as trees are high-rank categories, easily recognized. However, for some categories for example, "fish", other aquatic organisms are often included, such as turtles, crustaceans and dolphins. According to Mourão & Nordi (2002a), the classification of some aquatic mammals and invertebrates into the "fish" category is due to the fact that fishermen can group these organisms not only by morphological similarities but by sharing the same habitat.

The categories of organisms perceived by human populations are related to ecological salience of these classes of organisms and may be related to certain cultural usefulness of certain organisms for the population recognizing it, or to visibly notable features. Atran (1999) emphasizes that human populations more distant from nature tend to recognize a greater number of "life forms", since under these circumstances they do not have a detailed knowledge of living beings, unlike a human population that lives in close relationship with natural resources and tends to classify them into specific ranks (specific form) and name them using binomial names. Fishermen in Ilhabela for example, named 15 of the 24 fish species studied by binomial names. Begossi et al. (2008) used the same 24 species studied in this work in fishing communities on the coast of São Paulo (Bertioga, Ilhabela and Ubatuba) and found that species were named by 27 generic and 54 binomial names, binomial proved to be related to salient features of fish such as color and shape.

The use of the binomial in fish identification by fishermen of Ilhabela may indicate the recognition of distinct categories of natural resources and especially the close relationship of human population with exploited fish stocks, strengthening the idea of closeness between man and nature to create detailed popular classification systems, as emphasized by Atran (1999).

The morphological aspect in the binomial identification of organisms is very prominent in the literature (Berlin 1992). Studies show that morphological characteristics of fish are a strong trend in the composition of popular classification systems with binomial both among fishermen in coastal communities (Begossi & Garavello 1990, Begossi & Figueiredo 1995, Clauzet et al. 2007) among coastal fishermen in the Brazilian Amazon (Begossi et al. 2008). In Ilhabela (SP), results of popular binomial nomenclature reinforce the importance of morphological characteristics of organisms in folk systematic showing the predominance of morphological characters in fish identification, 56% binomial names being related to some morphology aspect of named fish. The main morphological features used by fishermen of Ilhabela for fish nomenclature were: color (37%) and shape (18.5%).

In addition to morphology, there are also ecological criteria for binomially such as those related to the habitat of the species. Among fishermen of northeastern Brazil, Marques (1991) found in Lagoon-Estuary Complex Mundaú-Manguaba (AL) various local names in reference to usual habitats of ethnospecies of the fish family locally recognized as "Moré family" (Gobiidae and Eleontridae) as for example, *Moré-de-Capim*, *Moré-de-Pau* and *Moré-de-Mangue*.

Among fishermen of Ilhabela, some habitat-related criteria binomial examples include: *goete-da-pedra/Cynoscion jamaicensis* (Vaillant & Bocourt, 1883) and *corvina-da-areia/Umbrina coroides* Cuvier, 1830. In relation to the ecological aspect of behavior, fishermen of Ilhabela identified the *bonito-pulador/Euthynnus alleteratus* (Rafinesque, 1810). Through association with plants were identified *garoupa-banana/Epinephelus morio* (Valenceinnes, 1828) and *godião-batata/Bodianus rufus* (Linnaeus, 1758) *and Bodianus pulchellus* (Poey, 1860). The *godião*/*Bodianus rufus* (Linnaeus, 1758) *and Bodianus pulchellus* (Poey, 1860), were also associated with other animals being identified as *godião-papagaio*. Binomially criteria related to the behavior and association with other animals and plants were also reported among fishermen in other regions of Brazilian coast (Begossi & Garavello 1990, Marques 1991, Begossi & Figueiredo 1995, Seixas & Begossi 2001).

In studies of fish folk taxonomy, one of the key questions is whether the fishermen recognize and classify the various species in different groups and their justifications. According to Paz & Begossi (1996) and to Begossi et al. (2008) fish can be locally recognized by fishermen as "cousins" or "relatives" and grouped into higher categories (high-ranking) locally known as "families" (folk families). Other folk taxonomy studies on different fishermen communities found the local perception of fish as relatives (Clauzet et al. 2007).

Such an approach was made to fishermen of Ilhabela from the research groups of fish that could be formed by fishermen interviewed with the 24 species used in research and the local criteria for such groups. Fishermen in Ilhabela formed eight fish groups based on local criteria that are overall similar to those of scientific taxonomy. The groups are composed of 16 species of 11 genera belonging to six biological families: Mugilidae, Labridae, Carangidae, Pomacentridae, Serranidae and Sciaenidae. The groups and comparison of local criteria to the fish taxonomy are as follows (Table 2).

In all the groups formed by the fishermen, species are of the same biological families. As for the fish identification, morphological characters are also the main reference for fishermen to form fish groups. In group 1 (n = 33), cited by 78.6% fishermen and made up of *Mugil curema* Valenciennes, 1836 *and M. platanus* Gunther, 1880, (Mugilidae): the main aspect observed by fishermen to the relationship among fish was morphology, demonstrated by responses such as

Table 2. Criteria for grouping and comparison with the scientific literature (N = 42).

Formed groups	N	%	Grouping criteria	Citations	N	%	Scientific taxonomy characters
Group 1	33	78.6	Morphology	Similar	15	35.7	The two species belong to the genus *Mugil* and family Mugilidae. This family is represented by the mullet and Parati that have elongated body almost cylindrical anteriorly and laterally compressed. They are coastal fish forming shoals (Menezes & Figueiredo 1985).
Mugil curema Valenciennes, 1836				Only size changes	5	11.9	
(*parati*)				Equal shape	4	9.5	
Mugil platanus Gunther, 1880				Equal color	2	4.8	
(*tainha*)			Behavior	They are together	9	21.4	
				Equal behavior	4	9.5	
				They mix shoal	1	2.4	
				Go floating	1	2.4	
				Make shoal	1	2.4	
			Feeding	Eat the same thing	2	4.8	
			Habitat	Live together	7	16.7	
			Others	Same family	2	4.8	
				Sisters	1	2.4	
				Same period	1	2.4	
Group 2	28	66.6	Morphology	Similar	8	19	The two species belong to the genus Bodianus and family Labridae. Can be identified by color and number of tracks on the first gill arch. Coastal fish, living together in coral reefs and rocky bottoms (Menezes & Figueiredo 1985).
Bodianus rufus (Linnaeus, 1758)				Equal	2	4.8	
Bodianus pulchellus (Poey, 1860)				Equal color	1	2.4	
(godiões)				Equal shape	1	2.4	
				Only color changes	1	2.4	
			Behavior	They are together	5	11.9	
				Equal behavior	2	4.8	
			Habitat	Live together	5	11.9	
				From stone	1	2.4	
			Others	Same family	2	4.8	
Group 3	28	66.6	Morphology	Similar	6	14.3	The two species belong to the genus Caranx and family Carangidae. Caranx species have well developed shells on the straight part of lateral line. Differences between *C. latus and C. crysos* refer to the number of rays in the anal and dorsal fins, number of shells on the side line and number of tracks in the gill arch (Menezes & Figueiredo 1980).
Caranx latus Agassiz, 1831				Equal shape	2	4.8	
(*xaréu*)				Equal color	1	2.4	
Caranx crysos (Mitchill, 1815)			Behavior	They are together	7	16.7	
(*xarelete*)				They mix shoal	4	9.5	
				Equal behavior	2	4.8	
			Feeding	Eat the same thing	4	9.5	
			Habitat	Live together	7	16.7	
			Others	Relatives	2	4.8	
				Fishing together	1	2.4	
				Brothers	1	2.4	

Table 2. Continued...

Formed groups	N	%	Grouping criteria	Citations	N	%	Scientific taxonomy characters
Group 4 *Stegastes fuscus* (Cuvier, 1830) (*café-torrado*) *Abudefduf saxatilis* (Linnaeus, 1758) (*tiniuna*)	22	52.4	Morphology	Similar	9	21.4	Both belong to the family Pomacentridae (Menezes & Figueiredo 1985). *S. fuscus*: dark coloration on the back and sides. Very common in ponds in the region between seas and coral reefs. Food: plankton, small invertebrates and plant matter (Menezes & Figueiredo 1985). *A. saxatilis:* uniform dark brown body with dark vertical stripes. It is abundant in ponds and pools of the intertidal region. Food: Small crustaceans, algae and marine invertebrates (Menezes & Figueiredo 1985).
				Equal shape	4	9.5	
				Equal color	3	7.1	
				Equal	2	4.8	
				Equal scale	2	4.8	
			Behavior	They are together	4	9.5	
				Equal behavior	2	4.8	
			Feeding	Eat the same thing	2	4.8	
			Habitat	Live together	8	19	
				From stone	1	2.4	
			Others	The same period	1	2.4	
Group 5 *Mycteroperca bonaci* (Poey, 1860) (*badejo*) *Mycteroperca acutirostris* (Valenciennes, 1828) (*miracelo*)	17	40.5	Morphology	Similar	10	23.8	Family Serranidae. The genus Mycteroperca includes medium to large size coastal fish. They live in rocky or sandy bottoms (Figueiredo & Menezes 1980). *M. bonaci*: Elongate Body, body height less than the head length, relatively small eyes, pre-operculum smooth and rounded eyes, without prickly lobes or indentation. Body uniformly light brown with longitudinally elongated rectangular darker spots and small circular orange spots distributed on the flanks and head (Rocha & Costa 1999). *M. acutirostris*: Compressed body. Torso and head are dark brown, covered with irregular white spots; 3-4 dark bands radiating from the eye, becoming sinuous grooves that extend to the lower body (Rocha & Costa 1999).
				Equal	3	7.1	
				Only color changes	2	4.8	
				Equal shape	1	2.4	
			Behavior	They are together	3	7.1	
				Equal behavior	1	2.4	
			Habitat	From stone	2	4.8	
				Live together	2	4.8	
			Others	It is the same fish	1	2.4	
Group 6 *Epinephelus marginatus* (Lowe, 1834) (*garoupa*) *Epinephelus morio* (Valenciennes, 1828) (*garoupa-São-Tomé*)	15	35.7	Morphology	Similar	8	19	Family Serranidae *E. marginatus:* low body, body height less than the head length. Orange-brown body and head, the yellowish ventral region near the base of pelvic fins; often irregular pale patches distributed across the torso and head, dark anal , caudal and dorsal fins with a quite narrow marginal white band (Rocha & Costa 1999). *E. morio*: tall body and slightly elongated, quite sharply top curve of the head profile. Varies from dark brown to reddish-brown, rosy-red ventral region; margin of anal, dorsal and caudal fins with very narrow white band, small black spots around the eyes (Rocha & Costa 1999).
				Only color changes	2	4.8	
				Equal	2	4.8	
				Equal shape	1	2.4	
			Behavior	They are together	1	2.4	
				Equal behavior	1	2.4	
			Habitat	Live together	3	7.1	
			Others	Same family	2	4.8	

Table 2. Continued...

Formed groups	N	%	Grouping criteria	Citations	N	%	Scientific taxonomy characters
Group 7 *Umbrina coroides* Cuvier, 1830 (*betara*) *Micropogonias furnieri* (Desmarest, 1823) (*curvina*)	11	26.2	Morphology	Similar	4	9.5	Belong to the family Sciaenidae that encompasses 17 genera with own characteristics (Menezes & Figueiredo 1980). *U. coroides*: silvery general color, dark oblique streaks below the dorsal fin above and below the parallel dorsal and posterior lateral line. Live in shallow coastal waters, mud or sand bottoms and estuarine regions. Food: benthic organisms (Menezes & Figueiredo 1980). *M. furnieri*: coastal species found in mud and sand bottoms at depths less than 60m in estuarine waters. Silvery body, dark back with oblique streaks. Food: worms, crustaceans and small fish (Menezes & Figueiredo 1980).
				Equal	1	2.4	
			Behavior	They are together	3	7.1	
				Equal behavior	1	2.4	
			Feeding	Same bait	1	2.4	
			Habitat	Live together	2	4.8	
				Live on the bottom	1	2.4	
				Together in mud	1	2.4	
			Others	Corvinas	1	2.4	
Group 8 *Umbrina coroides* Cuvier, 1830 (*betara*) *Micropogonias furnieri* (Desmarest, 1823) (*curvina*) *Cynoscion jamaicensis* Vaillant & Bocourt, 1883) (*goete*) *Menticirrhus americanus* (Linnaeus, 1758) (*betara*)	8	19	Morphology	Similar	4	9.5	Family Sciaenidae. *U. coroides*: idem to the previous grouping *M. furnieri*: idem to the previous grouping *C. jamaicensis*: silvery body, darker on back, clear fins, dark dorsal and caudal fins, dark pigmentation at the armpit upper part. Found at depths up to 100m over sand and/or mud bottoms. Food: fish and shellfish (Figueiredo & Menezes 1980). *M. americanus*: body ranging from light to dark gray, with elongated and oblique dark spots sometimes unclear. Usually found on sandy bottoms or sand and mud bottoms in shallow coastal waters and also estuarine regions (Menezes & Figueiredo 1980). Food: worms and benthic crustaceans (Menezes & Figueiredo 1980; Carvalho Filho 1999).
				Equal shape	2	4.8	
				Equal color	1	2.4	
			Behavior	They are together	2	4.8	
				Equal behavior	1	2.4	
				They mix shoal	1	2.4	
			Feeding	Eat the same thing	1	2.4	
			Habitat	Live together	6	14.3	
			Others	Together in the net	1	2.4	

"same shape" and "same color". Group 2 (66.6%, n = 28) formed by *Bodianus rufus* (Linnaeus, 1758) and *B. pulchellus* (Poey, 1860) (Labridae), was also identified by morphological criteria specifically related to color and shape of these fish. From comparisons between local groups formed by respondents and taxonomic literature, we can see similarities between scientific characters used for fish taxonomy and the criteria by which fishermen grouped fish. There are correspondences, for example, morphological characters of color and body shape, described to the scientific taxonomy to by fishermen to group fish revealed in responses such as, "they are similar", "they have the same color" and "they have equal shape". An example is the scientific description of the species *Mugil platanus* Gunther, 1880 and *M. curema* Valenciennes, 1836 (Mugilidae) (which were included in Group 1):

Mugilidae species were also grouped by fishermen from other regions of the Brazilian coast, being assigned to them a relationship according to local criteria of color, body shape, diet and habitat (Souza & Barrella 2001, Clauzet et al. 2007, Begossi et al. 2008).

In addition to the importance of morphological characters in the recognition of distinct fish groups, fishermen of Ilhabela also make use of ecological (habitat and food) and behavioral criteria (shoals/fish association) for species classification within the same group. Group 2, for example, formed by *Bodianus rufus* (Linnaeus, 1758) *and B. pulchellus* (Poey, 1860) (Labridae) cited by 66.6% of respondents (n = 28) was identified not only by morphological criterion (color and shape), but also behavioral and ecological criteria demonstrated in responses such as "living in the stone," "go together in the same place" among others. Such criteria were similar to those used in scientific description of such species: . Other works on folk taxonomy describe the use of ecological criteria by fishermen, for example, in Guaibim/BA where the species *B. pulchelus* (Poey, 1860) *and B. rufus* (Linnaeus, 1758) are recognized by local fishermen as fish of the same family based on the fact that they live in the same habitat (Clauzet et al. 2007). Group 3 *Caranx latus* Agassiz, 1831 *and C. crysos* (Mitchill, 1815) (Carangidae) cited by 66.6% of respondents (n = 28) based primarily on the fact "going together in shoal" and morphological similarities was also pointed out in studies of Clauzet et al. (2007) and Begossi et al. (2008), based on the same folk taxonomy criteria.

Mycteroperca bonaci (Poey, 1860), *M. acutirostris* (Valencienes, 1828), *Epinephelus marginatus* (Lowe, 1834) and *E. morio* (Valenciennes, 1828) belong to the family Serranidae (Figueiredo & Menezes 1980). According to the fishermen of Ilhabela, these species comprise two different groups: *M. bonaci* (Poey, 1860) and *M. acutirostris* (Valencienes, 1828) in group 5 (40.5%, n = 17) and *E. marginatus* (Lowe, 1834) and *E. morio* (Valenciennes, 1828) in group 6 (35.7%, n = 15). The local criteria used for these two groups are related to habitat and also performed consistent with the scientific literature and previously recorded in work of Begossi et al. (2008) among fishermen from other communities on the coast of São Paulo.

The species *Umbrina coroides* Cuvier, 1830 and *Micropogonias furnieri* (Desmarest, 1823) (Sciaenidae) appeared in two different groups, being grouped by 26.2% of fishermen as unique representatives of group 7 (n = 11) and by 19% of fishermen as representatives of the group 8 (n = 8), which also includes the species *Cynoscion jamaicensis* (Vaillant & Bocourt, 1883) and *Menticirrhus americanus* (Linnaeus, 1758). Even so, fishermen's grouping criteria for two groups corresponded to the taxonomic criteria found in the scientific literature and also reflect the perception of similarities among ecological aspects related to habitat and diet of such fish.

In addition to morphological, ecological and behavioral criteria observed for formation of fish groups, there was citation of criteria related to aspects of fishing activities of fishermen. For example, groups 1 (*Mugil curema* Valenciennes, 1836 and *M. platanus* Gunther, 1880, Sciaenidae) and 4 (*Stegastes fuscus* (Cuvier, 1830) and *Abudefduf saxatilis* (Linnaeus, 1758), Pomacentridae) were justified by citing "the same period." This criterion relates to the seasonality of captures of these species, which in the understanding of local fishermen makes them "relatives" and it is also a local criterion for classification as the others already mentioned: "going together", "eat the same thing" and "living together", can also be captured together at the same time.

In addition to seasonality, fishing technology is used by fishermen of Ilhabela as a criterion for fish grouping. Citations like: "fishing together," "when fishing one, fishing another" and "when one comes on the network, the other comes too", used to justify the group 3 (Carangidae): *Caranx latus* Agassiz, 1831 *and C. crysos* (Mitchill, 1815), and group 8 (Sciaenidae): *Umbrina coroides* Cuvier, 1830, *Micropogonias furnieri* (Desmarest, 1823), *Cynoscion jamaicensis* (Vaillant & Bocourt, 1883) and *Menticirrhus americanus* (Linnaeus, 1758), demonstrate this. For fishermen, if these fish are often caught together with the same fishing technology they are considered "relatives." The capture mode as a folk taxonomy criterion suggests of local ecological knowledge about the species through the experience acquired with fishing activities.

Overall, it may be noted that fishermen of Ilhabela differentiate fish species and recognize different groups existing in nature. It is evident in the results obtained the similarity between popular and scientific classification systems. The criteria used by the fishermen from Ilhabela to recognize and identify the fish as well as to distinguish themselves in different groups are in agreement with scientific taxonomy.

Conclusions

Among the many factors that influence the local classification of fish recorded in the results, the morphological aspect is more prominent in the popular classification system of fishing communities studied in Ilhabela (SP). Overall, the results of folk taxonomy show that the morphology (shape of the head and body, color and size of fish) is the main criterion of classification in local systems surveyed. Add up the morphology, ecological criteria related to habitat and fish behavior and aspects of fishing activity, such as shooting mode, totaling the representation of popular classification system of fishermen from Ilhabela.

Finally, the recognition of fish categories based on its habitat and behavior and fishing practices that demonstrated the fishermen of Ilhabela make this local classification system a potential knowledge to be used in conservation initiatives and scientific research on fish behavior. The local ecological knowledge about behavior and habitat of species when added to that scientific can become more efficient the conservation of different species living in the same habitat and sharing similar habits in nature.

Considering the difficulty of biological studies unravel the biodiversity, both in terms of collection effort and in time spent on research and the importance of local knowledge for efficient ways of management, it can be considered that the detailed popular classification system demonstrated in this study suggests that fishermen may be included in scientific studies as having important biological and ecological information on fish, which will add in conservation planning of fisheries resources.

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Mariposas Arctiinae (Lepidoptera: Erebidae) do estado de Santa Catarina, Brasil

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FERRO, V.G., RESENDE, I.M.H. & DUARTE, M. **The Arctiinae moths (Lepidoptera: Erebidae) of Santa Catarina state, Brazil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/en/abstract?inventory+bn01312042012

Abstract: A list of species was prepared by examining 2,772 specimens deposited in 10 Brazilian collections. A total of 499 arctiines were recorded in 30 municipalities, 1.4% of these species are endemic to the state of Santa Catarina. The most species-rich localities were Joinville, São Bento do Sul, Seara, and Brusque. Only 15 nights of samplings were performed in the 21st century. The deciduous forest has been extremely subsampled with respect to Arctiinae moths compared to the other types of vegetation found in the state of Santa Catarina. For a more comprehensive diagnostic of the species richness and composition of Arctiinae moths in Santa Catarina state, aiming conservation strategies of vulnerable habitats and taxa, samplings are needed in many municipalities in the state, especially in areas of deciduous forest and grasslands.
Keywords: *Atlantic Forest, Brazil, faunistic inventory, species composition, species list.*

FERRO, V.G., RESENDE, I.M.H. & DUARTE, M. **Mariposas Arctiinae (Lepidoptera: Erebidae) do estado de Santa Catarina, Brasil.** Biota Neotrop. 12(4): http://www.biotaneotropica.org.br/v12n4/pt/abstract?inventory+bn01312042012

Resumo: Uma lista de espécies foi preparada com base no exame de 2.772 espécimes depositados em 10 coleções brasileiras. Um total de 499 arctiíneos foi registrado em 30 municípios, sendo 1,4% dessas espécies endêmicas do estado de Santa Catarina. As localidades mais ricas em registros de espécies foram Joinville, São Bento do Sul, Seara e Brusque. Apenas 15 noites de amostragens foram realizadas no século 21. A floresta estacional decidual foi extremamente subamostrada no que diz respeito às mariposas Arctiinae em comparação com os outros tipos de vegetação encontrados no estado de Santa Catarina. Para um diagnóstico mais abrangente da riqueza e composição de espécies de mariposas Arctiinae no estado de Santa Catarina, visando estratégias de conservação de habitats e táxons vulneráveis, são necessárias amostragens em muitos municípios do estado, especialmente em áreas de floresta estacional decidual e de campos.
Palavras-chave: *Mata Atlântica, Brasil, inventário faunístico, composição de espécies, lista de espécies.*

Introdução

Erebidae é a segunda maior família de Noctuoidea (Zahiri et al. 2011) e compreende espécies que, no passado, pertenciam a grupos taxonômicos com status de família (Lymantriidae e Arctiidae). Apesar dos avanços recentes na área da Sistemática molecular, os erebídeos ainda são pouco estudados em aspectos taxonômicos. A filogenia proposta para essas mariposas, com base em sequências de DNA de oito genes de 237 espécies (Zahiri et al. 2012), estabele 18 subfamílias: Scoliopteryginae, Rivulinae, Anobinae, Hypeninae, Lymantriinae, Pangraptinae, Herminiinae, Aganainae, Calpinae, Hypocalinae, Eulepidotinae, Toxocampinae, Tinoliinae, Scolecocampinae, Hypenodinae, Boletobiinae, Erebinae e Arctiinae.

Arctiinae tem ampla distribuição geográfica e é em geral facilmente reconhecida pela coloração viva dos adultos e pela densa cobertura de cerdas das larvas. Compreende quase 11.000 espécies (6.000 para a região neotropical *sensu* Heppner 1991) distribuídas nas tribos Arctiini, Lithosiini, Syntomini e Amerilini (ver também Zahiri et al. 2012). Para o Brasil, são registradas 1.391 espécies de Arctiini e Lithosiini: 94 espécies no Pantanal, 116 nos Campos Sulinos, 145 na Caatinga, 753 na Amazônia (Ferro & Diniz 2010), 723 no Cerrado (Ferro et al. 2010) e 1.193 na Mata Atlântica (Ferro & Melo 2011).

A Mata Atlântica é a segunda maior floresta úmida do Novo Mundo. A maior parte dela localiza-se em território brasileiro, estendendo-se para o leste do Paraguai e nordeste da Argentina (Tabarelli et al. 2005). No Brasil, a Mata Atlântica está distribuída por mais de 3.300 km ao longo da costa, entre as latitudes 4 e 32° S (Tabarelli et al. 2005). No passado, este bioma ocupava aproximadamente 1,3 milhões de km^2 (Morellato & Haddad 2000). Atualmente, restam menos de 100 mil km^2 de vegetação (7,7% da área original) localizados em fragmentos pequenos e isolados (Gascon et al. 2000). Estes fragmentos continuam sofrendo forte pressão antrópica, principalmente através do corte ilegal de árvores, urbanização, agropecuária e invasão de espécies exóticas (Tabarelli et al. 2004). Apesar da grande redução de área, existem 8.000 espécies de plantas e 567 espécies de vertebrados endêmicos no bioma, sendo este incluído entre os hotspots de conservação da diversidade (Myers et al. 2000). A maioria (91,2%) das espécies de lepidópteros oficialmente ameaçadas de extinção no Brasil ocorre na Mata Atlântica (Freitas & Marini-Filho 2011).

O estado de Santa Catarina (SC) apresenta uma das maiores áreas de vegetação remanecente de Mata Atlântica do país (2.210.061 ha, 23% da área com vegetação nativa do bioma no Brasil) (Fundação... & Instituto... 2011). Apesar disso, praticamente não existem artigos sobre a lepidopterofauna de SC (ver Carneiro et al. 2008), em especial sobre as espécies com atividade noturna. Contudo, existe uma grande quantidade de material depositado em coleções. Sabe-se que os dados originados de coleções tendem a ser enviezados (em favor de espécies de insetos grandes, coloridas e de interesse dos naturalistas e de sítios mais acessíveis de coleta) (Ferro & Diniz 2008) e, portanto, seu uso é problemático em estudos sobre riqueza de espécies (Hortal et al. 2008). Apesar disso, o uso de dados de coleções é bem menos problemático em estudos sobre a composição de espécies (Ferro & Melo 2011). Esse tipo de dado também é bastante útil para dar uma primeira visão do estado de conhecimento da composição de espécies em escalas mais amplas, especialmente se as espécies estudadas compreendem organismos muito diversos e pouco amostrados, como as mariposas Arctiinae e os demais insetos, e se estas ocorrerem em regiões com elevada taxa de desmatamento, como a Mata Atlântica. Este trabalho tem como objetivo apresentar uma lista das espécies de mariposas Arctiinae de Santa Catarina, considerando o material depositado em coleções brasileiras com histórico de pesquisadores e naturalistas que coletaram no sul do país, além de fornecer uma primeira visão geral sobre a composição de Arctiinae nesse estado e indicar áreas prioritárias para a realização de futuros inventários. A lista foi construída a partir da compilação de dados de 2.772 indivíduos depositados em dez coleções brasileiras. Esta é a primeira lista dessas mariposas para o estado de Santa Catarina. Esperamos que os resultados de nosso estudo sirvam de base para estudos sobre a conservação de lepidópteros na Mata Atlântica de Santa Catarina e de outros estados brasileiros.

Material e Métodos

A lista das espécies de Arctiinae foi baseada em indivíduos depositados em dez coleções brasileiras: Coleção Particular Vitor O. Becker (VOB), Camacan, Bahia; Universidade de Brasília (UnB), Brasília, Distrito Federal; Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Amazonas; Departamento de Zoologia (DZUP), Universidade Federal do Paraná, Curitiba, Paraná; Fundação Instituto Oswaldo Cruz (FIOC), Rio de Janeiro, Rio de Janeiro; Museu Paraense Emilio Goeldi (MPEG), Belém, Pará; Museu Entomológico Ceslau Biezanko da Universidade Federal de Pelotas (MECB), Pelotas, Rio Grande do Sul; Museu de Zoologia Prof. Adão José Cardoso (ZUEC), Universidade Estadual de Campinas, Campinas, São Paulo; Museu de Zoologia (MZSP), Universidade de São Paulo, São Paulo, São Paulo; Museu Nacional (MNRJ), Universidade Federal do Rio de Janeiro, Rio de Janeiro, Rio de Janeiro. Foram registrados os dados de coleta de todos os exemplares com ocorrência para o estado de Santa Catarina. A identificação das espécies foi feita por comparação com material depositado na Coleção Particular Vitor O. Becker (cujas identificações das espécies foram confirmadas através da comparação com os tipos) ou por meio das pranchas e descrições de Draudt (1916-1917); os nomes dos táxons seguem a bibliografia disponível (Hampson 1898, 1900, 1901, 1914, 1920, Dietz IV & Duckworth 1976, Watson & Goodger 1986, Dietz IV 1994, Bendib & Minet 1999, Piñas-Rubio et al. 2000, Piñas-Rubio & Manzano 2003, Simmons & Weller 2006, Cerda 2008, Pinheiro & Duarte 2010). Para os exemplares sem coordenadas geográficas e altitudes, foram usadas as coordenadas e altitudes das sedes dos municípios. O ruído causado pelo uso de coordenadas e altitudes das sedes dos municípios foi distribuído de forma semelhante para a maioria dos registros, já que cerca de 97% dos indivíduos não apresentavam as coordenadas exatas em suas etiquetas de coleta. As coordenadas geográficas e altitudes foram obtidas no sistema de informação "splink" (http://splink.cria.org.br/geoloc?criaLANG=pt), sendo também consultado o banco de dados de tipos do acervo do National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (http://collections.nmnh.si.edu/search/ento/) para complementação da lista de espécies.

Resultados e Discussão

Nas dez coleções visitadas, foram observados 2.772 exemplares de Arctiinae com ocorrência para SC, pertencentes a 493 espécies (Tabela 1). Foram encontrados também registros de outras seis espécies no banco de dados de tipos depositados no National Museum of Natural History, Smithsonian Institution, totalizando 499 espécies com registro para o estado (Tabela 1); são elas: *Cosmosoma arpi* Dognin, 1924; *Dycladia broteas* Schaus, 1892; *Ormetica pretiosa* (Schaus, 1921); *Pseudaethria cessogae* Schaus, 1924; *Symphlebia nigranalis* (Schaus, 1915) e *Leucanopsis austina* (Schaus, 1941). Com exceção desta última (com registro para o município de Corupá), todas as demais espécies foram descritas com base em exemplares coletados em Joinville (http://collections.nmnh.si.edu/search/ento/). Dentre as coleções visitadas, as coleções MZSP, VOB, DZUP e MNRJ apresentaram o maior número de registros de espécies para o estado de SC.

Tabela 1. Lista das 499 espécies de Arctiinae com registro de coleta para o estado de Santa Catarina.

Table 1. List of 499 Arctiinae species recorded in Santa Catarina state.

Espécies	Ocorrência em Santa Catarina
Arctiini (444 espécies)	
Aclytia flavigutta (Walker, 1854)	Jaraguá do Sul, Florianópolis
Aclytia heber (Cramer, 1780)	Barra Velha, Brusque, Joinville
Aclytia reducta Rotthschild, 1912	Joinville
Aclytia terra Schaus, 1896	Jaraguá do Sul, Joinville
Adoxosia nydiana Schaus, 1929	São Joaquim
Aemilia pagana (Schaus, 1894)	Florianópolis
Aethria analis Schaus, 1901	Joinville, Rio dos Cedros
Aethria haemorrhoidalis (Stoll, [1790])	Florianópolis
Aethria melanobasis (Druce, 1897)	Joinville
Aethria paula Schaus, 1894	Joinville
Agaraea semivitrea Rothschild, 1909	Gaspar, Joinville, Timbó
Agaraea uniformis (Hampson, 1898)	São Bento do Sul, Urubici
Agyrta albisparsa Hampson, 1898	Brusque, Joinville, Florianópolis, São Bento do Sul
Agyrta micilia (Cramer, [1779])	Joinville
Amaxia chaon (Druce, 1883)	Joinville
Amaxia corata Schaus, 1921	Joinville
Amaxia hebe Schaus, 1892	Joinville, Monte Castelo, São Bento do Sul, Timbó
Ammalo helops (Cramer, [1775])	Brusque, Jaraguá do Sul, Joinville, São Bento do Sul, Seara
Ammalo travassosi Rego Barros, 1974	Seara
Antichloris caca Hübner, 1827	Anita Garibaldi, Joinville
Antichloris eriphia (Fabricius, 1777)	Joinville, São Bento do Sul
Argyroeides braco (Herrich-Schäffer, [1855])	Anita Garibaldi, Joinville, Seara
Argyroeides nephelophora Hampson, 1914	Seara
Argyroeides ophion (Walker, 1854)	Anita Garibaldi, Brusque, Joinville, São Bento do Sul, Timbó
Argyroeides sanguinea Schaus, 1896	Anita Garibaldi, Joinville, Porto Belo, Seara
Argyroeides variegata Kaye, 1911	Joinville, Monte Castelo
Argyroeides vespina Schaus, 1901	Anita Garibaldi
Atyphopsis roseiceps Druce, 1898	Joinville, Timbó
Baritius acuminata (Walker, 1856)	Brusque, Joinville, Santa Cecília
Belemnia eryx (Fabricius, 1775)	Joinville
Bernathonomus minuta Fragoso, 1953	Joinville
Bernathonomus piperita (Herrich-Schäffer, [1855])	Joinville, Rio das Antas, São Bento do Sul
Bertholdia albipuncta Schaus, 1896	Joinville, Seara
Bertholdia almeidai Travassos, 1950	Bom Jardim da Serra, Seara
Bertholdia grisescens Rothschild, 1909	Blumenau
Bertholdia pseudofumida Travassos, 1950	Brusque, Joinville, Timbó
Bertholdia specularis (Herrich-Schäffer, [1853])	Lages
Biturix rectilinea (Burmeister, 1878)	Joinville, Timbó
Callopepla emarginata (Walker, 1854)	Joinville, Timbó
Callopepla grandis Rothschild, 1912	Seara
Callopepla inachia (Schaus, 1892)	Anita Garibaldi, Joinville, Florianópolis
Cyanopepla similis (Heylaerts, 1890)	Joinville
Calodesma amica (Stoll, [1781])	São Bento do Sul
Calodesma collaris (Drury, 1782)	Brusque, Seara
Calodesma contracta (Walker, 1854)	Joinville, Seara
Calodesma dioptis (Felder, 1874)	Seara
Calodesma quadrimaculata Hering, 1925	Joinville, Seara
Calonotos verdivittata (Klages, 1906)	Joinville, Lauro Muller
Carales astur (Cramer, 1777)	Joinville, Seara
Carales maculicollis Walker, 1855	Joinville, São Bento do Sul

Espécies endêmicas (que ocorrem exclusivamente no estado) são indicadas com * e espécies registradas apenas no banco de dados do acervo do National Museum of Natural History, Smithsonian Institution, Washington, DC, USA com #. NI significa espécie não identificada. Dados baseados principalmente em 2.772 indivíduos depositados em dez coleções brasileiras.

Endemic species (occurring only in the state) are indicated by * and species recorded only in National Museum of Natural History – Smithsonian Institution by #. NI means unidentified species. Data based mainly on 2772 individuals deposited in ten Brazilian collections.

Tabela 1. Continuação...

Espécies	Ocorrência em Santa Catarina
Carathis australis Rothschild, 1909	Corupá, Joinville, São Bento do Sul, Seara
Carathis byblis (Schaus, 1892)	Joinville
Castrica phalaenoides (Drury, 1773)	Joinville
Cercopimorpha dolens (Schaus, 1905)	Joinville, São Bento do Sul
Cercopimorpha postflavida (Rothschild, 1912)	São Bento do Sul
Chetone histrio Boisduval, 1890	Blumenau
Chrostosoma echemus (Cramer, 1781)	Seara
Cissura decora Walker, 1854	Blumenau, Brusque, Joinville, São Bento do Sul
Coreura fida (Hübner, 1827)	Joinville, Rio do Sul, São Bento do Sul
Coreura simsoni (Druce, 1885)	Joinville
Correbidia calopteridia (Butler, 1878)	Joinville
Correbidia elegans (Druce, 1884)	Joinville
Correbidia joinvillea Schaus 1921	Brusque, Joinville, Florianópolis
Correbidia sp. 3	São Bento do Sul
Cosmosoma annexa (Herrich-Schäffer, [1854])	Seara
Cosmosoma arpi Dognin, 1924*#	Joinville
Cosmosoma auge (Linnaeus, 1767)	Brusque, Gaspar, Joinville, Rio das Antas, São Bento do Sul, Seara
Cosmosoma centralis (Walker, 1854)	Joinville, Monte Castelo, São Bento do Sul, São Joaquim, Seara
Cosmosoma durca Schaus, 1896	Joinville, Florianópolis, Timbó
Cosmosoma elegans Butler, 1876	Joinville, Florianópolis, São Bento do Sul
Cosmosoma leuconoton Hampson, 1898	Anita Garibaldi, Joinville, Florianópolis, São Bento do Sul, Seara
Cosmosoma pellucida Lathy, 1899	Seara
Cosmosoma pheres (Cramer, 1782)	Joinville
Cosmosoma plutona Schaus, 1894	Anita Garibaldi, Florianópolis, Seara
Cosmosoma remota (Walker, 1854)	Florianópolis, Timbó
Cosmosoma subflamma (Walker, 1854)	Joinville
Cosmosoma teuthras restrictum Butler, 1876	Florianópolis
Cosmosoma xanthistis Hampson, 1898	Seara
Cratoplastis catherinae (Rothschild, 1916)	Brusque, Joinville, São Bento do Sul
Ctenucha divisa Walker, 1856	Lages, Urubici
Ctenucha jonesi Rothschild, 1912	Joinville, Rio dos Cedros, São Bento do Sul, Seara
Ctenucha mortia Schaus, 1901	Joinville
Ctenucha palmeira (Schaus, 1892)	Joinville, Florianópolis
Ctenucha vittigera (Blanchard, 1852)	Bom Jardim da Serra, São Joaquim
Cyanopepla fastuosa (Walker, 1854)	Anita Garibaldi, Joinville
Cyanopepla jucunda (Walker, 1854)	Joinville, Lages, Rio das Antas, São Bento do Sul, Timbó, Urupema
Dasysphinx torquata Druce, 1883	Joinville, Seara
Delphyre albiventus (Druce, 1898)	Joinville
Delphyre brunnea (Druce, 1898)	São Bento do Sul
Delphyre flaviceps (Druce, 1905)	Joinville
Delphyre minuta (Möschler, 1877)	Joinville
Delphyre oviplaga (Rothschild, 1933)	Joinville, Florianópolis, São Bento do Sul, Timbó
Delphyre roseiceps Dognin, 1909	Brusque
Demolis albicostata Hampson, 1901	Joinville, Timbó
Demolis albitegula (Rothschild, 1935)	Joinville, São Bento do Sul
Desmidocnemis hypochryseis Hampson, 1898	Anita Garibaldi, Joinville
Dinia eagrus (Cramer, 1779)	Barra Velha, Brusque, Joinville, Seara
Dinia mena (Hübner, 1827)	Joinville
Diptilon doeri (Schaus, 1892)	Seara
Diptilon flavipalpis Hampson, 1911	Seara
Diptilon gladia Jones, 1914	São Bento do Sul

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Tabela 1. Continuação...

Espécies	Ocorrência em Santa Catarina
Diptilon halterata (Fabricius, 1775)	Joinville
Diptilon philocles (Druce, 1896)	Seara
Diptilon telamonophorum Prittwitz, 1870	Seara
Dycladia lucetius (Stoll, 1781)	Brusque, Joinville, Praia Grande, São Bento do Sul, Seara
Dysschema amphissa (Geyer, 1832)	Jaraguá do Sul, Joinville, São Bento do Sul, Seara
Dysschema boisduvalii (van der Hoeven & de Vriese, 1840)	São Joaquim
Dysschema fantasma (Butler, 1873)	Corupá, Joinville, São Bento do Sul, Seara
Dysschema hilarina (Weymer, 1914)	Bom Jardim da Serra, Corupá, Mafra, Papanduva, São Bento do Sul, São Joaquim, Seara, Urubici
Dysschema hypoxantha Hübner, 1818	Seara
Dysschema luctuosa (Dognin, 1919)	São Joaquim, Urubici
Dysschema marginata (Guérin-Méneville, [1844])	São Bento do Sul
Dysschema neda (Klug, 1836)	Joinville, Papanduva, São Bento do Sul
Dysschema picta (Guérin-Méneville, [1844])	Brusque, Gaspar, Joinville, São Bento do Sul, Seara
Dysschema sacrifica (Hübner, [1831])	Corupá, Joinville, Rio das Antas, São Bento do Sul, Seara
Dysschema sp. 3	Seara
Dysschema sp. 5	Seara
Dysschema subapicalis (Walker, 1854)	Gaspar, Joinville, São Bento do Sul
Dysschema trapeziata (Walker, [1865])	São Joaquim
Dysschema tricolor (Sulzer, 1776)	Joinville
Echeta divisa (Herrich-Schäffer, [1855])	Joinville
Echeta juno (Schaus, 1892)	Corupá, Joinville, Florianópolis
Echeta minerva (Schaus, 1915)	Florianópolis, Seara
Elysius chimaera (Druce, 1893)	Joinville
Elysius cingulata (Walker, 1856)	Joinville, São Bento do Sul, Seara
Elysius conjunctus Rothschild, 1910	Jaraguá do Sul, São Bento do Sul
Elysius conspersus Walker, 1855	Blumenau, Joinville
Elysius meridionalis Rothschild, 1917	Joinville, Florianópolis, São Bento do Sul
Elysius ordinaria (Schaus, 1894)	Joinville, São Bento do Sul, São Joaquim
Elysius pyrosticta Hampson, 1905	Lages, São Bento do Sul, Seara, Timbó, Urubici
Epidesma crameri (Travassos, 1938)	São Bento do Sul
Epidesma parva (Rothschild, 1912)	Brusque
Epidesma ursula (Stoll, [1781])	Brusque, Joinville
Episcea extravagans Warren, 1901	Joinville, São Bento do Sul
Episcepsis endodasia Hampson, 1898	Joinville, Monte Castelo, São Bento do Sul
Episcepsis venata Butler, 1877	Florianópolis, Timbó
Erruca cardinale (Hampson, 1898)	Bom Jardim da Serra, Brusque, Joinville, São Bento do Sul
Erruca consors (Walker, 1854)	Brusque, Joinville
Erruca deyrolii Walker, 1854	Brusque, Joinville
Erruca hanga (Herrich-Schäffer, [1854])	Bom Jardim da Serra, Brusque, Canoinhas, Joinville, São Bento do Sul, São Joaquim
Erruca sanguipuncta (Druce, 1898)	Brusque, Joinville, Florianópolis, São Bento do Sul
Euagra azurea (Walker, 1854)	Brusque, Joinville, São Bento do Sul
Euagra coelestina (Cramer, 1782)	Joinville
Eucereon aeolum Hampson, 1898	Joinville
Eucereon apicalis (Walker, 1856)	Canoinhas, Joinville, São Bento do Sul, Timbó
Eucereon arenosum Butler, 1877	Taió, Timbó
Eucereon atrigutta Druce, 1905	Timbó
Eucereon chalcodon Druce, 1893	Barra Velha, Gaspar, Joinville, Porto Belo, São Bento do Sul, Timbó
Eucereon discolor Walker, 1856	Joinville
Eucereon dorsipuncta Hampson, 1905	Blumenau

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Tabela 1. Continuação...

Espécies	**Ocorrência em Santa Catarina**
Eucereon formosum Dognin, 1905	Joinville
Eucereon ladas Schaus, 1892	Joinville, Florianópolis, São Bento do Sul
Eucereon nubilosa Rothschild, 1912	Brusque, São Bento do Sul
Eucereon plumbicollum Hampson, 1898	Brusque, Joinville, Florianópolis, Timbó
Eucereon pometinum Druce, 1894	São Bento do Sul
Eucereon pseudarchias Hampson, 1898	Joinville, Florianópolis
Eucereon punctatum (Guérin, 1844)	Blumenau, Joinville, São Bento do Sul
Eucereon quadricolor (Walker, 1855)	Joinville, São Bento do Sul, Seara, Timbó
Eucereon rosa (Walker, 1854)	São Bento do Sul
Eucereon scyton (Cramer, 1777)	Joinville, Florianópolis
Eucereon sp. 3	São Bento do Sul
Eucereon striatum Druce, 1889	Joinville, Florianópolis
Eucereon tarona Hampson, 1898	Blumenau, Joinville, São Bento do Sul
Eucereon velutinum Schaus, 1896	Brusque, São Bento do Sul, Timbó
Euceriodes wernickei (Draudt, 1917)	Brusque, Joinville, Timbó
Euchaetes rizoma (Schaus, 1896)	Joinville
Euchlaenidia transcisa (Walker, 1854)	Joinville, São Bento do Sul, Seara
Eupseudosoma grandis Rothschild, 1909	Blumenau
Eupseudosoma involuta (Sepp, [1849])	Blumenau, Brusque, Joinville
Eurata helena (Herrich-Schäffer, [1855])	Florianópolis, Seara, Taió
Eurata herrichii Butler, 1876	Lages
Eurata schausi Hampson, 1898	Rio das Antas, Florianópolis, Seara, Urubici
Eurata stictibasis Hampson, 1898	Canoinhas, Lages, Rio das Antas, Florianópolis
Euthyone celenna (Schaus, 1892)	Brusque, Joinville, Timbó
Galethalea pica (Walker, 1855)	Bom Jardim da Serra, Joinville, São Bento do Sul
Graphea marmorea Schaus, 1894	Corupá, São Bento do Sul
Graphea paramarmorea Travassos, 1956	Joinville, Seara
Gymnelia laennus (Walker, 1854)	Joinville
Gymnelia xanthogastra (Perty, 1834)	Joinville, Timbó
Halysidota cinctipes Grote, [1866]	Blumenau
Halysidota cyclozonata Hampson, 1901	São Bento do Sul
Halysidota interstriata Hampson, 1901	Brusque
Halysidota pearsoni Watson, 1980	Jaraguá do Sul, São Bento do Sul
Halysidota schausi Rothschild, 1909	São Bento do Sul
Halysidota striata Jones, 1908	Bom Jardim da Serra, Santa Cecília, São Joaquim
Halysidota tessellaris (Smith, 1797)	Joinville
Halysidota underwoodi Rothschild, 1909	São Bento do Sul
Heliactinidia nigrilinea (Walker, 1856)	Brusque, Gaspar
Heliura assimilis Rothschild, 1912	Timbó
Heliura subplena (Walker, 1854)	Brusque, Gaspar, Joinville, Florianópolis, Timbó
Heterodontia haematica (Perty, 1833)	Joinville
Holophaea erharda Schaus, 1927	Seara
Homoeocera acuminata (Walker, 1856)	Anita Garibaldi, Joinville
Horama panthalon viridifusa (Schaus, 1904)	Florianópolis
Hyalarctia sericea Schaus, 1901	Seara
Hyaleucerea gigantea Druce, 1884	Taió
Hyalurga fenestrata (Walker, 1855)	Brusque, Gaspar, Joinville, São Bento do Sul
Hyalurga subnormalis Dyar, 1914	Jaraguá do Sul
Hyalurga syma (Walker, 1854)	Brusque, Joinville
Hyperandra appendiculata (Herrich-Schäffer, [1856])	Brusque, Joinville
Hypercompe brasiliensis (Oberthür, 1881)	Brusque, Timbó

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Tabela 1. Continuação...

Espécies	Ocorrência em Santa Catarina
Hypercompe cunigunda (Stoll, [1781])	Joinville, São Bento do Sul
Hypercompe jaguarina (Schaus, 1921)	São Bento do Sul, Joinville
Hypercompe kinkelini (Burmeister, 1880)	Brusque, Joinville, Rio das Antas, Florianópolis, Seara
Hypercompe laeta (Walker, 1855)	Corupá, Joinville
Hypercompe magdalenae (Oberthür, 1881)	Joinville
Hypercompe sp. 4	Lages
Hyperthaema caroei Jörgensen, 1935	Joinville, São Bento do Sul, Seara
Hyperthaema signatus (Walker, 1862)	Seara
Hypidalia enervis (Schaus, 1894)	Bom Jardim da Serra, Canoinhas, Joinville, Lages, Florianópolis, Urubici
Hypocrita bicolora (Sulzer, 1776)	Joinville, São Bento do Sul, Seara
Hyponerita ishima Schaus, 1933	Florianópolis, Timbó
Hyponerita pinon (Druce, 1911)	Joinville
Hyponerita rhodocraspis Hampson, 1909	Joinville
Ichoria chalcomedusa Druce, 1893	Florianópolis
Ichoria tricincta (Herrich-Schäffer, [1855])	Bom Jardim da Serra, Joinville, Monte Castelo, São Joaquim
Idalus admirabilis (Cramer, 1777)	Joinville
Idalus agastus Dyar, 1910	Corupá, Seara, Timbó, Urubici
Idalus albescens (Rothschild, 1909)	Seara
Idalus citrina Druce, 1890	São Bento do Sul
Idalus flavicostalis (Rothschild, 1935)	Joinville, Seara
Idalus herois Schaus, 1889	Joinville
Idalus iragorri (Dognin, 1902)	Joinville, Timbó
Idalus lineosus Walker, 1869	Joinville, Florianópolis, São Bento do Sul
Idalus metacrinis (Rothschild, 1909)	Brusque, Joinville
Idalus sp. 1	São Bento do Sul
Idalus vitrea (Cramer, 1780)	Joinville, Seara
Ilipa tengyra (Walker, 1854)	Corupá, Joinville, Florianópolis
Isanthrene incendiaria (Hübner, 1927)	Rio do Sul
Isanthrene pertexta Draudt, 1917	Florianópolis
Ischnocampa admeta Hampson, 1920	Brusque
Ischnocampa lithosioides (Rothschild, 1909)	Joinville
Ischnocampa lugubris (Schaus, 1892)	Joinville
Isia intricata Walker, 1856	Brusque, Lages, Papanduva, São Bento do Sul, Seara
Ixylasia semivitreata Hampson, 1905	Joinville, São Bento do Sul
Ixylasia trogonoides (Walker, 1864)	Joinville, Florianópolis, São Bento do Sul
Lampruna rosea Schaus, 1894	Corupá, São Bento do Sul
Lepidokirbyia vittipes (Walker, 1855)	Timbó
Lepidolutzia sp. 1	São Bento do Sul
Lepidoneiva telephus (Walker, 1854)	Brusque, Joinville, Florianópolis, Seara
Lepidozikania cinerascens (Walker, 1855)	Blumenau, Joinville, São Bento do Sul
Leucanopsis acuta (Hampson, 1901)	Brusque, Joinville
Leucanopsis athor (Schaus, 1933)	Timbó
Leucanopsis austina (Schaus, 1941)*#	Corupá
Leucanopsis biedala (Schaus, 1941)	Joinville, Timbó
Leucanopsis dallipa (Jones, 1908)	São Bento do Sul
Leucanopsis daltoni (Schaus, 1941)	Bom Jardim da Serra
Leucanopsis fuscosa (Jones, 1908)	Bom Jardim da Serra, São Joaquim
Leucanopsis jonesi (Rothschild, 1909)	São Joaquim
Leucanopsis leucanina (Felder & Rogenhofer, 1874)	Bom Jardim da Serra, Joinville, Lages, São Joaquim
Leucanopsis mandus (Herrich-Schäffer, [1855])	Bom Jardim da Serra, Monte Castelo

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Espécies	Ocorrência em Santa Catarina
Leucanopsis oruba (Schaus, 1892)	Joinville, Seara, Timbó
Leucanopsis pseudomanda (Rothschild, 1910)	Monte Castelo, São Joaquim
Leucanopsis sablona (Schaus, 1896)	Monte Castelo, Seara
Leucanopsis squalida (Herrich-Schäffer, [1855])	Joinville, Florianópolis, São Joaquim, Timbó
Leucanopsis strigulosa (Walker, 1855)	Brusque
Leucanopsis terola (Schaus, 1941)	Papanduva, Florianópolis, São Joaquim
Leucanopsis umbrosa (Hampson, 1901)	Seara
Leucotmemis emergens (Walker, 1865)	Brusque
Leucotmemis nexa (Herrich-Schäffer, [1854])	Joinville, Seara
Lophocampa arpi (Dognin, 1923)	Joinville, Seara
Lophocampa atrimaculata (Hampson, 1901)	Blumenau, Timbó
Lophocampa citrina (Sepp, [1852])	Blumenau, Brusque
Lophocampa modesta (Kirby, 1892)	Timbó
Lophocampa romoloa (Schaus, 1933)	Florianópolis
Lophocampa ronda (Jones, 1908)	São Bento do Sul, Seara
Loxophlebia brasiliensis Rothschild, 1911	Barra Velha, Joinville, Seara
Loxophlebia broteas (Schaus, 1892)*#	Joinville
Loxophlebia flavinigra Jones, 1908	Jaraguá do Sul, Seara
Loxophlebia picta (Walker, 1854)	Brusque, São Bento do Sul, Timbó
Machadoia xanthosticta (Hampson, 1901)	Bom Jardim da Serra, Canoinhas, Lages, Monte Castelo, Papanduva, Rio das Antas, São Joaquim, Seara
Mallodeta clavata (Walker, 1854)	Joinville
Mazaeras conferta Walker, 1855	Joinville, São Bento do Sul
Mazaeras francki Schaus, 1896	Bom Jardim da Serra, São Bento do Sul, São Joaquim, Seara
Mazaeras melanopyga (Walker, 1869)	Joinville
Melese babosa (Dognin, 1894)	Blumenau, Joinville, São Bento do Sul
Melese castrena Schaus, 1905	Brusque
Melese dorothea (Stoll, 1782)	Joinville
Melese hebetis Rothschild, 1909	Seara
Melese ocellata Hampson, 1901	Brusque
Melese paranensis Dognin, 1911	Seara
Melese peruviana Rothschild, 1909	Brusque, Joinville, São Bento do Sul
Mesothen catherina (Schaus, 1892)	Anita Garibaldi, Brusque, Joinville, São Bento do Sul, Timbó
Mesothen desperata (Walker, 1856)	Florianópolis
Mirandisca harpalyce (Schaus, 1892)	Joinville, São Bento do Sul, Seara
Munona iridescens Schaus, 1894	Corupá, Florianópolis, São Bento do Sul
Myrmecopsis aurifera (Klages, 1906)	Brusque
Myrmecopsis deceptans (Zerny, 1912)*	Joinville
Myrmecopsis ichneumonea (Herrich-Schäffer, [1854])	Jaraguá do Sul, Joinville
Myrmecopsis laticincta (Druce, 1884)	Jaraguá do Sul
Myrmecopsis noverca (Schaus, 1901)	Seara, Timbó
Myrmecopsis polistes (Hübner, 1827)	Joinville
Myrmecopsis rubripalpus (Hampson, 1901)	Joinville, São Bento do Sul
Nelphe confinis (Herrich-Schäffer, [1855])	Joinville, Seara
Nelphe setosa (Sepp, 1848)	Joinville
Neonerita dorsipuncta Hampson, 1901	Blumenau, Brusque, Seara, Timbó
Neotrichura nigripes (Heylaerts, 1890)	Jaraguá do Sul, Joinville, Florianópolis
Neritos repanda Walker, 1855	Joinville, São Bento do Sul, Seara
NI103	São Bento do Sul
NI106	São Bento do Sul

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Espécies	Ocorrência em Santa Catarina
NI125	Seara
NI21	Seara
NI23	Joinville
NI33	Seara
NI35	Canoinhas, Lages, São Joaquim
NI48	Joinville
NI54	São Joaquim
NI7	São Bento do Sul
NI77	São Bento do Sul
NI83	Anita Garibaldi, Joinville
NI86	São Bento do Sul
NI92	São Bento do Sul
Nyridela acroxantha (Perty, 1833)	Joinville, Florianópolis, São Bento do Sul
Nyridela chalciope (Hübner, [1827])	Brusque
Ochrodota pronapides(Druce,1894)	Brusque
Opharus basalis Walker, 1856	Brusque, Joinville, São Bento do Sul, Seara
Opharus bimaculata (Dewitz, 1877)	Florianópolis, Seara
Opharus flavimaculata Hampson, 1901	Corupá, Joinville, São Bento do Sul, Seara
Opharus notata (Schaus, 1892)	Joinville
Opharus procroides Walker, 1855	Brusque, Joinville, Seara
Opharus rema (Dognin, 1891)	Brusque, Joinville, Florianópolis, São Bento do Sul, Seara
Opharus sp. 2	São Bento do Sul
Ormetica chrysomelas (Walker, 1856)	Joinville, São Bento do Sul, São Joaquim, Seara, Timbó
Ormetica fulgurata (Butler, 1876)	Joinville, São Bento do Sul
Ormetica melea (Druce, 1900)	Joinville
Ormetica neira (Schaus, 1905)	Joinville, São Bento do Sul, Timbó
Ormetica pretiosa (Schaus, 1921)*#	Joinville
Ormetica rothschildi Watson, 1975	São Bento do Sul
Pachydota albiceps (Walker, 1856)	Brusque, Joinville
Pachydota ducasa Schaus, 1905	São Bento do Sul
Paracles affinis (Rothschild, 1910)	São Bento do Sul
Paracles bilinea (Schaus, 1901)	Joinville, São Joaquim, Seara, Timbó, Urubici
Paracles brunnea (Hübner, [1831])	Joinville
Paracles costata (Burmeister, 1878)	Bom Jardim da Serra, São Joaquim
Paracles duckinfieldia (Schaus, 1896)	Corupá
Paracles fervida (Schaus, 1901)	Brusque, Joinville
Paracles fusca (Walker, 1856)	Blumenau, Bom Jardim da Serra, Brusque, Mafra, São Bento do Sul
Paracles honora (Schaus, 1896)	Lages
Paracles paula (Schaus, 1896)	Brusque
Paracles sp. 4	Joinville
Paracles variegata (Schaus, 1896)	Bom Jardim da Serra, Joinville, Lages, Papanduva, São Joaquim, Seara, Urubici
Paraethria triseriata (Herrich-Schäffer, [1855])	Blumenau, Joinville, Florianópolis, São Bento do Sul
Pareuchaetes aurata (Butler, 1885)	Joinville, Seara
Parevia vulmaria Schaus, 1924	Brusque
Pelochyta cinerea (Walker, 1855)	Joinville, Rio das Antas, São Bento do Sul, São Joaquim, Seara, Urubici
Pelochyta pallida (Schaus, 1901)	Bom Jardim da Serra, São Bento do Sul, Timbó
Phaegoptera albimacula (Jones, 1908)	São Joaquim, Seara
Phaegoptera chorima Schaus, 1896	Corupá, Joinville, São Bento do Sul, São Joaquim, Seara
Phaegoptera depicta Herrich-Schäffer, [1855]	Brusque, Corupá, Joinville, São Bento do Sul, Seara

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Phaegoptera flavopunctata Herrich-Schäffer, [1855]	Joinville, Florianópolis, São Bento do Sul, São Joaquim
Phaegoptera granifera Schaus, 1892	Blumenau, Joinville, São Bento do Sul
Phaegoptera histrionica Herrich-Schäffer, [1853]	Brusque, São Bento do Sul, Timbó
Phaegoptera pseudocatenata Travassos, 1955	Seara
Phaegoptera punctularis Herrich-Schäffer, [1855]	Bom Jardim da Serra, Joinville, São Joaquim
Phaegoptera schaefferi Herrich-Schäffer, [1855]	Corupá, Joinville, Monte Castelo, Florianópolis, São Joaquim
Phaegoptera sp. 1	São Bento do Sul
Phaegoptera sp. 4	São Bento do Sul
Phaegoptera superba (Druce, 1911)	Joinville, Papanduva, São Bento do Sul, Timbó
Phaloe cruenta (Hübner, 1823)	Joinville, Porto Belo, Rio das Antas, São Bento do Sul, Seara
Pheia albisigna (Walker, 1854)	Brusque, São Bento do Sul
Pheia haematosticta Jones, 1908	Joinville
Philoros rubriceps (Walker, 1854)	Gaspar, Joinville, Rio das Antas, Florianópolis, São Bento do Sul, São Joaquim, Timbó
Phoenicoprocta analis Schrottky, 1909	Anita Garibaldi, Joinville, Florianópolis, Seara
Phoenicoprocta baeri (Rothschild, 1911)	Seara
Phoenicoprocta corvica (Dognin, 1910)	São Bento do Sul
Phoenicoprocta haemorrhoidalis (Fabricius, 1775)	Brusque, Joinville
Phoenicoprocta teda (Walker, 1854)	Joinville, Porto Belo, Taió
Phoenicoprocta vacillans (Walker, 1856)	Joinville
Phoeniostacta haematabasis Hampson,1898	Florianópolis, São Bento do Sul
Pionia elongata (Dognin, 1890)	Blumenau
Pionia lycoides (Walker, 1854)	Brusque, Gaspar, Joinville, São Bento do Sul, Timbó
Poecilosoma chrysis (Hübner, 1823)	Brusque, Joinville
Poliopastea indistincta (Butler, 1876)	Brusque, Joinville
Pompilopsis tarsalis (Walker, 1854)	Joinville
Pryteria unifascia (Druce,1899)	Araquari
Pseudaethria cessogae Schaus, 1924#	Joinville
Pseudohyaleucerea vulnerata (Butler, 1875)	Joinville, São Bento do Sul, Seara
Pseudomya tipulina (Hübner, 1812)	Brusque, Gaspar, Taió, Timbó
Pseudophaloe tellina (Weymer, 1895)	Seara
Pseudosphex fulvisphex (Druce, 1898)	Brusque
Psilopleura vittata (Walker, 1864)	Brusque
Ptychotricos elongatus Schaus, 1906	Florianópolis, São Bento do Sul
Ripha sp. 3	Corupá, São Bento do Sul
Rhipha subflammans (Rothschold, 1909)	Joinville, São Bento do Sul, Seara
Rhynchopyga meisteri (Berg, 1883)	Bom Jardim da Serra, Joinville, Florianópolis, São Bento do Sul, São Joaquim
Rhynchopyga sp.	Joinville
Robinsonia dewitzi Gundlach, 1881	Blumenau, Brusque, Joinville, São Bento do Sul
Robinsonia longimacula Schaus, 1915	Joinville
Romualdia elongata (Felder, 1874)	Joinville, Seara
Romualdia opharina (Schaus, 1921)	Corupá, Joinville, São Bento do Sul
Saurita attenuata Hampson, 1905	Joinville, Taió
Saurita intricata (Walker, 1854)	Joinville
Saurita nigripalpia (Hampson, 1898)	Joinville
Saurita sericea (Herrich-Schäffer, [1854])	Florianópolis, Seara
Saurita sp.	Joinville
Sauritinia dubiosa Schaus, 1905	Joinville
Scaptius pseudoprumala (Rothschild, 1935)	Joinville
Scaptius sanguistrigata (Dognin, 1910)	Timbó

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Tabela 1. Continuação...

Espécies	Ocorrência em Santa Catarina
Scaptius submarginalis (Rothschild, 1909)	Brusque
Selenarctia elissa (Schaus, 1892)	Joinville
Selenarctia elissoides (Rothschild, 1909)	Porto Belo
Selenarctia flavidorsata Watson, 1975	Brusque, Joinville, Florianópolis
Sphecosoma aenetus (Schaus, 1896)	Brusque, Joinville, Praia Grande, Florianópolis, Seara
Sphecosoma flavia (Schaus, 1898)	Florianópolis, São Bento do Sul, Seara, Timbó, Urubici
Sphecosoma melissa Schaus, 1896	Brusque, Jaraguá do Sul, Joinville, Seara, Taió
Sphecosoma testacea (Walker, 1854)	Seara
Sthenognatha gentilis Felder, 1874	Joinville, São Bento do Sul
Sutonocrea lobifer (Herrich-Schäffer, [1855])	Brusque, Joinville
Sutonocrea reducta (Walker, 1856)	Joinville, Timbó
Sychesia coccina Jordan, 1916	Brusque, São Bento do Sul, Seara
Sychesia dryas (Cramer, 1775)	São Bento do Sul
Sychesia erubescens Jordan, 1916	Joinville, Seara
Symphlebia abdominalis (Herrich-Schäffer, [1855])	São Bento do Sul
Symphlebia catenata (Schaus, 1905)	Mafra, Papanduva, São Bento do Sul, Seara
Symphlebia distincta (Rothschild, 1933)	Monte Castelo, São Bento do Sul
Symphlebia lophocampoides Felder, 1874	Joinville, Lages, Papanduva, São Joaquim, Seara
Symphlebia nigranalis (Schaus, 1915)*#	Joinville
Symphlebia perflua (Walker, 1869)	Joinville, São Bento do Sul
Symphlebia suanus (Druce, 1902)	São Bento do Sul, Urubici
Tessella sertata (Berg, 1882)	Joinville, São Bento do Sul, Seara
Tessellarctia semivaria (Walker, 1856)	Bom Jardim da Serra, Brusque, São Joaquim, Seara, Urubici
Theages leucophaea (Walker, 1855)	São Bento do Sul, Seara, Timbó
Theages xanthura Schaus, 1910	São Bento do Sul
Thysanoprymna pyrrhopyga (Walker, 1865)	Brusque, Joinville, São Bento do Sul, Urubici
Tipulodes ima Boisduval, 1832	Brusque, Joinville, Porto Belo, São Bento do Sul, Seara
Trichura cyanea Schaus, 1892	Joinville
Trichura melanosoma Hampson, 1898*	Brusque, Joinville
Tricypha imperialis (Heylaerts, 1884)	Brusque, São Bento do Sul
Tricypha nigrescens Rothschild, 1909	Gaspar, São Bento do Sul
Uranophora banghaasi (Draudt, 1915)	Blumenau, Rio dos Cedros, São Bento do Sul
Uranophora castra (Hampson, 1898)	Joinville, Lages, São Bento do Sul, São Joaquim
Uranophora sp.	Joinville
Uranophora splendida (Herrich-Schäffer, [1854])	Corupá, Joinville
Utetheisa ornatrix (Linnaeus, 1758)	Joinville, Seara
Virbia divisa (Walker, 1864)	Joinville, Rio das Antas, São Bento do Sul, São Joaquim, Seara, Urubici
Virbia medarda (Stoll, [1781])	São Joaquim
Virbia ovata Rothschild, 1910	Joinville, Monte Castelo, Seara
Viviennea ardesiaca (Rothschild, 1909)	Seara
Viviennea dolens (Druce, 1904)	Seara
Viviennea flavicincta (Herrich-Schäffer, [1855])	Corupá, Joinville, São Bento do Sul, Timbó
Viviennea moma (Schaus, 1905)	Brusque, Joinville
Viviennea salma (Druce, 1896)	Brusque, São Bento do Sul
Xanthophaeina levis (Druce, 1899)	Joinville, São Bento do Sul, Timbó
Xanthyda drucei (Kirby, 1892)	Brusque, Joinville, Florianópolis, Timbó
Lithosiini (55 espécies)	
Agylla argentea (Walker, 1863)	Seara
Agylla argentifera (Walker, 1866)	Timbó
Agylla polysemata Schaus, 1899	Timbó
Agylla separata (Schaus, 1894)	São Bento do Sul, Seara

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Tabela 1. Continuação...

Espécies	Ocorrência em Santa Catarina
Agylla sp. 1	Papanduva
Agylla sp. 11	Joinville
Agylla sp. 5	Canoinhas
Agylla subvoluta Schaus, 1905	Timbó
Apistosia judas Hübner, 1818	São Bento do Sul
Areva subfulgens (Schaus, 1896)	Brusque, São Bento do Sul, Seara
Areva trigemmis (Hübner, 1827)	Joinville
Callisthenia plicata (Butler, 1877)	Brusque
Chionosia apicalis (Zeller, 1874)	Brusque
Cisthene blanda (Jones, 1914)	Brusque, São Bento do Sul
Cisthene calochroma (Snellen, 1878)	São Joaquim
Cisthene cryptopyra (Hampson, 1903)	Timbó
Cisthene dives (Schaus, 1896)	Barra Velha, Brusque, Joinville, Seara
Cisthene endoxantha (Hampson, 1903)	Joinville, Timbó
Cisthene fasciata (Schaus, 1896)	Joinville, Lauro Muller, Monte Castelo, São Bento do Sul
Cisthene griseola (Rothschild, 1913)	Joinville
Cisthene rosacea (Schaus, 1896)	Timbó
Cisthene ruficollis (Schaus, 1896)	Joinville
Cisthene sp.	São Bento do Sul
Cisthene triplaga (Hampson, 1905)	Seara
Clemensia distincta Schaus, 1905	Brusque
Clemensia inleis Schaus, 1905	Brusque, Joinville
Clemensia marmorata (Schaus, 1896)	Brusque
Clemensia panthera (Schaus, 1896)	Brusque, Joinville
Clemensia quinqueferana (Walker, 1863)	Brusque
Diarhabdosia mandana Dyar, 1907	Brusque, Gaspar, Joinville, São Bento do Sul, Timbó
Dolichesia lignaria Rothschild, 1913	Brusque
Eudesmia ruficollis (Donovan, 1798)	Lages, Santa Cecília
Euthyone melanocera (Schaus, 1899)	Seara
Euthyone purpurea (Jones, 1914)	Lages, Urubici
Euthyone simplex (Walker, 1854)	Brusque
Lamprostola pascuala (Schaus, 1896)	Brusque
Lycomorphodes bipartita (Walker, 1866)	Seara
Lycomorphodes dichroa Dognin, 1912	Seara
Lycomorphodes strigosa (Butler, 1877)	Brusque
Lycomorphodes suspecta (Felder, 1875)	Timbó
Metallosia chrysotis Hampson, 1900	Brusque, Joinville
Metalobosia cuprea (Schaus, 1896)	Joinville, Seara
Metalobosia varda (Schaus, 1896)	Brusque
Nodozana endoxantha Jones, 1908	São Joaquim, Seara
Nodozana jucunda Jones, 1914	Barra Velha, Brusque, Timbó
Nodozana rhodosticta (Butler, 1878)	Seara
Odozana obscura (Schaus, 1896)	Brusque, Joinville
Prepiella miniola Hampson, 1900	Brusque
Pronola magniplaga Schaus, 1899	Brusque, Gaspar, Joinville, Timbó
Rhodographa phaeoplaga Schaus, 1899	Brusque
Talara barema Schaus, 1896	Brusque
Talara bombycia Schaus, 1896	Brusque
Talara ditis (Butler, 1878)	Brusque, Joinville
Talara niveata (Butler, 1878)	Brusque
Xantholopha purpurascens Schaus, 1899	São Joaquim

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O número de espécies registradas para SC representa cerca de 8% das espécies dos neotrópicos (Heppner 1991), 36% da fauna de Arctiinae registrada para o país (Ferro & Diniz 2010) e 42% da fauna registrada para a Mata Atlântica (Ferro & Melo 2011). A fauna de SC apresentou maior riqueza de espécies do que a do estado do Rio Grande do Sul (RS) (329 espécies, Ferro & Teston (2009), dados também baseados em mariposas depositados em coleções). Acreditamos que o maior número de espécies de Arctiinae em SC em relação ao RS deve-se, principalmente, a diferenças do histórico das amostragens nos dois estados (por exemplo, intensidade amostral e pesquisadores residentes nos estados). Cerca de 65% das espécies das subtribos Ctenuchina e Euchromiina amostradas em oito localidades do estado do Paraná (Marinoni & Dutra 1996) foram registradas em SC.

Oitenta e nove por cento dos indivíduos observados nas coleções brasileiras foram identificados em nível específico, 5% em nível genérico e 6% em nível de tribo. A grande maioria das espécies (89%) pertence à tribo Arctiini (Tabela 1). Essa predominância de Arctiini em relação à Lithosiini já havia sido verificada em outros trabalhos (Hilt & Fiedler 2006, Ferro & Diniz 2007, Ferro & Teston 2009, Ferro et al. 2010). Esse resultado pode ser explicado pelo fato de Arctiini ser um táxon mais diverso do que Lithosiini (Heppner 1991). Além disso, os principais taxonomistas de Arctiinae do Brasil (por exemplo, Lauro Travassos e Alfredo R. do Rego Barros) tinham como objeto de estudo as espécies de Arctiini. A explicação para esse interesse enviesado pelos Arctiini aparentemente está no fato das espécies serem maiores, mais robustas e mais conspícuas do que as de Lithosiini, despertando, assim, maior interesse dos naturalistas que coletaram lepidópteros no estado durante o século XX.

Trinta municípios do estado tiveram registro de coleta de Arctiinae (Tabela 2). Isso equivale a apenas 10% dos municípios de SC. Das quatro fitofisionomias de Mata Atlântica que ocorrem em SC, *i.e.* Floresta Ombrófila Densa, Floresta Ombrófila Mista, Floresta Estacional Decidual e Estepe (Fundação... & Instituto... 2011), a grande maioria dos municípios registrados em nosso estudo (29) estão situados em áreas de floresta ombrófila mista e de floresta ombrófila densa (Tabela 2). Apenas um município situado em área de estepe teve registro de coleta de Arctiinae e nenhum registro foi observado em área de floresta estacional decidual (Tabela 2). O número de registros de espécies por município variou de 1 a 274 espécies. De acordo com o material depositado nas coleções visitadas, o município com maior número de registros de espécies foi Joinville, seguido de São Bento do Sul (162), Seara (129) e Brusque (114) (Tabela 2).

Tabela 2. Coordenadas geográficas, altitude (m), tipo de vegetação, número de ocasiões amostrais, de espécies e de indivíduos coletados em cada uma das 30 municípios do estado de Santa Catarina que apresentaram registro de coleta de Arctiinae.

Table 2. Geographic coordinates, altitude (m), vegetation type, number of sampling occasions, species, and individuals sampled in each of the 30 municipalities of Santa Catarina State.

Localidade	Coordenadas	Altitude	Vegetação	Ocasiões amostrais	Espécies	Indivíduos
Anita Garibaldi	27° 41’ 20” S e 51° 07’ 48” W	885	Floresta ombrófila mista	1	14	27
Araquari	26° 22’ 12” S e 48° 43’ 19” W	9	Floresta ombrófila densa	1	1	1
Barra Velha	26° 37’ 55” S e 48° 41’ 02” W	35	Floresta ombrófila densa	2	6	9
Blumenau	26° 55’ 08” S e 49° 03’ 58” W	21	Floresta ombrófila densa	12	21	24
Bom Jardim da Serra	28° 20’ 10” S e 49° 37’ 26” W	1.245	Floresta ombrófila mista	4	22	118
Brusque	27° 05’ 53” S e 48° 55’ 01” W	36	Floresta ombrófila densa	31	114	330
Canoinhas	26° 10’ 37” S e 50° 23’ 24” W	839	Floresta ombrófila mista	3	7	10
Corupá	26° 25’ 30” S e 49° 14’ 35” W	75	Floresta ombrófila densa	6	21	29
Florianópolis	27° 35’ 46” S e 48° 32’ 56” W	3	Floresta ombrófila densa	5	60	111
Gaspar	26° 55’ 52” S e 48° 57’ 29” W	18	Floresta ombrófila densa	2	14	17
Jaraguá do Sul	26° 17’ 28” S e 49° 02’ 24” W	29	Floresta ombrófila densa	8	12	12
Joinville	26° 18’ 14” S e 48° 50’ 42” W	3	Floresta ombrófila densa	42	274	793
Lages	27° 48’ 58” S e 50° 19’ 34” W	884	Estepe	7	18	23
Lauro Muller	28° 23’ 31” S e 49° 23’ 46” W	220	Floresta ombrófila mista	2	2	3
Mafra	26° 06’ 40” S e 49° 48’ 18” W	793	Floresta ombrófila mista	2	3	3
Monte Castelo	26° 27’ 43” S e 50° 13’ 52” W	820	Floresta ombrófila mista	1	13	23
Papanduva	26° 22’ 12” S e 50° 08’ 38” W	788	Floresta ombrófila mista	5	10	14
Porto Belo	27° 09’ 25” S e 48° 33’ 11” W	1	Floresta ombrófila densa	7	6	6
Praia Grande	29° 11’ 46” S e 49° 57’ 01” W	45	Floresta ombrófila densa	1	2	2
Rio das Antas	26° 53’ 53” S e 51° 04’ 26” W	830	Floresta ombrófila mista	2	12	46
Rio do Sul	27° 12’ 50” S e 49° 38’ 35” W	341	Floresta ombrófila mista	2	2	2
Rio dos Cedros	26° 44’ 17” S e 49° 16’ 26” W	85	Floresta ombrófila densa	4	3	4
Santa Cecília	26° 57’ 36” S e 50° 25’ 34” W	1.100	Floresta ombrófila mista	2	3	5
São Bento do Sul	26° 15’ 02” S e 49° 22’ 41” W	838	Floresta ombrófila mista	70	162	458
São Joaquim	28° 17’ 35” S e 49° 55’ 52” W	1.353	Floresta ombrófila mista	10	41	115
Seara	27° 08’ 56” S e 52° 18’ 36” W	550	Floresta ombrófila mista	86	129	472
Taió	27° 06’ 58” S e 49° 59’ 53” W	359	Floresta ombrófila densa	1	7	9
Timbó	26° 49’ 23” S e 49° 16’ 16” W	68	Floresta ombrófila densa	15	67	91
Urubici	28° 00’ 54” S e 49° 35’ 28” W	915	Floresta ombrófila mista	5	17	19
Urupema	27° 57’ 07” S e 49° 52’ 23” W	1.350	Floresta ombrófila densa	1	1	2

O estado apresentou sete espécies (1,4%) endêmicas, das quais seis ocorreram em Joinville (Tabela 1). As espécies mais comumente encontradas no estado foram *Dysschema hilarina* (Weymer, 1914), *Machadoia xanthosticta* (Hampson, 1901) (presentes em oito municípios), *Philoros rubriceps* (Walker, 1854) e *Paracles variegata* (Schaus, 1896) (presentes em sete municípios) (Tabela 1). *D. hilarina* também foi frequente no RS (Ferro & Teston 2009).

Duzentos e vinte sete espécies (45,5%) foram registradas em apenas uma localidade (Tabela 1). Esse resultado indica que o esforço de coleta em SC ainda é baixo e que muitas espécies ainda podem ser descobertas no estado. A proporção de espécies raras em SC, definidas como aquelas com ocorrência em apenas um município, foi maior do que a encontrada no RS (33%, Ferro & Teston 2009) e na Mata Atlântica brasileira (25%, Ferro & Melo 2011).

Do levantamento realizado nas coleções brasileiras, foram totalizadas 340 ocasiões de coleta de Arctiinae em SC (Tabela 2). As coletas foram mais intensas nas décadas de 1950 e 1970. Apenas 15 ocasiões de coleta foram realizadas no século XXI.

Santos et al. (2008) indicaram que o estado de SC possui uma prioridade baixa para a realização de inventários de borboletas no Brasil. Contudo, isso não se aplica para o táxon investigado em nosso estudo. O estado está consideravelmente subamostrado com relação às mariposas Arctiinae. Isso pode ser verificado pela alta porcentagem de espécies raras, pelo baixo número de municípios e pelo baixo número de ocasiões amostrais em cada um deles, pela inexistência de coletas em áreas de floresta estacional decidual, pela escassez de amostragens realizadas nesse século e pela falta de trabalhos publicados com Arctiinae no estado, fato também ressaltado por Carneiro et al. (2008) para borboletas. É urgente investir em amostragens em novos municípios do estado, principalmente em áreas de floresta estacional decidual e de estepe, e reamostrar nos municípios com baixo esforço amostral, além de investir em pesquisa básica e na formação de pessoal para dar continuidade aos levantamentos faunísticos.

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Occurrence of thrushes in an urban fragment of Araucaria forest in southern Brazil

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Abstract: Seasonal segregation among syntopic species can be viewed as one of the available strategies for coexistence, reducing competitive process. The present work therefore aimed to interpret the assemblage structures comprising birds of the genus *Turdus* (Turdidae), through the analysis of seasonal variation in the species occurrence in a forest remnant located in the southcenter State of Paraná. Mist-netting was employed twice a month for capturing birds, totalling an annual effort of 7488 h.m^2. The frequency of occurrence, constancy and class of species dominance was determined, together with the parameters generally used in studies of ecological communities (richness, abundance, diversity and evenness). A total of 162 individuals were captured, representing five species. *Turdus rufiventris* was the most constant and frequent species. *Turdus amaurochalinus* and *Turdus leucomelas* were captured with variable constancies and frequencies along the seasons. *Turdus amaurochalinus* was also very common and may present an overlapping process between migrant and non-migrant individuals during spring. *Turdus albicolis* was considered accessory, whereas *Turdus subalaris* was only registered during the reproductive period. Hence, it was possible to observe that seasonal modifications occurred both in the frequency of occurrence and in the constancy and dominance of species. These results indicated the possibility of a lower use of the environment during the breeding season, as well as the presence of a higher number of individuals in summer and increased abundance of *Turdus rufiventris* and *T. leucomelas* during autumn and winter.
Keywords: *passeriformes, seasonal segregation, Turdidae, Turdus.*

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Resumo: Segregações sazonais entre espécies sintópicas podem ser interpretadas como táticas utilizadas para a coexistência, diminuindo processos competitivos. Neste contexto, o presente trabalho buscou interpretar a estrutura da assembléia formada por aves do gênero *Turdus* (Turdidae) para averiguar a possibilidade de padrões distintos de ocorrência em função da variação sazonal em um fragmento florestal situado no Centro-sul do Estado do Paraná. Foram utilizadas redes ornitológicas para a captura das aves, com um esforço amostral anual de 7488 h.m^2. Por meio das capturas quinzenais foi possível a obtenção do índice de frequência de ocorrência, constância e classes de dominância das espécies, bem como, de parâmetros ecológicos utilizados em estudos de comunidades. Um total de 162 indivíduos pertencentes a cinco espécies foram capturados. *Turdus rufiventris* foi a espécie mais frequente e constante durante o estudo. *Turdus amaurochalinus* e *T. leucomelas* foram capturadas com frequências e constâncias variáveis entre as estações do ano, sendo que, para *T. amaurochalinus* houve evidências de sobreposição de populações migrantes e não migrantes durante a primavera. *Turdus albicollis* foi considerada acessória, enquanto *T. subalaris* foi registrada somente durante a temporada reprodutiva. Desta forma, foi possível observar que ocorrem modificações sazonais, tanto na frequência de ocorrência, quanto na constância e dominância das espécies. Tais resultados indicam a possibilidade de menor intensidade do uso do ambiente durante o período reprodutivo, assim como a presença de um maior número de espécies no verão e aumento da abundância de *T. rufiventris* e *T. leucomelas* durante o outono e inverno.
Palavras-chave: *passeriformes, segregação sazonal, Turdidae, Turdus.*

Introduction

The Turdidae family occurs worldwide, representing 162 species (Clement 2000). In this family, the genus *Turdus* is prominent as a passerine group with a higher level of species richness, with 65 to 70 species (Clement 2000, Voelker et al. 2007). In Brazil, 17 thrush species are currently recorded among three genera: *Cichlopsis* (one species), *Catharus* (three) and *Turdus* (13), according to Clement (2000), Collar (2005) and CBRO (Comitê... 2011).

In Brazil, although studies focusing on *Turdus* species are not incipient, the issue is still seldom explored (Vogel 2012). Many studies aimed to establish the natural history parameters of species and we can cite studies concerning aspects of migration *e.g. Turdus subalaris* (Seebohm, 1887) (Alves 2007) and occurrence patterns of *T. amaurochalinus* Cabanis, 1851 (Capllonch et al. 2008). More recently, there are works highlighting some predation aspects of *T. rufiventris* Vieillot, 1818 (Leite et al. 2010) and feeding habits of *T. leucomelas* Vieillot, 1818 (Sazima & D'Angelo 2011). In the field of parasitology there have been contributions, such as some studies involving mites (Storni et al. 2005) and plumicolous insects (Enout et al. 2009) associated with *T. albicollis* Vieillot, 1818 and *T. leucomelas*, respectively.

Studies on interactions that allow the coexistence of turdid species have been conducted by Gasperin & Pizo (2009) and Vogel et al. (2011a). These studies suggest a high level of overlap in the feeding habit of these species, which may enhance competition processes. Alves (2007), evaluating the research of Maia-Gouvêa et al. (2005), suggests that there is a segregation pattern among the nine syntopic species of Turdidae recorded at Parque Nacional de Itatiaia, in Rio de Janeiro. They note that nesting of *Turdus flavipes* (Vieillot, 1818) was limited to vegetation on slopes between 800 and 1800 m above sea level, whereas *T. leucomelas* and *T. amaurochalinus* were registered from 400 to 1200 m. This observation provides evidence of an altitudinal segregation among species that nest locally.

Additionally, Maia-Gouvêa et al. (op. cit.) observe segregation in the abundance of *T. albicollis* between the dry and rainy seasons, providing evidence that, in addition to the known altitudinal migrations of the group (Clement 2000, Alves 2007, Capllonch et al. 2008), there are also processes of seasonal segregation occurring in the occupational structure of the environment for such assemblages. Cody (1974) suggests that temporal segregation is a strategy for niche partitioning, decreasing direct competition for the environmental resources, and therefore enabling coexistence.

Research dealing with the Turdidae family has shown a tendency for the substitution of natural landscapes by agricultural fields (Burfield & Brooke 2005), nest predation and environmental effects on reproductive success (Kurucz 2010, Robinson et al. 2010). However, to achieve better conclusions from surveys focusing on such parameters it is necessary to have a thorough understanding of basic aspects of the species' ecology. Such information, in the Brazilian scenario, is still scarce, local and little discussed. Therefore, studies dealing with the seasonal dynamic occurrence of the species are also important as a trigger to future research.

In this context, the purpose of the present study was to evaluate whether the thrush species occurring in the same habitat vary seasonally in abundance, constancy and frequency of occurrence. If variations in these parameters are encountered, this provides indications of alternative usage of the environment that can be related to strategies for reducing competition.

Materials and Methods

1. *Study area*

The Parque Municipal das Araucárias (PMA) is located in the city of Guarapuava, state of Paraná, ≈ 25° 21' S and 51° 28' W. It is an area of environmental protection, according to the municipal law number 198/91, dated June 5th 1981 (Cordeiro & Rodrigues 2007). It comprises 104 ha, including 41 ha of Araucaria moist forest (Figure 1).

The park surrouding area is composed by an agricultural area in the north and by an urban area in the south. The regional climate is under the influence of the extratropical zone, resulting in temperatures of mesothermic type (Maack 1981). The annual average temperature is about 17 °C, with cold winters and moderated summers due to the altitude, and annual average evaporation is about 850 mm (Thomaz & Vestena 2003). Rainfall is evenly distributed throughout the year (mean annual rainfall is close to 2000 mm), without a dry season (Thomaz & Vestena 2003). The rainiest month is January and the driest month is August (Maack 1981). The mean altitude in the PMA is 1,040 m. The mean temperature of the hottest months (summer) is about 25°C, with 10 to 20 frosts occurring during winter (Maack 1981).

According to Cordeiro & Rodrigues (2007), five plant species (*Araucaria angustifolia* (Bertol.) Kuntze, *Campomanesia xanthocarpa* Berg., *Casearia decandra* Jacq., *Capsicodendron dinisii* Schwanke and *Allophylus edulis* (St. Hil.) Radlk), together comprise a phytosociological index of importance value of 65% in the structure of the forest remnant. Exotic species within the local flora are also present, representing 12% of the arboreal species richness. Among the species with zoocoric potential are *Hovenia dulcis* Thunberg and *Ligustrum lucidum* W. T. Wait.

2. *Fieldwork*

The study was performed from December 2008 to November 2009. In order to investigate the structure of the assemblages, surveys on the understorey were performed using mist nets. We used six nets (three of 35 mm mesh and another three of 20 mm mesh), each 6.0 m long by 3.0 m high, arranged from 50 to 150 cm above ground level. During implementation of the pilot project, the complete randomization of the network was found to be inefficient for the capture of specimens. Thus, the net sites were chosen after analysis on the day preceding each survey, with locations where the highest activity of the studied species being selected in order to maximize captures. The captures took into account the need to sample both edges and interior environments. The nets were opened at 07:00 and remained open until sunset. The nets were checked each 30 minutes. The field effort comprised four days sampling per month, with a duration of 12 hours per day (48 hours per month), totalling 3456 h/net/year in a sampling effort of 7488 h.m^2, calculated from Straube & Bianconi (2002). The captured individuals were banded with numbered metal rings supplied by CEMAVE (*Centro Nacional de Pesquisa e Conservação de Aves Silvestres*).

3. *Data analysis*

The Shannon–Wiener index was applied to obtain the diversity values for the structural analysis of the assemblages among the seasons. This index is suitable for irregular sampling, which was used because the intervals between samples were not always equal, due to bad weather conditions.

Dominance and equitability indexes were also used. The Berger-Parker index was used to estimate dominance. Pielou's equitability was used because samplings were undertaken in the same place. Additional estimations were performed based on the similarity of seasons through the Bray–Curtis index and proportional capturability for 1.000 h.m^2. Calculations of ecological indexes were performed with recaptures that occurred in different seasons only.

The species dominance classes were calculated based on Palissa et al. (1977), $D\% = (i/t) \times 100$, where i = total number of individuals of a species, and *t* = total of sampled individuals, being: *D* = > 10% Eudominant; *D* = > 5 ⊦ 10% Dominant; *D* = > 2 ⊦ 5% Subdominant; *D* = 1 ⊦ 2% Recessive; and *D* = < 1% Rare. This index was applied to the annual results in order to establish the type of dominance of a species along the sampling year. This calculation did not take recaptures into account.

Constancy was found with the index $C = p \times 100/N$ according to Gimenes & Anjos (2000), where *p* is the number of surveys containing the analysed species and *N* the total number of surveys. The following grouping categories were proposed: *C* = > 50% Constant; *C* = 25 ⊦ 50% Accessory; and *C* = < 25 Accidental. This index was applied both for each season and annually in order to diagnose a possible shift in the species occurrence along the seasons.

Results

A total of 162 specimens were captured and 13 were recaptured during the study, totalling 175 captures. *Turdus rufiventris* accounted for 57 captures and four recaptures. *Turdus leucomelas* (n = 51) totalled eight recaptures. Of the eight specimens of *T. albicollis*, there was only one recapture. Specimens of *T. amaurochalinus* and *T. subalaris* were not recaptured from a total of 42 and four specimens, respectively (Table 1). The annual variation in abundance of species showed that *T. amaurochalinus*, *T. leucomelas* and *T. rufiventris* are present throughout the year, with an increase in abundance during autumn and winter (Figure 2).

Concerning the abundance of species among seasons, there was a considerable similarity in the thrush assemblages between autumn and winter (0.93), while the lowest similarity was observed between autumn and spring (0.51). Summer and autumn and spring and summer seasons presented similarities of 0.60 and 0.63, respectively. The data summary is shown in Table 2. The highest diversity (*H'* = 1.32) was found in summer for five species, while the lowest occurred in spring (*H'* = 0.96), with three species. A high equitability was observed in winter (*j'* = 0.90) and major dominance of *T. amaurochallinus* was identified in spring (0.55), representing a total of 162 captures in a year (not taking into account recaptured

Table 1. Total of thrush captures and recaptures in the Parque Municipal das Araucárias, southern Brazil.

Tabela 1. Total de capturas e recapturas de turdídeos no Parque Municipal das Araucárias, Sul do Brasil.

Species	**Total per year**	**Recaptured**	**Capture rate**
	N	***N***	**Birds/1000 h.m^2**
Turdus rufiventris	57	4	7.61
Turdus leucomelas	51	8	6.81
Turdus amaurochalinus	42	0	5.60
Turdus albicollis	8	1	1.06
Turdus subalaris	4	0	0.53

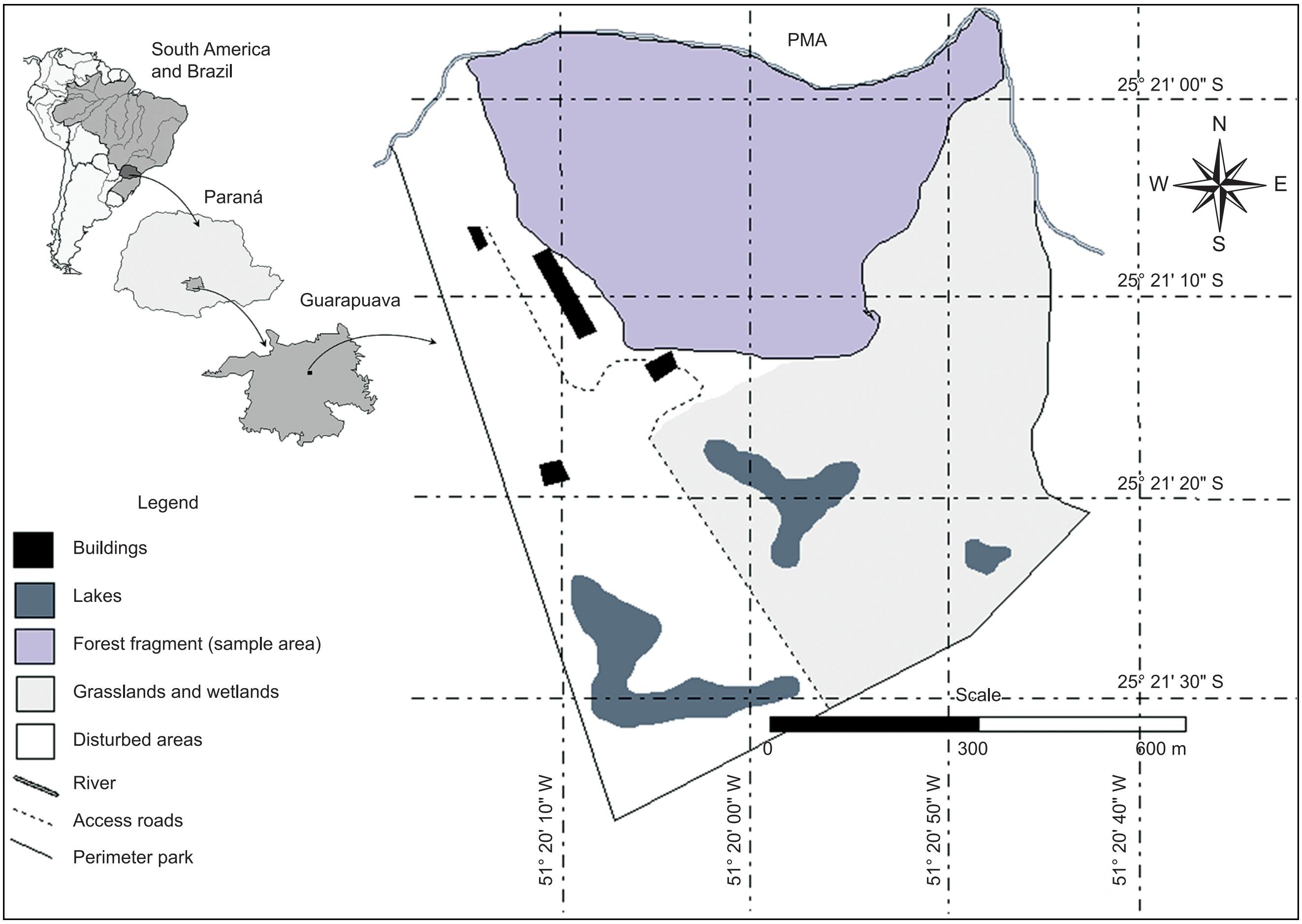

Figure 1. Location of the Parque Municipal das Araucárias in the municipality of Guarapuava, Southern Brazil.

Figura 1. Localização do Parque Municipal das Araucárias no Município de Guarapuava, Sul do Brasil.

species in different seasons), and 175 when recaptures were taken into account.

Data shown in Table 3 suggest that *Turdus rufiventris* was constant throughout the four sampled seasons, being more frequent in winter (*C* = 75.0%). *Turdus leucomelas* was considered accessory during summer and accidental in spring, being constant in the remaining seasons. *Turdus amaurochalinus* was accessory only in summer, but constant in the remaining seasons with a relative increase in spring in comparison to the remaining seasons (*C* = 84.6%). In its turn, *T. albicollis* was taken as accessory (*C* = 30.4%) only in winter, being accidental in summer and autumn and not occurring in spring. Finally, *T. subalaris* was accidental in summer and autumn and did not occur in the remaining seasons.

Table 2. Ecological indices related to the samplings performed at the Parque Municipal das Araucárias, southern Brazil.

Tabela 2. Índices ecológicos relacionados com as amostragens realizadas no Parque Municipal das Araucárias, Sul do Brasil.

Indexes	Seasons			
	Summer	Autumn	Winter	Spring
Richness	5	5	4	3
Individuals	28	61	57	29
Diversity *H*'	1.32	1.31	1.24	0.96
Evenness *J*'	0.82	0.81	0.90	0.87
Dominance	0.50	0.40	0.38	0.55

Discussion

The Turdidae family is commonly found in urban areas in southern Brazil (Gasperin & Pizo 2009). More specific studies also demonstrate that the genus *Turdus* is commonly captured using mist nets, as in Efe et al. (2007), which found a higher abundance of *T. rufiventris*. However, Gasperin & Pizo (2009) stated that the second most abundant *Turdus* species was *T. amaurochalinus*, differing from the present study that indicated *T. rufiventris* in the first place and *T. leucomelas* in the second place, what shows that the most abundant species positions must reflect local conditions more than the higher geographical scale.

In the survey performed at the Parque Municipal das Araucárias the highest similarity index was found between autumn and winter (0.93), which may be related to the fructification in this period of the exotic species *Ligustrum lucidum*, a frequent food resource for birds. Scheibler & Melo-Junior (2003) note that *L. lucidum* is often utilized as food by thrushes during winter. It is thus postulated that these species were more dependent on this resource in milder periods, resulting in a higher assemblages similarity between autumn and winter.

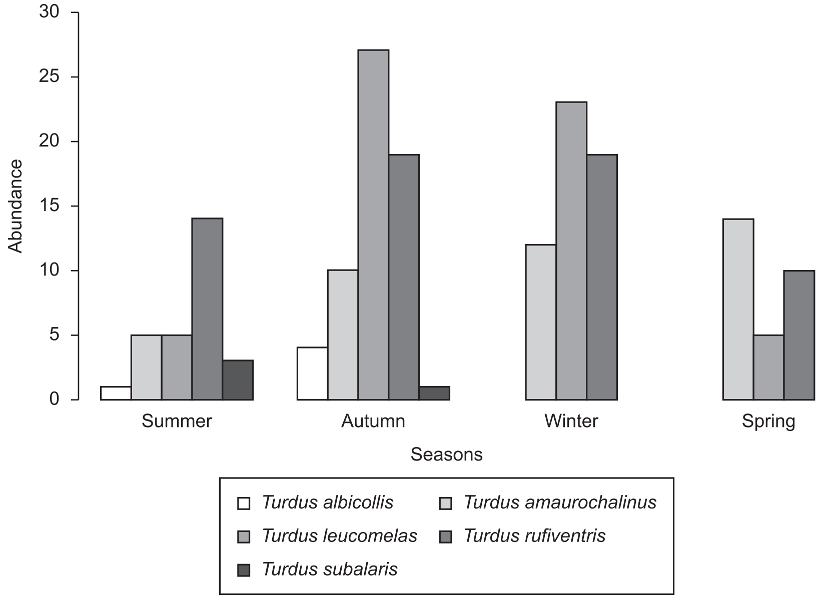

Figure 2. Seasonal variation in abundance of five *Turdus* species in the Parque Municipal das Araucárias, southern Brazil.

Figura 2. Variação sazonal na abundância de cinco espécies de *Turdus* no Parque Municipal das Araucárias, Sul do Brasil.

Table 3. Constancy (*C*) and dominance (*D*) of five *Turdus* species at the Parque Municipal das Araucárias, southern Brazil.

Tabela 3. Constância (*C*) e dominância (*D*) de cinco espécies de turdídeos no Parque Municipal das Araucárias, Sul do Brasil.

Species	Seasonal constancy (*C*%)				Total overall	
	Summer	Autumn	Winter	Spring	(*C*%)	(*D*%)
Turdus rufiventris	53.80	75.00	84.60	53.80	66.60	35.18
Turdus leucomelas	30.40	91.60	76.90	23.00	54.90	31.48
Turdus amaurochalinus	38.40	50.00	53.80	84.60	56.80	25.93
Turdus albicollis	7.60	1.60	30.40	0.00	13.70	4.94
Turdus subalaris	1.50	1.60	0.00	0.00	7.80	2.47

Diversity in summer was higher (*H'* = 1.32) due to the presence of *Turdus subalaris*. This species occurred exclusively in summer and in early autumn (a single individual in the last season). According to Antas & Valle (1987), this species breeds in southern South America and uses the southern border of the Amazon as wintering areas. Alves (2007) suggests that there should be a lack of fidelity to return areas by *T. subalaris*, which might explain why the species, which occurred in summer 2008, was not sampled in spring 2009, despite it being concomitantly visually registered in neighbouring areas.

Turdus albicollis, which presented constancy values of 7.6% in summer and 1.6% in autumn, showed a relative increase in occurrence frequency during winter (30.4%), becoming an accessory species. This bird is considered sensitive to processes of forest fragmentation (Sick 1997, Collar 2005, Gasperin & Pizo 2009) and its presence may indicate the capacity of this forest fragment to support small populations of this bird. In the present study, *T. albicollis* was more frequent than reported by Lopes & Anjos (2007), who reported its presence only in winter at the campus of Universidade Estadual de Londrina (northern state of Paraná).

Turdus rufiventris is considered a common species in studies in the vicinity of the study area (Vogel et al. 2011b). The species, as expected, was constant throughout the study due to its non-migratory behaviour, as described by Sick (1997) and Collar (2005). Its annual constancy (*C* = 66.6%) establishes its resident status. In the present study, despite the few recaptures of *T. rufiventris* at PMA, it was found to be constant throughout two seasons (autumn and spring), which infers the permanence of at least some individuals throughout the breeding and non-breeding periods. Ludvig et al. (1994) verify that adults of *Turdus merula* (Linnaeus, 1758) in an urban park in Budapest (Hungry) stayed or returned to the studied fragment in spring. That work described how in the spring season pairs presented a more evident agonistic defensive behaviour, displaying the territorial pattern for the genus. Lomáscolo et al. (2010) demonstrate that *T. rufiventris*, although tolerant to altered habitats, suffers high nest predation in relation to natural areas, which is compensated by choosing safer microhabitats for nest building. Therefore, these data emphasize the importance of urban fragments in the maintenance of some anthropophilic bird species. Despite the majority of bird species inhabiting urban environments having characteristics that allow them to use such unnatural habitats, small fragments are, for example, as important as nocturnal shelters (Lomáscolo et al. 2010).

The decrease in the constancy of *Turdus leucomelas* in spring and summer could be related to factors emphasized by Alves (2007) as a means of intraspecific spatial segregation during breeding periods, as it coincides with the pattern described for the south region of Brazil (Sick 1997). Additionally, in this period, sexual activity in the field was also verified. Cohen & Lindell (2004) observed that specimens of *Turdus assimilis* Cabanis, 1850, commonly return with their offspring to the forests immediately after breeding in adjacent areas, providing evidence for the employment of a distinct habitat during the breeding season. In the same way, many individuals of *T. leucomelas* are perhaps using urban environments for reproduction, as verified in the field, and returning to PMA in the autumn and winter for feeding.

On the other hand, the increase in the frequency of occurrence of *Turdus amaurochalinus* in spring can be seen as an overlapping of migrant individuals over resident individuals. Such a phenomenon is cited by Sick (1997) because not all individuals migrate. This observation is similar to results of a study conducted by Capllonch et al. (2008). They observe that, in the preferred breeding habitat in areas of Argentina, there is an overlap of migrant thrushes over local resident specimens from September to October. Gonzaga et al. (2000) mention capturing the species in Maricá Restinga in Rio de Janeiro between April and July. Alves (2007) reports two samples in two periods of the year in the Cerrado near to Brasília city (Central Brazil) in May and between August and October. Although *T. amaurochalinus* has been frequent in the sampled forest fragment, its occurrence at the site should be related to temporary use, resting, or simply as shelter during displacements through the landscape, since the species is common in open habitats (Ridgely & Tudor 2001).

The pattern of occurrence found for the thrush assemblages that comprises the site shows that *T. subalaris* is the less abundant species and only occurs in summer and early autumn, an occurrence pattern that, according to Clement (2000), is coincident with the breeding season. In theory, such an occurrence could be related to the period, given its increased average temperatures in southern Paraná State (Maack 1981). Such heating periods culminate in increased food resources (*e.g.* insects and fruits), favouring the occurrence of breeding sites for this species (Sick 1997). The abundance of resources reduces competition pressure and allows species to coexist (Putman 1996). However, with dwindling resources, the optimum tactic is to make seasonal movements in search of better environmental conditions (Alves 2007). The species included in this study are perceived to be very similar, both morphologically and functionally (Sick 1997), mainly in terms of trophic guilds (Clement 2000, Gasperin & Pizo 2009). The morphological proximity among the species can provide a convergence in habitat occupation and therefore a niche overlap (Cody 1974, Putman 1996). According to Vogel et al. (2011a) there is some possibility of competitive edge between *T. rufiventris* and *T. leucomelas* due to the higher trophic niche breadth of *T. rufiventris*. Therefore, studies taking into account the sharing of breeding sites are essential to explain the dynamics of species abundance throughout the seasons.

As noted by Remsen Junior & Good (1996), many studies have failed to consider any attempt to correct the deviations caused by the several factors that influence the capture of birds. Among these factors are changes in the seasonal activity patterns of birds (Malizia 2001), in daily environmental parameters (Mallet-Rodrigues & Noronha 2003), and in the habitat type and size (Lövei et al. 2001). However, due to morphological similarities among these species and similar behavioural habits, it is reasonable to infer that our estimates could function as a parameter between catch rates and abundance of species (Table 1). Nonetheless, due to the relatively low quantity of available data, this conclusion need to be treated with caution.

In summary, thrush assemblages at PMA is dynamic, variable and possibly related to seasonal factors, once the variation in constancy and abundance values of species along seasons are taken into account. A monitoring study could confirm this pattern, since the rate of capture is a complex index. *Turdus rufiventris* was the most constant and abundant species in this study. *Turdus leucomelas* presented patterns of decrease in its occurrence frequency in the spring samplings, possibly indicating a local population reduction as individuals search for specific areas for nidification. The occurrence patterns of *T. albicollis* at PMA might be associated with altitudinal displacement movements, a phenomenon already referred to in relation to the congeneric species. In turn, for *T. amaurochalinus* the occurrence of an overlap of migrant individuals or populations over the resident ones is possible, and the occurrence of *T. subalaris* was only observed during its migratory passage in summer. Although not the ultimate aim of this paper, we agree with the works of Galina & Gimenes (2006) and Catian & Aranda (2009), who draw attention to the relevance of urban–forested ecosystems in the maintenance of several bird species. There is a frequent use of these habitats not only by the resident species but also by migratory birds which use the sites as resting areas when in migration, obtaining food, shelter and reproductive sites.

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