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Saturniid moths (Lepidoptera: Bombycoidea) from an Atlantic Rain Forest fragment in southeastern Brazil

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ABSTRACT

The light-attracted silk moths (Lepidoptera: Saturniidae) of the Boraceia Biological Station in the municipality of Salesópolis, state of São Paulo, southeastern Brazil have been sampled over more than seven decades (1942-2013). A total of 6,288 individuals (including a gynandromorph) belonging to five subfamilies, 46 genera and 133 species were identified. Hemileucinae was the most abundant and species-rich subfamily, followed by Ceratocampinae, Arsenurinae, Saturniinae, and Oxyteninae. *Hylesia* Hübner, *Automeris* Hübner, and *Dirphiopsis* Bouvier (Hemileucinae) were the dominant genera in abundance and species richness. Only *Automeris illustris* (Walker), *Gamelia remissoides* Lemaire, and *Hidripa paranensis* (Bouvier) (Hemileucinae) were recorded in all months of sampling. *Hylesia metapyrrha* (Walker) was the most abundant saturniid species recorded at the station, with 375 specimens, followed by *Hylesia oratex* Dyar with 265 specimens, *Dirphia muscosa* Schaus with 261 specimens (all Hemileucinae); *Copaxa canella* Walker (Saturniinae) with 232 specimens, and *Lonomia* cf. *obliqua* Walker (Hemileucinae) with 106 specimens. Fifteen additional species were each represented by more than 100 specimens. The importance of the Boraceia Biological Station to the maintenance of the saturniid moth diversity in the Atlantic Forest is discussed.

Key words: conservation, inventory, neotropical, phenology, research promotion, silk moths.

INTRODUCTION

Moths and butterflies are important organisms in tropical ecosystems because they interact widely with the vegetation and local fauna (Gilbert 1984, Miller 1993, Bonebrake et al. 2010, Johnson et al. 2017, Goldstein 2017). Their feeding habits, great diversity, ease of sampling, and the relatively well known taxonomy of some groups, such as Saturniidae, make them potentially important organisms for use in monitoring the biological diversity in different communities (Brown and Freitas 1999, 2000a, b, Basset et al. 2017, Mitter et al. 2017).

Saturniidae is comprised of 2,349 species worldwide in 169 genera, and is the most species-rich family of Bombycoidea (van Nieukerken et al. 2011). Saturniidae has been divided into nine subfamilies: Agliinae, Arsenurinae, Ceratocampinae, Cercophaninae, Hemileucinae,

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Ludiinae, Oxyteninae, Salassinae, and Saturniinae (Minet 1994, Regier et al. 2008, van Nieukerken et al. 2011). Of these, five are represented in the Brazilian fauna (Lemaire and Minet 1998, Duarte et al. 2012): the most speciose subfamily, Hemileucinae, consists of 630 species in 51 genera; the cosmopolitan Saturniinae is represented by 480 species in 59 genera; Ceratocampinae has 170 species in 27 genera; and the Neotropical endemic Arsenurinae and Oxyteninae are represented by 60 species in 10 genera and 35 species in three genera, respectively (Lemaire and Minet 1998). More than one-third of the species estimated for Saturniidae occur in the Neotropics (Lemaire and Minet 1998, Duarte et al. 2012). In Brazil, approximately 500 species have been recorded (Camargo et al. 2017). Recently, over 500 saturniid species from the Neotropics were described by Brechlin and Meister in the journal *Entomo-Satsphingia*, which would add many species to the family, despite these authors' dubious method of splitting previous available names into cryptic groups (Nässig et al. 2010, St. Laurent et al. 2015).

Adult saturniid moths are mostly nocturnal, except for males of several species in Saturniinae, Hemileucinae, Agliinae, and Ceratocampinae (e.g., *Anisota* spp., see also Lemaire and Minet 1998). The females of *Heliconisa* Walker, 1855 are essentially diurnal, as well as the females of *Ithomisa* Oberthür, 1881, which fly at the end of the day and also at night. The mouthparts of these insects are inchoate and they do not feed during their short 5–12-day adult life (Janzen 1984). Strong sexual dimorphism is observed in species of Ceratocampinae, Hemileucinae, and Oxyteninae; females can weigh more than twice as much as males, usually bear filiform antennae (pectinate in males), and are larger with more rounded wings than in males (Janzen 1984).

BRAZILIAN INVENTORIES OF SATURNIIDAE

The southern states of Brazil, Rio Grande do Sul, Santa Catarina, and Paraná, have partially inventoried their saturniid fauna. After approximately a decade of investigations in Rio Grande do Sul, 113 species in four subfamilies were recorded: Hemileucinae (61 species, 54%), Ceratocampinae (30, 27%), Arsenurinae (12, 11%), and Saturniinae (10, 9%) (Nunes et al. 2004, Specht et al. 2005a, b, Prestes et al. 2009). Although we have some efforts of sampling in Rio Grande do Sul, mainly focusing on groups of medical importance, there is still a need for long-term and systematic inventories to know the composition and distribution of the saturniids in different vegetation formations (e.g., grasslands, dense ombrophilous and seasonal deciduous forests, Araucaria forest) in this region of Brazil (see also vegetation map of Buriol et al. 2007).

To determine the Santa Catarina saturniid fauna, Siewert et al. (2010) used data from six important Brazilian lepidopteran collections, as well as geographic distributions provided by Lemaire (1978, 1980, 1988, 2002). They recorded a total of 149 species in 50 genera, including 90 (60%) species of Hemileucinae, 32 (21%) of Ceratocampinae, 16 (11%) of Arsenurinae, and 11 (7%) of Saturniinae. We can state that the saturniid fauna of Santa Catarina is still poorly sampled. Only eight municipalities in the entire state have been sampled to date (see the map in Siewert et al. 2010), and it is necessary to intensify sampling efforts in the main vegetation formations in the state (e.g., deciduous, dense ombrophilous, and subtropical ombrophilous forests).

Knowledge of the lepidopteran fauna of Paraná is certainly the most extensive of the southern states of Brazil. However, with regard to the saturniids, long-term surveys of these moths have intensified only recently. During an entomological survey conducted between 1986 and 1987 in eight localities in Paraná, Marinoni and Dutra (1991) sampled different groups of Lepidoptera with malaise and light traps (modified from the "Luiz de Queiroz" model light trap; see Silveira Neto and Silveira 1969). The saturniids were studied by Marinoni et al. (1997), resulting in the identification of 83 species distributed as follows: Hemileucinae (38 species, 46% of all species sampled), Ceratocampinae (25, 30%), Arsenurinae (10, 12%), Saturniinae (9, 11%), and Oxyteninae (1, 1%). More recently, Santos et al. (2015) sampled the community of Saturniidae in a montane mixed ombrophilous forest in the eastern part of the state (Vossoroca, Tijucas do Sul, 25º50'08.93"S, 49º02'55.20"W, elevation 880 m). They used black and mercury-vapor mixed bulbs, and identified 86 species of saturniids: Hemileucinae (56 species, 65% of all species sampled), Ceratocampinae (17, 20%), Arsenurinae (5, 6%), Saturniinae (7, 8%), and Oxyteninae (1, 1%). We believe that a greater collecting effort in poorly sampled localities in Paraná will expand the list of species currently recorded from the nine localities sampled to date.

The saturniid fauna in the Cerrado (Brazilian savanna) has been documented by Camargo and Becker (1999) and A. Camargo et al. (unpublished data). Data from several entomological collections in Brazil were extensively searched. As a result, 202 species from 74 localities in 10 states and the Federal District were recorded (A. Camargo et al., unpublished data). Of these, 119 (58.9%) were Hemileucinae, 48 (23.7%) Ceratocampinae, 22 (10.9%) Arsenurinae, 11 (5.4%) Saturniinae, and 2 (1%) Oxyteninae. Of the six terrestrial biomes in Brazil (Amazon Forest, Atlantic Forest, Cerrado, Caatinga, Pampa, and Pantanal; see also Instituto Brasileiro de Geografia e Estatística 2004), the Cerrado is the second largest. This biome covers approximately 2,000,000 km^2, with a continuous distribution throughout the entire Central-West region, western Bahia and Minas Gerais, as well as disjunct distribution areas in northern and northeastern São Paulo and northern Paraná (Filardi et al. 2007). The Cerrado borders three other biomes and is considered a world biodiversity hotspot (Myers et al. 2000). Although extensive efforts have been made to sample saturniids in the Brazilian Cerrado, these moths remain little known in some states that still contain remnants (strongly threatened by human action) of this biome.

In addition, as part of an extensive entomological catalog, Zikán and Zikán (1968) listed the lepidopteran (not all suborders) fauna from the Itatiaia region, which included the family Saturniidae (Saturnioidea in Zikán and Zikán 1968). This region is located between the states of Rio de Janeiro and Minas Gerais and varies widely in altitude, from approximately 500 m to more than 2,400 m (Zikán and Zikán 1940). Zikán and Zikán (1968) listed 125 species from 33 genera: Hemileucinae, 70 species (56%); Ceratocampinae, 33 (26%); Arsenurinae, 7 (6%); Saturniinae, 12 (10%); and Oxyteninae, 3 (3%), with 28 undetermined species, totaling 153 species. However, their determinations should be revised with the current nomenclature, in order to develop an accurate survey.

As we can see, the Brazilian Saturniidae are still unsatisfactorily understood with respect to species distribution, taxonomy, and biological information (e.g., Albertoni and Duarte 2015), although some knowledge is available for species with medical or economic value (Lemaire 2002, Specht et al. 2008). Undeniably, faunal inventories are vital to understanding and monitoring local biodiversity (Silveira et al. 2010). Saturniid moths were efficiently attracted at night via light trap, and we report herein a species list from long-term survey data (more than 70 years) collected in a strategically located fragment of Atlantic Rain Forest (Boraceia Biological Station) in the state of São Paulo, southeastern Brazil.

The main objective of developing this list of species is to increase the knowledge and understanding of Brazilian biodiversity, allowing eventual amplification of the predictive capacity of lepidopteran fauna responses to global changes, particularly changes in land use and land cover and climate changes. The large extent of the reserve within which the Boraceia Biological Station is located, and because it contains mostly primary forest, two rare characteristics in fragments of Atlantic Rain Forest, make the biological station highly important for studies of the biodiversity of this biome. The importance of standardized local biological inventories and studies of community composition is evident, as in the case of the present study.

Longino and Colwell (1997) emphasized the importance of biological inventories for conservation purposes, since they allow descriptions and characterizations of communities in terms of species richness, abundance and complementarity with other communities. Obtaining such information is important, for example, in setting priorities for monitoring and conservation actions. The Saturniidae, which is usually prominent among the lepidopteran fauna due to the diversity and ecological importance of its members, and is commonly among the best-studied moth families in a given locality (Santos et al. 2015), has been the target of a number of previous inventories in Brazil.

MATERIALS AND METHODS

STUDY AREA

The survey of saturniid moths was conducted at the Boraceia Biological Station (BBS) (23º39′S, 45º53′W, elevation 850 m), located in the municipality of Salesópolis, state of São Paulo, in southeastern Brazil. The Biological Station is managed by the Museu de Zoologia of the Universidade de São Paulo (MZSP) and has an area of 96 ha. The station is located within the largest fragment of Brazilian Atlantic Rain Forest, which includes several parks and other types of conservation units (Travassos Filho and Camargo 1958, Custodio Filho 1989) (Figure 1). The climate is wet tropical, Cfa in Köppen's classification (Köppen 1948). Measurements from 1925 to 1944 identified Boraceia as one of the most humid regions in Brazil, with a mean annual rainfall of 3,058 mm (Setzer 1946).

MOTH SAMPLING

Sampling of saturniid moths in the BBS started in 1942, with the entomologist Romualdo Ferreira D'Almeida. A few years later, the entomologists Lauro Travassos, Lauro Travassos Filho, Ernesto Xavier Rabello, and several associates continued the series, with extensive collections spanning decades (Travassos Filho and Camargo 1958). A recent inventory was conducted by the senior author, over 13 consecutive months in 2012 and 2013 (see also Table I).

Nocturnal moths were attracted and collected using mercury-vapor mixed bulbs placed near the white wall of one of the scientists' residences (Duarte et al. 2008). Specimens collected after 2004 were killed by injection of aqueous ammonia solution in the thorax. We have no records about how specimens were killed in expeditions carried out before 2004. Most specimens sampled from September 1942 to June 2013 were stored, identified and labeled with a registration number in addition to the previous labels. All records were stored in a digitalized database, which is intended to be of free public access through the *World Wide Web*. All material is deposited in the MZSP, but some of the specimens collected by Lauro Travassos were deposited in the Entomological Collection of the Oswaldo Cruz Institute, Rio de Janeiro, Brazil, and those species not represented in the MZSP were included in our list, as a complement to the number of saturniid species recorded for the BBS (Miranda et al. 2015).

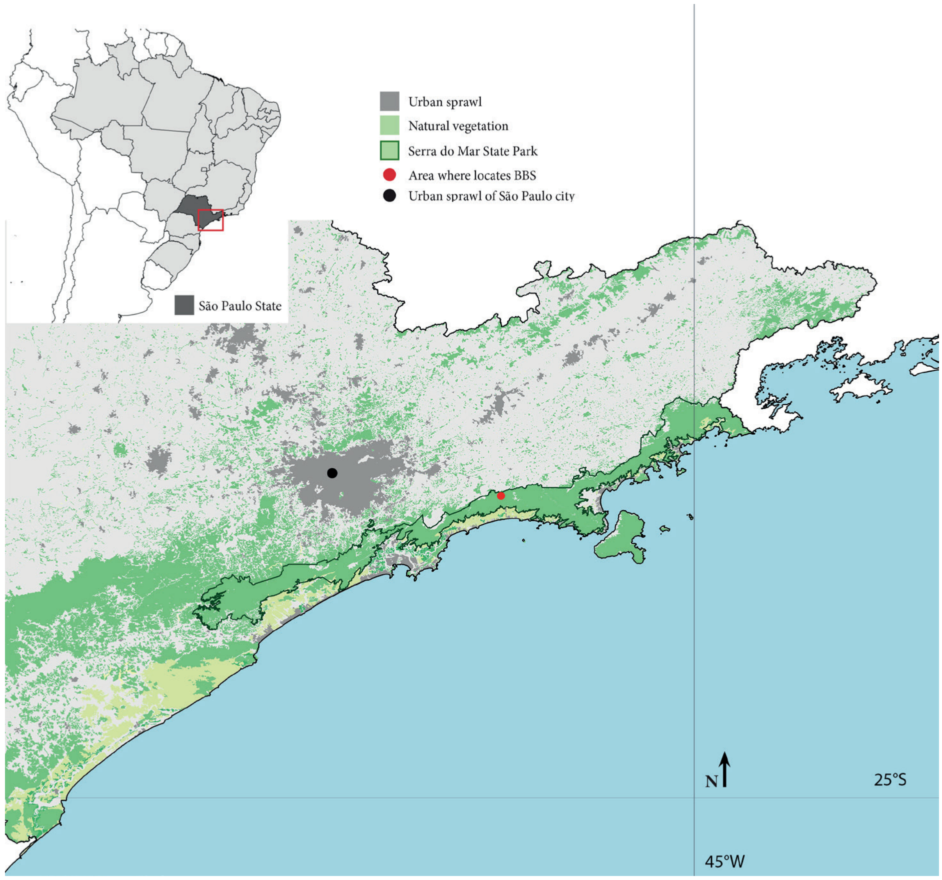

Figure 1 - Sampling area (red dot) within the largest fragment of Brazilian Atlantic rain forest.

SPECIES IDENTIFICATION AND DATA ANALYSES

Previous identifications of the specimens deposited in the MZSP collection were verified, and nomenclature was checked using Lemaire (1978, 1980, 1988, 2002). To update previous reports, we used Mielke et al. (2005), Wolfe (2005), Specht et al. (2006), and Brechlin and Meister (2011). In addition to this literature, we used the content and associated data available in the member-restricted area of the website http://www.silkmoths.bizland.com/indexos.htm. To obtain more precise identification of specimens, 63 males of several morphospecies were dissected and data concerning the genitals were compared with literature and/or with that from previously extracted organs. Dissections were conducted as follows: the abdomen was cut at segments IV–V and placed in a boiling 10% KOH solution for approximately 10 min. The tegument and internal contents were removed, the abdomen was placed in chlorazol black solution for approximately 1 min, and the genitals were separated from the abdomen. All parts were preserved in a container with glycerin, labeled, and given a unique code.

Most moths were pinned and dried, but a few were identified and placed in entomological envelopes, on which the sample origin and species identification were annotated.

RESULTS AND DISCUSSION

The lepidopteran collection of the MZSP hosts 6,288 specimens of Saturniidae (5,735 males, 552 females, and one gynandromorph) captured at the BBS between 1942 and 2013. More than

TABLE I
Months and years with records of Saturniidae (Lepidoptera) from the Boraceia Biological Station, São Paulo, Brazil.

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1942		X		X					X		X	X
1943												X
1946							X					
1947									X		X	X
1948	X	X	X	X	X	X	X	X	X	X	X	X
1949	X	X	X	X	X	X	X	X	X	X	X	X
1950	X	X	X					X	X			
1951			X								X	
1952	X				X	X					X	
1953										X		
1954		X		X		X	X	X	X	X		
1956									X	X		
1957	X		X	X						X	X	
1958			X						X		X	X
1959		X	X			X	X		X		X	
1960										X		
1961								X				
1962	X			X			X	X	X	X	X	X
1963		X	X			X			X			
1964	X	X								X	X	X
1965	X	X	X	X	X	X	X	X	X	X	X	X
1966	X	X	X		X	X	X	X	X	X	X	X
1967		X	X	X			X	X	X	X	X	X
1968	X	X	X	X	X			X	X	X	X	X
1969	X	X		X			X	X				
1970										X		
1983										X		
1985	X									X		
1987										X		
1989										X		
1991										X		
1995										X		
1997				X								
1999				X								
2000									X	X	X	
2001		X		X				X	X	X		
2002			X							X		
2003				X								
2004				X	X							
2008									X			
2010									X			
2012		X	X	X	X	X	X	X	X	X	X	X
2013	X	X	X			X						
Total*	13	16	15	16	8	10	11	13	20	24	17	13

*Number of campaigns with monthly sampling between 1942 and 2013.

94% of the specimens examined were identified to the species level, and consisted of 43 genera and 126 species. The greatest abundance and number of species were observed for Hemileucinae, with 3,645 specimens (58%) of 77 species (61.1%), followed by Ceratocampinae with 1,298 specimens (20.6%) of 23 species (18.4%), Arsenurinae with 659 specimens (10.5%) of 14 species (11.2%), Saturniinae with 557 specimens (8.9%) of 10 species (7.9%), and Oxyteninae with 129 specimens (2.1%) of two species (1.6%) (Tables II and III). Besides the species deposited at MZSP, Miranda et al. (2015) recorded seven other species (one Arsenurinae, three Ceratocampinae, and three Hemileucinae, also listed in Table III) belonging to three genera from the BBS and apparently deposited only in the Entomological Collection of the Oswaldo Cruz Institute. Therefore, a total of 46 genera and 133 species are recorded from this biological station.

The distribution of the saturniid species among subfamilies in the BBS follows the pattern in most South American surveys (Ecuador: Racheli and Racheli 2005, 2006, Brazil: Marinoni et al. 1997, Camargo and Becker 1999, Nunes et al. 2004, Prestes et al. 2009, Siewert et al. 2010). Hemileucinae is the most speciose subfamily, followed by Ceratocampinae, Arsenurinae, Saturniinae, and Oxyteniinae (not infrequently, surveys do not include this subfamily because it has been raised to family rank). Worldwide, Hemileucinae is the subfamily with the largest number of species; Saturniinae, the only subfamily distributed worldwide, is next in species richness. However, although this pattern has also been observed in the Brazilian Cerrado, Camargo and Becker (1999) demonstrated that, as a percentage, Ceratocampinae and Arsenurinae together amount to almost the same proportion as Hemileucinae in this biome (48.2% Hemileucinae *vs.* 47.0% Ceratocampinae plus Arsenurinae). They explained this importance of Ceratocampinae and Arsenurinae in the Cerrado by the biology of these moths. It seems that the caterpillars, which bury in the soil to pupate, have higher survival in environments with a pronounced dry season.

The most abundant genera with the most species in the BBS belonged to the subfamily Hemileucinae. The genus *Hylesia* Hübner, [1820] was represented by 1,433 specimens in 17 species, including *Hylesia* sp. 1, sp. 2, and sp. 3. The next most speciose genera were *Automeris* Hübner, [1819] (Hemileucinae) with 404 specimens from nine species, and *Dirphiopsis* Bouvier, 1928 with 266 specimens from seven species. *Dirphia* Hübner, [1819], with six species, was the second most abundant genus with 432 specimens. *Rothschildia* Grote, 1897 (Saturniinae) was the only genus not belonging to Hemileucinae to be represented by six species, with 226 specimens.

The genus *Hylesia* is usually markedly dominant in surveys of Saturniidae in Brazil. In Paraná and Rio Grande do Sul, for example, 14 (16.3% of all species) and nine (8%) species of this genus were recorded, respectively. For BBS, 17 species (13.5% of all species) were recorded, including three morphospecies, in addition to a set of 40 specimens identified only at the genus level.

Hylesia is among the genera with the most complex taxonomy in Saturniidae due to the its phenotypic homogeneity and wide geographic distribution, covering the entire Neotropical region, from Mexico to Argentina (Lemaire 2002). Knowing that this genus is one of the most problematic in the family, the remarkable density of species and specimens sampled in the BBS makes this biological station a promising area for further studies on these saturniids. Dissections of the genitalia from 26 specimens showed that it is difficult to use the information from this part of the body for species separation (Wheeler 2008, Schlik-Steiner et al. 2010). Studies involving different tools to contribute to the delimitation of species of the genus are extremely important, both

TABLE II
Number of species and individuals of all genera in each subfamily of Saturniidae, collected from the Boraceia Biological Station between 1942 and 2013. Gyn= Gynandromorph.

	Subfamilies /Genera	Species number	Individuals			
			Female	Male	Gyn	Total
1	**Arsenurinae**	**15**	**42**	**617**		**659**
1	*Arsenura*	4	6	163		169
2	*Copiopteryx*	3	18	194		212
3	*Dysdaemonia***	1	–	–		–
4	*Loxolomia*	1	2	9		11
5	*Paradaemonia*	4	5	80		85
6	*Rhescyntis*	1	0	13		13
7	*Titaea*	1	11	158		169
2	**Ceratocampinae**	**26**	**61**	**1236**	**1**	**1298**
8	*Adeloneivaia*	4	10	160		170
9	*Adelowalkeria*	2	4	187		191
10	*Almeidella*	1	2	53		55
11	*Cicia*	2	1	13		14
12	*Citheronia*	2	3	39	1	43
13	*Eacles*	4	12	345		357
14	*Neorcarnegia*	1	0	1		1
15	*Oiticella*	2	2	46		48
16	*Othorene*	2	16	255		271
17	*Procitheronia*	2	6	106		112
18	*Ptiloscola***	1	–	–		–
19	*Schausiella*	1	0	9		9
20	*Scolesa***	1	–	–		–
21	*Syssphinx*	1	5	22		27
3	**Hemileucinae**	**80**	**394**	**3251**		**3645**
22	*Austrolippa*	2	6	11		17
23	*Automerella*	3	3	23		26
24	*Automeris*	9	51	353		404
25	*Automeropsis*	1	0	1		1
26	*Callodirphia*	1	2	0		2
27	*Catacantha*	2	3	15		18
28	*Cerodirphia*	5	20	143		163
29	*Dirphia*	7	26	406		432
30	*Dirphiopsis*	7	19	247		266
31	*Gamelia*	2	3	70		73
32	*Hidripa*	2	16	148		164
33	*Hylesia*	16	92	1341		1433
34	*Hyperchiria*	1	3	46		49
35	*Hyperchirioides*	1	3	4		7
36	*Leucanella*	4	44	27		71
37	*Lonomia*	2	64	126		190
38	*Molippa*	1	4	85		89
39	*Periga*	6	8	46		54
40	*Prohylesia*	1	0	8		8
41	*Pseudautomeris*	5	27	139		166
42	*Pseudodirphia*	1	0	1		1
43	*Travassosula*	1	0	11		11
4	**Oxyteninae**	**2**	**3**	**126**		**129**
44	*Oxytenis*	2	3	126		129
5	**Saturniinae**	**10**	**52**	**505**		**557**
45	*Copaxa*	4	29	302		331
46	*Rothschildia*	6	23	203		226
	Total	133	552	5735	1	6288

** Genera listed in Miranda et al. (2015).

TABLE III
Species of Saturniidae (Lepidoptera) collected between 1942 and 2013 from the Boraceia Biological Station, São Paulo, Brazil. Voucher material is deposited in the MZSP collection or was listed by Miranda et al. (2015). Gyn = Gynandromorph.

	Taxa	Individuals			
		Females	Males	Gyn	Total
1	**Arsenurinae**	**42**	**617**		**659**
1	*Arsenura armida armida* (Cramer, 1779)	2	50		52
2	*Arsenura biundulata* Schaus, 1906	4	110		114
3	*Arsenura sylla hercules* (Walker, 1855)	0	1		1
4	*Arsenura xanthopus* (Walker, 1855)	0	2		2
5	*Copiopteryx derceto* (Maassen, 1872)	2	18		20
6	*Copiopteryx semiramis phoenix* (Deyrolle, 1869)	0	17		17
7	*Copiopteryx sonthonnaxi* É. André, 1905	16	159		175
8	*Loxolomia serpentina* Maassen, 1869	2	9		11
9	*Dysdaemonia brasiliensis* Rothschild, 1906**	-	-		-
10	*Paradaemonia mayi* (Jordan, 1922)	4	43		47
11	*Paradaemonia meridionalis* Camargo, O. Mielke & Casagrande, 2007	0	27		27
12	*Paradaemonia orsilochus* (Maassen, 1869)	1	9		10
13	*Paradaemonia pluto* (Westwood, 1854)	0	1		1
14	*Rhescyntis pseudomartii* Lemaire, 1976	0	13		13
15	*Titaea tamerlan tamerlan* (Maassen, 1869)	11	158		169
2	**Ceratocampinae**	**61**	**1236**	**1**	**1298**
16	*Adeloneivaia boisduvalii* (Doûmet, 1859)**	-	-		-
17	*Adeloneivaia* cf. *catharina* (Bouvier, 1927) [F]	1	0		1
18	*Adeloneivaia fallax* (Boisduval, 1872)	9	153		162
19	*Adeloneivaia subangulata subangulata* (Herrich-Schäffer, [1855])	0	7		7
20	*Adelowalkeria flavosignata* Walker, 1865	0	34		34
21	*Adelowalkeria tristygma* (Boisduval, 1872)	4	153		157
22	*Almeidella almeidai* Oiticica, 1946	2	53		55
23	*Cicia crocata* (Boisduval, 1872)	1	12		13
24	*Cicia nettia* (Schaus, 1921)	0	1		1
25	*Citheronia laocoon* (Cramer, 1777)	1	18	1	20
26	*Citheronia phoronea* (Cramer, 1779)	2	21		23
27	*Eacles ducalis* Walker, 1855	4	123		127
28	*Eacles imperialis magnifica* Walker, 1855	8	96		104
29	*Eacles lauroi* Oiticica, 1938	0	53		53
30	*Eacles mayi* Schaus, 1920	0	73		73
31	*Neorcarnegia basirei* (Schaus, 1892)	0	1		1
32	*Oiticella brevis* (Walker, 1855)	1	41		42
33	*Oiticella convergens* (Herrich-Schäffer, [1855])	1	5		6
34	*Othorene cadmus* (Herrich-Schäffer, 1854)	13	107		120
35	*Othorene peggyae* Brechlin & Meister, 2011	3	148		151
36	*Procitheronia principalis* (Walker, 1855)	5	58		63
37	*Procitheronia purpurea* (Oiticica, 1930)	1	48		49
38	*Ptiloscola cinerea* (Schaus, 1900)**	-	-		-
39	*Schausiella arpi* (Schaus, 1892)	0	9		9
40	*Scolesa viettei* Travassos, 1959**	-	-		-
41	*Syssphinx molina* (Cramer, 1780)	5	22		27
3	**Hemileucinae**	**394**	**3251**		**3645**
42	*Austrolippa convergens* (Walker, 1855)		1		1
43	*Austrolippa cruenta* (Walker, 1855)	6	10		16

TABLE III (continuation)

	Taxa	Individuals			
		Females	Males	Gyn	Total
44	*Automerella chrisbrechlinae* Brechlin & Meister, 2015	1	15		16
45	*Automerella flexuosa* (C. Felder & R. Felder, 1874)	1	8		9
46	*Automerella rubicunda* (Schaus, 1892) [F]	1	0		1
47	*Automeris basalis* (Walker, 1855)	7	26		33
48	*Automeris beckeri* (Herrich-Schäffer, 1856)	9	95		104
49	*Automeris bilinea tamphilus* Schaus, 1892	1	44		45
50	*Automeris illustris* (Walker, 1855)	7	131		138
51	*Automeris inornata* (Walker, 1855)	8	50		58
52	*Automeris melanops* (Walker, 1865)	0	7		7
53	*Automeris muscula* (Vuillot, 1892) [F]	6	0		6
54	*Automeris intermedius* (Bouvier, 1929) [F]	3	0		3
55	*Automeris tristis* (Boisduval, 1875) [F]	10	0		10
56	*Automeropsis umbrata* (Boisduval, 1875)	0	1		1
57	*Callodirphia arpi* (Schaus, 1908) [F]	2	0		2
58	*Catacantha oculata* (Schaus, 1921)	0	1		1
59	*Catacantha ferruginea* (Draudt, 1929)	3	14		17
60	*Cerodirphia apunctata* Dias & Lemaire, 1991	0	1		1
61	*Cerodirphia opis* (Schaus, 1892)	9	57		66
62	*Cerodirphia rosacordis* (Walker, 1855)	0	3		3
63	*Cerodirphia vagans* (Walker, 1855)	11	66		77
64	*Cerodirphia zikani* (Schaus, 1921)	0	16		16
65	*Dirphia araucariae* Jones, 1908	0	1		1
66	*Dirphia baroma* (Schaus, 1906)	16	67		83
67	*Dirphia dolosa* Bouvier, 1929	1	47		48
68	*Dirphia fornax* (Druce, 1903)	2	35		37
69	*Dirphia muscosa* Schaus, 1898	7	254		261
70	*Dirphia sombrero* Le Cerf, 1934	0	2		2
71	*Dirphia triangulum* Walker, 1855**	-	-		-
72	*Dirphiopsis delta* (Foetterle, 1902)	0	32		32
73	*Dirphiopsis epiolina* (C. Felder & R. Felder, 1874)	5	90		95
74	*Dirphiopsis multicolor* (Walker, 1855)	6	59		65
75	*Dirphiopsis picturata* (Schaus, 1913)	6	26		32
76	*Dirphiopsis trisignata* (C. Felder & R. Felder, 1874)	1	14		15
77	*Dirphiopsis undulinea* (F. Johnson, 1937)	1	3		4
78	*Dirphiopsis wanderbilti* Pearson, 1958	0	23		23
79	*Gamelia catharina* (Draudt, 1929)	2	2		4
80	*Gamelia remissoides* Lemaire, 1967	1	68		69
81	*Hidripa paranensis* (Bouvier, 1929)	16	126		142
82	*Hidripa perdix* (Maassen & Weyding, 1885)	0	22		22
83	*Hylesia corevia* Schaus, 1900	3	46		49
84	*Hylesia falcifera* (Hübner, 1825)	5	76		81
85	*Hylesia maurex* Draudt, 1929	4	44		48
86	*Hylesia metapyrrha* (Walker, 1855)	20	355		375
87	*Hylesia minasia* Schaus, 1921	0	4		4
88	*Hylesia munonia* Schaus, 1927	0	135		135
89	*Hylesia nanus* (Walker, 1855)	1	46		47
90	*Hylesia nigricans* Berg, 1875	1	37		38
91	*Hylesia oratex* Dyar, 1913	16	249		265
92	*Hylesia paulex* Dognin, 1922	0	30		30
93	*Hylesia rufex* Draudt, 1929	0	12		12

TABLE III (continuation)

	Taxa	Individuals			
		Females	Males	Gyn	Total
94	*Hylesia scortina* Draudt, 1929	5	111		116
*	*Hylesia* sp.	29	11		40
95	*Hylesia* sp. 1	0	118		118
96	*Hylesia* sp. 2	0	3		3
97	*Hylesia* sp. 3	0	11		11
98	*Hylesia vindex* Dyar, 1913	8	53		61
99	*Hyperchiria incisa incisa* Walker, 1855	3	46		49
100	*Hyperchirioides bulaea* (Maassen & Weyding, 1885)	3	4		7
101	*Leucanella gibbosa* (Conte, 1906)	21	26		47
102	*Leucanella janeira* (Westwood, 1854)	8	1		9
103	*Leucanella memusae gardineri* Lemaire, 1973**	-	-		-
104	*Leucanella viridescens viridescens* (Walker, 1855) [F]	15	0		15
105	*Lonomia antoniae* Brechlin & Meister, 2015	16	68		84
106	*Lonomia* cf. *obliqua* Walker, 1855	48	58		106
107	*Molippa sabina* Walker, 1855	4	85		89
108	*Periga acuta* C. Mielke & Meister, 2013	0	2		2
109	*Periga* cf. *intervales* C. Mielke, Joerke, Miranda & Costa, 2017	0	3		3
110	*Periga circumstans* Walker, 1855	3	12		15
111	*Periga falcata* Walker, 1855	5	7		12
112	*Periga* sp. 1	0	10		10
113	*Periga* sp. 2	0	12		12
114	*Prohylesia zikani* Draudt, 1929	0	8		8
115	*Pseudautomeris brasiliensis* (Walker, 1855)	10	38		48
116	*Pseudautomeris coronis* (Schaus, 1913)	9	56		65
117	*Pseudautomeris grammivora* (Jones, 1908) [F]	2	0		2
118	*Pseudautomeris hubneri* (Boisduval, 1875)	6	45		51
119	*Pseudautomeris luteata* (Walker, 1865)**	-	-		-
120	*Pseudodirphia catarinensis* (Lemaire, 1975)	0	1		1
121	*Travassosula subfumata* (Schaus, 1921)	0	11		11
4	**Oxyteninae**	**3**	**126**		**129**
122	*Oxytenis bicornis* Jordan, 1924	3	85		88
123	*Oxytenis modaustralis* Brechlin & Meister, 2014	0	41		41
5	**Saturniinae**	**52**	**505**		**557**
124	*Copaxa canella* Walker, 1855	23	209		232
125	*Copaxa decrescens* Walker, 1855	0	35		35
126	*Copaxa joinvillea* Schaus, 1921	5	21		26
127	*Copaxa mielkeorum* Brechlin & Meister, 2010	1	37		38
128	*Rothschildia arethusa* (Walker, 1855)	1	19		20
129	*Rothschildia aurota speculifera* (Walker, 1855)	3	47		50
130	*Rothschildia belus* (Maassen, 1873)	0	5		5
131	*Rothschildia hesperus betis* (Linnaeus, 1758)	13	39		52
132	*Rothschildia hopfferi* (C. Felder & R. Felder, 1859)	2	63		65
133	*Rothschildia jacobaeae* (Walker, 1855)	4	30		34
	Individuals (only from MZSP)	**552**	**5735**	**1**	**6288**
	Number of species	**84**	**118**	**1**	**133**
	Species with no representative of the respective sex (only from MZSP)	**42**	**8**	**–**	**126**

* Males and females of *Hylesia* sp. that were not morphospecified are not included in the total number of species.

** Species listed by Miranda et al. (2015).

[F] Species represented only by female individuals.

for the subgeneric categorization of the traditional taxonomy and for the systematics and use of this knowledge to elucidate the relationships among species or groups of species (R. Dell'Erba and M. Duarte, unpublished data).

Among the saturniid species of the BBS deposited in the MZSP Lepidoptera Collection, 12 are represented by singletons: two species of Arsenurinae, *Arsenura sylla hercules* (Walker, 1855) and *Paradaemonia pluto* (Westwood, 1854); three of Ceratocampinae, *Adeloneivaia* cf. *catharina* (Bouvier, 1927), *Cicia nettia* (Schaus, 1921), and *Neorcarnegia basirei* (Schaus, 1892); and seven of Hemileucinae, *Austrolippa convergens* (Walker, 1855), *Automerella rubicunda* (Schaus, 1892), *Automeropsis umbrata* (Boisduval, 1875), *Catacantha oculata* (Schaus, 1921), *Cerodirphia apunctata* Dias & Lemaire, 1991, *Dirphia araucaria* Jones, 1908, and *Pseudodirphia catarinensis* (Lemaire, 1975).

Hylesia metapyrrha (Walker, 1855) was the most abundant saturniid species recorded in the BBS, with 375 specimens, followed by *Hylesia oratex* Dyar, 1913 with 265 specimens; *Dirphia muscosa* Schaus, 1898 with 261 specimens (all Hemileucinae); *Copaxa canella* Walker, 1855 (Saturniinae) with 232 specimens; and *Lonomia* cf. *obliqua* Walker, 1855 (Hemileucinae) with 106 specimens. In addition, 15 other species were represented by more than 100 specimens in the MZSP Collection (Table III). Only *Automeris illustris* (Walker, 1855), *Gamelia remissoides* Lemaire, 1967, and *Hidripa paranensis* (Bouvier, 1929) (Hemileucinae) were recorded in all months of sampling (Table IV). Five other species appear to be constant in the BBS, although they have not been recorded in one month throughout the period of sampling (Table IV): Arsenurinae: *Copiopteryx sonthonnaxi* É. André, 1905; Ceratocampinae: *Othorene cadmus* (Herrich-Schäffer, [1855]); Hemileucinae: *H. metapyrrha*; Oxyteninae: *Oxytenis bicornis* Jordan, 1924; and Saturniinae: *Copaxa canella*.

CONCLUSIONS

The number of species among the subfamilies of Saturniidae recorded from the Boraceia Biological Station followed a similar pattern to that observed in most inventories conducted in Brazil and other countries of South America. Although the number of species increased sporadically with an increasing number of samples at a given location, collections from different altitudes or phytophysiognomies of the matrix region may greatly increase the species number. In total, 133 saturniid species were recorded, with no endemism to the BBS.

We found it prudent not to compare statistically our results on species richness with other surveys, because clearly the sampling efforts were not the same, and also because the phytophysiognomies are quite different from those in the BBS. The collection of Saturniidae from the BBS deposited in the MZSP is the result of more than 70 years of sampling accumulation, and thus it is not perfectly suitable for such comparisons. However, the number of species (133 species) recorded in the present study was obtained in a single sampling site (see details in the Materials and Methods section), and is comparatively high in relation to the number of species inventoried for the Brazilian Cerrado biome (202 species), the Itatiaia region (125 species), and Rio Grande do Sul (113 species), Santa Catarina (149 species), and Paraná (131 species).

The importance of the BBS for the Saturniidae assemblage of the Atlantic region of São Paulo is due especially to its location, within a context of well-preserved Atlantic Rain Forest that extends along the northern to southern coast of the state, including the Serra do Mar State Park (Figure 1). For this reason, the BBS and its facilities are located in a strategic position and are therefore highly valuable for the knowledge and conservation of the

TABLE IV
Phenology of the species of Saturniidae recorded between 1942 and 2013 from the Boraceia Biological Station, Salesópolis, São Paulo, Brazil (based on the material deposited in the MZSP).

Taxa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Arsenurinae												
Arsenura armida	X	X	X						X			X
Arsenura biundulata		X	X	X	X			X				
Arsenura sylla								X				
Arsenura xanthopus		X									X	
Copiopteryx derceto							X	X	X	X		
Copiopteryx semiramis	X	X	X	X							X	
Copiopteryx sonthonnaxi	X	X	X	X		X	X	X	X	X	X	X
Loxolomia serpentina	X	X	X								X	X
Paradaemonia mayi							X	X	X	X	X	
Paradaemonia meridionalis	X	X								X	X	X
Paradaemonia orsilochus	X	X	X									X
Paradaemonia pluto								X				
Rhescyntis pseudomartii	X	X	X			X	X	X	X		X	
Titaea tamerlan	X	X	X	X				X	X	X	X	X
Ceratocampinae												
Adeloneivaia cf. *catharina*												X
Adeloneivaia fallax	X	X	X	X		X		X	X	X	X	X
Adeloneivaia subangulata			X									
Adelowalkeria flavosignata	X	X	X							X	X	X
Adelowalkeria tristygma	X	X	X				X	X	X	X	X	X
Almeidella almeidai								X	X	X		
Cicia crocata	X		X	X				X				X
Cicia nettia												X
Citheronia laocoon		X	X						X	X	X	X
Citheronia phoronea	X										X	X
Eacles ducalis		X							X	X	X	X
Eacles imperialis	X	X	X						X	X	X	
Eacles lauroi							X	X	X			
Eacles mayi								X	X	X		
Neorcarnegia basirei			X									
Oiticella brevis	X	X	X					X	X	X	X	X
Oiticella convergens	X		X	X			X			X		
Othorene cadmus	X	X	X	X		X	X	X	X	X	X	X
Othorene peggyae	X	X	X					X	X	X	X	X
Procitheronia principalis	X	X	X						X	X	X	X
Procitheronia purpurea									X	X		
Schausiella arpi	X	X								X		X

TABLE IV (continuation)

Taxa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Syssphinx molina	X	X	X						X	X	X	X
Hemileucinae												
Austrolippa convergens				X								
Austrolippa cruenta		X	X		X		X	X	X	X		
Automerella chrisbrechlinae	X	X					X	X				
Automerella flexuosa	X	X										
Automerella rubicunda							X					
Automeris basalis							X	X	X	X		
Automeris beckeri							X	X	X	X		
Automeris bilinea	X		X	X		X		X		X	X	X
Automeris illustris	X	X	X	X	X	X	X	X	X	X	X	X
Automeris inornata							X	X	X			
Automeris melanops		X	X						X			
Automeris muscula	X	X						X	X			
Automeris intermedius		X							X	X		
Automeris tristis	X	X	X					X	X			
Automeropsis umbrata									X			
Callodirphia arpi				X		X						
Catacantha oculata	X											
Catacantha ferruginea	X	X	X				X	X		X		
Cerodirphia apunctata	X											
Cerodirphia opis	X	X		X	X	X	X					X
Cerodirphia rosacordis											X	X
Cerodirphia vagans			X	X	X	X	X	X	X	X	X	X
Cerodirphia zikani						X	X					
Dirphia araucariae						X						
Dirphia baroma				X	X	X	X	X				
Dirphia dolosa						X	X	X	X			
Dirphia fornax	X	X	X									X
Dirphia muscosa	X	X			X	X	X	X	X	X	X	X
Dirphia sombrero						X		X				
Dirphiopsis delta				X	X	X	X					
Dirphiopsis epiolina				X		X	X	X	X			
Dirphiopsis multicolor	X	X		X	X		X	X	X	X	X	X
Dirphiopsis picturata						X	X	X	X			
Dirphiopsis trisignata	X	X	X									
Dirphiopsis undulinea						X	X					
Dirphiopsis wanderbilti					X	X	X	X	X			
Gamelia catharina							X	X				X

TABLE IV (continuation)

Taxa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gamelia remissoides	X	X	X	X	X	X	X	X	X	X	X	X
Hidripa paranensis	X	X	X	X	X	X	X	X	X	X	X	X
Hidripa perdix				X	X	X	X	X				
Hylesia corevia			X	X	X							
Hylesia falcifera	X	X	X	X		X	X	X				
Hylesia maurex			X	X	X		X					X
Hylesia metapyrrha	X	X	X	X	X	X		X	X	X	X	X
Hylesia minasia						X	X					
Hylesia munonia			X	X	X	X						
Hylesia nanus	X	X	X	X		X	X		X	X	X	X
Hylesia nigricans	X	X	X									
Hylesia oratex		X	X	X								
Hylesia paulex	X	X	X	X	X						X	X
Hylesia rufex					X	X						
Hylesia scortina	X	X	X			X	X	X	X			X
Hylesia sp.	X		X	X		X						
Hylesia sp. 1			X	X	X							
Hylesia sp. 2			X	X								
Hylesia sp. 3			X									
Hylesia vindex			X	X							X	X
Hyperchiria incisa	X	X	X					X	X	X		
Hyperchirioides bulaea	X	X						X	X			
Leucanella gibbosa	X	X		X	X	X		X			X	X
Leucanella janeira				X	X	X	X					
Leucanella viridescens	X	X					X		X		X	
Lonomia antoniae		X	X	X		X		X				
Lonomia cf. *obliqua*	X	X	X			X	X	X	X		X	X
Molippa sabina	X	X	X					X	X	X		
Periga acuta			X									
Periga cf. *intervales*			X			X						
Periga circumstans							X	X	X	X	X	
Periga falcata					X	X	X				X	X
Periga sp. 1				X	X	X	X					
Periga sp. 2				X							X	X
Prohylesia zikani	X							X				
Pseudautomeris brasiliensis	X	X				X	X	X	X	X		X
Pseudautomeris coronis			X	X								
Pseudautomeris grammivora	X											
Pseudautomeris hubneri	X			X	X	X	X	X	X	X		X

TABLE IV (continuation)

Taxa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pseudodirphia catarinensis			X									
Travassosula subfumata	X						X	X		X		
Oxyteninae												
Oxytenis bicornis	X	X	X		X	X	X	X	X	X	X	X
Oxytenis modaustralis	X	X	X	X	X	X		X	X			
Saturniinae												
Copaxa canella	X	X	X	X		X	X	X	X	X	X	X
Copaxa decrescens	X	X	X						X	X	X	
Copaxa joinvillea	X						X	X	X	X		
Copaxa mielkeorum		X						X	X	X		
Rothschildia arethusa	X	X	X					X	X	X	X	
Rothschildia aurota	X	X	X					X	X	X	X	X
Rothschildia belus			X						X	X	X	
Rothschildia hesperus	X	X	X	X							X	X
Rothschildia hopfferi	X	X	X	X				X	X	X	X	
Rothschildia jacobaeae	X	X		X			X	X	X	X	X	X

biodiversity of the Atlantic Rain Forest (Chiquetto-Machado et al. 2018). It is no coincidence that more than 70 years ago, in the early 1940, José Pinto da Fonseca, then head of the Entomology Division of the Biological Institute (São Paulo, SP), made several references to the importance of the BBS for knowledge of the local fauna and of its surroundings (Travassos Filho and Camargo 1958).

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