

# The Muscidae (Diptera) from the Atlantic Forest of Serra de Paranapiacaba, southeastern Brazil

Silvio Shigueo Nihei<sup>1,3</sup>; Anderson Tatsuki Tamakoshi<sup>1,4</sup>; Priscylla Moll<sup>1,5</sup> & Rodrigo Ferreira Krüger<sup>2,6</sup>

<sup>1</sup> Universidade de São Paulo (USP), Instituto de Biociências (IB-USP), Departamento de Zoologia. São Paulo, SP, Brasil.

<sup>2</sup> Universidade Federal de Pelotas (UFPEL), Instituto de Biologia (IB), Departamento de Microbiologia e Parasitologia (DEMP). Pelotas, RS, Brasil.

<sup>3</sup> ORCID: <http://orcid.org/0000-0002-6887-6282>. E-mail: [silvionihei@gmail.com](mailto:silvionihei@gmail.com)

<sup>4</sup> ORCID: <http://orcid.org/0000-0003-3954-1018>. E-mail: [anderson.tamakoshi@gmail.com](mailto:anderson.tamakoshi@gmail.com)

<sup>5</sup> ORCID: <http://orcid.org/0000-0002-0226-7732>. E-mail: [pmoll.bio@gmail.com](mailto:pmoll.bio@gmail.com)

<sup>6</sup> ORCID: <http://orcid.org/0000-0003-1040-8299>. E-mail: [rfrkruger@gmail.com](mailto:rfrkruger@gmail.com)

**Abstract.** A first survey of Muscidae in the State of São Paulo (Southeastern Brazil) is presented here with a one-year of Malaise trap collecting from August 2010 to July 2011 at the Biological Reserve Alto da Serra de Paranapiacaba (23°46'00"-23°47'10"S, 46°18'20"-46°20'40"W, 750-891 m of altitude). A total of 1,284 individuals of muscids were collected, and 15 genera and 39 species of Muscidae were identified. So far, only one muscid species had been recorded to the Reserve, which now has its Muscidae diversity increased to 40 species. Thirteen species are new records for the State of São Paulo. With this, the number of species of Muscidae species known to occur in the State of São Paulo is increased to 169. The interval between November and February was higher in number of individuals and number of species. Muscidae presented a seasonal pattern, with more abundance and diversity in that interval. The study area is covered by secondary forest and very close to São Paulo metropolitan area, and the composition of the fauna of Muscidae signalizes this environment changing and anthropic stress with nine species with synanthropic habits, two of them are typically synanthropic species.

**Keywords.** Diversity; Inventory; Neotropical region; Seasonality; State of São Paulo; Survey.

## INTRODUCTION

The family Muscidae is worldwide distributed and include about 5,200 described species in 187 genera (Pape *et al.*, 2011). In the Neotropical Region there are over 800 species and 85 genera (Couri & Carvalho, 2005). The family is greatly abundant in all continents, occurring in most oceanic islands, and also in the Arctic and regions of tundra vegetation (Huckett & Vockeroth, 1987). Muscid flies have diverse feeding habits, including predators, phytophagous, saprophagous, anthophilous, parasites and haematophagous (Couri, 1999; Savage & Vockeroth, 2010; Carvalho *et al.*, 2012).

There are a number of studies with inventory of Diptera in the Neotropics (*e.g.*, Carvalho & Couri, 1991; Couri *et al.*, 2000; Pamplona *et al.*, 2000; Krüger *et al.*, 2010; Borkent *et al.*, 2018; Zafalon-Silva *et al.*, 2018), on the other hand, several studies focused on groups with agricultural or forensic importance (*e.g.*, Ferraz *et al.*, 2009; Mulieri *et al.*, 2011; Garcia *et al.*, 2003; Cavallari *et al.*, 2015; Carvalho *et al.*, 2017; Olea *et al.*, 2017). With regard to Muscidae, there are a number of inventories in Brazil, but unbalanced between

the different Brazilian biomes and states. For example, while there is a voluminous literature on Muscidae for the States of Paraná and Rio de Janeiro (*e.g.*, Carvalho *et al.*, 1984; D'Almeida, 1991; Pamplona *et al.*, 2000; Oliveira *et al.*, 2002; Costacurta *et al.*, 2003; Couri & Carvalho, 2005; Leandro & D'Almeida, 2005; Rodríguez-Fernández *et al.*, 2006; Couri & Barros, 2009), the most rich and populous Brazilian State remains with the Muscidae diversity knowledge still incipient. Furthermore, it is relatively scarce the Muscidae surveys in the Neotropics based on the use of non-baited collecting techniques (*e.g.*, Carvalho & Couri, 1991; Costacurta *et al.*, 2003; Rodríguez-Fernández *et al.*, 2006; Krüger *et al.*, 2010; Zafalon-Silva *et al.*, 2018). The present study is the first exhaustive survey of Muscidae for the State of São Paulo based on non-baited collectings. Previous surveys focused on urban and/or cadaveric fauna (Linhares, 1981; Dias *et al.*, 2014; Cavallari *et al.*, 2015). In Brazil, 358 species are described and recorded, 156 of these occur in the State of São Paulo (Lowenberg-Neto & Carvalho, 2013, with updates from Pereira-Colavite & Carvalho, 2012; Cavallari *et al.*, 2015; Fogaça & Carvalho, 2018). In this article we surveyed the Muscidae of the

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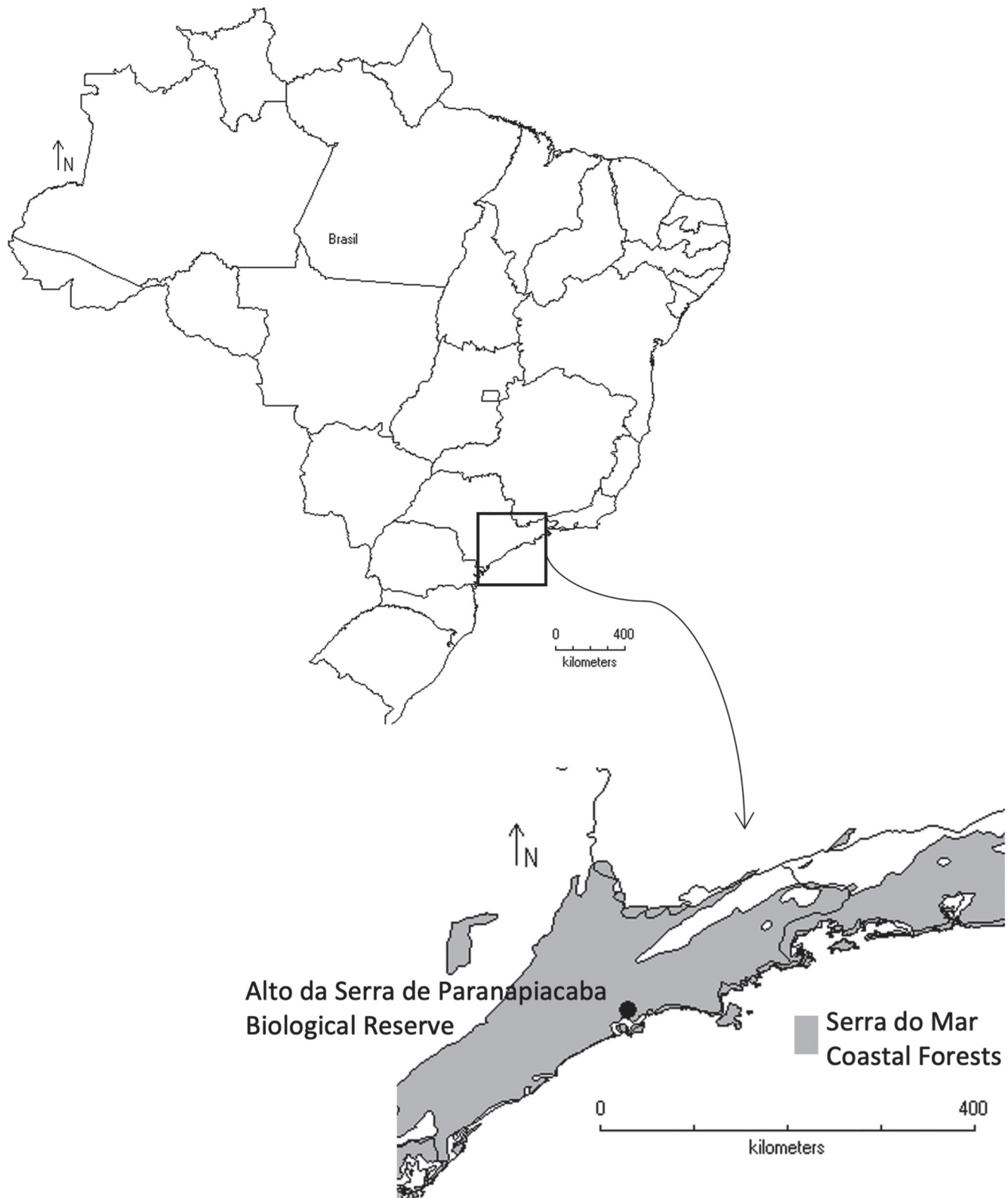


Biological Reserve Alto da Serra de Paranapiacaba (State of São Paulo, southeastern Brazil) in the Atlantic Forest biome, and analyzed its abundance, diversity and seasonality throughout a one-year collecting period. So far, only one muscid species had been recorded to the Biological Reserve of Paranapiacaba (Townsend, 1927; Lowenberg-Neto & Carvalho, 2013).

## MATERIAL AND METHODS

### Study area and collection

This survey took place in the Biological Reserve Alto da Serra de Paranapiacaba (Fig. 1) ( $23^{\circ}46'00''$ ,  $23^{\circ}47'10''$ S;  $46^{\circ}18'20''$ ,  $46^{\circ}20'40''$ W, 750-891 m of altitude), located



**Figure 1.** Location of the Biological Reserve Alto da Serra de Paranapiacaba, State of São Paulo, southeastern Brazil ( $23^{\circ}46'00''$ ,  $23^{\circ}47'10''$ S;  $46^{\circ}18'20''$ ,  $46^{\circ}20'40''$ W, 750-891 m of altitude).

in the municipality of Santo André, State of São Paulo, Brazil. The reserve is situated slightly under the Capricorn Tropic (23°27'S), in a transition area between the Tropical and the Subtropical climates zones (Gutjahr & Tavares, 2009). According to Köppen's classification, the climate type is *Cwa*, temperate and humid, with dry winter and hot summer. The mean temperature at summer (December-March) is 20°C, and 14°C on winter (June-September), with temperature range of 6°C (Gutjahr & Tavares, 2009). The area is predominantly covered with secondary Atlantic Forest under different successional stages, and that altered flora is due to historical anthropic intervention (Sugiyama *et al.*, 2009), as this area is very close to São Paulo metropolitan area.

Insects were collected using Malaise traps, installed at three different point of the Reserve: trap 1 was located at 23°46'38"S, 46°18'42,7"W; trap 2 at 23°46'44,6"S, 46°18'40,2"W; and trap 3 at 23°46'45,7"S, 46°18'29,2"W. Traps were installed and material had been collected continuously from August 2010 to July 2011. Sampling vessels were replaced monthly, and the collected material taken to the lab for sorting and identification.

### Identification

The specimens were recognized until the genera and species level, using identification keys in Carvalho (2002). When necessary, taxonomic revisions were consulted, containing updated identification keys and descriptions (e.g., Pereira-Colavite & Carvalho, 2012; Nihei & Carvalho, 2007; among others). All studied material was pinned and, in most cases, males and/or females were dissected to study their terminalia, which were compared to drawings and descriptions in the literature. The dissected terminalia were cleared with 10% KOH solution, then neutralized with acetic acid solution and washed with water; after examination, they were stored in microvials with glycerine and pinned with the respective specimen. The material was deposited at the Museu de Zoologia, Universidade de São Paulo, São Paulo (MZSP).

### Data analyses

Quantitative data were analyzed by calculating Shannon diversity and Berger-Parker dominance indexes (Magurran, 1988) to compare the diversity and proportional abundance of species among the four stations of the year. These calculations were performed in the software *DivEs v2.0* (Rodrigues, 2005). To analyze the seasonality abundance in the four seasons of the year, we conducted the Kruskal-Wallis statistical test for non-parametric samples using the software *Past version 2.17c* (Hammer *et al.*, 2001). We have applied a Kruskal-Wallis post-test called Bonferroni Correction, used to reduce the chances of obtaining false-positive results (type I errors) when several pairwise tests are made for one dataset (Nakagawa, 2004).

The estimation of the number of species and extrapolation of this variable and their respective confidence in-

tervals (95%) as a function of abundance was performed in R using the statistical package *iNEXT* (Hsieh *et al.*, 2016) based on the methodologies proposed by Colwell *et al.* (2012) and Chao *et al.* (2014).

Collector curves were obtained for the Biological Reserve Alto da Serra de Paranapiacaba and for each seasonal season within the same area.

## RESULTS

Within the one-year of Malaise trap collected material, seven families of Calypttrata were surveyed: Calliphoridae, Fanniidae, Mesembrinellidae, Muscidae, Rhinophoridae, Sarcophagidae and Tachinidae. Those seven families accounted a total of 3,451 individuals, with Muscidae as the most abundant, with 1,284 individuals (37%). Excluding the genera formerly belonging to "Coenosiinae" (*sensu* Carvalho *et al.*, 2005), the collected material of Muscidae was restricted to 397 individuals, and a total of 15 genera and 39 species of Muscidae were identified (Table 1 and Appendix) from the three subfamilies of Muscidae: Muscinae, Cyrtoneurinae and Mydaeinae (following the subfamilial classification *sensu* Haseyama *et al.*, 2015). Thirteen species are new records for the State of São Paulo: *Dolichophaonia machadoi* (Albuquerque, 1958), *D. simplex* (Albuquerque, 1958), *Helina discreta* (Wulp, 1896), *H. gigantea* Albuquerque, 1956, *H. regobarrosi* Albuquerque, 1958, *Neomuscina anajeensis* Pereira-Colavite & Carvalho, 2012, *N. transporta* Snyder, 1949, *Neurotrixa sulina* Costacurta & Carvalho, 2005, *Phaonia advena* Snyder, 1957, *P. annulata* (Albuquerque, 1957), *P. grandis* (Couri, 1982), *P. lentiginosa* Snyder, 1957 and *Polietina minor* (Albuquerque, 1956). With this, the number of species of Muscidae known to occur in the State of São Paulo is increased to 169.

Quantitative data analysis reveals that the interval between November and February had both more individuals (Fig. 2) and more species (Fig. 3) collected. Those three-month period have a sequence of 60-55-56 individuals, while other months reached up to 36 individuals. For species number, we had a variation of 14 to 18 species. Shannon diversity index confirms summer with the highest diversity, followed by spring, autumn and winter (Table 2). On the other hand, Berger-Parker dominance shows summer with the lowest rate, followed by spring and autumn, and with winter with the highest rate. In Berger-Parker dominance, the lower the index the higher the dominance of such taxon (Table 2).

The estimated values of Chao for the richness of muscid species in the Biological Reserve was  $65.009 \pm 12.198$ . The Chao estimator is accurate in its lower limit and based on it, we can infer that about 52 species are expected in the area, seven more than the observed richness. This value can reach 105 species, which is an overestimate due to the 14 singletons (species with only one individual) (31.11%) (Table 3). There is also no trend towards stabilization of the collector curve (Fig. 4a), corroborating Chao's analysis for the Biological Reserve.

**Table 1.** Species of Muscidae (excluding “Coenosiinae”) from Biological Reserve Alto da Serra de Paranapiacaba with the number of individuals per season in the period August 2010 to July 2011. Asterisks indicate new records to State of São Paulo.

Species	Winter	Spring	Summer	Autumn
<i>Cyrtoneurina alifusca</i>	1	1	6	1
<i>Cyrtoneurina costalis</i>	0	0	0	1
<i>Cyrtoneuropsis maculipennis</i>	7	11	41	18
<i>Cyrtoneuropsis polystigma</i>	3	14	21	0
<i>Dolichophaonia machadoi*</i>	5	6	3	1
<i>Dolichophaonia simplex*</i>	0	1	0	0
<i>Helina discreta*</i>	0	0	3	1
<i>Helina gigantea*</i>	0	2	0	0
<i>Helina praecipua</i>	1	0	0	0
<i>Helina regobarrosi*</i>	0	0	3	0
<i>Morellia humeralis</i>	0	0	1	0
<i>Morellia nigricosta</i>	0	0	3	0
<i>Mydaea plaumanni</i>	3	1	3	1
<i>Myospila mediatubunda</i>	0	1	1	0
<i>Neomuscina anajeensis*</i>	0	1	0	0
<i>Neomuscina atincticosta</i>	0	0	1	0
<i>Neomuscina inflexa</i>	0	0	2	0
<i>Neomuscina neosimilis</i>	0	0	2	0
<i>Neomuscina schadei</i>	0	0	0	1
<i>Neomuscina transporta*</i>	0	1	0	0

Species	Winter	Spring	Summer	Autumn
<i>Neurotrixa sulina*</i>	0	0	1	0
<i>Phaonia advena*</i>	5	16	20	12
<i>Phaonia annulata*</i>	0	0	1	1
<i>Phaonia grajauensis</i>	0	0	2	0
<i>Phaonia grandis*</i>	29	25	32	25
<i>Phaonia lentiginosa*</i>	2	5	7	3
<i>Phaonia shannoni</i>	2	1	1	0
<i>Phaonia similata</i>	0	1	0	0
<i>Phaonia trispila</i>	1	0	0	0
<i>Philornis amazonensis</i>	0	1	1	0
<i>Polietina minor*</i>	0	0	1	0
<i>Polietina prima</i>	0	0	3	3
<i>Polietina orbitalis</i>	0	0	1	0
<i>Polietina steini</i>	0	0	2	0
<i>Polietina univittata</i>	0	0	3	1
<i>Pseudoptilolepis fulvapoda</i>	1	6	4	1
<i>Pseudoptilolepis nudapleura</i>	0	0	1	0
<i>Psilochaeta pampiana</i>	0	0	2	0
<i>Synthesiomomyia nudiseta</i>	0	0	0	1

**Table 2.** Shannon diversity and Berger-Parker dominance indexes. The highest rates are highlighted in bold.

	Shannon's index	Berger-Parker
<b>Autumn</b>	0,8181	0,3521
<b>Winter</b>	0,7643	0,5
<b>Spring</b>	0,9609	0,266
<b>Summer</b>	<b>1,0979</b>	<b>0,2398</b>

**Table 3.** Muscidae richness (Chao) from August 2010 to July 2011 at the Biological Reserve Alto da Serra de Paranapiacaba (ReBio) in São Paulo, Brazil. Observed values (Obs), estimated (est), standard error of the estimated values (SE), lower (LL) and upper (UL) limits of the estimated values.

Local/Season	Richness (Chao)				
	Obs	est	SE	LL	UL
ReBio	45	65.009	12.198	51.649	105.217
Spring	27	37.003	7.942	29.541	66.375
Summer	35	75.230	28.364	46.584	174.720
Autumn	17	27.507	10.125	19.146	68.441
Winter	16	19.948	5.228	16.549	44.380

**Table 4.** Pairwise Kruskal-Wallis analyses. Correction of Bonferroni are in gray color. Significant values are underlined.

	Winter	Spring	Summer	Autumn
<b>Winter</b>		0,262	<u>0,0005</u>	0,629
<b>Spring</b>	1		<u>0,013</u>	0,532
<b>Summer</b>	<u>0,003</u>	0,077		<u>0,0009</u>
<b>Autumn</b>	1	1	<u>0,006</u>	

Estimates of Muscidae richness for each season of the year, as well as their extrapolation, reveal interesting patterns of sampling effort for this conservation unit. In Table 3 we can see that there are higher values in the summer than in any other season, without a trend of sta-

bilization in the collector curve for summer, spring and autumn, while in the winter the collections were sufficient (Fig. 4b).

The seasonality analysis using Kruskal-Wallis statistical test (Table 4) showed a seasonal pattern for the abundance of Muscidae throughout the year, with significant difference between the number of individuals distributed in the stations. The difference among the stations found at Kruskal-Wallis test was due to the abundance of individuals in the summer when compared to the winter and fall seasons. Furthermore, the circular analysis (Fig. 5) supported the seasonal variation of Muscidae indicating a clustered distribution ( $r = 0,913$ ).

The five most abundant species (Fig. 6) were *Phaonia grandis* (28.17%), *Cyrtoneuropsis maculipennis* Macquart, 1843 (19.54%), *Phaonia advena* (13.45%), *Cyrtoneuropsis polystigma* (Wulp, 1896) (9.13%), and *Phaonia lentiginosa* (4,31%).

## DISCUSSION

In the Biological Reserve Alto da Serra de Paranapiacaba, only one muscid species, *Philornis mima* (Townsend, 1927), had been recorded so far (Townsend, 1927; Lowenberg-Neto & Carvalho, 2013). With the 39 species found in the present survey, the Muscidae diversity of the Reserve is increased to a total of 40 species.

Malaise traps are efficient in collecting very active flying insects that can be intercepted by its tents, especially Hymenoptera and Diptera (Campos et al., 2000). In tropical rain forests of the Neotropical Region, Diptera is the most collected order when using Malaise traps (Dutra & Marinoni, 1994; Brown, 2005). Costacurta et al. (2003) and Rodríguez-Fernández et al. (2006) analyzed the composition, species richness and abundance of Muscidae in six

localities in Paraná State, southern Brazil in the Atlantic Forest biome, during one-year with Malaise traps. Krüger et al. (2010) surveyed four localities in southern Brazilian grasslands in the Pampa biome using a one-year Malaise traps collecting; and Zafalon-Silva et al. (2018) collected Muscidae in the 35 areas in the Coastal Plain of the Rio Grande do Sul State, southern Brazil. Borkent et al. (2018) surveyed three localities in the Costa Rican cloud forests using 13-month Malaise traps.

When considering the main surveys of Muscidae for southern Brazil (Rodríguez-Fernández et al., 2006; Krüger et al., 2010; Zafalon-Silva et al., 2018), we observe that the richness in this family, disregarding the Coenosiinae, is 109 species for Paraná State (Rodríguez-Fernández et al., 2006), 59 species for localities in the grasslands and south coast of Lagoa dos Patos (Krüger et al., 2010) and 63 species for the coastal plain of the Rio Grande do Sul (Zafalon-Silva et al., 2018), values that are 31 to

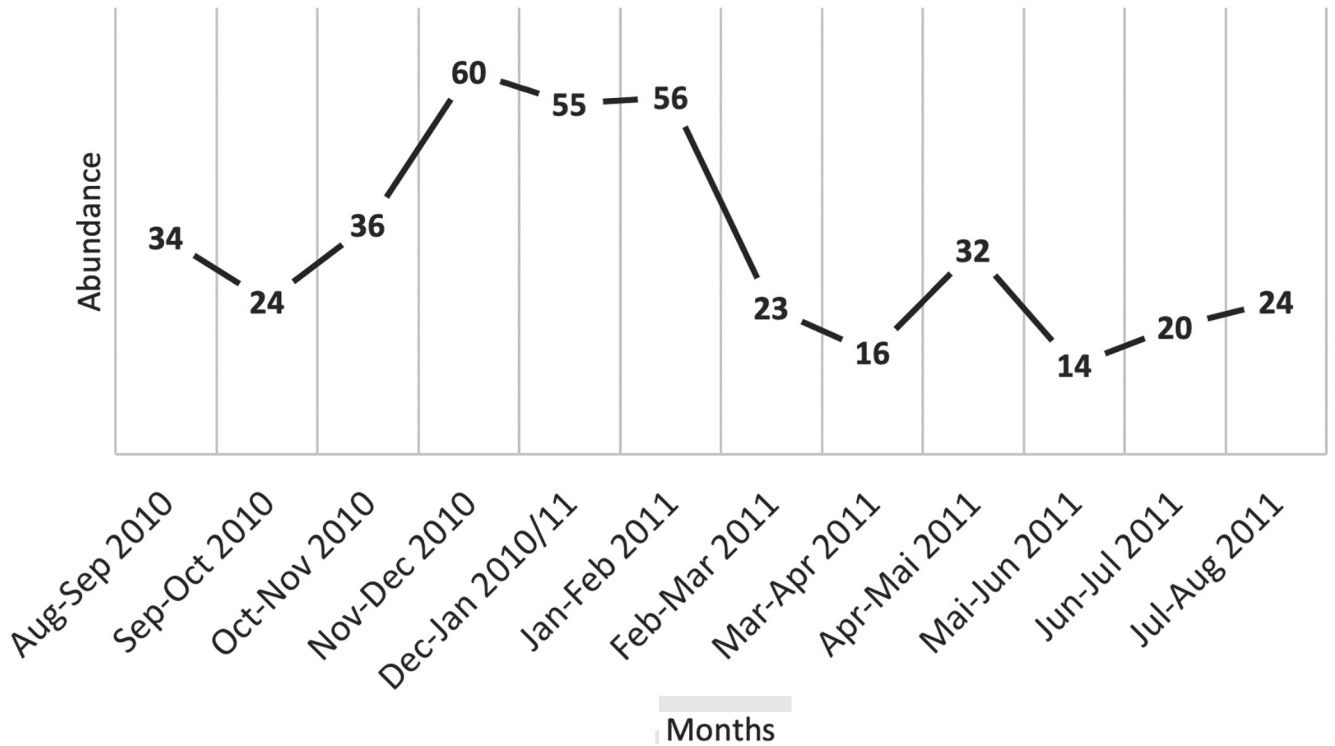


Figure 2. Number of individuals of Muscidae per month for the whole year of study.

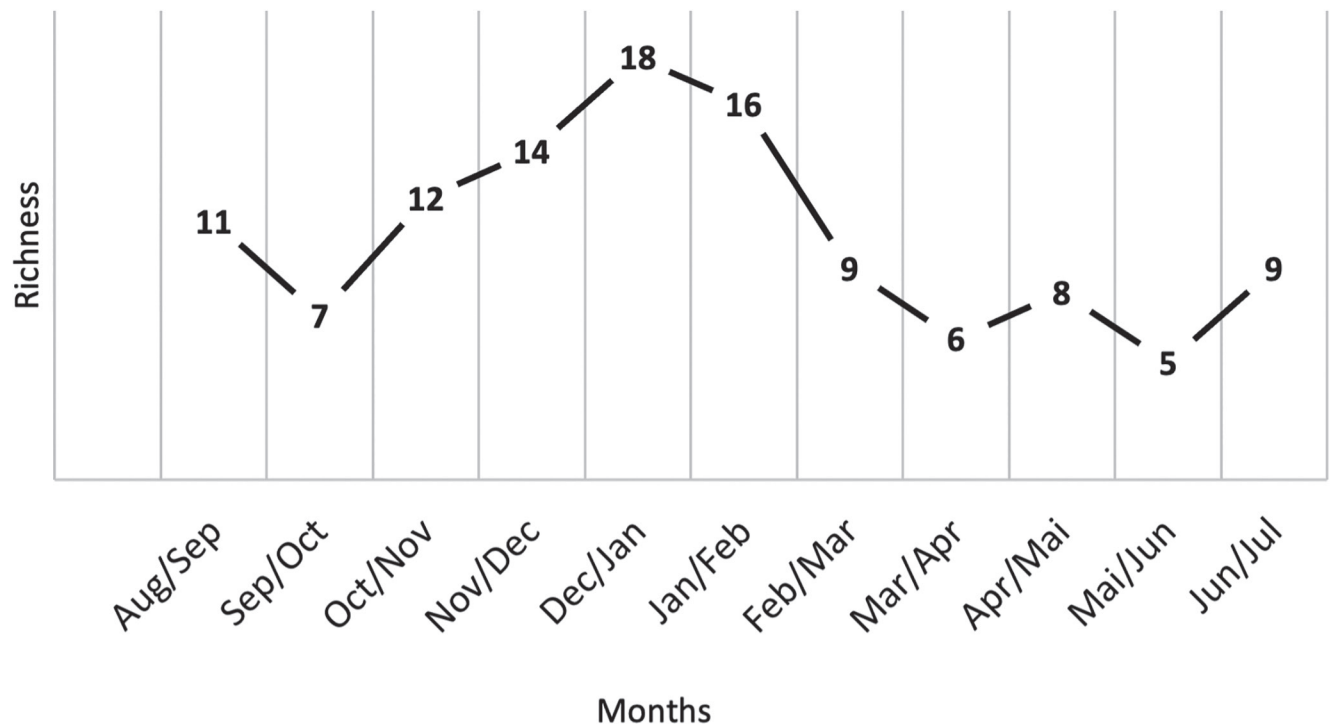
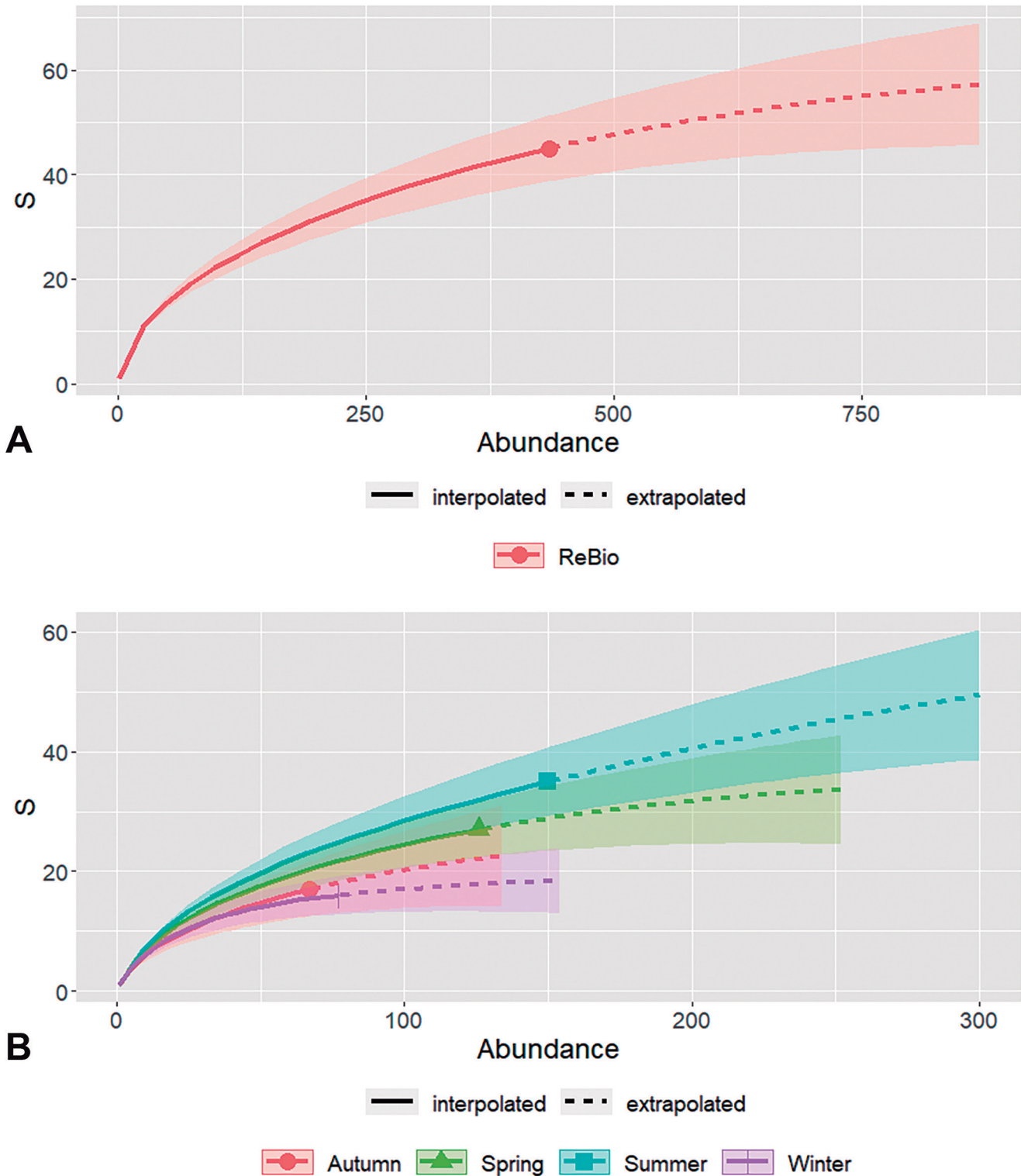


Figure 3. Number of species of Muscidae per month for the whole year of study.



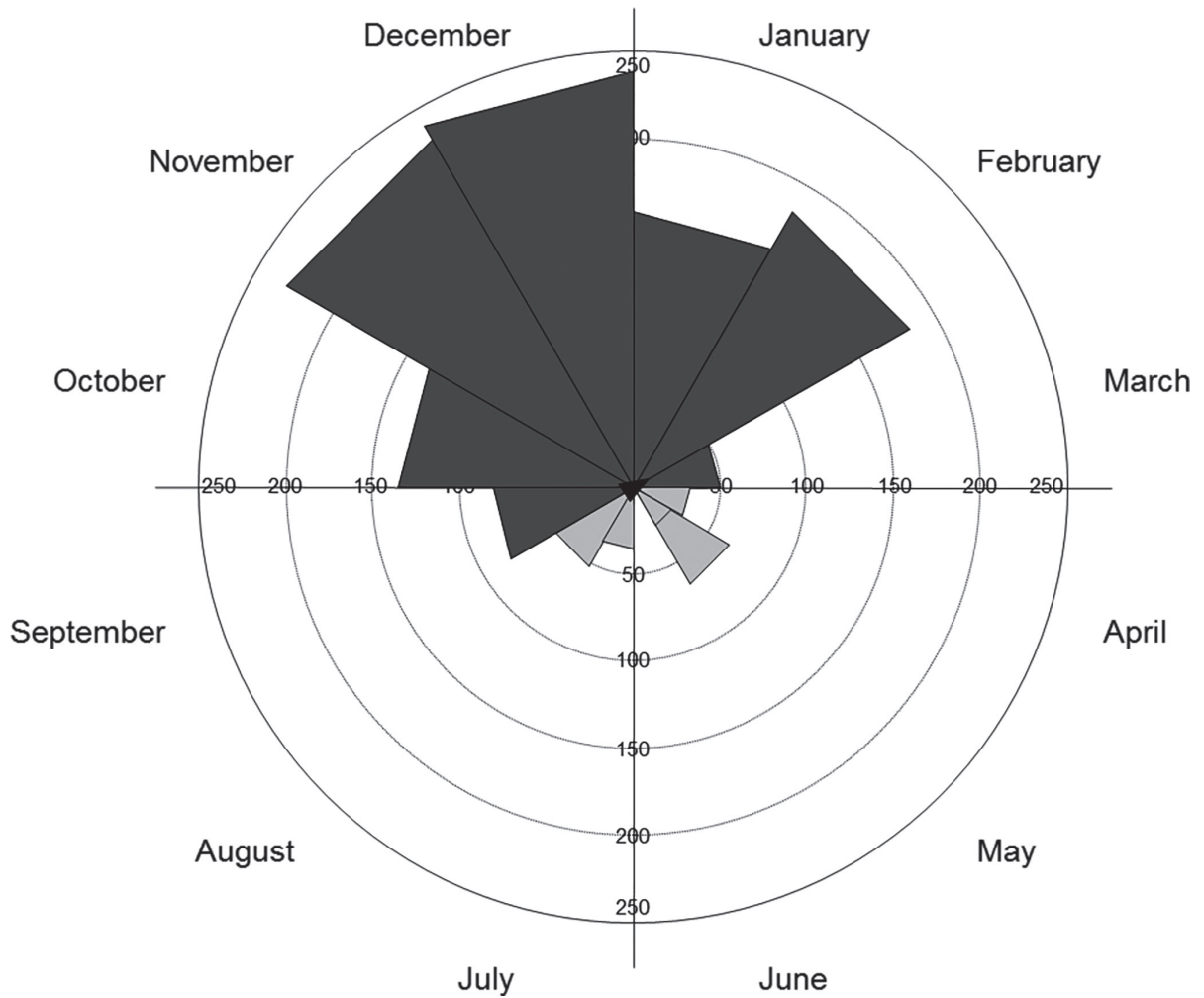
132% higher than that found for Biological Reserve of Paranapiacaba. It is worth mentioning that the morphospecies richness values are also much higher than those found here, varying from 23% of the fauna in Krüger *et al.* (2010) to 38% in Rodríguez-Fernández *et al.* (2006), while in this work only four species were not nominally identified (8.89%). Therefore, when disregarding mor-

phospecies, the richness in the Biological Reserve of Paranapiacaba was of 41 species, values close to those found by Krüger *et al.* (2010) and Zafalon-Silva *et al.* (2018), 45 and 42 species, respectively. In Paraná, the richness was of 67 species (Rodríguez-Fernández *et al.*, 2006), remaining 63% higher than in Paranapiacaba. The collections carried out at the Biological Reserve of

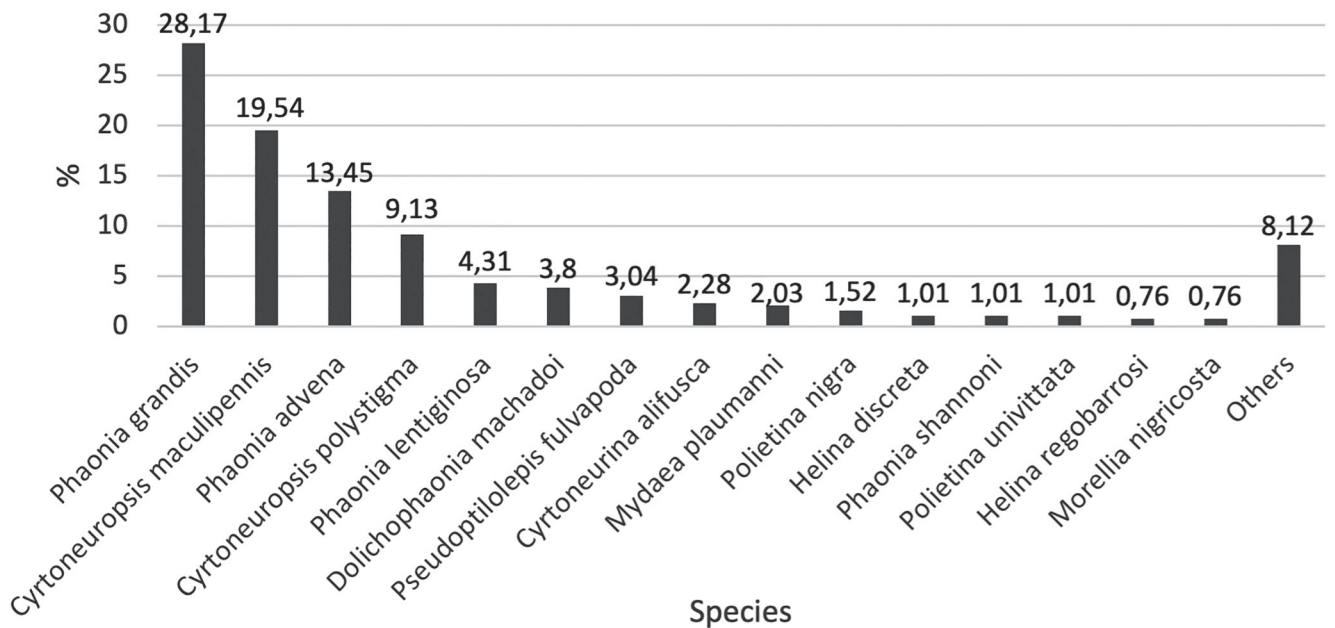


**Figure 4.** Species accumulation curve based on the abundance of muscids captured with Malaise traps at the Biological Reserve Alto da Serra de Paranapiacaba, State of São Paulo. The solid line represents the observed richness of the collection and the dashed line the richness estimated by Chao 1. (A) corresponds to the estimates for the Reserve considering all collections. (B) corresponds to the estimates for each season of the year: spring (green), summer (blue), autumn (purple) and winter (red).

# Muscidae



**Figure 5.** Circular representation of the number of collected individuals of Muscidae per month, for the whole year of study. Dark grey = rainy season; light grey = dry season.  $r$  = concentration index.



**Figure 6.** Relative frequency of 15 most abundant species of Muscidae sampled. The column "others" comprises 24 low abundant species.

Paranapiacaba used traps that were placed close to each other (separated by hundreds of meters), and this may explain the much higher values in Paraná, where the collections were carried out in almost the entire State (separated by hundreds of kilometers). Nevertheless, we can estimate a great richness for Muscidae in the Atlantic Forest of São Paulo State, since in a reduced area as the Biological Reserve of Paranapiacaba, the richness found was to similar to that found in areas of much larger collections as Rio Grande do Sul, wherein sampled localities were separated by dozens of kilometers. In fact, the Chao estimate in Table 3 extrapolates more species to be collected at Paranapiacaba and, in this case, we can consider estimates higher than the estimated one. Thus, the curve of the collector is still increasing for this area.

Interestingly, the fauna found in the Biological Reserve of Paranapiacaba is more similar to the fauna of Paraná, sharing 31.71% of the species, while only 8% of Paranapiacaba species were also observed in Rio Grande do Sul and in Paraná. However, none of those shared species occurs either in the Coastal Plain of RS or in the Sulrio-grandense Shield. And ten species (24.4%) occur in all these locations and have a wide distribution in Brazil.

The seasonal pattern of Muscidae showed the family individuals more abundant on summer, based on Kruskal-Wallis statistical test (Table 4) and circular analysis (Fig. 5). Previous studies have demonstrated that tropical insect abundance decreases in the dry season (e.g., Pinheiro et al., 2002; Da Silva et al., 2011), but far less than in temperate zones (Wolda, 1988). The pairwise test comparing summer and spring resulted in a statistically relevant difference, but after Bonferroni Correction, this difference was not considered statistically significant (Table 4). On the other hand, Bonferroni tests confirmed seasonal pattern of Muscidae with high abundance in the summer and less in autumn and winter.

Da Silva et al. (2011) and Pinheiro et al. (2002) performed seasonal analyses for insect abundance in the Brazilian Cerrado (savannah) and found that most insect orders (Coleoptera, Hymenoptera, Hemiptera, Isoptera, etc.) showed a clustered distribution, being more abundant in the wet season. However, in both studies, the order Diptera was randomly distributed, contrary to the results observed here and focused on Muscidae. This could be related to the groups studied in each case, revealing perhaps the most abundant groups of Diptera might be equally distributed the whole year, while Muscidae might be more vulnerable to environmental and/or biotic conditions that affect their abundance. Moreover, these studies were performed in different biomes other than Atlantic Forest. Traditionally, Cerrado is characterized by a bimodal rainfall distribution, with two well-defined, dry and wet, seasons (Silva et al., 2008), whereas Atlantic Forest is characterized by having high temperature and precipitation during the whole year (IBGE, 1992). However, climatic studies in Paranapiacaba have demonstrated that precipitation suffers a decrease in December and January (Gutjahr & Tavares, 2009), when Muscidae reached its peaks in both abundance and diversity. Unfortunately, there are just a few studies with

seasonality of Neotropical muscids. Using fruit-baited traps, Azevedo et al. (2015) found the muscids much less abundant in the rainy season in Barbalha municipality (State of Ceará, northeastern Brazil), characterized by Cerrado (savannah) and Caatinga (semi-arid) vegetations. Results of Costacurta et al. (2003) in three localities of State of Paraná (southern Brazil) also supports the correlation between Muscidae abundance and air humidity: the lower the humidity, the higher the abundance. However, as pointed out by Azevedo & Krüger (2013) for southern Brazilian calliphorids, each species may respond differently (even inversely) to temperature and humidity interactions, therefore, it demands a careful examination on the species other than all the family.

The Paranapiacaba Reserve is covered by secondary Atlantic Forest under different successional stages (Sugiyama et al., 2009). The composition of the Muscidae fauna from the Paranapiacaba Reserve comprises mostly typically forest species, however there is a number of species with some degree of synanthropic habits. Within its 39 species, only two species, *Myospila meditabunda* (Fabricius, 1781) and *Synthesiomyia nudiseta* (Wulp, 1883), are considered typically synanthropic (Carvalho et al., 2005; Lowenberg-Neto & Carvalho, 2013). In Colombia, *S. nudiseta* was classified as having "strong preference for dense human settlements" (Uribe et al., 2010), and in Brazil we have it recorded in rural and urban environments and forest fragments (D'Almeida & Almeida, 1998). Besides, seven species found in Paranapiacaba have some association to human inhabited areas in Brazil: *Cyrtoneuropsis maculipennis*, *C. polystigma*, *Morellia humeralis* (Stein, 1919), *Mydaea plaumanni* Snyder, 1941, *Phaonia trispila* (Bigot, 1885), *Pseudoptilepis fulvapoda* Snyder, 1949 and *Psilochaeta pampiana* (Shannon & Del Ponte, 1926) (Linhares, 1981; Carvalho et al., 1984; Oliveira, 1986; Kasai et al., 1990; Lomônaco & Almeida, 1995; Moura et al., 1997; Pamplona et al., 2000; Carvalho et al., 2002; Barbosa et al., 2009). And *Cyrtoneuropsis polystigma* was also considered symbovine (Oliveira, 1986). However, some species have contrasting information, for example, in Colombia (Uribe et al., 2010), *C. maculipennis* is classified as a species with "complete avoidance of human settlements", as well as *Polietina orbitalis* (Stein, 1904).

The occurrence of exotic and/or synanthropic species in natural preserved areas has been associated to edge effect by some authors (Lima-Ribeiro, 2008; Ferraz et al., 2010; Barbosa et al., 2014). Furthermore, the complex composition of the Muscidae fauna in the Biological Reserve of Paranapiacaba reveals that while this Reserve still bears most of its fauna with typically forest species, the presence of some typically synanthropic species may signalize that its proximity to São Paulo metropolitan area has imposed an increasing anthropic pressure (Leandro & D'Almeida, 2005).

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## AUTHORS' CONTRIBUTIONS

**Silvio S. Nihei:** Conceptualization, Data curation, Investigation, Methodology, Investigation, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, and Writing – review & editing. **Anderson T. Tamakoshi:** Data curation, Formal analysis, Investigation, Methodology, Software, and Writing – original draft. **Priscylla Moll:** Data curation, Formal analysis, Investigation, Methodology, Software, and Writing – original draft. All the authors actively participated in the discussion of the results, they reviewed and approved the final version of the paper. **Rodrigo F. Krüger:** Methodology, Software, and Writing – original draft and Writing – review & editing.

## CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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## APPENDIX: LIST OF EXAMINED MATERIAL

The species are listed in alphabetical order. Asterisk indicates new records to State of São Paulo. All material deposited at the Museu de Zoologia, Universidade de São Paulo, Brazil (MZSP).

***Cyrtoneurina alifusca* Couri, 1982**: 1 male, 21.x-19.xi.2010, Gudin & Nihei col.; 1 male, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 3 males, 21.xii.2010-21.i.2011, Sato & Nihei col.; 2 males, 21.i-22.ii.2011, Gudin & Dios col.

***Cyrtoneurina costalis* (Walker, 1853)**: 1 male, 22.iii-19.iv.2011, Moll & Nihei col.

***Cyrtoneuropsis maculipennis* Macquart, 1843**: 1 female, 21.vii-21.viii.2010, Moll & Nihei col.; 2 males, 1 female, 21.viii-21.ix.2010, Gudin & Nihei col.; 3 females, 21.ix-21.x.2010, Dios & Nihei col.; 1 male, 4 females, 21.x-19.xi.2010, Gudin & Nihei col.; 1 male, 13 females, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 1 male, 8 females, 21.xii.2010-21.i.2011, Sato & Nihei col.; 3 males, 13 females, 21.i-22.ii.2011, Gudin & Dios col.; 6 females, 23.ii-21.iii.2011, Moll, Nihei & Dias col.; 1 male, 3 females, 22.iii-19.iv.2011, Moll & Nihei col.; 2 males, 6 females, 19.iv-23.v.2011, Moll & Gudin col.; 3 females, 23.v-20.vi.2011, Moll, Almeida & Tamakoshi col.; 2 males, 1 female, 20.vi-23.vii.2011, Moll, Tamakoshi, Ribeiro col.

***Cyrtoneuropsis polystigma* (Wulp, 1896)**: 1 female, 21.vii-21.viii.2010, Moll & Nihei col.; 2 males, 21.viii-21.ix.2010, Gudin & Nihei col.; 4 males, 2 females, 21.ix-21.x.2010, Dios & Nihei col.; 2 males, 4 females, 21.x-19.xi.2010, Gudin & Nihei col.; 5 males, 4 females, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 4 males, 1 female, 21.xii.2010-21.i.2011, Sato & Nihei col.; 3 males, 4 females, 21.i-22.ii.2011, Gudin & Dios col.

***Dolichophaonia machadoi* (Albuquerque, 1958)\***: 4 females, 21.vii-21.viii.2010, Moll & Nihei col.; 2 females, 21.viii-21.ix.2010, Gudin & Nihei col.; 4 females, 21.x-19.xi.2010, Gudin & Nihei col.; 2 females, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 1 female, 21.i-22.ii.2011, Gudin & Dios col.; 1 female, 19.iv-23.v.2011, Moll & Gudin col.; 1 female, 20.vi-23.vii.2011, Moll, Tamakoshi, Ribeiro col.

***Dolichophaonia simplex* (Albuquerque, 1958)\***: 1 female, 21.viii-21.ix.2010, Gudin & Nihei col.

***Helina aff. discreta* (Wulp, 1896)\***: 3 females, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 female, 23.ii-21.iii.2011, Moll, Nihei & Dias col.

***Helina gigantea* Albuquerque, 1956\***: 2 females, 21.x-19.xi.2010, Gudin & Nihei col.

***Helina praecipua* (Walker, 1853)**: 1 male, 23.v-20.vi.2011, Moll, Almeida & Tamakoshi col.

***Helina regobarrosi* Albuquerque, 1958\***: 1 male, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 1 female, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 female, 21.i-22.ii.2011, Gudin & Dios col.

***Morellia humeralis* (Stein, 1919)**: 1 female, 21.i-22.ii.2011, Gudin & Dios col.

***Morellia nigricosta* Hough, 1900**: 3 females, 21.i-22.ii.2011, Gudin & Dios col.

***Mydaea plaumanni* Snyder, 1941**: 1 female, 21.ix-21.x.2010, Dios & Nihei col.; 3 females, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 female, 19.iv-23.v.2011, Moll & Gudin col.; 1 female, 23.v-20.vi.2011, Moll, Almeida & Tamakoshi col.; 2 females, 20.vi-23.vii.2011, Moll, Tamakoshi, Ribeiro col.

***Myospila meditabunda* (Fabricius, 1781)**: 1 female, 21.x-19.xi.2010, Gudin & Nihei col.; 1 female, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.

***Neomuscina anajeensis* Pereira-Colavite & Carvalho 2012\***: 1 female, 21.x-19.xi.2010, Gudin & Nihei col.

***Neomuscina atincticosta* Snyder, 1949**: 1 male, 21.xii.2010-21.i.2011, Sato & Nihei col.

***Neomuscina inflexa* (Stein, 1918):** 2 females, 21.xii.2010-21.i.2011, Sato & Nihei col.

***Neomuscina neosimilis* Snyder, 1949:** 1 female, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 1 female, 21.xii.2010-21.i.2011, Sato & Nihei col.

***Neomuscina schadei* Snyder, 1949:** 1 female, 23.ii-21.iii.2011, Moll, Nihei & Dias col.

***Neomuscina transporta* Snyder, 1949\*:** 1 female, 21.x-19.xi.2010, Gudin & Nihei col.

***Neurotrixa sulina* Costacurta & Carvalho, 2005\*:** 1 female, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.

***Phaonia advena* Snyder, 1957\*:** 2 females, 21.vii-21.viii.2010, Moll & Nihei col.; 2 males, 7 females, 21.viii-21.ix.2010, Gudin & Nihei col.; 3 females, 21.ix-21.x.2010, Dios & Nihei col.; 1 male, 5 females, 21.x-19.xi.2010, Gudin & Nihei col.; 1 male, 13 females, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 5 females, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 male, 21.i-22.ii.2011, Gudin & Dios col.; 4 females, 23.ii-21.iii.2011, Moll, Nihei & Dias col.; 2 females, 22.iii-19.iv.2011, Moll & Nihei col.; 6 females, 19.iv-23.v.2011, Moll & Gudin col.; 1 female, 23.v-20.vi.2011, Moll, Almeida & Tamakoshi col.; 2 females, 20.vi-23.vii.2011, Moll, Tamakoshi, Ribeiro col.

***Phaonia annulata* (Albuquerque, 1957)\*:** 1 female, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 male, 19.iv-23.v.2011, Moll & Gudin col.

***Phaonia grajauensis* (Albuquerque, 1957):** 2 female, 21.xii.2010-21.i.2011, Sato & Nihei col.

***Phaonia grandis* (Couri, 1982)\*:** 1 male, 12 females, 21.vii-21.viii.2010, Moll & Nihei col.; 3 males, 9 females, 21.viii-21.ix.2010, Gudin & Nihei col.; 1 male, 6 females, 21.ix-21.x.2010, Dios & Nihei col.; 5 females, 21.x-19.xi.2010, Gudin & Nihei col.; 11 females, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 1 male, 4 females, 21.xii.2010-21.i.2011, Sato & Nihei col.; 3 males, 13 females, 21.i-22.ii.2011, Gudin & Dios col.; 1 male, 5 females, 23.ii-21.iii.2011, Moll, Nihei & Dias col.; 2 male, 5 females, 22.iii-19.iv.2011, Moll & Nihei col.; 1 male, 11 females, 19.iv-23.v.2011, Moll & Gudin col.; 8 females, 23.v-20.vi.2011, Moll, Almeida & Tamakoshi col.; 2 males, 6 females, 20.vi-23.vii.2011, Moll, Tamakoshi, Ribeiro col.

***Phaonia lentiginosa* Snyder 1957\*:** 2 males, 21.vii-21.viii.2010, Moll & Nihei col.; 1 female, 21.viii-21.ix.2010, Gudin & Nihei col.; 1 female, 21.ix-21.x.2010, Dios & Nihei col.; 3 females, 21.x-19.xi.2010, Gudin & Nihei col.; 1 male, 5 females, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 female, 21.i-22.ii.2011, Gudin & Dios col.; 1 female, 22.iii-19.iv.2011, Moll & Nihei col.; 2 females, 19.iv-23.v.2011, Moll & Gudin col.

***Phaonia shannoni* (Carvalho & Pont, 1993):** 1 female, 21.vii-21.viii.2010, Moll & Nihei col.; 1 female, 21.viii-21.ix.2010, Gudin & Nihei col.; 1 female, 21.i-22.ii.2011, Gudin & Dios col.; 1 female, 20.vi-23.vii.2011, Moll, Tamakoshi, Ribeiro col.

***Phaonia similata* (Albuquerque, 1957):** 1 female, 21.viii-21.ix.2010, Gudin & Nihei col.

***Phaonia trispila* (Bigot, 1885):** 1 male, 1 female, 23.v-20.vi.2011, Moll, Almeida & Tamakoshi col.

***Philornis amazonenses* Couri, 1983:** 1 female, 21.viii-21.ix.2010, Gudin & Nihei col.; 1 female, 21.i-22.ii.2011, Gudin & Dios col.

***Polietina minor* (Albuquerque, 1956)\*:** 1 female, 21.i-22.ii.2011, Gudin & Dios col.

***Polietina orbitalis* (Stein, 1904):** 1 female, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.

***Polietina prima* (Couri & Machado, 1990):** 2 females, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 female, 21.i-22.ii.2011, Gudin & Dios col.; 2 females, 23.ii-21.iii.2011, Moll, Nihei & Dias col.; 1 male, 22.iii-19.iv.2011, Moll & Nihei col.; 1 female, 19.iv-23.v.2011, Moll & Gudin col.

***Polietina steini* (Enderlein, 1927):** 2 females, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.

***Polietina univittata* Couri & Carvalho, 1996:** 1 female, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 2 females, 21.i-22.ii.2011, Gudin & Dios col.; 1 female, 23.ii-21.iii.2011, Moll, Nihei & Dias col.

***Pseudoptilolepis fulvapoda* Snyder, 1949:** 2 females, 21.viii-21.ix.2010, Gudin & Nihei col.; 3 females, 21.ix-21.x.2010, Dios & Nihei col.; 1 female, 21.x-19.xi.2010, Gudin & Nihei col.; 1 female, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 1 male, 1 female, 21.xii.2010-21.i.2011, Sato & Nihei col.; 1 female, 21.i-22.ii.2011, Gudin & Dios col.; 1 female, 23.ii-21.iii.2011, Moll, Nihei & Dias col.; 1 female, 20.vi-23.vii.2011, Moll, Tamakoshi, Ribeiro col.

***Pseudoptilolepis nudapleura* Snyder, 1949:** 1 female, 21.xii.2010-21.i.2011, Sato & Nihei col.

***Psilochaeta pampiana* (Shannon & Del Ponte, 1926):** 1 male, 19.xi-21.xii.2010, Gudin, Araya & Nihei col.; 1 male, 21.xii.2010-21.i.2011, Sato & Nihei col.

***Synthesiomyia nudiseta* (Wulp, 1883):** 1 female, 23.ii-21.iii.2011, Moll, Nihei & Dias col.