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Soldier flies (Diptera: Stratiomyidae) on semideciduous seasonal forest fragments, with a list of species for São Paulo State, Brazil, and two new records of species for the country

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ABSTRACT

Although the species richness of Stratiomyidae (Diptera) in Brazil (~340 species) is one of the highest for the family worldwide, we still do not know the actual number of species, the extent of their distribution, or the species seasonal dynamics for a single area in the Neotropics. The soldier fly fauna in the semideciduous seasonal forests, which cover a major area of the countryside of the state of São Paulo, is poorly known compared to the best-known areas in the Atlantic Forest for stratiomyids, such as the ombrophilous forests on the southeast coast. With the constant habitat fragmentation of the remnants of the semideciduous forests in the state for crops and pastures for cattle, we are losing valuable data about biodiversity. This study details the stratiomyids for a single area in the Neotropical Region, using a standardized collecting methodology with Malaise traps, from May 2010 to December 2011. Here, we provide a list of 41 stratiomyid species and 25 genera in eight subfamilies from a total of 1,533 specimens collected in the Reserva Biológica e Ecológica Augusto Ruschi, Sertãozinho, Brazil. The current number of species/morphospecies reported for the state of São Paulo is raised to 113, with *Merosargus golbachi* James, 1971 *in* James and McFadden, 1971 and *M. tripartitus* James, 1971 *in* James and McFadden, 1971 reported for the first time to Brazil. Our analyses estimate even higher richness in the studied area, probably between 48 to 114 species, indicating that further collection efforts are needed.

Introduction

The Atlantic Forest is one of the largest and most threatened biomes in Brazil. It originally encompassed 1.5 million km² of the country, extending through most of the Brazilian coast and interior areas of Central and Southern regions, in 17 states, and also reaching Argentina and Paraguay (Ribeiro et al., 2009, 2011). It has been recognized as a biodiversity hotspot, with a high number of endemic species for several groups of organisms (Myers et al., 2000; Mittermeier et al., 2004). However, it has suffered, since the beginning of the 16th century, severe habitat loss and fragmentation, mainly derived from anthropogenic activities. Therefore, only 12,4% of the original Atlantic Forest is left, mainly represented by small, isolated, and degraded fragments (Ribeiro et al., 2011; Fundação SOS Mata Atlântica, 2021).

The Atlantic Forest is composed of rather diverse vegetal physiognomies, which includes humid forests, such as the ombrophilous dense forests, more often along the Brazilian coast, and a biologically dry forest, which is a semideciduous seasonal forest, that occurs in the interior of the states (Silva and Casteleti, 2005; Fundação SOS Mata Atlântica, 2021). The Atlantic Forest occupied most of São Paulo's surface, representing about 67% taking into consideration all types of vegetal formation, and the Cerrado with 33%, covered, discernibly, areas of the Northeast and Central-east of the state, although also present on the Northwest and Central-west areas (Instituto Florestal, 2020). Today, only about 23% of the state is still covered by Atlantic Forest, however, this is concentrated near the coast, representing over 10% of all native vegetation left in the state (Instituto Florestal, 2020). Semideciduous seasonal forests covered large areas of the interior of São Paulo (Fundação SOS Mata Atlântica, 2021), but currently, only 7% of this type of forest is left (Instituto Florestal, 2020) and fragmented into several small remnants, which are surrounded by an anthropized matrix, that includes especially in the Northwest and Northeast of São Paulo, large areas for monocultures of sugarcane and citrus (*Citrus* spp.) (Ribeiro et al., 2011; Tanaka-Junior and Noll, 2011).

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The majority of records for the Diptera fauna of the Atlantic Forest still come from relatively few locations (Amorim and Santos, 2018), especially from sites along the coast of the states, which is mostly characterized by ombrophilous forests and where most expeditions were conducted. As pointed out by Oliveira et al. (2016), some biomes or regions and areas of Brazil are historically more sampled and studied than others, which is due to both access roads and the amount of infrastructure to reach these areas, as well as the high relative diversity of certain groups of organisms in the studied locations, which can be influenced with the establishment of researchers that will focus on certain taxa.

A few well-known areas also had one or more experts impacting the study of the taxa. One of those is Nova Teutônia (district of Seara), Santa Catarina, covered mainly by ombrophilous mist forests, which was intensively sampled by Fritz Plaumann in the 20th century, who sent insects to be studied by experts in Brazil and outside (Lubenow, 2016; Radin and Corazza, 2018). For several families of Diptera, Nova Teutônia is still quite representative in the number of species. For example, the number of records of Phoridae from there (235) is as high as the whole phorid fauna of well-known states such as Rio de Janeiro, with 239 (Ament, 2017). In reality, these biases (choice of more accessible well-known areas and preference for certain taxonomic groups) affect our knowledge about biodiversity, so patterns of species richness and endemism are likely to be correlated with collecting effort (Oliveira et al., 2016), indicating that our data might not represent the actual diversity and distribution of species (Troudet et al., 2017).

For certain dipteran taxa, as is the case of Stratiomyidae, knowledge of their fauna is also quite limited and outdated even in the so-called best-known areas, close to major urban centers, such as São Paulo and Rio de Janeiro, and their adjacent regions, since there are no recent species lists or faunistic studies for the family and description of species or revisions may take longer to provide such data. Currently, 216 out of 342 Brazilian species of soldier flies are reported from the Atlantic Forest, with 82 species occurring in the state of São Paulo. Most of them, however, are based on old literature records, for which only the type locality or few localities are known.

Stratiomyids are often species-rich in surveys that use Malaise traps (Amorim et al., 2022; Riccardi et al., 2022). However, not only surveys of stratiomyid species are scarce, but also little is known about their community structure, especially in terms of density and how they can be affected by natural factors, such as climate, temperature, and humidity, in the Neotropics. Detailed knowledge of the fauna of the family allows, in this sense, to expand the comprehension of the diversity of the family and generate more data on the distribution of species, which can be used to reevaluate or reinforce areas of endemism.

Here we provide an illustrated list of species of Stratiomyidae for a single area in the Neotropical Region, which includes a detailed study of seasonality and an updated list of species for the state of São Paulo, Brazil. Hopefully, this study will indicate new areas for collecting Diptera in the state and stimulate additional collecting efforts in dry forests.

Material and methods

Study area

The collecting was conducted at the Reserva Ecológica e Biológica Augusto Ruschi (REBIO) (Fig. 1), 21º10.52'S 48º5.47'W, located at about 12.5 km from the central area of the municipality of Sertãozinho, in the Northeastern region of the state of São Paulo, Brazil. The REBIO, created in 1985, Law No. 4,557, is part of the area of the "Centro de Pesquisa de Bovinos de Corte, Instituto de Zootecnia" (CP Corte, Sertãozinho) (also known as "Fazenda Experimental de Sertãozinho"). Currently, it protects remnants of the Semideciduous Seasonal Forest in a Conservation Unit

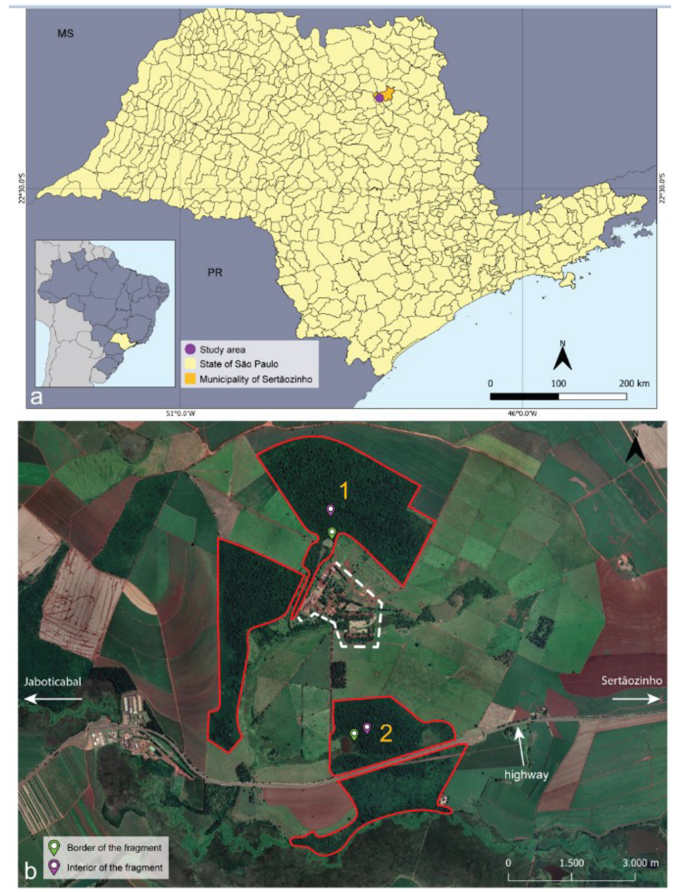

Figure 1 Map of the area of study, with limits of all municipalities of the state of São Paulo. (a) Limits of the municipality of Sertãozinho and studied area; (b) Satellite image of the Reserva Ecológica e Biológica Augusto Ruschi, with head office and research buildings outlined in white, larger fragments outlined in red, and numbers 1 and 2 represent the areas of sampling.

(https://uc.socioambiental.org/pt-br/arp/858). Overall, the area of the "Fazenda Experimental" has approximately 2,260 ha and the remnants of the forest compose ~490 ha (Rebelo and Garófalo, 1997). The REBIO is surrounded by a matrix of anthropic use, mostly comprising large areas for sugarcane and eucalypt plantations, and pastures for cattle.

The Reserve has an average elevation of about 548 meters above sea level and it is drained by the Boa Vista and Santo Antônio streams, being delimited to the south by Ribeirão da Onça. The climate type according to the Köppen classification is Cwa (Alvares et al., 2013), with a well-defined dry season from April to August, in which the winter (from June to August) is very dry and cold (Tidon-Sklorz and Sene, 1992; Rebelo and Garófalo, 1997). The average temperature of the coldest month (July) is 28.2ºC, with the average lowest temperature of 9.8ºC, and in the hottest months (February, September, and October), the average is 32.5ºC, with typical tropical climate rains. The average annual temperature is 30.5ºC. The average annual rainfall is about 1,300 mm, with the wettest months (over 100 mm per month) from November to March.

Collecting methods

The specimens were collected in two of the four major fragments of the Reserve (Fig. 1), which are referred to as fragments 1 and 2, between May 2010 to December 2011, with an additional collecting effort in September 2014. In each fragment, PET bottle traps (Fig. 2d) and two types of Malaise traps (black roof and white roof Malaise traps, Fig. 2e-2f) were installed at two collecting points, one of each trap near the central area of each fragment (referred to as the interior) and near the border (referred to as the border), *i.e.*, only two collecting points in each fragment (Fig. 1b). The PET bottle traps consisted of plastic bottles of 2 liters, containing a solution of water and liquid unscented soap. Each bottle was painted yellow internally and painted black externally, and had a frontal opening of ~10 cm to allow insects to enter. Each string with five bottle was positioned about 1,5 m above the ground level (Fig. 2d).

In each fragment (interior and border collecting points), black roof Malaise traps and PET bottle traps were fortnightly visited for 20 months (between May 2010 to December 2011) to extract samples and replace the preserving liquid of each trap. The white roof Malaise traps were set up exclusively at the central point of the fragments (interior) and the samples were, as well, retrieved every 15 days (between January to December 2011; although soldier flies only started to show up in March 2011). Additionally, a Shannon trap was used in one collecting event in the fragment 2 (interior), only in September 2014, sweeping nets were used (but not extensively) on the occasions of extracting samples and replacing the preserving liquid of the Malaise traps, but retrieving specimens on three occasions, and one additional black roof Malaise trap, with visits to extract samples from only three to 15 days, was also kept in the collecting point of the fragment 2 (interior) for a short period. As these additional collecting methods were not standardized and were used for a shorter period in the areas, the species and specimens captured by them were not added to the analysis correlating climate and species richness and abundance.

Specimen processing and identification

The specimens collected with Malaise traps and PET bottle traps were stored in vials with 80% alcohol solution since the moment of their

Figure 2 Sampling sites at the Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil. (a-c) Areas near an artificial lake, fragment 2; (d) Bottle traps set up in the field; (e) Black roof Malaise trap; (f) White roof Malaise trap.

collection and were all mounted on pins (larger specimens) or glued to card points (tiny paper triangles) and then mounted on pins (smaller specimens). All specimens were labeled (locality and determination labels) and deposited in the Diptera collection of the Museu de Zoologia da Universidade de São Paulo, Brazil (MZUSP).

Stratiomyids were identified to the genus level using the identification key given in Woodley (2009). The identification of species was performed using keys [*e.g.*, James (1940) for species of *Cyphomyia* Wiedemann, 1819; James and McFadden (1971) for species of *Merosargus* Loew, 1805], original descriptions, and type specimen photographs. For most genera, no keys or recent taxonomic revisions are available, and for a considerable number of species, type specimen images are still not available as well. As a result, some specimens could only be identified to genus level and, if recognized as separate species, a morphospecies code was given to each species, *e.g.*, '*Sargus* sp. 1'.

The digital habitus photographs (dorsal and lateral views) of the species were taken using a Leica DC 500 camera coupled to a Leica M16 stereomicroscope, and then they were assembled using the software Helicon Focus 7.6.6., with further editing and preparation of the plates with Adobe Photoshop.

Data treatment and analysis

The stratiomyid fauna at the reserve was characterized quantitatively and qualitatively. First, we elaborated a large dataset (which is a datasheet, in Excel format, Supplementary File 1), including all specimens alphabetically ordered by subfamily, genus, and species, with collecting date and sampling technique. This was used to estimate richness, relative abundance, and the number of species represented by one and two specimens (singletons and doubletons). A graph showing the number of genera and species per subfamily was made with Excel.

The species accumulation curve was constructed using the Mao Tau method, from the accumulation of species during the entire collection period, using all sampling techniques. To determine the community's sampling sufficiency, richness estimators Chao 1, Chao 2, Jackknife 1, Jackknife 2, and Bootstrap were calculated. For the calculation of Chao 1 and Chao 2, the classic option was selected, and for Jackknife 1 and 2 and Bootstrap, 100 randomizations were used. Each distinct collecting date was considered as a sample, totalizing 52 samples or collecting events. These analyses were performed with EstimateS 9.1.0 (Colwell, 2013), then a graph was generated in Excel.

The correlation between climate (average temperature, precipitation, and relative humidity) with the number of species and specimens of soldier flies in each month was performed with Spearman's nonparametric correlation test using PASt 4.06 (Hammer et al., 2001). As the two distinct types of Malaise traps did not overlap during the entire collecting period (the black roof model stayed a bit longer), they were analyzed separately in PASt. Their results were transformed into graphs in Excel, and then could be compared and discussed. The climate data were obtained from the Instituto Nacional de Pesquisas Espaciais, Centro de Previsão de Tempo e Estudos Climáticos (INPE/CPTEC), Instituto de Zootecnia CP Corte, Sertãozinho, and Usina Cana Verde, Sertãozinho. To evaluate the effectiveness of the two types of Malaise traps (black roof and white roof models) for collecting soldier flies exclusively in the specific period they overlapped in the collecting point in the interior of the fragments (between January to December of 2011), a chi-square test was used.

Secondly, we elaborated a dataset with all records of Stratiomyidae known from the state of São Paulo (Supplementary File 2). The distributional data provided for each species is based on data from the literature, including the older and the most recent papers for which coordinates are often available. Some occurrences may refer to specific localities such as municipalities, districts, roads, or farms, or to a locality that changed its name. In this sense, when relevant, additional information to correct or complement what was originally written is made available in square brackets. When coordinates were not available, the records were georeferenced using Google Earth (or Google Maps) by using location names as a reference in the search, and then choosing the coordinates of the approximate center of the location.

The first Excel sheet of this dataset is alphabetically ordered by subfamily, genus, and specific epithet and includes locality, geographic coordinate, collecting year, and a column that indicates which study provides which occurrence. The second Excel sheet includes the cities alphabetically arranged, the total of occurrences and the unique coordinates for each city, based on the records given in the previous Excel sheet. The same coordinate, 23º32'56"S 46º38'20"W, referring to the municipality of São Paulo was attributed to some historical records for which the given data in the original publication is superficial, such as "Cidade Jardim", "district of Ipiranga", "district of Jaraguá", "Horto Florestal (Estadual)", "Jaguara", "Parque Cajuru", and "Ressaca". No coordinates are available for the localities "Batavia" [see Pimentel and Pujol-Luz (2001): 16] or "Batea" [*e.g.*, see James (1943): 376] and "Matta da Serra" [see Iide and Mileti (1981): 921], so they were not included in the map.

The maps were elaborated with QGis 3.16.10 and the limits of the reserve were established from a satellite image obtained with Google Earth. The shapefile with the Atlantic Forest remnants was obtained here: http://mapas.sosma.org.br/.

Results

A total of 1,533 specimens of Stratiomyidae were collected in the survey, corresponding to 41 species in 25 genera and eight subfamilies (Table 1, Figs. 3-7). A little more than half of these species were assigned to known species (n = 22 species), implying that some species possibly correspond to new taxa, such as *Sargus* sp. 1, which has been stated as an undescribed taxon elsewhere [see Fachin et al. (2022); Riccardi et al. (2022); in both also as *Sargus* sp. 1]. The number of species and individuals sampled in each month by each collecting method is found in Supplementary File 1.

New records of taxa

The sargines *Merosargus golbachi* James, 1971 (Fig. 5l) and *M. tripartitus* James, 1971 (Fig. 6c), both described in James and McFadden (1971), are here reported for the first time to Brazil. Previously, they both have been known from other South American countries, with *M. golbachi* originally in Argentina and more recently found in Paraguay (Fachin et al., 2022) and *M. tripartitus* in Ecuador and Peru. Additionally, eight species and 10 genera are new records for the state of São Paulo (Table 1).

Overall species richness

The richest subfamily in the number of species at the Reserve is Sarginae with 13 species, followed by Pachygastrinae (which is the highest in the number of genera), with nine species, and by Clitellariinae and Stratiomyinae with three species each (Fig. 8). *Merosargus* Loew, 1855 (Sarginae), with five, *Sargus* Fabricius, 1805 (Sarginae), *Cyphomyia* Wiedemann, 1830 (Clitellariinae), and *Hermetia* Latreille, 1804 (Hermetiinae), with four each, and *Psephiocera* Enderlein, 1914 (Pachygastrinae), with only two species are the five most speciose genera at the Reserve (Table 1). Together, these five genera accounted for 46.3% of the observed stratiomyid species richness. In contrast, 20 genera were represented by one single species:

Table 1
Taxonomic composition and sampling months of soldier flies collected at the Reserve Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil, from May 2010 to December 2011 and in September 2014. *New record for the state of São Paulo. **New record for Brazil.

Subfamily	Species	Male	Female	Total	Month of occurrence		
					2010	2011	2014
Beridinae							
	Heteracanthia ruficornis Macquart, 1850	-	1	1	-	Oct, Nov	-
	Oplachantha sp. 1	10	5	15	Oct, Nov, Dec	Feb, Oct, Nov, Dec	-
Chiromyzinae							
	Barbiellinia sp. 1	62	-	62	May, Jun, Jul, Aug, Oct	May, Jun, Jul, Aug, Oct, Nov	-
	Chiromyza sp. 1	1025	14	1039	Apr, May, Jun, Jul, Aug	Apr, May, Jun, Jul, Aug, Sep	-
Clitellariinae							
	Cyphomyia aurifrons Wiedemann, 1830	1	1	2	Oct	Oct	-
	Cyphomyia gracilicornis Gerstaecker, 1857	39	77	116	Oct, Nov, Dec	Sep, Oct, Nov	-
*	*Cyphomyia leucocephala* Wiedemann, 1819	-	1	1	Nov, Dec	-	-
	Cyphomyia sp. 1	1	-	1	-	Sep	
*	*Diaphorostylus* sp. 1	1	1	2	Nov, Dec	-	-
	Euryneura sp. 1	22	1	23	Aug, Oct	-	-
Hermetiinae							
*	*Hermetia albitarsis* Fabricius, 1805	-	6	6	-	Sep, Oct, Dec	-
	Hermetia brachygastropsis Fachin and Hauser, 2022	-	1	1	-	Sep	-
	Hermetia currani Lindner, 1949	-	1	1	-	Sep, Oct	-
	Hermetia illucens (Linnaeus, 1758)	-	1	1	-	Aug	-
Pachygastrinae							
*	*Chorophthalmyia brevicornis* Lindner, 1964	-	1	1	Nov, Dec	-	-
*	*Cyclotaspis* sp. 1	-	1	1	Oct	-	-
*	*Eidalimus* sp. 1	1	12	13	Oct, Nov, Dec	Sep, Oct, Nov	-
*	*Manotes* sp. 1	1	4	5	Oct, Nov, Dec	Nov	-
*	*Panacris lucida* Gerstaecker, 1857	1	-	1	Oct	-	-
*	*Popanomyia* sp. 1	-	1	1	Nov, Dec	-	-
	Psephiocera sp. 1	1	2	3	-	Aug, Sep, Oct, Nov	-
	Psephiocera sp. 2	1	4	5	Nov, Dec	Oct, Nov	-
*	*Strobilaspsis* sp. 1	-	1	1	Nov, Dec	-	-
Raphiocerinae							
	Raphiocera sp. 1	1	-	1	-	Sep	-
Sarginae							
	Acrochaeta ruschii Fachin and Amorim, 2015	7	12	19	Oct, Nov, Dec	Jan, Mar, Apr, Aug to Dec	-
*	*Merosargus brunneus* Lindner, 1933	1	-	1	Nov	-	-
	Merosargus cingulatus Schiner, 1868	3	9	12	Oct, Nov, Dec	Feb, Mar, Aug, Sep, Oct, Nov	Sep
**	*Merosargus golbachi* James, 1971 *in* (James and McFadden, 1971)	5	1	6	-	Sep, Oct, Nov	-
*	*Merosargus nebulifer* James, 1971 *in* (James and McFadden, 1971)	4	6	10	Oct, Nov	Sep, Oct, Nov	-
*	*Merosargus opaliger* Lindner, 1931	14	16	30	May, Jun, Oct, Nov, Dec	Mar, Jun, Sep, Oct, Nov, Dec	-
**	*Merosargus tripartitus* James, 1971 *in* (James and McFadden, 1971)	2	1	3	-	Oct, Nov, Dec	-
*	*Microchrysa bicolor* (Wiedemann, 1830)	1	7	8	Nov, Dec	Sep, Oct, Nov	Sep
	Pteticus testaceus (Fabricius, 1805)	12	14	26	Nov, Dec	Jan to Dec	-
	Sargus fasciatus Fabricius, 1805	2	-	2	Sep, Oct	-	Sep
	Sargus thoracicus Macquart, 1834	37	50	87	May to Dec	Jan to Apr, Aug to Nov	Sep
	Sargus sp. 1	2	3	5	Sep, Oct, Nov, Dec	Nov, Dec	-
	Sargus sp. 2	-	4	4	-	Apr, Jul, Aug, Sep, Oct, Dec	-
Stratiomyinae							
	Chloromelas sp. 1	1	-	1	-	Aug, Sep	-
*	*Glariopsis* sp. 1	-	3	3	Nov, Dec	Oct, Nov	-
*	*Myxosargus* sp. 1	6	6	12	Sep, Oct, Nov, Dec	Sep, Oct, Nov	-
*	*Myxosargus* sp. 2	1	-	1	-	Nov	-
Total		1265	268	1533			

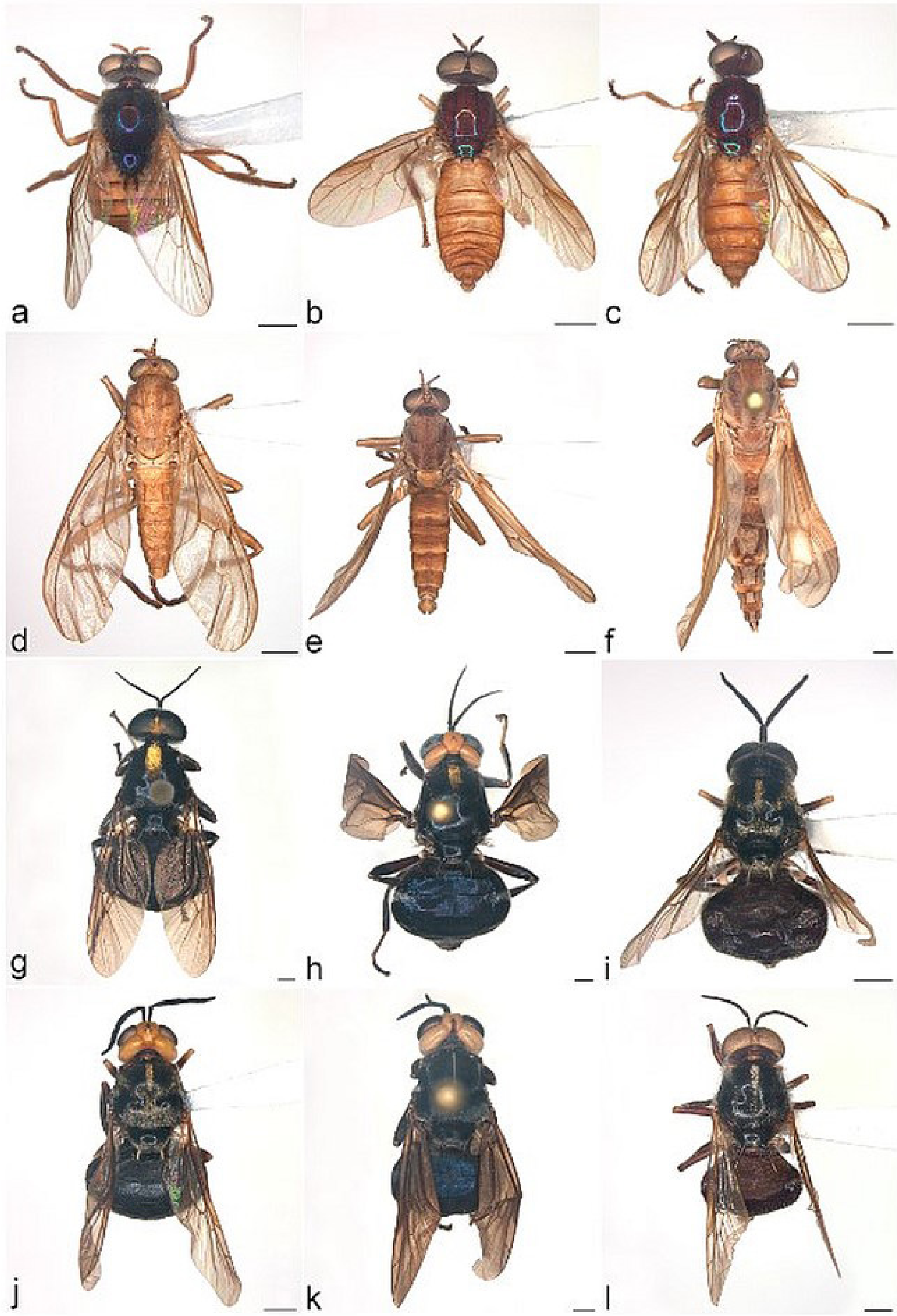

Figure 3 Stratiomyids from the Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil. (a) *Heteracanthia ruficornis* Macquart, 1850, female; (b) *Oplachantha* sp. 1, male; (c) *Oplachantha* sp. 1, female; (d) *Barbiellinia* sp. 1, male; (e) *Chiromyza* sp. 1, male; (f) *Chiromyza* sp. 1, female; (g) *Cyphomyia aurifrons* Wiedemann, 1830, male; (h) *C. aurifrons*, female; (i) *C. gracilicornis* Gerstaecker, 1857, male; (j) *C. gracilicornis*, female; (k) *C. leucocephala* Wiedemann, 1819, female; (l) *Cyphomyia* sp. 1, male. Scale bar, 1 mm.

one genus in Raphiocerinae, two in Beridinae, three each in Clitellariinae and Sarginae, four in Stratiomyinae, and seven in Pachygastrinae.

In terms of abundances, nearly 72% of all specimens (1,101) correspond to Chiromyzinae, followed by Sarginae, with 13.9% (213 specimens), Clitellarinae, with 9.4% (145), Pachygastrinae, with 2% (31), and by Stratiomyinae (17), Beridinae (16), Hermetiinae (9), and Raphiocerinae (1), which altogether represent only about 2.8% of all specimens. Fifteen and three species were collected as singletons and doubletons, respectively, representing 43.9% of all species observed, with most of the rare species in Pachygastrinae (five) and Hermetiinae (three). Another 11 species, 26.8% of all species, were represented by relatively few specimens, from 3 to 10: one species in Hermetiinae, one in Stratiomyinae, three in Pachygastrinae, and six in Sarginae. The remaining 12 species (one species each in Beridinae, Pachygastrinae and Stratiomyinae, two each in Chiromyzinae and Clitellariinae, and five in Sarginae), 29.3% of all species, have 10 specimens or more, representing alone 94.8% (1,454 specimens) of all specimens (Table 1). In the Beridinae, Chiromyzinae, Clitellariinae, Hermetiinae, Pachygastrinae, Sarginae, and Stratiomyinae, the most abundant species of each subfamily had twice more specimens or even more than the second most abundant species in each subfamily, such as the sargines *Sargus thoracicus* Macquart, 1834, with 87 and *Merosargus opaliger* Lindner, 1931, with

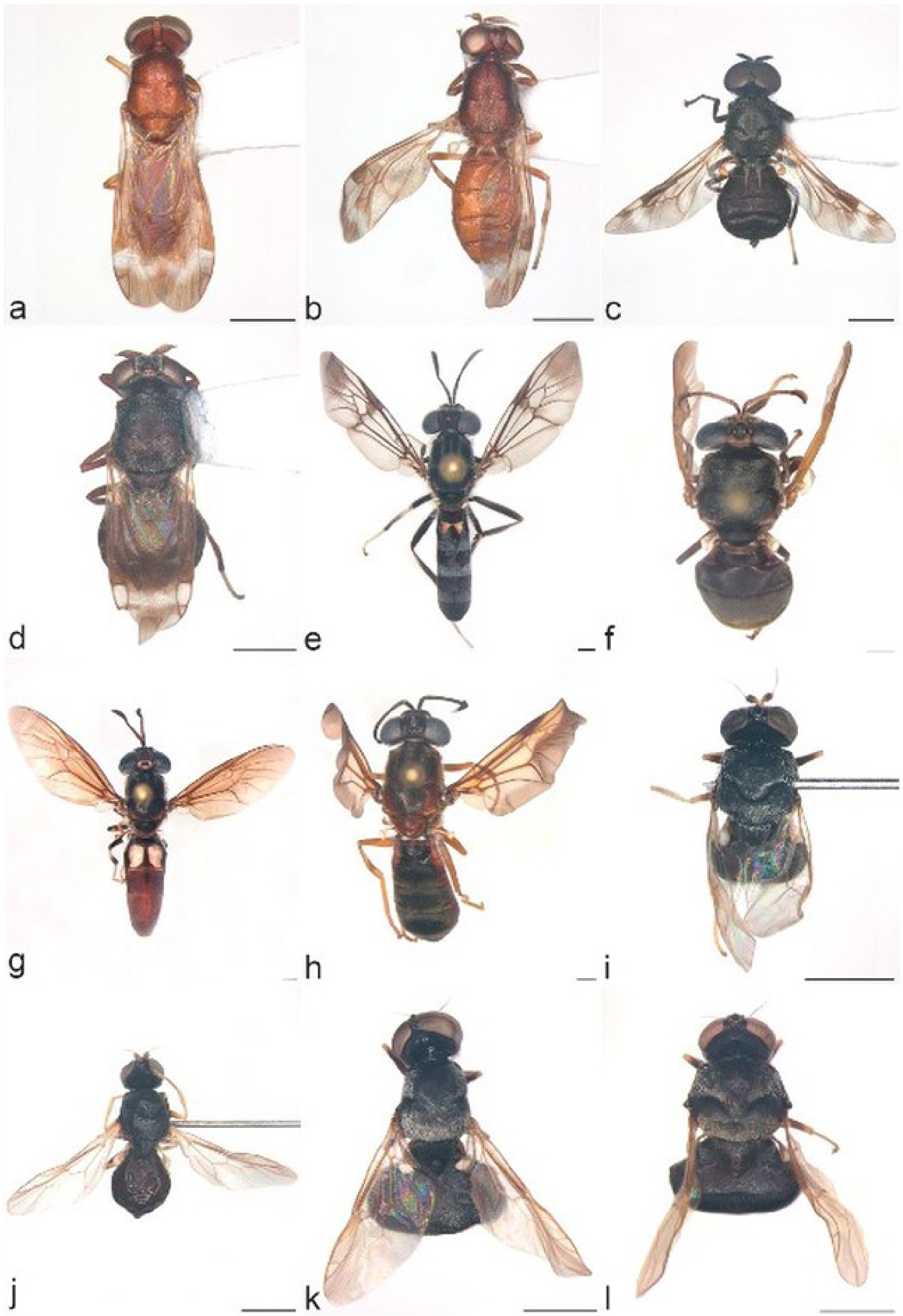

Figure 4 Stratiomyids from the Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil. (a) *Diaphorostylus* sp. 1, male; (b) *Diaphorostylus* sp. 1, female; (c) *Euryneura* sp. 1, male; (d) *Euryneura* sp. 1, female; (e) *Hermetia albitarsis* Fabricius, 1805, female; (f) *H. brachygastropsis* Fachin & Hauser, 2022, female; (g) *H. illucens* (Linnaeus, 1758), female; (h) *H. currani* Lindner, 1949, female; (i) *Chorophthalmyia brevicornis* Lindner, 1964, female; (j) *Cyclotaspis* sp. 1, female; (k) *Eidalimus* sp. 1, male; (l) *Eidalimus* sp. 1, female. Scale bar, 1 mm.

30 specimens. The most dominant of all, however, is *Chiromyza* sp. 1, which accounted alone for nearly 70% of all specimens.

In a comparison of the two fragments at the Reserve, fragment 1 has the higher abundance, with nearly 70% of all specimens captured (1,063 specimens), which is due to the high number of *Chiromyza* sp. 1 (851). On the other hand, fragment 2 is the richest, with 37 species, 16 of which were exclusively found on this site. In contrast, only four species were exclusively found in fragment 1 (Table 2).

Effects of climate factors

Soldier flies were recorded in every month of the year, with the highest number of species in the rainy months (between September and December 2010/2011) (Figs. 10 and 11), with a sizable increase in the number of species at the beginning of spring. As the two Malaise trap models did not overlap for the whole period they stayed at the collecting sites, the analyses of the climate factors and species richness

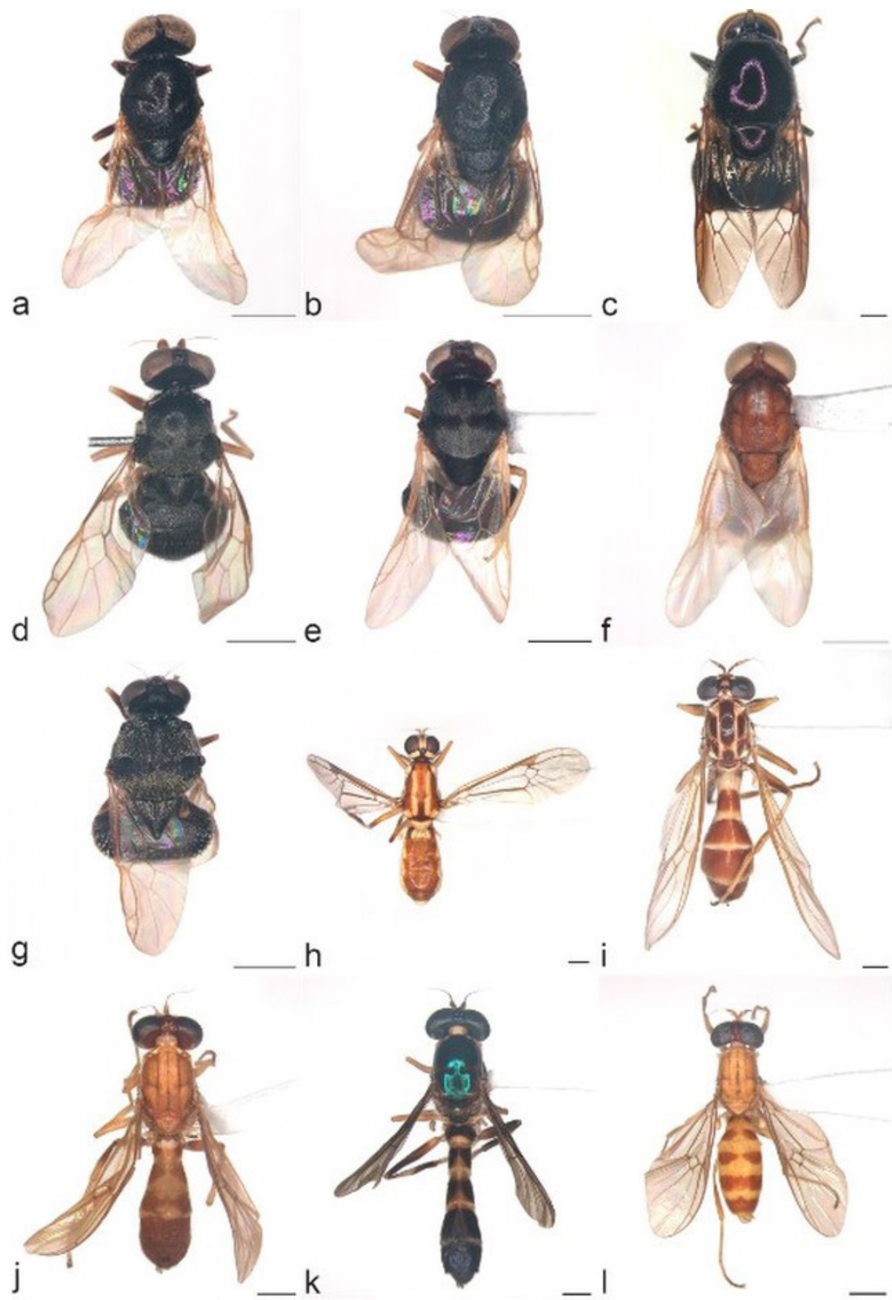

Figure 5 Stratiomyids from the Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil. (a) *Manotes* sp. 1, male; (b) *Manotes* sp. 1, female; (c) *Panacris lucida* Gerstaecker, 1857, male; (d) *Popanomyia* sp. 1, female; (e) *Psephiocera* sp. 1, female; (f) *Psephiocera* sp. 2, male; (g) *Strobilaspsis* sp. 1, female; (h) *Raphiocera* sp. 1, male; (i) *Acrochaeta ruschii* Fachin & Amorim, 2015, female; (j) *Merosargus brunneus* Lindner, 1933, male; (k) *M. cingulatus* Schiner, 1868, male; (l) *M. golbachi* James, 1971 *in* James & McFadden, 1971, male. Scale bar, 1 mm.

and abundance of the two traps were generated separately (Tables 3 and 4; Figs. 10 and 11). Only for the specimens collected with the white roof model, Spearman's test indicated a negative correlation for mean relative humidity regarding richness and abundance, while the other variables showed no correlation with abundance and richness (Table 4).

For black roof Malaise traps, June 2010 and 2011 presented the highest number of specimens collected, with 342 and 237, respectively, due to the high number of *Chiromyza* sp. 1 collected in these periods (n = 334 in 2010 and n = 231 in 2011). In the two years, November had the highest number of species, with 10 and seven, in 2010 and 2011, respectively. In 2010, it was followed by October and in 2011 by September, with six species each (October 2011 presented five species) (Fig. 9). For white roof Malaise traps, July and October 2011 produced the highest number of specimens, with 68 and 71, respectively (Fig. 10). In July 2011, all specimens belonged to *Chiromyza* sp. 1, but in October 2011, over half of the specimens (48) were assigned to *Cyphomyia gracilicornis* Gerstaecker, 1857. Similarly, November presented the highest species diversity using white roof Malaise traps with 18 species, followed by September and October, with 10 and 11, respectively. Besides *Chiromyza* sp. 1, which was evidently abundant and nearly exclusive of the dry season, from April to August (n = 641 specimens in 2010 and n = 301 in 2011, both

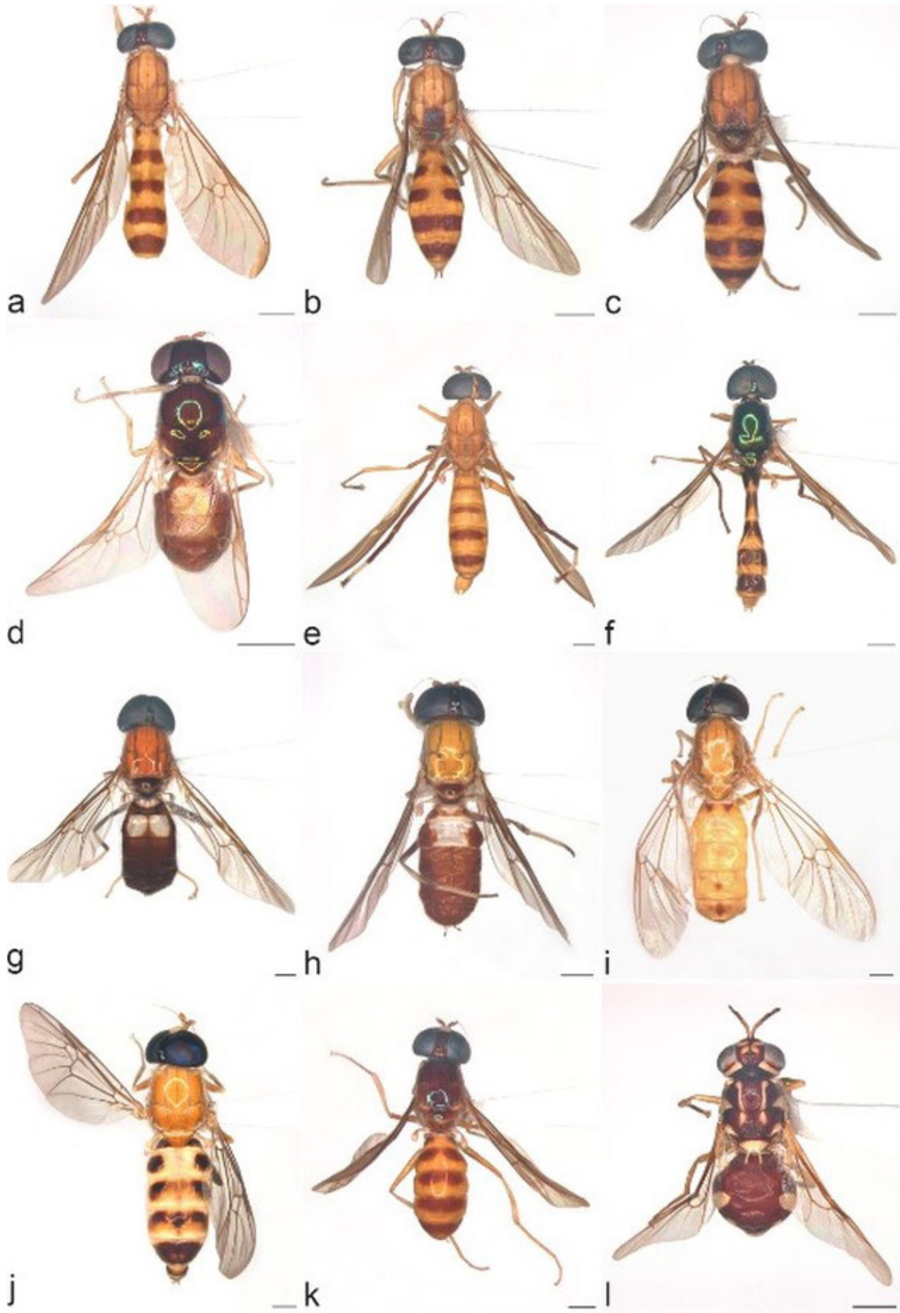

Figure 6 Stratiomyids from the Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil. (a) *Merosargus nebulifer* James, 1971 *in* James & McFadden, 1971, male; (b) *M. opaliger* Lindner, 1931, female. (c) *M. tripartitus* James, 1971 *in* James & McFadden, 1971, female; (d) *Microchrysa bicolor* (Wiedemann, 1830), female; (e) *Pteticus testaceus* (Fabricius, 1805), male; (f) *Sargus fasciatus* Fabricius, 1805, male; (g) *S. thoracicus* Macquart, 1834, male; (h) *S. thoracicus*, female; (i) *Sargus* sp. 1, male; (j) *Sargus* sp. 1, female; (k) *Sargus* sp. 2, female; (l) *Glariopsis* sp. 1, female. Scale bar, 1 mm.

with black roof Malaise traps; n = 83 in 2011 with white roof Malaise traps), and another 56 specimens of *Barbiellinia* sp. 1 collected in the same period, only a few other species were collected in such period of the year. Overall, the black roof Malaise yielded during the dry season of each year, only other five species, all Sarginae, and 10 specimens: *Acrochaeta ruschii* Fachin & Amorim, 2015, *Merosargus opaliger*, *Ptecticus testaceus* (Fabricius, 1805); *Sargus thoracicus*, and *Sargus* sp. 2. The white roof Malaise produced another five species and 13 specimens, which were almost all Sarginae—*A. ruschii*, *P. testaceus*, *S. thoracicus*, and *Sargus* sp. 2—, except for the unique specimen of *Hermetia illucens* Latreille, 1804 (Hermetiinae). Nevertheless, it is unlikely that *H. illucens* is exclusive to the dry season, as it is known for other months and introduced worldwide (Woodley, 2001; Roháček and Hora, 2013; Ståhls et al., 2020). Except for six *Barbiellinia* sp. 1 and another two *Chiromyza* sp. 1 collected in September, October, and November, chiromyzines were not reported in the rainy season. In contrast, Clitellariinae and Hermetiinae were very often captured in the rainy season. Only one species of each subfamily, *Euryneura* sp. 1 (17) and *H. illucens* (1), was collected in August. The subfamily Sarginae was the only one captured more extensively in both seasons, represented by at least five species and 23 specimens in the dry season, but definitely richer and more abundant in the rainy season.

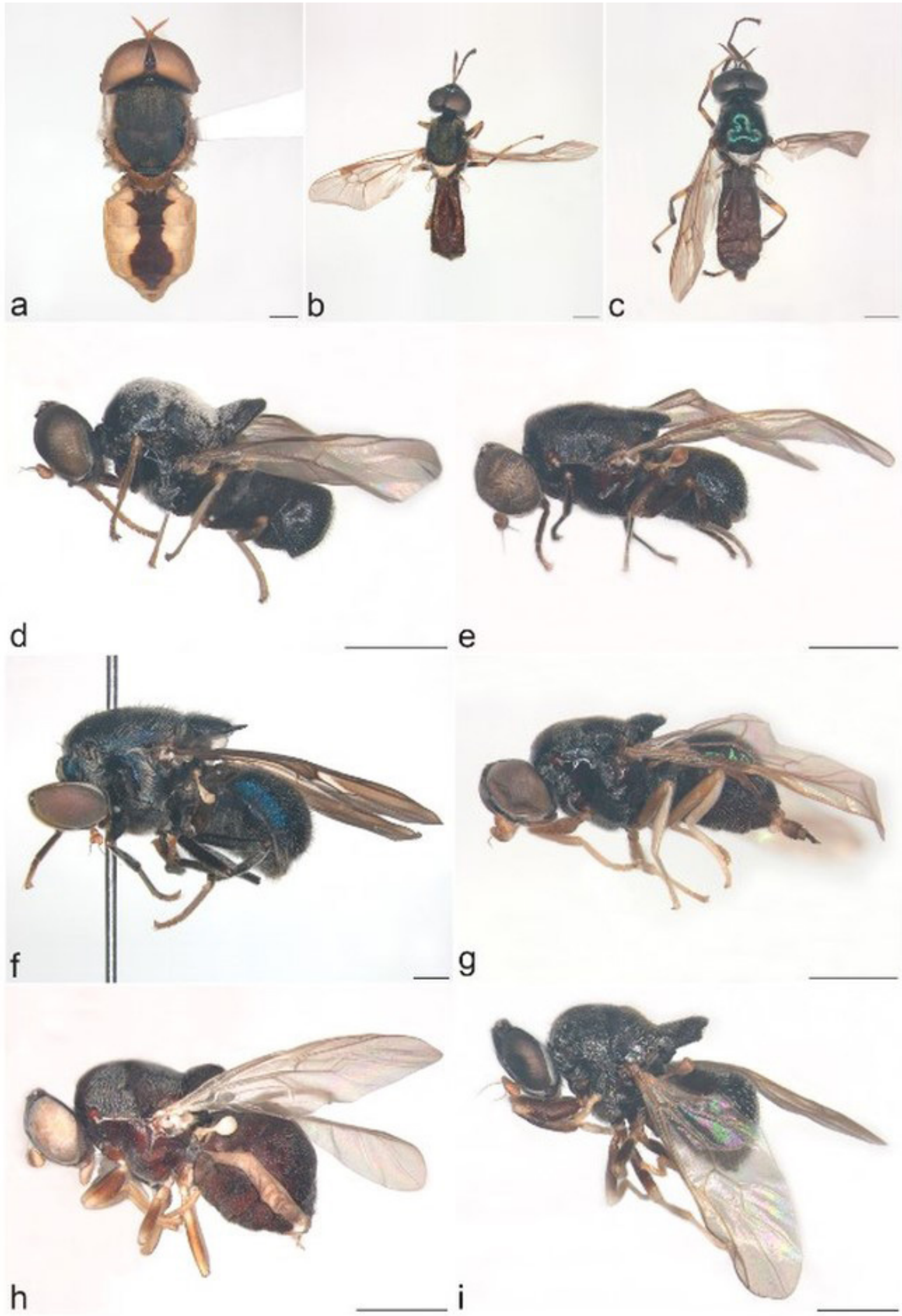

Figure 7 Stratiomyids from the Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil. (a) *Chloromelas* sp. 1, male; (b) *Myxosargus* sp. 1, male; (c) *Myxosargus* sp. 2, male; (d) *Eidalimus* sp. 1, male; (e) *Manotes* sp. 1, male; (f) *Panacris lucida*, male; (g) *Popanomyia* sp. 1, female; (h) *Psephiocera* sp. 1, female; (i) *Strobilapsis* sp. 1, female. Scale bar, 1 mm.

Effects of collecting methods

The highest number of specimens and species were collected with Malaise traps (1,491 specimens; 40 species). Together, the remaining collecting methods, of which the Shannon trap and sweeping nets were only used occasionally and for a short period of time, yielded very low numbers, representing only 42 specimens and five species as follows: sweep net (31 specimens, six species), PET bottle trap (10 specimens, one species), and Shannon trap (one specimen and one species). Although no species were exclusively collected with less productive methods, nearly all specimens of *Euryneura* sp. 1 (Clitellariinae), 22 out of 23, were captured using the sweep net alone.

Overall, black roof Malaise captured 1,231 specimens and 29 species, and white roof Malaise, 260 specimens and 29 species, as well (Table 2). The species composition greatly differs between these two methods, with black roof Malaise producing 11 and white roof Malaise 10 unique species. In terms of unique species captured with black roof Malaise, most were from Pachygastrinae (5 of 11), followed by Sarginae (3 of 11), and it also yielded the single specimen of Raphiocerinae—*Raphiocera* sp. 1. In contrast, the white roof model had mostly unique species from Hermetiinae (3 of 10), followed by Stratiomyinae (2 of 10). Moreover, a combination of two traps uniquely collected two species of Clitellariinae: *Cyphomyia aurifrons* Wiedemann, 1820 (white roof Malaise and sweep net) and *Euryneura* sp. 1 (black roof Malaise and sweep net). However,

Table 2
Taxonomic composition by areas sampled and collecting methods at the Reserve Ecológica e Biológica de Sertãozinho, São Paulo, Brazil. Collecting methods: BRM, black roof Malaise trap; WRM, white roof Malaise trap; PBT, PET Bottle trap; SW, sweep net; ST, Shannon trap.

Subfamily	Species	Fragment 1		Fragment 2		Collecting methods				
		Border	Interior	Border	Interior	BRM	WRM	PBT	SW	ST
Beridinae										
	Heteracanthia ruficornis	-	-	-	1	-	1	-	-	-
	Oplachantha sp. 1	1	3	-	11	11	3	-	1	-
Chiromyzinae										
	Barbiellinia sp. 1	-	-	3	59	46	16	-	-	-
	Chiromyza sp. 1	379	472	28	160	943	83	10	3	-
Clitellariinae										
	Cyphomyia aurifrons	-	2	-	-	-	1	-	1	-
	Cyphomyia gracilicornis	1	54	-	61	51	65	-	-	-
	Cyphomyia leucocephala	-	-	-	1	1	-	-	-	-
	Cyphomyia sp. 1	-	1	-	-	-	1	-	-	-
	Diaphorostylus sp. 1	-	-	-	2	2	-	-	-	-
	Euryneura sp. 1	-	18	4	1	1	-	-	22	-
Hermetiinae										
	Hermetia albitarsis	1	4	-	1	1	5	-	-	-
	Hermetia brachygastropsis	-	-	-	1	-	1	-	-	-
	Hermetia currani	-	-	-	1	-	1	-	-	-
	Hermetia illucens	-	1	-	-	-	1	-	-	-
Pachygastrinae										
	Chorophthalmyia brevicornis	-	-	-	1	1	-	-	-	-
	Cyclotaspis sp. 1	-	-	-	1	1	-	-	-	-
	Eidalimus sp. 1	-	5	-	8	7	6	-	-	-
	Manotes sp. 1	-	1	-	5	5	1	-	-	-
	Panacris lucida	-	-	-	1	1	-	-	-	-
	Popanomyia sp. 1	-	-	-	1	1	-	-	-	-
	Psephiocera sp. 1	-	1	-	2	-	3	-	-	-
	Psephiocera sp. 2	-	2	-	3	2	3	-	-	-
	Strobilapsis sp. 1	-	-	-	1	1	-	-	-	-
Raphiocerinae										
	Raphiocera sp. 1	-	-	1	-	1	-	-	-	-
Sarginae										
	Acrochaeta ruschii	8	10	-	1	14	5	-	-	-
	Merosargus brunneus	-	1	-	-	1	-	-	-	-
	Merosargus cingulatus	1	4	3	4	5	3	-	3	1
	Merosargus golbachi	-	5	-	1	-	6	-	-	-
	Merosargus nebulifer	-	7	-	3	4	6	-	-	-
	Merosargus opaliger	5	17	-	8	17	13	-	-	-
	Merosargus tripartitus	-	-	2	1	2	1	-	-	-
	Microchrysa bicolor	-	4	1	3	6	2	-	-	-
	Pteticus testaceus	1	6	5	14	11	15	-	-	-
	Sargus fasciatus	1	-	1	-	1	-	-	-	-
	Sargus thoracicus	28	14	10	35	75	11	-	1	-
	Sargus sp. 1	3	-	-	2	5	-	-	-	-
	Sargus sp. 2	1	1	-	2	3	1	-	-	-
Stratiomyinae										
	Chloromelas sp. 1	-	-	-	1	-	1	-	-	-
	Glariopsis sp. 1	-	1	-	2	2	1	-	-	-
	Myxosargus sp. 1	-	-	5	7	9	3	-	-	-
	Myxosargus sp. 2	-	-	-	1	-	1	-	-	-
Total		429	634	63	407	1231	260	10	31	1

this might be purely coincidental as the use of sweep net is not exactly selective for strats.

In a comparison of effectiveness between the two types of Malaise traps from January to December 2011—the interval the two types of traps overlapped in the interior of the fragments only (Table 5)—, the chi-squared test showed that the black model produced significantly more specimens (n = 322 specimens) than the white model (n = 260 specimens). In contrast, the white model was more effective to yield species (29 species) than the black model (18 species), even with a lower number of specimens captured. The chi-squared values obtained were: X^2 23.507, p = 0.014978 for the species richness test and X^2 298.03, p = 2.2774E-57 for the abundance test.

Table 3
Spearman correlation for climate factors and abundance and richness of soldier flies collected using black roof Malaise traps from May 2010 to December 2011.

	Mean temperature (°C)	Precipitation (mm)	Relative humidity (%)
Abundance	-0,38215	-0.37363	-0,28077
Richness	0,34262	0,2582	-0,0030444

Table 4
Spearman correlation for climate factors and abundance and richness of soldier flies collected using white roof Malaise traps from January 2011 to December 2011. Asterisk (*) indicate statistical significance at the level of 0.05 probability.

	Mean temperature (°C)	Precipitation (mm)	Relative humidity (%)
Abundance	0,056949	-0.41003	-0,62643*
Richness	0,27243	-0.078234	-0,43589

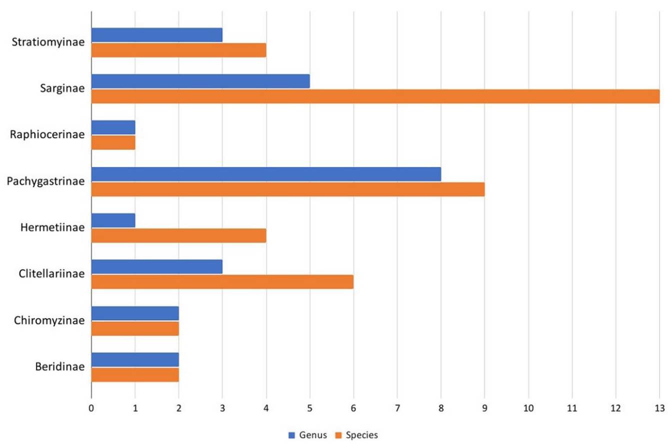

Figure 8 Diversity of genera and species in each subfamily at the Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil.

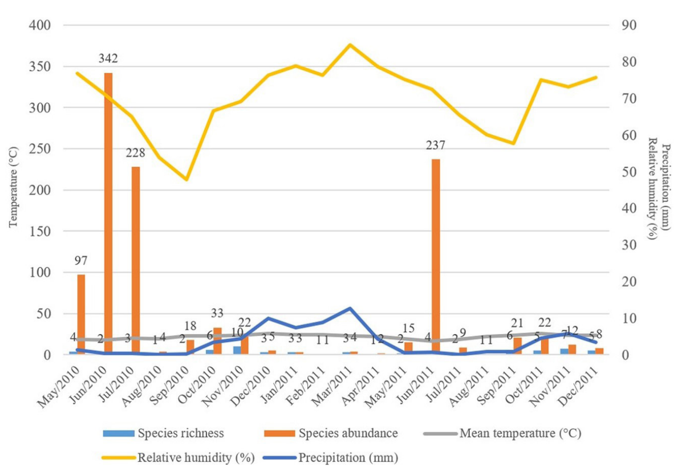

Figure 9 Climate and seasonal data of soldier flies collected using black roof Malaise traps at the Reserva Ecológica e Biológica de Sertãozinho, São Paulo, Brazil.

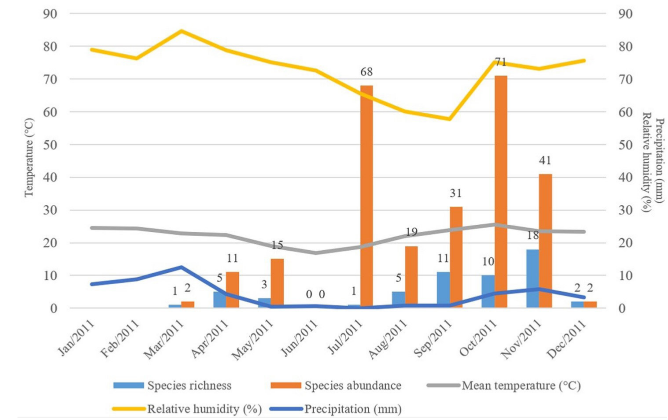

Figure 10 Climate and seasonal data of soldier flies collected using white roof Malaise traps at the Reserva Ecológica e Biológica de Sertãozinho, São Paulo, Brazil.

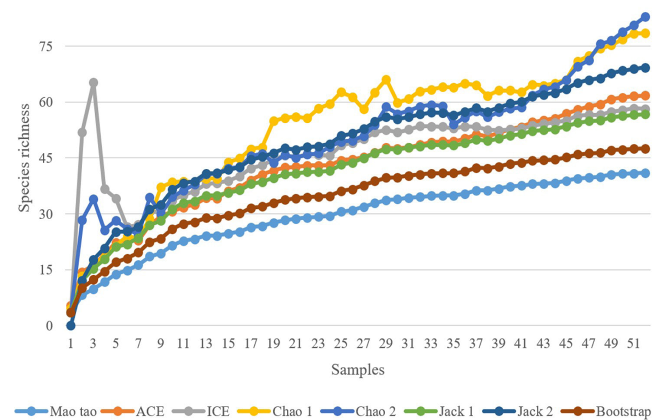

Figure 11 Species accumulation curve and performance of the richness estimators of the Stratiomyidae collected at Reserva Ecológica e Biológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil, from May 2010 to December 2011 and in September 2014.

Stratiomyidae records and species of São Paulo

Based on all the literature known to us containing taxonomic and distributional data, there are 261 records of Stratiomyidae and 92 unique coordinates previous to this study, representing 56 municipalities of the state of São Paulo (Supplementary File 2). Only one previous record of *Chrysochlorina incompleta* (Curran, 1929) from "Pôrto Cabral, Rio Paraná, SP, X.1941 (Travassos F.º)" [see Iide (1966): 105] is not taken into account, as this currently refers to a location within the limits of the state of Mato Grosso do Sul, in the municipality of Anaurilândia. Among the cities recorded, the five most sampled hold 44,8% of all the sampling sites in the state, 117 out of 261: São Paulo (n = 60), Salesópolis (n = 25), Barueri (n = 11), Juquiá (n = 11), and Jundiaí (n = 10). Another nine localities well sampled hold from five to nine records each, 56 in total (21,5% of all occurrences). The majority of municipalities, however, 44 out of 56, had four or fewer records each, 88 in total (33,70% of all occurrences).

The list of species for the state includes 113 species (Table 6), of which only 20 remain as morphospecies. The only species for which a formal record is not available, although it has been mentioned for the state, is *Ptecticus inversus* Curran, 1934 (Leal and Oliveira, 1979). As it is likely a widespread species in Brazil (Leal and Oliveira, 1979: 54–55), it remains on the list. However, another four species (*Auloceromyia* sp., *Hermetia* sp., *Merosargus* sp., and *Sargus* sp.) given by Cavallari et al. (2015): 6 (Table 2) were not included, since the vouchers could not be retrieved for checking the identifications. As undoubtedly there are several undescribed species for the state and additional species known in other states that most likely occur in São Paulo, the number of species herein presented will likely change in the near future.

Table 5
Species richness and abundances in each Malaise trap model, from January to December 2011, individually.

Month	Species richness		Abundance	
	Black roof model	White roof model	Black roof model	White roof model
Jan/2011	2	0	2	0
Fev/2011	2	0	2	0
Mar/2011	3	1	5	2
Apr/2011	0	5	0	11
May/2011	2	3	15	15
Jun/2011	2	0	196	0
Jul/2011	3	1	69	68
Aug/2011	1	5	1	19
Sep/2011	4	11	8	31
Oct/2011	4	10	16	71
Nov/2011	4	18	6	41
Dec/2011	2	2	2	2

Discussion

Over the first half of the 20th century, a few lists of soldier flies were produced for the Neotropics [*e.g.*, Lindner (1929), (1941), (1956)] and what they have in common is that they were mostly based on a few days or weeks of collecting, rendering little material, although in many cases, these lists still represent in large part the current knowledge of an area or country [*e.g.*, Lindner (1941) for Peru, (1956) for Bolivia]; other lists were the result of compilations of material from different collections and collecting points [*e.g.*, Lindner (1951); Fachin et al. (2022)]. In contrast, this is the first checklist of soldier flies for an individual area in the state of São Paulo and one of the few ever conducted for the family in the Neotropical Region, based on a long-term collecting project. The only other survey, which collected over many months, uninterruptedly, including the Stratiomyidae, also addressed the whole dipteran fauna of a four-hectare patch of cloud forest at Zurquí de Moravia, San José, Costa Rica (Borkent et al., 2018). Compared to their results, which had two white roof Malaise traps (Borkent et al., 2018: 309, Fig. 2b; similar to one of our types of Malaise traps, Fig. 2c) continuously sampling the area for about 13 months—besides other collecting methods as we did—, the species richness and abundance of our area were higher. While they had 36 species and 15 genera in Zurquí, which is at 1,600 meters above sea level (Borkent et al., 2018: 57, Table 1), the present study yielded 41 species and 25 genera. Only if taking into account their two additional sites (Tapantí and Las Alturas), that yielded exclusively from Zurquí, eight and 12 species, respectively, is that the number of species of the three sites altogether (Zurquí, Tapantí, and Las Alturas) is higher than our study, increased to 56 species. The abundance of specimens of the three sites summed, however, was much smaller (291) than that at the reserve in Sertãozinho (1,533). Even when disregarding the number of specimens of *Chiromyza* sp. 1 (1,039, Table 1), there are still 494 specimens left in our study. Another two recurrent species in the reserve and elsewhere [see Fachin et al. (2022); Riccardi et al. (2022): 10, Table 1]—*Ptecticus testaceus* and *Sargus thoracicus*—, with 26 and 87 specimens respectively, but not collected in Borkent et al. (2018) (see their supplementary file), although they occur in Costa Rica (Woodley, 2001: 218, 229), also contributes for a high overall abundance. If these three species are disregarded, the total number of specimens at the reserve in Sertãozinho is reduced to 381, which is a similar number obtained in Costa Rica (291). However, information on the abundance of stratiomyid per species in their study is not available, so comparisons are limited.

As noted, soldier flies are often abundant and rich in faunistic studies. In another long-term survey conducted in Central Brazilian areas (Lamas et al., 2015; more here: https://media.fapesp.br/bv/uploads/pdfs/science_of_the_amazon_2_10_11.pdf), which had more sampling sites and collecting methods (from August 2011 to February 2013), the total number of stratiomyids sorted out from traps, curated, and identified was 2,560 specimens (DAF, data unpublished), but with only three *Chiromyza* sp. and a total of 85 chiromyzines altogether. Finally, in the Mitaraka expedition, in French Guiana (Touroult et al., 2018), only 14 specimens of *Chiromyza* sp. out of 882 soldier flies were found (DAF, data unpublished). As Chiromyzinae, including *Chiromyza* Wiedemann, 1820, are widespread in the Neotropical Region (Woodley, 2001, 2009)—present both in humid and more dry environments—and that very little is known about the seasonality of these flies and of stratiomyids in general from other areas, is probable that the higher numbers of *Chiromyza* in Sertãozinho and low numbers of the same group in other areas are due to a combination of lack of study and biases of the collecting methods used. It could also be, that in our study area, there was a mass emergence of these *Chiromyza* sp. 1, likely because there was a favorable condition and then a large number was captured.

This study adds two new records of species to Brazil and eight species and 10 genera to the state of São Paulo, with a revised list of all records and species once reported for the state (see Supplementary File 2). It is not surprising that collecting in new areas or intensive collecting, for a long period, even in well-known sites can yield new records and undescribed taxa. Recently, for example, a large-scale survey in the Parc national du Mercantour listed 53 species of organisms new to France (Ichter et al., 2022). Similarly, a second collection in Ilha of Maracá, Roraima, Brazil (Riccardi et al., 2022), in the Amazon Forest, presented 29 records of dipteran species new to the country and 165 records new to the state, with dozens of undescribed species. Additionally, the sampling of the dossel fauna of insects (Amorim et al., 2022) has revealed new records and species that can be distributed in the canopy and above, but not at the ground level. Such faunistic studies of Diptera, but not only [see Touroult et al. (2018); Prado et al. (2019)], from a certain studied area listing all known species, are being newly produced (Marín-Armijos et al., 2017) and constantly updated [see Krolow et al. (2017); Withers and Claude (2021)], giving us then a clearer impression of biodiversity and revealing that our knowledge about species richness and distribution, even in well-known areas (Clem et al., 2022), is still in construction.

Our study, in this sense, not only adds new distributional data of the species and new records of taxa to the state and country thus reducing the Linnean and Wallacean shortfalls, but it reveals, at the same time, that the number of species at the reserve in Sertãozinho might be higher, from 47 (only six species above the current number) to up 105 species, which is over twice the number of species in the

Table 6
List of Stratiomyidae species and morphospecies recorded from the state of São Paulo, Brazil, with corresponding literature that reports each species in the state.

No.	Species	References
Subfamily Beridinae		
1.	*Archistratiomys rufipalpis* (Wiedemann, 1830)	Enderlein (1921)
2.	*Arcuavena barbiellinii* (Bezzi, 1908)	Bezzi (1908)
3.	*Heteracanthia ruficornis* Macquart, 1850	Lindner (1933); this study
4.	*Oplachantha bellula* (Williston, 1888)	Carrera (1944)
5.	*Oplachantha cincticornis* Enderlein, 1921	James (1977)
6.	*Oplachantha tricolor* (Wiedemann, 1828)	Enderlein (1921); James (1977)
7.	*Oplachantha* sp. 1	This study
Subfamily Chiromyzinae		
8.	*Barbiellinia hirta* Bezzi, 1922	Bezzi (1922)
9.	*Barbiellinia lineata* (Enderlein, 1921)	Enderlein (1921)
10.	*Barbiellinia murcicornis* (Enderlein, 1921)	Enderlein (1921)
11.	*Barbiellinia parvicornis* (Enderlein, 1921)	Enderlein (1921)
12.	*Barbiellinia* sp. 1	This study
13.	*Chiromyza ochracea* Wiedemann, 1820	Bezzi (1922); Lindner (1933)
14.	*Chiromyza viridis* Bezzi, 1922	Bezzi (1922)
15.	*Chiromyza vittata* Wiedemann, 1822	Bezzi (1922)
16.	*Chiromyza* sp. 1	This study
17.	*Mesomyza tenuicornis* Enderlein, 1921	Enderlein (1921); Lindner (1933); Oliveira and Pujol-Luz (2000)
Subfamily Chrysochlorininae		
18.	*Cacosis niger* (Wiedemann, 1819)	Iide (1973)
19.	*Chrysochlorina albipes* James, 1939	Iide (1966)
20.	*Chrysochlorina bezziana* Iide, 1966	Iide (1966)
21.	*Chrysochlorina costalimai* Iide, 1966	Iide (1966)
22.	*Chrysochlorina incompleta* (Curran, 1929)	Iide (1966)
23.	*Chrysochlorina pluricolor* (Bigot, 1879)	Carrera (1944); Iide (1966)
24.	*Chrysochlorina vespertilio* (Fabricius, 1805)	Iide (1966)
Subfamily Clitellariinae		
25.	*Auloceromyia vespiformis* Lindner, 1969	Vianna et al. (2003)
26.	*Chordonota inermis* (Wiedemann, 1819)	James (1940)
27.	*Cyphomyia aurifrons* Wiedemann, 1830	Lindner (1928, 1933); Carrera (1944); this study
28.	*Cyphomyia gracilicornis* Gerstaecker, 1857	Carrera (1944); this study
29.	*Cyphomyia leucocephala* Wiedemann, 1819	This study
30.	*Cyphomyia* sp. 1	This study
31.	*Diaphorostylus* sp. 1	This study
32.	*Euryneura kerteszi* Iide, 1968	Iide (1968)
33.	*Euryneura robusta* Kertész, 1908	Iide (1968)
34.	*Euryneura* sp. 1	This study
Subfamily Hermetiinae		
35.	*Chaetosargus hirticornis* (Wiedemann, 1830)	Iide (1967)
36.	*Chaetosargus secundus* (Albuquerque, 1955)	Albuquerque (1955); Iide (1975)
37.	*Hermetia albitarsis* Fabricius, 1805	This study
38	*Hermetia brachygastropsis* Fachin and Hauser, 2022	Fachin and Hauser (2022)
39.	*Hermetia pulchra* Wiedemann, 1830	Lindner (1933)
40.	*Hermetia currani* Lindner, 1949	This study
41.	*Hermetia illucens* (Linnaeus, 1758)	Lindner (1928); Iide and Mileti (1976); Carvalho et al. (2000); Ferrari et al. (2009); Cavallari et al. (2015); this study
42.	*Hermetia itatiaiensis* Lindner *in* James, 1973	Iide and Mileti (1981)
43.	*Hermetia teevani* Curran, 1934	Lindner (1935)
44.	*Hermetia virgata* Lindner, 1949	Lindner (1949)
Subfamily Pachygastrinae		
45.	*Acanthinomyia elongata* (Wiedemann, 1824)	Carrera (1944)
46.	*Artemita podexargenteus* Enderlein, 1914	Ururahy-Rodrigues (2004); James (1971)
46.	*Chorophthalmyia brevicornis* Lindner, 1964	This study
48.	*Cosmariomyia argyrosticta* Kertész, 1914	Kertész (1914)
49.	*Cyclotaspis* sp. 1	This study
50.	*Eidalimus* sp. 1	This study
51.	*Iidemyia microdonta* (Kertész, 1908)	Pujol-Luz (2008)
52.	*Ligyromyia columbiana* Kertész, 1916	Lindner (1933)
53.	*Manotes* sp. 1	This study
54.	*Panacris lucida* Gerstaecker, 1857	This study
55.	*Panacris maxima* Kertész, 1908	Pujol-Luz and Galinkin (2004)
56.	*Popanomyia* sp. 1	This study
57.	*Psephiocera flavipes* Enderlein, 1914	Lindner (1933)
58.	*Psephiocera modesta* (Lindner, 1949)	Xerez et al. (2003)
59.	*Psephiocera* sp. 1	This study
60.	*Psephiocera* sp. 2	This study
61.	*Strobilaspis* sp. 1	This study

Table 6
Continued...

No.	Species	References
Subfamily Raphiocerinae		
62.	*Analcocerus atriceps* Loew, 1855	Pimentel and Pujol-Luz (2001)
63.	*Analcocerus orbitalis* James, 1943	Pimentel and Pujol-Luz (2001)
64.	*Analcocerus taurus* James, 1943	James (1943); Pimentel and Pujol-Luz (2001)
65.	*Dicamptocrana jorgenseni* Frey, 1934	Fachin et al. (2022)
66.	*Dicranophora astuta* Williston, 1888	Pimentel and Pujol-Luz (2001)
67.	*Dicranophora bispinosa* (Wiedemann, 1830)	Pimentel and Pujol-Luz (2001)
68.	*Pseudohistiodroma fascipennis* (James, 1943)	James (1943); Pimentel and Pujol-Luz (2001)
69.	*Raphiocera armata* (Wiedemann, 1830)	Carrera (1944); Pimentel and Pujol-Luz (2001)
70.	*Raphiocera hoplistes* (Wiedemann, 1830)	James (1943); Pimentel and Pujol-Luz (2001)
71.	*Raphiocera hortulana* (Wiedemann, 1830)	James (1943); Pimentel and Pujol-Luz (2001)
72.	*Raphiocera papaveroi* Pimentel and Pujol-Luz, 2002	Pimentel and Pujol-Luz (2002)
73.	*Raphiocera* sp. 1	This study
Subfamily Sarginae		
74.	*Acrochaeta asapha* Fachin and Amorim, 2015	Fachin and Amorim (2015)
75.	*Acrochaeta dimidiata* Lindner, 1949	Fachin and Amorim (2015)
76.	*Acrochaeta fasciata* Wiedemann, 1830	Fachin and Amorim (2015)
77.	*Acrochaeta polychaeta* Fachin and Amorim, 2015	Fachin and Amorim (2015)
78.	*Acrochaeta pseudofasciata* Fachin and Amorim, 2015	Fachin and Amorim (2015)
79.	*Acrochaeta pseudopolychaeta* Fachin and Amorim, 2015	Fachin and Amorim (2015)
80.	*Acrochaeta ruschii* Fachin and Amorim, 2015	Fachin and Amorim (2015)
81.	*Merosargus azureus* (Enderlein, 1914)	James and McFadden (1971); Fachin and Amorim (2015)
82.	*Merosargus brunneus* Lindner, 1933	This study
83.	*Merosargus cingulatus* Schiner, 1868	Fachin and Amorim (2015); this study
84.	*Merosargus festivus* Williston, 1888	Fachin and Amorim (2015)
85.	*Merosargus gracilis* Williston, 1888	James (1941); Iide and Pujol-Luz (1999)
86.	*Merosargus golbachi* James, 1971	This study
87.	*Merosargus longiventris* (Enderlein, 1914)	Fachin and Amorim (2015)
88.	*Merosargus nebulifer* James, 1971	This study
89.	*Merosargus obscurus* (Wiedemann, 1830)	Fachin and Amorim (2015)
90.	*Merosargus opaliger* Lindner, 1931	This study
91.	*Merosargus sexnotatus* James, 1941	James (1941)
92.	*Merosargus taeniatus* (Wiedemann, 1830)	Fachin and Amorim (2015)
93.	*Merosargus tripartitus* James, 1971	This study
94.	*Microchrysa bicolor* (Wiedemann, 1830)	This study
95.	*Ptecticus inversus* Curran, 1934	Leal and Oliveira (1979)
96.	*Ptecticus lanei* James, 1941	James (1941); Leal and Oliveira (1979)
97.	*Ptecticus testaceus* (Fabricius, 1805)	Leal and Oliveira (1979); Fachin and Amorim (2015); this study
98.	*Sargus fasciatus* Fabricius, 1805	Lindner (1933); Fachin and Amorim (2015); this study
99.	*Sargus flavoniger* Lindner, 1928	Fachin and Hauser (2018)
100.	*Sargus thoracicus* Macquart, 1834	Lindner (1933); Fachin and Amorim (2015); this study
101.	*Sargus* sp. 1	This study
102.	*Sargus* sp. 2	This study
Subfamily Stratiomyinae		
103.	*Chloromelas barbata* Lindner, 1935	Lindner (1935)
104.	*Chloromelas* sp. 1	This study
105.	*Glariopsis* sp. 1	This study
106.	*Hoplitimyia costalis* (Walker, 1836)	Walker (1836)
107.	*Hoplitimyia mutabilis* (Fabricius, 1787)	Lindner (1933)
108.	*Myxosargus* sp. 1	This study
109.	*Myxosargus* sp. 2	This study
110.	*Nothomyia borgmeieri* (Lindner, 1933)	Lindner (1933)
111.	*Nothomyia lopesi* (Lindner, 1935)	James (1942)
112.	*Rhingiopsis jamesi* Barretto, 1947	Barretto (1947)
113.	*Rhingiopsis lanei* Barretto, 1947	Barretto (1947)

reserve and as species-rich as the entire state of São Paulo (Fig. 11). Our study also shows that there is, also for stratiomyids, a concentration of records near large urban centers and to the coast of the state (Fig. 12), reinforcing Oliveira et al. (2016) findings and statements, where there are both the majority of infrastructure and facilities for research (*e.g.*, the Boracéia Biological Station, located in Salesópolis, only 110 km from the city of São Paulo, provided 25 out of 261 soldier flies records) and the largest fragments of the Atlantic Forest still preserved and protected in conservation units. The challenge is now to continue and expand the documentation of the diversity of flies and, particularly, of soldier flies, in the areas of the state covered by semideciduous seasonal forests.

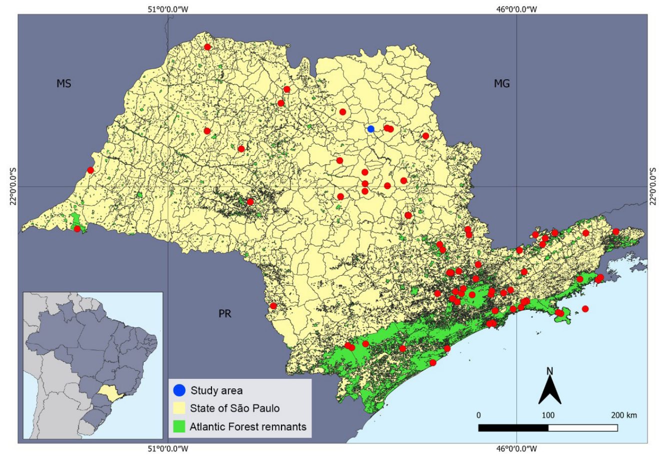

Figure 12 Map with the distribution of all 92 unique coordinates from the stratiomyid dataset throughout the Atlantic Forest remnants in the state of São Paulo, Brazil.

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Conflicts of interest

The authors declare no conflicts of interests.

Author contribution statement

DAF, VRSB, VCS and HCO contributed to the study conception and design. Material preparation, data collection and analysis were performed by DAF, VRSB, and HCO. The first draft of the text and the figures were prepared by DAF and VRSB. DAF, VRSB, VCS and HCO commented on previous versions of the manuscript. DAF, VRSB, VCS and HCO read and approved the final manuscript.

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Supplementary Material

The following online material is available for this article:

Supplementary File 1 - Species of Stratiomyidae at the Reserva Biológica e Ecológica Augusto Ruschi, Sertãozinho, São Paulo, Brazil, with all species and specimens sampled by each collecting date and each trap.

Supplementary File 2 - Species of Stratiomyidae in the state of São Paulo, Brazil, with all reported localities and their respectives references.