**The Social Wasp Community (Hymenoptera, Vespidae) in an Area of Atlantic Forest, Ubatuba, Brazil**

Olga Coutinho Togni 1*, Gabriela de Almeida Locher 1, Edilberto Giannotti 1 and Orlando Tobias Silveira 2

1 Universidade Estadual Paulista, Instituto de Biociências, Departamento de Zoologia, CEP 13506-900, Rio Claro, SP, Brazil.
2 Museu Paraense Emílio Goeldi, Campus de Pesquisas, Departamento de Zoologia, CEP 66040-170, Belém, PA, Brazil.

* Corresponding author. E-mail: olgatogni@yahoo.com.br

**ABSTRACT:** The Brazilian Atlantic Forest is of great relevance to biological conservation, and is among the areas in South America with the highest levels of diversity and endemism. The aim of this study was to survey the social wasp species in the subfamily Polistinae in Ubatuba, São Paulo state, in southwestern Brazil. Collecting work was conducted from May 2007 to May 2008 using attractive PET bottle traps and active searching. Twenty-one species belonging to eight genera were found, among which some may be considered rare in southeastern Brazil such as Mischocyttarus parallelogrammus and Polybia pallens (8.49%). A correlation between species richness and relative humidity (r = 0.6435; p = 0.0176) was observed. Values of species richness were a little higher in the super humid (Sm = 11) than in the less humid (Sm = 9) season. This suggests that this season may have more favorable environmental conditions for a greater richness of species to found colonies. Despite not having a very high species richness compared with other surveys, the collected species in this study can be considered rare in southeastern Brazil, emphasizing the complexity of the Atlantic Forest biome and its relation to the diversity of wasps.

**INTRODUCTION**

Social wasps (Vespidae, Polistinae) are remarkably abundant in Brazil (Raveret-Richter 2000), acting as predators, nectar collectors (Suzuki 1978; Carpenter and Marques 2001; Aguiar and Santos 2007), and prey (Jeanne 1975; Gadagkar 1991; Raw 1997) in the food chain.

Due to the importance and abundance of the taxon, studies on the diversity and abundance of social wasps have been conducted across different regions and environments, such as cultivated fields and human-modified environments (Rodrigues and Machado 1982; Marques et al., 1993; Santos et al., 1996; Lima et al., 2000; Marques et al., 2005; Ribeiro Junior, 2008; Santos et al., 2009a; Santos et al., 2009b; Alvarenga et al., 2010; Aued et al., 2010; Santos and Presley, 2010; Souza et al., 2011; Tanaka Junior and Noll, 2011; Locher, 2012), in areas of “cerrado” (semi-deciduous tropical forest or Brazilian savanna) (Richards 1978; Diniz and Kitayama, 1994; Mechi 1996; 2005; Melo et al., 2005; Souza and Prezoto 2006; Elpino-Campos et al., 2007; Souza et al., 2008; Santos et al., 2009b; Lima et al., 2010; Henrique-Simões et al., 2011; Tanaka Junior and Noll, 2011), “campos rupestres” montane savannas (characteristic vegetation of areas above 800-900 m of altitude that presents open vegetation with a stratum of monocot herbs, sub-shrubs and shrubs of dicots) (Silva-Pereira and Santos, 2006; Clemente 2009; Prezoto and Clemente, 2010), “caatinga”, (Tropical deciduous xerophytic woodland) (Melo et al. 2005; Santos et al., 2006; Santos et al., 2009a), riparian forest (Mechi 1996; Silveira et al., 2008; Souza et al., 2008; Clemente 2009; Souza et al., 2010; Henrique-Simões et al., 2011; Pereira and Antonialli-Junior, 2011; Locher, 2012), different environments of the Atlantic Forest (Melo et al. 2005; Hermes and Köhler, 2006; Santos et al., 2007; Souza et al., 2008; Clemente, 2009; Gomes and Noll, 2009; Lima et al., 2010; Prezoto and Clemente, 2010; Tanaka Junior and Noll, 2011), and the Amazon Forest (Raw 1998; Silveira 2002; Silveira et al., 2005; Morato et al., 2008; Silveira et al., 2008; Silva and Silveira, 2009).

Inventorying an area is the first step towards its conservation and rational use (Melo et al., 2005). By undertaking a survey of species of social wasps, several aspects of their biology and behavior must be considered, such as colony seasonality, foraging activity, and nesting habits. Brazilian rainforests represent a peak of biodiversity, and in this sense, certain localities possess the greatest abundance and richness of known species on the planet (Machado et al., 1998), including in their diversity of social wasps (Richards 1978).

The social wasps in Brazil have the asynchronous colony cycle. This pattern has been well-described for the genera Mischocyttarus, Polistes and Polybia (Gobbi and Zucchi 1980; Simões and Mecchi 1983; Gobbi 1984; Simões et al., 1985; Gobbi and Simões 1988; Marques et al., 1992; Giannotti and Machado, 1994; Giannotti et al., 1995; Giannotti, 1998). On the other hand, the foraging activity of Polistinae may be primarily limited by physical factors (Spradbery 1973), such as light intensity, temperature, air humidity, and wind speed, and some studies have shown that individual wasps forage more intensively during the warmest and least humid hours of the day (Giannotti et al., 1995; Andrade and Prezoto, 2001; Resende et al., 2001).

The present article presents the results of the first inventory of social wasps in an area of the Atlantic Forest in the northern coastal region of São Paulo state, in southwestern Brazil, emphasizing the importance of this
group for further studies on the Conservation Biology of the region. In addition, we sought to analyze and verify the existence of relationships between the temporal distribution of humidity and temperature and the richness and abundance of species identified.

**Materials and Methods**

**Study area**

The study site was in the Angelim Rainforest, a nature reserve in ombrophilous dense forest, located in the Atlantic Forest biome (Veloso *et al.* 1991), situated in Ubatuba city, (23°23′ S, 45°03′ W) São Paulo state, southwestern Brazil (Figure 1). The area is privately owned by Paul and Edna Thomsen and contains a total of 760 ha covered by native vegetation. Eighty percent of the area occurs within the State Park of Serra do Mar. The farm has several trails that provide access to sites in dense forest, some of which accompany the course of the Angelim River that originates in the nearby hills within the property.

The climate in the region, according to Köppen’s classification (Köppen 1948), is tropical rainforest with an average annual temperature of approximately 26.72°C, and constant humidity with an annual average humidity of 73.45%. The region has two seasons: (1) super humid with frequent rains from October to April, and (2) a less humid season from May to September with less constant rainfall, but without any water deficit (Bencke and Morellato 2002).

**Collecting procedures**

Twenty-five points were marked along the studied trail, with a distance of at least 100 meters between each in order to avoid the occurrence of pseudo-replicates; that is, individuals from the same wasp colony collected at separate sampling sites. Thirteen monthly collecting rounds were performed from May 2007 to May 2008, with each consisting of two days of fieldwork at the study site, with a one-week interval between. The relative humidity and environmental temperature at each sampling point were measured by digital thermohygrometer, making it possible to calculate a monthly average of these climatic variables and correlate them to local wasp diversity.

**Attractive traps**

Attractive traps made from two-liter plastic PET bottles (Melo *et al.* 2001; Souza and Prezoto 2006) were installed at each marked point. Four circular holes were made in each bottle and 200 mL of attractive liquid were placed inside. Two types of attractants were used: 1) guava juice, or 2) a blend containing 84 grams of sardines (equivalent to a tin) per liter of water. The traps were placed monthly at each of the 25 sampling points, and removed after one week. Individual wasps found in the bottles were collected with a sieve and tweezers and placed in vials to be fixed in 70% ethanol.
**Active searching**

Active searching relied on the use of entomological nets to search for individuals on pathways and trails in the area, and checking flowers, tree cavities, broad-leaved plants and buildings for the presence of wasps in the study area (Elpino-Campos et al. 2007). Individuals were actively sampled during the two days every month in which the area was visited for a total of 10 hours of monthly sampling effort.

**Identification of collected material**

All specimens were collected in accordance with the permit number 11413-1 of the Brazilian Institute of Environment and Renewable Natural Resources, IBAMA, and were deposited in the Entomological Collection at the Department of Zoology, Universidade Estadual Paulista “Júlio de Mesquita Filho” (UNESP), campus of Rio Claro, SP, Brazil and at the Entomological Collection at Museu Paraense Emílio Goeldi, Bélem, PA, Brazil. Species were identified through the use of dichotomous keys (Richards 1978; Carpenter and Marques 2001; Pickett and Wenzel 2007; Silveira et al. 2008; Cooper 1997) and by comparison with specimens in the aforementioned collections. Voucher specimens were deposited on the Entomological Collection at the Department of Zoology UNESP Rio Claro or on the Entomological Collection at Museu Paraense Emílio Goeldi (Table 2).

**Data analysis**

The relative abundance of each species was calculated by dividing the abundance of the species by the total number of individuals collected. To assess the constancy of species in relation to monthly samplings, we used the formula $C = P \times 100 / N$, proposed by Bodenheimer (1955 apud Silveira-Netto et al. 1976), where:

- $P$ = number of samples containing a certain species;
- $N$ = total number of samples;

Data were grouped into the following categories: (1) constant species, present in over 50% of the samples; (2) accessory species, present in 25% to 50% of samples; (3) accidental species, present in less than 25% of samples.

To verify the existence of significant differences in the richness and abundance of species of wasps collected during different seasons, the Mann-Whitney U test was performed, using the software BioEstat 5.0 (Ayres et al. 2007). In addition, we applied the Spearman correlation test (BioEstat 5.0) to verify a possible relationship between the diversity of social wasps and environment temperature and relative humidity, which were measured monthly.

**Results**

A total of 2104 social wasp individuals (Vespidae, Polistinae) were collected, representing 21 species in eight genera (Table 1).

Table 2 presents the total abundance (A), relative abundance (RA%), the constancy (C), and richness (S) for species and samples found in the Angelim Rainforest, and how they were distributed throughout the year. Agelaia angulata had the highest abundance (A = 1353), representing more than half of the total number of individuals collected, with a relative abundance of 64.31%, and thus was considered the dominant species. Relative abundances were higher than 1% for the following species:

| TAXON                          | RELATIVE ABUNDANCE (%) | LESS HUMID SEASON | SUPER HUMID SEASON |
|-------------------------------|------------------------|-------------------|-------------------|
| *Agelaia angulata* (Fabricius, 1804) | 82.60                  | 49.61             |
| *Agelaia sp. n. centralis* (Cameron, 1907) | 7.47                  | 12.17             |
| *Agelaia multipicta* (Haliday, 1836) | 0.75                   | 0.60              |
| *Agelaia vicina* (de Saussure, 1854) | 0.64                   | 2.49              |
| *Angiopolybia pallens* (Lepeletier, 1836) | 2.45                   | 14.14             |
| *Apoica pallens* (Fabricius, 1804) | 0.32                   | 0.17              |
| *Polybia bifasciata* de Saussure, 1854 | 0.00                   | 0.43              |
| *Polybia cattilifex* Moebius, 1856 | 1.28                   | 5.66              |
| *Polybia fastidiosuscula* de Saussure, 1854 | 0.11                   | 0.60              |
| *Polybia ignobilis* (Haliday, 1836) | 0.32                   | 0.17              |
| *Polybia jurinei* de Saussure, 1854 | 0.53                   | 0.34              |
| *Polybia occidentalis* (Olivier, 1791) | 1.07                   | 6.60              |
| *Protopolybia exigua* (de Saussure, 1854) | 0.11                   | 0.00              |
| *Synoeca cyanea* (Fabricius, 1775) | 0.32                   | 0.09              |

**Mischocyttarini**

- *Mischocyttarus cassununga* (von Ihering, 1903): 0.00 (0.77)
- *Mischocyttarus paralelogrammus* Zikán, 1935: 0.43 (0.69)
- *Mischocyttarus rotundicolis* (Cameron, 1912): 0.11 (0.34)
- *Mischocyttarus socialis* (de Saussure, 1854): 1.17 (2.40)
- *Mischocyttarus wagneri* (Buysson, 1908): 0.11 (0.00)

**Polistini**

- *Polistes carnifex* (Fabricius, 1775): 0.00 (0.17)
- *Polistes versicolor* (Olivier, 1791): 0.21 (2.57)

**Species richness**

|             | 18 | 19 |

---

Togni et al. | Social Wasps in Ubatuba, Brazil
Among the constant species: Agelaia angulata, A. nr. centralis, A. multipicta, Angiopolybia pallens, Polybia catillifex, P. occidentalis, Mischocyttarus parallelogrammus, M. socialis and Polistes versicolor, only Agelaia angulata and A. nr. centralis showed a constancy of 100%, while Angiopolybia pallens was not sampled in June 2007 and M. socialis was not sampled in October 2007 (Table 2).

The species considered as accidental were Polybia bifasciata, P. fastidiosuscula, P. ignobilis, Protopolybia exigua, Synoeca cyanoea, Mischocyttarus wagneri and Polistes carnifex. We collected only one individual of the species Protopolybia exigua, in May 2007, and of Mischocyttarus wagneri in August 2007 (Table 2).

In Table 3, the relative abundance of each species and species richness for each season (less humid and super humid) are depicted. In the super humid season, 19 species were collected and Mischocyttarus cassununga, Polybia carnifex and Polistes bifasciata were unique for this period. In the less humid season, we found 18 species, with Mischocyttarus wagneri and Protopolybia exigua being unique for this period. With respect to the species that showed relative abundances greater than 1.0%, only Agelaia angulata was more abundant in the less humid season. Being very abundant and with very populous colonies (Richards 1978), A. angulata presents adaptations to maintain its population during the months in which food resources are less available, such as nectar and insects. Furthermore, the attractive liquids used in traps may have represented an extra food source (Elpino-Campos et al. 2007). The remaining species: A. nr. centralis, A. vicina, Angiopolybia pallens Mischocyttarus socialis, Polistes versicolor, Polybia catillifex and P. occidentalis were collected during the super humid season. For species with relative abundances less than 1%, it is noted that, excluding Mischocyttarus wagneri which was collected only once, all other independent-founding M. cassununga, M. parallelogrammus, M. rotundicolis, M. socialis, Polistes carnifex and P. versicolor were more abundant at the super humid season. As the large populations of Agelaia are better prepared to face shortages of resources, it may be that the tribes Mischocyytarrini and Polistini, with smaller colonies, have a greater sensitivity to decreases in temperature, humidity and consequently the shortage of food sources.

### Table 2

| SPECIES                  | A     | RA%  | C  | MONTHS | CATALOGUE NUMBER |
|-------------------------|-------|------|----|--------|------------------|
| Agelaia angulata        | 1353  | 64.31| ●  | m      | DZRC 1205 - 1219 |
| A. nr. centralis        | 212   | 10.08| ●  | j      | DZRC 1220 - 1226 |
| A. multipicta           | 14    | 0.67 | ●  | j      | MPEG 11.101.714  - 11.101.725 |
| A. vicina               | 35    | 1.66 | □  | j      | DZRC 1237 - 1251 |
| Angiopolybia pallens    | 188   | 8.94 | ●  | □      | MPEG 11.101.714  - 11.101.725 |
| Apoica pallens          | 5     | 0.24 | □  | m      | DZRC 1252        |
| Polybia bifasciata      | 5     | 0.24 | X   | □      | MPEG 11.101.714  - 11.101.725 |
| P. catillifex           | 78    | 3.71 | ●  | □      | DZRC 1261 - 1269 |
| P. fastidiosuscula      | 8     | 0.38 | X   | #      | DZRC 1259 - 1260 |
| P. ignobilis            | 5     | 0.24 | X   | #      | DZRC 1287 - 1287 |
| P. jurinei              | 9     | 0.43 | □  | □      | DZRC 1288 - 1290 |
| P. occidentalis         | 87    | 4.13 | ●  | #      | 1270 - 1286      |
| Protopolybia exigua     | 1     | 0.05 | X   | #      | MPEG 11.101.714  - 11.101.725 |
| Synoeca cyanoea         | 4     | 0.19 | X   | #      | DZRC 1253        |
| Mischocyttarus cassununga| 9    | 0.43 | □  | □      | DZRC 1322 - 1326 |
| M. parallelogrammus     | 12    | 0.57 | ●  | #      | DZRC 1316 - 1321 |
| M. rotundicolis         | 5     | 0.24 | □  | #      | MPEG 11.101.714  - 11.101.725 |
| M. socialis             | 39    | 1.85 | ●  | #      | DZRC 1302 - 1315 |
| M. wagneri              | 1     | 0.05 | X   | #      | MPEG 11.101.713  |
| Polistes carnifex       | 2     | 0.10 | X   | #      | DZRC 1291        |
| P. versicolor           | 32    | 1.52 | ●  | #      | DZRC 1292 - 1301 |

Number of individuals | 2104 | 186 | 78 | 106 | 400 | 99 | 404 | 152 | 83 | 100 | 129 | 137 | 162 | 68

Richness (S) | 21 | 13 | 6 | 5 | 12 | 10 | 12 | 10 | 11 | 10 | 13 | 10 | 8
Although there is no significant difference in species richness between the two seasons (z = 1.0714, p = 0.2840), one can observe (Figure 2A) that in the super humid season (Sm = 11) the average richness was greater than in the less humid season (Sm = 9). In the super humid season the lowest number of species collected was 10, in October, February and April, and greatest richness was 13 species in March. In the less humid season, there was a decreased richness mainly in the months of June and July, with six and five species, respectively. Despite the observed decrease in these months, in May 2007 the richness was equal to the highest found in the super humid season, or 13 species. This number is likely due to the fact that the month of May represents the beginning of the drier period, and therefore, wasp colonies have just recently been exposed to less favorable conditions.

![Figure 2](image_url)  
**Figure 2.** Diversity of social wasps related to temperature and relative humidity during the months of the year in Angelim Rainforest, Ubatuba, SP: (a) Richness of species (Sm = average richness of each season) and (b) Abundance of species (Am = mean abundance of each).

Regarding the number of individuals collected, a slight seasonal difference (not significant) was observed in mean abundance, with a value of 166.71 individuals at the super humid season and 156.17 in the less humid season. There was no significant difference in abundance between seasons (z = 0.8571, p = 0.3914), with observed peaks in August and October 2007 (Figure 2B).

Also in Figure 2, it can be noted that the environmental temperature varied little throughout the year, with the lowest temperature 23.87°C occurring in June 2007, and the highest (29.40°C) occurring in February 2008. Although lower values of richness, (especially in June and July) and lower rates of abundance (such as in May 2008), could be noted, probably as a result of the decrease in temperature, an increase in the diversity of social wasps was not observed in the warmer months. By using the Spearman test, it was not possible to establish a significant correlation between temperature and species richness (r = 0.2770, p = 0.3596) or abundance (r = 0.0604, p = 0.8445).

However, by examining the values of relative humidity greater than 80% recorded in May and December 2007 and January 2008, greater richness values can be noted (13, 11 and 11 respectively), while in June and July 2007 and May 2008, a smaller number of species were collected and are coincident with lower relative humidity (Figure 2A). This trend is confirmed by the Spearman test that showed a significant positive correlation between relative humidity and species richness of social wasps in Angelim Rainforest (r = 0.6435, p = 0.0176). Contrary to expectations, in May 2008 the lowest abundance and the lowest humidity were observed. There was no significant correlation between these variables (r = 0.0604, p = 0.8445), reflecting the lack of pattern in the relationship between species abundance and relative humidity in this study.

**DISCUSSION**

Survey studies on this group of social wasps in Brazil have become relatively frequent (Table 3). Since 2005 at least two annual surveys related to the diversity of social wasps were published, however, knowledge on the richness of these communities in the Atlantic Forest remains scarce.

The studies of Melo et al. (2005), Hermes and Köhler (2006), Santos et al. (2007), Souza et al. (2008), Gomes and Noll (2009), Prezoto and Clemente (2010), Lima et al. (2010), and Tanaka Junior and Noll (2011) addressed regions of the Atlantic Forest, reporting quite different richness estimates from the present study. A lack of studies in São Paulo state is apparent, as evidenced in Table 3. Richards (1978) found 105 species (111 including subspecies) in museums around the world originating from municipalities in the state of São Paulo, with only the species *Apoica pallens* having not been previously listed by him. However, it should be noted that *Apoica pallens* had been listed by other authors for the state of São Paulo (Rodrigues and Machado 1982; Mechi 1996; Locher 2012).

Considering the results of inventories carried out in southeastern Brazil (Rodrigues and Machado 1982; Mechi 1996; 2005; Souza and Prezoto 2006; Elpino-Campos et al. 2007; Ribeiro Junior 2008; Souza et al. 2008; Clemente 2009; Gomes and Noll 2009; Alvarenga et al. 2010; Auad et al. 2010; Lima et al. 2010; Prezoto and Clemente 2010;
Souza et al. 2010; Henrique-Simões et al. 2011; Souza et al. 2011; Tanaka Junior and Noll 2011; Locher 2012), it is observed that the most abundant species in Ubatuba, Agelaia angulata, A. nr. centralis and Angiopolybia palennis were not collected in other studies, with the latter having been observed in another area of Atlantic Forest in Bahia (Santos et al. 2007). These three species are more common in the inventories of the North and Northeast regions of Brazil, generally covered by “cerrado” and Amazonian rainforests (Silveira 2002; Melo et al. 2005; Silveira et al. 2005; Santos et al. 2007; Morato et al. 2008; Silveira et al. 2008).

The species Polybia catilliflex and Mischocyttarus parallelogrammus, which had high abundance in the Angelim Rainforest, were not listed in any other survey. Richards (1978) reported the occurrence of M. parallelogrammus only in the states of Minas Gerais, Rio de Janeiro and São Paulo. These data reinforce the need for more studies on the northern coast of São Paulo. This result may be related to the lack of studies in the Atlantic Forest, but can also be explained by the complexity of this biome. In a study on the community of social wasps of three ecosystems of Itaparica Island, in Bahia state (mangrove, ombrophilous dense forest and restinga), there was a significant correlation between plant diversity and the diversity of species of wasps (Santos et al. 2007). It was observed that the ombrophilous dense forest has a larger and more complex variety of plants than other biomes studied, and consequently a greater richness of the fauna, which can be explained by the heterogeneity of the environment and the existence of a wide variety of niches (Santos et al. 2007).

In general, species in the tribe Epiponini, especially those of the genus Agelaia, showed the greatest abundances. This result may be due to the population size of this group of swarm-founding wasps with medium to large colonies that may have millions of individuals (Zucchi et al. 1995). Moreover, in swarm-founding wasps, a greater specialization occurs among individuals in a colony, which reduces the chance of death of the queen and contributes to a more effective defense of the colony (Jeanne 1991).

The tribes Mischocyttarini and Polistini are independent-founding and have colonies composed of only a few dozen wasps (Richards 1978; Gadagkar 1991; Reeve 1991) which may be reflected in the low abundances found for these species. However, in this study, M. parallelogrammus and P. versicolor had low abundances, but were considered constant species. The remaining species Agelaia vicina, Apoica pallens, Polybia jurinii, Mischocyttarus cassununga and M. rotundicolis, were considered accidental species. Thus, of the twenty-one species collected, nine (42.86%) were classified as constant species, five (23.81%) were considered accessory species and seven (33.33%) were accidental species. The high percentage of constant species may also be explained by the high complexity of the ombrophilous dense forest, which has numerous food resources that can provide greater chances of survival and reproduction (Santos et al. 2007).

The greatest number of species of wasps sampled in more humid conditions does not mean that a larger number of individuals perform foraging activity under these conditions, but may mean that this period has better environmental conditions, contributing to a higher richness of species to found their colonies. At the localities: “Mata do Baú” in the city of Barroso, Minas Gerais state, “Patrocínio Paulista”, SP and “Ibitipoca State Park” in the city of Lima Duarte, MG, the highest species richness values were observed in the warmer and humid months of the year (Souza and Prezoto 2006; Lima 2008; Ribeiro Junior 2008; Clemente 2009). Thus, it can be seen in Figure 2B, that in August and October 2007, which were the months with highest abundances, high relative humidity was not observed. In the wettest month, January 2008, there was a relatively low number of individuals, corroborating the data that humidity and foraging would be inversely proportional. Moreover, the high relative humidity during this period may be due to high rainfall that reduces flight activity (Giannotti et al. 1995; Andrade and Prezoto 2001; Resende et al. 2001).

Overall, this study, despite not having observed a very high species richness compared with other surveys, is of great importance with regards to the need for further studies in the region and the collection of species with low occurrence records in southeastern Brazil such as Mischocyttarus parallelogrammus and Polybia catilliflex. Furthermore, this study emphasizes the complexity of the Atlantic Forest biome and its relation to the diversity of wasps, with the frequent collection of species common in the Amazon Forest: Agelaia angulata, A. sp. prox. centralis and Angiopolybia palennis. A correlation between species richness and relative humidity was also noted, demonstrating the influence abiotic factors can have on populations.

ACKNOWLEDGMENTS: We thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for financial support.

LITERATURE CITED

Aguiar, C.M.L. and G.M.D.M. Santos. 2007. Compartilhamento de recursos florais por vespas sociais (Hymenoptera: Vespidae) e abelhas (Hymenoptera: Apoidea) em uma área de caatinga. Neotropical Entomology 36: 836–842.

Alvarenga, R.D., M.M. De Castro, H.H. Santos-Prezoto and E. Prezoto. 2010. Nesting of social wasps (Hymenoptera, Vespidae) in urban gardens in Southeastern Brazil. Sociobiology 55(2): 445–452.

Andrade, F.R. and F. Prezoto. 2001. Horários de atividade forrageadora e material coletado por Polistes ferreri Saussure, 1853 (Hymenoptera, Vespidae), nas diferentes fases de seu ciclo biológico. Revista Brasileira de Zoociências 3: 117–128.

Auxa, A.M., C.A. Carvalho, M.A. Clemente and E. Prezoto. 2010. Diversity of social wasps (Hymenoptera) in a silvipastoral system. Sociobiology 55(2): 627–636.

Ayres, M., M. Ayres Junior, D.L. Ayres and A.A. Santos. 2007. Bio-ESTAT – Aplicações estatísticas nas áreas das ciências bio-médicas. Belém, PA: Ong Mamirauá. 364 pp.

Bencke, S.C.C. and L.P.C. Morellato. 2002. Estudo comparativo da fenologia de nove espécies arbóreas em três tipos de floresta atlântica no sudeste do Brasil. Revista Brasileira de Botânica 25: 237–248.

Carpenter, J.M. and O.M. Marques. 2001. Estudo comparativo da fenologia de nove espécies arbóreas em três tipos de floresta atlântica no sudeste do Brasil. Revista Brasileira de Botânica 25: 237–248.

Clemente, M.A. 2009. Vespas sociais (Hymenoptera, Vespidae) do Parque Estadual do Itibipoco-MC: estrutura, composição e visitação floral. M.Sc. Dissertation. Juiz de Fora: Universidade Federal de Juiz de Fora. 79 pp.

Cooper, M. 1997. The subgenus Megacanthopus Duke of Mischocyttarus of Saussure (Hym., Vespidae), with a key and three new species. Journal of Hymenoptera Research 3: 133–
Social wasps of two wetland ecosystems in Brazilian Amazonia (Hymenoptera, Vespidae, Polistinae). *Acta Amazonica* 38(2): 333–344.

Silveira, O.T., M.C. Espósito, J.N. Dos Santos and F.E. Gemaque. 2005. Social wasps and bees captured in carrion traps in a rainforest in Brazil. *Entomological Science* 8(1): 33–39.

Simões, D. and M.R. Mecchi. 1983. Estudo sobre a fenologia de *Polybia (Myrapetra) paulista* Théron, 1896 (Hymenoptera, Vespidae). *Naturalia* 8: 185–191.

Simões, D., N. Gobbi and B.R. Batarce. 1985. Mudanças sazonais na estrutura populacional em colônias de 3 espécies do gênero *Mischocyttarus*. *Naturalia* 10: 89–105.

Souza, A.R., D.F.A. Venâncio, J.C. Zanuncio and F. Prezoto. 2011. Sampling methods for assessing social wasps species diversity in a eucalyptus plantation. *Journal of Economic Entomology* 104(3): 1120–1123.

Souza, M.M. and F. Prezoto. 2006. Diversity of social wasps (Hymenoptera: Vespidae) in Semideciduous forest and cerrrado (savanna) regions in Brazil. *Sociobiology* 47(1): 135–147.

Souza, M.M., M.J. Silva, M.A. Silva and N.R.G. Assis. 2008. A capital dos marimbondos - vespas sociais Hymenoptera, Vespidae do município de Barroso, Minas Gerais. *MG Biota* 1(3): 24–38.

Souza, M.M., J. Louzada, J.E. Serrão and J.C. Zanuncio. 2010. Social wasps (Hymenoptera: Vespidae) as indicators of conservation degree of riparian forests in southeast Brazil. *Sociobiology* 56(2): 387–396.

Spradbery, J.P. 1973. *Wasps: An account of the biology and natural history of solitary and social wasps*. Seattle: University of Washington Press. 408 pp.

Suzuki, T. 1978. Area, efficiency and time of foraging in *Polistes chinensis antennalis* Pérez (Hymenoptera: Vespidae). *Journal of the Kansas Entomological Society* 28: 179–189.

Tanaka Junior, G.M. and F.B. Noll. 2011. Diversity of social wasps on Semideciduous Seasonal Forest fragments with different surrounding matrix in Brazil. *Psyche* 2011: 1–8.

Veloso, H.P., A.L.R. Rangel-Filho and J.C.A. Lima. 1991. *Classificação da vegetação brasileira, adaptada a um sistema universal*. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística. 133 pp.

Zucchi, R., S.F. Sakagami, F.B. Noll, M.R. Mecchi, S. Mateus, M.V. Baio and S.N. Shima. 1995. *Agelaia vicina*, a swarm-founding Polistine with the largest colony size among wasps and bees (Hymenoptera: Vespidae). *Journal of the New York Entomological Society* 103(2): 129–137.

Received: July 2013

Accepted: December 2013

Published online: February 2014

Editorial responsibility: Matthew Smart