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Species composition, relative abundance and distribution of social wasps fauna on different ecosystems

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Abstract

The state of Minas Gerais has high biodiversity, characterized by strong ecosystem heterogeneity that favors high richness of social wasps. There are currently 109 species known to occur in the state, however, there is lack of information concerning the distribution of these social insects among different ecosystems. The objective of this study was to evaluate social wasp species richness and distributions by ecosystem, thereby generating data for use in discerning relevant and priority environments for vespid conservation in Minas Gerais. We evaluated articles, theses, and dissertations published up to the year 2016 containing data on biodiversity of social wasps in natural and agricultural environments. We found 18 studies, in which the highest reported species richness was in semideciduous seasonal forest (n = 68), followed by Cerrado (n = 53), ombrophilous forest (n = 39), deciduous seasonal forest, and campos rupestres (n = 35). The lowest richness was reported in mixed forest (n = 21) and high-altitude fields (n = 19). Considering the high degree of landscape diversity of the state of Minas Gerais, more studies are needed to accurately assess social wasp diversity in these ecosystems, especially Cerrado. Ombrophilous and deciduous forests should be considered strongly relevant for these social insects, especially the Rio Doce State Park and the Rio Pandeiros Wildlife Refuge.

Introduction

The netropical region presents high biodiversity as a result of ecosystem heterogeneity that includes Cerrado, campos rupestres, high-altitude fields, deciduous (dry) and semideciduous forest, Atlantic forest, and Caatinga (Scolforo & Carvalho, 2006). Studies of various taxa in Minas Gerais have revealed highly rich plant (Mendonça & Lins, 2000), amphibian (Feio et al., 2008), and insect communities, including social wasps (Brunismann et al., 2016; Prezoto et al., 2016).

Social wasps carry out numerous ecological functions, including floral visitation and pollination. Several studies on socials waspsthat are floral visitors of different species of Angiosperms have been conducted in Brazilian ecosystems such as Cerrado (Mechi, 2005), Araucária Forest (Hermes & Kohler, 2006) and Caatinga (Santos et al., 2006), as well as in urban areas (Silva-Pereira & Santos, 2006; Hermes & Kohler, 2006).

Although wasps are more frequently regarded as floral resource thieves (Hunt et al., 1991; Santos et al., 2010); recent papers show that wasps can also effectively contribute to pollination (Shuttleworth & Johnson, 2009). In a study with *Schinus terebinthifolius* Raddi (Anacardiaceae), Suhs et al. (2009) showed that social wasps, especially *Polistes versicolor* (Olivier, 1791), *Polybia sericea* (Olivier, 1791), *Polistes simillimus* (Zikán, 1951), and *Polybia ignobilis* (Haliday, 1836), were more representative in richness and abundance than bee species, being considered efficient pollinators. Other studies, such as Barros (1998) and Hermes and Kohler, (2006) also demonstrated the efficiency of the wasps as pollinators.

These insects also play a role in controlling agricultural pests (Prezoto et al., 2008; Elisei et al., 2010), and are sensitive to environmental changes, making them useful as indicators of environmental quality (Souza et al., 2010). Minas Gerais has been more frequently sampled than other Brazilian states and regions (Prezoto et al., 2016), and there are currently 109 social wasp species known to occur in the state (http://vespas.ifs.ifsuldeminas.edu.br/). However, there is currently a paucity of information concerning species distributions among ecosystems, and studies that discuss phytophysiognomy (Santos et al., 2007; Santos et al., 2009).

The study of biological diversity, species distributions, and richness on social wasps are relevant because biodiversity directly influences natural and agricultural ecosystem function through effects on trophic network structure (Clemente et al., 2012; Clemente et al., 2013), pollination (Suhs et al., 2009; Barros, 2009; Hermes & Kohler, 2006), nutrient cycling (Gomes et al., 2007), and ecological succession, among other processes (Souza et al., 2010).

It is estimated that ecosystems that still have low sampling may present a high unknown richness, and may be of considerable relevance for the conservation of social wasps. Therefore, the objective of this study was to better understand the social wasp richness and species geographic distributions among ecosystems, with the purpose of identifying relevant and priority environments for vespid conservation.

Materials and methods

We evaluated data of occurrence of social wasps in different ecosystems between coordinates north 14º13'52'' and south 22º55'22'', east 39º51'23'' e a west 51º02'56''. The data used in this study are derived from articles, theses, books, catalogues and dissertations published in 2006 up to 2016 with data on social wasp biodiversity in natural and agricultural environments, totaling 18 studies (Table 01). We followed the species classifications proposed by Oliveira Filho (2006). We evaluated the social wasp richness and species distributions in seven distinct ecosystems: 1. seasonal semideciduous rain forest, 2. deciduous seasonal dry (forest, 3. ombrophilous forest, 4. mixed forest (all on the Atlantic forest domain); 5. Cerrado; 6. campos rupestres, and 7. high-altitude fields (Figure 01).

Semideciduous rain forests are formed by arboreal species that have a deciduous rate of around 50% and a climate varying between tropical and tropical at altitude, whereas deciduous dry forests have around 90% and semiarid climate, and forests Ombrophilous to deciduous is around 10% and tropical climate. The mixed forests are composed of *Araucaria angustifolia* Kuntze 1898 associated with species of semidecidual rainforest, tropical climate of altitude; Cerrado shows variable vegetation, from rural, savanna and forest formations, tropical climate; Campos Rupestres areas are characterized by rocky outcrops of quartz, located in areas above 900 meters of altitude, endemic flora and tropical climate of altitude; and Altitude Fields show a predominance of species of the family Poaceae and flora very similar to the Patagonia Fields, southern Argentina, altitude above 1,000 meters and altitude topical climate (Oliveira Filho, 2006).

Table 01. Biodiversity studies of social wasps carried out in the state of Minas Gerais by author, date, ecosystem, and number of species registered.

Author	Year	Ecosystem	Number of Species
Souza & Prezoto	2006	Seasonal semideciduous rain forest	38 (45)*
Souza et al.	2010	Seasonal semideciduous rain forest	36
Souza et al.	2015 b	Seasonal semideciduous rain forest	34
Albuquerque et al.	2015	Seasonal semideciduous rain forest	34
Jacques et al.	2012	Seasonal semideciduous rain forest	26
Barbosa	2015	Seasonal semideciduous rain forest	36
Auad et al.	2010	Agricultural system inserted in seasonal semideciduous rain forest	13
Freitas et al.	2015	Agricultural system inserted in seasonal semideciduous rain forest	19
Clemente	2009	Ombrophilous forest	5
Souza et al.	2012	Ombrophilous forest	38
Elpino-Campos et al.	2007	Cerrado	29
Simões et al.	2012	Cerrado	32
Jacques et al.	2015	Agricultural system inserted in Cerrado	29
Brunismann et al.	2016	Seasonal semideciduous dry forest	37
Prezoto & Clemente	2010	Campo Rupestre	23 (24)*
Souza et al.	2008	Campo Rupestre	32
Souza et al.	2015 a	high-altitude fields and mixed forest	22 (23)*
Bruger	2014	Seasonal semideciduous rain forest	23

*The sum of species recorded by the listed authors and those recorded since the study.

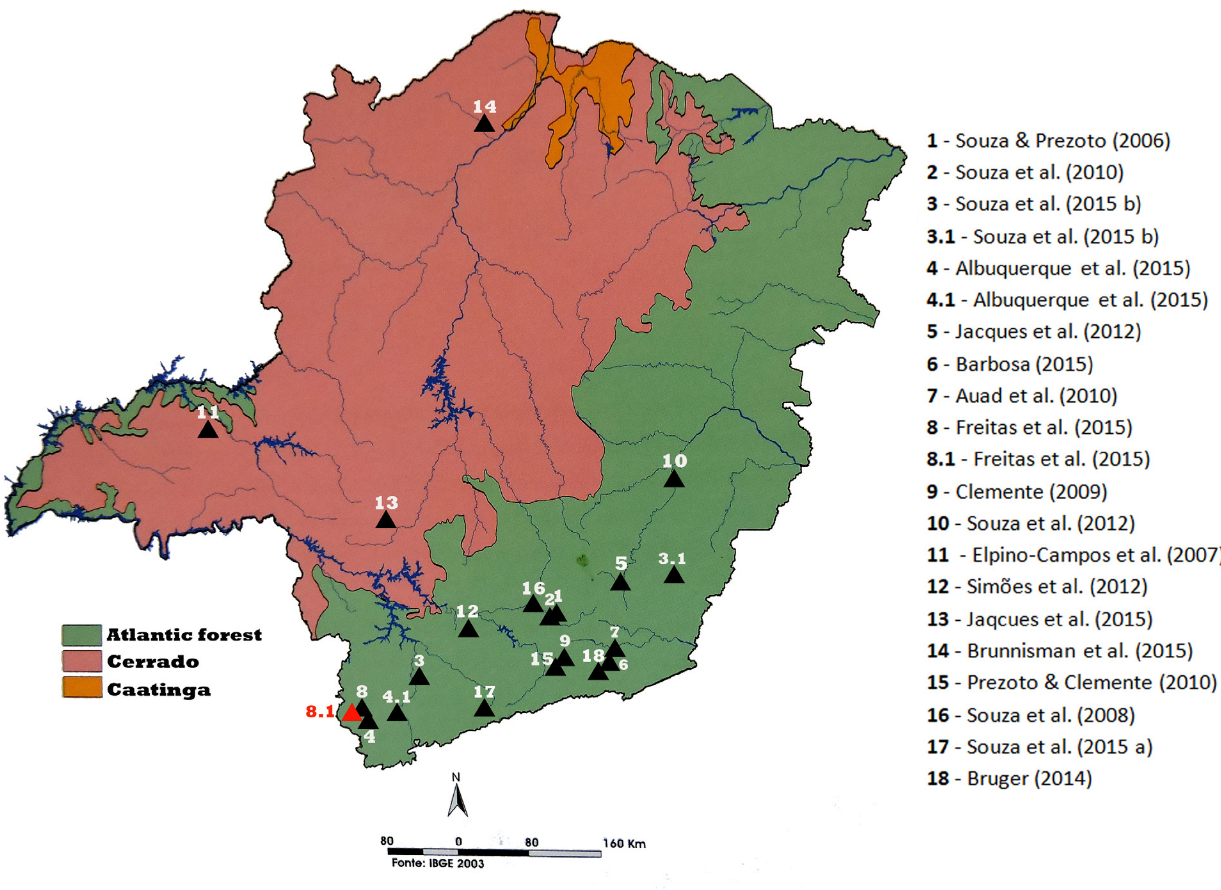

Fig 01. Map of records of species of social wasps in the state of Minas Gerais, Brazil.

Results and Discussion

A total of 109 species of 16 genera of social wasps were recorded in seven distinct ecosystems (Table 02). The exception three species *Mischocyttarus buysoni* (Ducke, 1906), *Polybia brunnea* (Curtis, 1844) e *Polybia emaciata* (Saussure, 1854) Which has a record for the study area (Richard, 1978), but there is no occurrence information per ecosystem.

Nine of the 18 studies (50%) carried out in our research were in semideciduous seasonal rain forest (hereafter SSRainFor), which together reported a total of 68 social wasp species, being 16 species of them exclusive to this forest type (Table 02). Semideciduous SEasonal Rain Forests have the largest number of studies due to wide distribution in Minas Gerais. Seasonal semideciduous forests are widely distributed in areas with a seasonal rainfall regime in the Atlantic forest and Cerrado domains. It is the predominant vegetation typology in these domains, and occurs in the form of enclaves and forests associated with permanent or intermittent bodies of water (Scolforo & Carvalho, 2006). About 50% of the territory of Minas Gerais occurs in the Atlantic forest domain according to the Atlas of Evolution of Forest Remnants and Associated Ecosystems in the Atlantic Forest Domain (SOS Mata Atlântica Foundation, 2002).

Social wasp richness in semideciduous seasonal rain forest is considerable, with social wasp richnes ranging from 13 to 45 species among the study sites in the evaluated scientific works. The lowest richness values for this biome were reported in Freitas et al., (2015) (s = 19) and Auad et al., (2010) (s = 13), both of which share the characteristic of being carried out in agricultural systems within forest areas. According to Santos et al. (2009), despite the relative structural homogeneity of vegetation in environments with agricultural systems, there is high availability of resources such as nectar, prey, and water, which can support high numbers of social wasp species. However, Lawton (1983) and Santos et al. (2007) demonstrated that environments with higher structural complexity facilitate the establishment and survival of greater numbers of species. Vegetation structure influences social wasp communities directly through provisioning of nesting and food resources, and indirectly through influencing variation in temperature and air humidity, as well as the amount of shade in the environment.

Some social wasp species nest only under certain conditions, selecting nest sites according to vegetation density and type, extent of canopy closure, and the shape and arrangement of leaves and other plant structures (Santos & Gobbi, 1998). This partly contributed to the higher richness in other sites compared to those situated in agrarian systems.

Clemente (2009) recorded only five species in an ombrophilous forest site, while Souza et al. (2012) recorded 38 species; in this ecosystem 39 species of social wasps have been recorded, with 17 exclusive species (Table 02). Clemente (2009) justifies the low sample numbers in this forest fragment (dense ombrophilous forest) due to local floristic composition, which presents trees varying from 17 to 25 meters. This canopy type (i.e., height) restricts light penetration inside the forest, reducing visibility making it difficult to search for and capture wasps. The Atlantic forest fragment in the current study contains clearings formed by tree fall (Fontes, 1997), which facilitates active search and collection of social wasps due to higher visibility in those areas. For example, a study with *Synoeca cyanea* demonstrated that light intensity is positively correlated with the number of foraging individuals (Elisei et al., 2005). Dense vegetation also makes it difficult to find species and colonies, which may be imperceptible in this type of environment (Wenzel & Carpenter, 1994). These data corroborate those of Souza and Prezoto, (2006) in a semi-deciduous forest which had lower richness (n=25) than Cerrado fields (n=33). Togni et al., (2014) also reported nine wasp species actively captured in anthropogenic and open forest areas, whereas in the closed forest (i..e, a site with a lower light intensity) only five species were found by active collection. In the Amazon forest, Silveira (2002) reported difficulty in capturing social wasps in the forest interior, and were only effective only near the edges. However, Santos et al. (2007) reported higher wasp richness in Atlantic forest (18 species) compared to Restinga (16 species) and mangrove (eight species). This difference is richness may be associated with differences in environmental conditions (e.g., salinity, temperature, aridity) in sites with lower richness.

In the study by Souza et al. (2012) in ombrophilous forest, 38 social wasp species were recorded the Rio Doce State Park (19º38'00.00" S and 42º31'00.00" W), which is greater than that reported in studies in São Paulo (Togni et al., 2014) and Bahia (Santos et al., 2007). This may be partially attributed to the greater degree of conservation and lower anthropogenic activity in the Rio Doce area. These factors can affect the distribution and diversity of these insects, because conserved or regenerating environments typically present a mosaic of vegetation which provides higher availability of food and nesting resources, as well as habitat for species with more restricted ecological needs. The large size of the Rio Doce area also increases the number of nesting sites and population gene flow relative to smaller sites (Souza et al., 2012). Most species were found at the forest edge, again likely due to the difficulty of capture in dense and closed forest area. Fifteen species were found exclusively in the state park area, which justifies the creation of conservation plans for the Rio Doce State Park for maintenance of social wasp diversity in Minas Gerais. The high number of exclusive species also justifies additional studies in the area (Souza et al., 2012).

Three of the studies were carried out in Cerrado of Minas Gerais, with a total of 53 social wasp species, seven exclusive (Table 02). Jacques et al., (2015) registered 29 species in an agricultural system inserted in the Cerrado. This high richness can be explained by the fact that many species of social wasps present a degree of synanthropy (Michulleti et al., 2013). The same study also has a very diverse and structurally heterogeneous environment, which may explain the considerable number of species collected. This is because more structurally complex sites can support the coexistence of a greater number of species, mainly due to higher availability of microhabitats, greater protection against predators, and greater availability and diversity of food resources and substrate for nesting (Santos et al., 2007; Souza et al., 2014).

The second study in Cerrado was conducted by Elpino-Campos et al. (2007) a portion of the Ecological Reserve of the Itororó Hunting and Fishing Club in Uberlândia (15º57'46.57" S, 48º26'13.36" W), Minas Gerais (CCPIU), The authors registered 29 species of social wasps distributed among 10 genera. The authors report that the study areas are Cerrado fragments that have been subject to anthropogenic (e.g., intentional fires, deforestation, cultivation) or natural alterations (fire). Fire events are common in the Cerrado and natural events are necessary for ecological balance of this ecosystem (Oliveira & Marquis, 2002). However, when they occur frequently as a result of anthropogenic activity, they can easily diminish diversity. The authors reported that three fires occurred during the study period, which may explain the low number of colonies found for most species collected, and perhaps generally the lower numbers of species recorded in the area.

The third Cerrado study, carried out by Simões et al. (2012) in the Unilavras/Boqueirão Biological Reserve in Ingaí (21º20'01.62" S, 44º59'01.41" W), recorded the greatest richness among the Cerrados of Minas Gerais, with a total of 32 species and 10 genera. This was the first study carried out in the southern portion of Minas Gerais, and the high local diversity of social wasps stands out compared to studies carried out in other regions of the state. The study site is surrounded by pasture and agricultural areas, and thus may act as a refuge, protecting organisms from pesticides (which are used in most of the surrounding areas). According to the Jacques et al. (2015) favorable climate conditions in the region may have also contributed to the high observed richness through effects on foraging activity, as demonstrated in several previous studies (Giannotti et al., 1995; Elpino-Campos et al., 2007; Auad et al., 2010). Higher temperature and precipitation, in particular, may have influenced the observed species richness, as there is greater variation in these factors in Cerrado than in forest areas. In Minas Gerais, the Cerrado corresponds to 57% of the state territory, and three studies have indicated the area as containing the second highest number of social wasps in the state. This highlights the need to expand studies in this ecosystem, as richness is likely underestimated.

The campos rupestres site presented 35 species, with one exclusive (Table 02). Souza et al. (2010) found 32 social wasp species at the APA São José (21°05'00.77" S 44°10'03.70" W) in the central-southern region of Minas Gerais, an area with strong anthropogenic activity resulting in high incidence of fire. Despite the human impact, this are produced the first state record for two species: *Polistes davillae*, which was previously thought to occur only in Mato Grosso and Amazonas states, and *Mischocyttarus ypiranguensis,* which has been reported in São Paulo state. Another two species were reported for only the second time, including *Mischocyttarus marginatus*, for which a single record exists for Minas Gerais found among the exemplar specimens deposited at the Federal University of Paraná (Richards, 1978), and *M. mirificus*, which has a peculiar nesting pattern with colonies resembling roots hanging on rocky walls, which makes then highly inconspicuous. Additional studies are needed to better elucidate the factors that influence such unique patterns of nest construction among social wasp species. Souza et al. (2010) also reported that the in areas of campo rupestre (21°05'00.77" S 44°10'03.70" W) contain the largest number of vespid species in the country (also in campo rupestres), and suggest that conservation of these areas of campo rupestre is of paramount importance for the maintenance of social wasp diversity in Brazil.

Clemente (2009) found 14 social wasp species in campos rupestres (21º40'00.67" S, 43º52'01.38" W). Diversity was higher (H'=2.16) than in riparian forest (H' = 1, 43) and Atlantic forest (H '= 0.18) present in APA São José. Campos rupestres are composed of vegetation structure with a high diversity of grasses, herbs, and shrubs distributed along quartzite outcrops, and these areas are generally considered to be severe environments compared to riparian forest. However, wasp species with greater ecological tolerance such as *Protonectarina sylveirae* Saussure, 1854, *Polybia sericea*, *P. paulista*, *P. canadensis*, *P. ignobilis*, *Apoica pallens*, *Brachygastra. lecheguana*, are generally dominant in open ecosystems such as campos rupestres (Silva-Pereira & Santos, 2006).

The only study of deciduous (dry) forest reported 35 species, six of which were exclusive (Table 02) (Brunismann, et al., 2016). Dry forest occupies only 3.5% of the vegetation cover in Minas Gerais, and this ecosystem is unique to the state. The few studies carried out in dry forest revealed a rich fauna of insects (Oliveira et al., 2011) and plants (Sales et al. 2009). This foest type also hosts the highest number of social wasps genera in the state (N=14) (Brunismann et al. 2016), and, together with the Rio Doce State Park (19º38'00.00" S e 42º31'00.00" W) presents the most distinct fauna in Minas Gerais, which makes this forest type a priority for the conservation of social vespids.

Mixed forests and high-altitude fields were evaluated by Souza et al. (2015a) in the Papagaio State Park (22º12'18.22"S e 44º47'11.30"W), and yielded 21 and 19 species of social wasps, respectively, with one species exclusive to mixed forest (Table 02). These richness values are the lowest reported among studies in the state. The high-altitude field ecosystem in Souza et al. (2015a) is situated above 1,600 meters, and at this elevation abiotic factors may be quite different from those at other, lower-altitude sites. For example, low temperatures, among other factors, may negatively affect social wasp richness, as found in other studies of high-altitude fields (Albuquerque et al., 2015). There is also a paucity of studies in this ecosystem type (only one), as well as in mixed forest, which was poorly sampled in terms of effort compared to the study in high-altitude fields (Souza et al., 2015a).

Considering the complexity and diversity of ecosystems of the state of Minas Gerais, there is a strong need for additional studies of social wasp diversity. We suggest that ombrophilous and deciduous forests should be considered of high relevance for conservation of these social insects, especially sites within the Rio Doce State Park (19º38'00.00" S e 42º31'00.00" W) and Rio Pandeiros Wildlife Refuge (15.50552°S, 044.75714°W).

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Table 02. Species of social wasps recorded in different ecosystems: SSF (Seciduous seasonal dry forest), HAF – (High-altitude fields), CR- (High-altitude fields), CE – (Cerrado), OF- (High-altitude fields), SRF – (Seasonal semideciduous rain forest), CMF – (Complex Mixed Forest). (Presence 1/Absence 0).

Species of social wasps (109)	SSF	HAF	CR	CE	OF	SRF	CMF
Agelaia angulata (Fabricius, 1804)	0	0	0	0	1	0	0
Agelaia centralis (Cameron, 1907)	0	0	0	1	1	0	0
Agelaia myrmechophila (Ducke, 1905)	0	0	0	0	1	0	0
Agelaia multipicta (Haliday, 1836)	1	1	1	1	0	1	1
Agelaia pallipes (Olivier, 1792)	0	0	0	1	0	1	0
Agelaia vicina (De Saussure, 1854)	1	1	1	1	1	1	1
Total of 6 species	2	2	2	4	4	3	2
Apoica gelida van der Vecht 1972	1	0	0	1	0	1	0
Apoica pallens (Fabricius, 1804)	1	0	1	1	1	1	0
Apoica thoracica duBuysson 1906	1	0	0	1	0	0	0
Total of 3 species	3	0	1	3	1	2	0
Brachygastra augusti (De Saussure, 1854)	1	0	1	0	1	1	0
Brachygastra lecheguana (Latreille, 1804)	1	1	1	1	1	1	1
Brachygastra moebiana (De Saussure, 1867)	1	0	0	0	0	0	0
Total of 3 species	3	1	2	1	2	2	1
Chartergellus communis Richards, 1978	1	0	0	1	0	0	0
Total of 1 specie	1	0	0	1	0	0	0
Chartergus globiventris de Saussure, 1854	1	0	0	0	0	0	0
Total of 1 specie	1	0	0	0	0	0	0
Clypearia angustior Ducke, 1906	1	0	0	0	1	1	0
Total of 1 specie	1	0	0	0	1	1	0
Epipona tatua (Cuvier, 1797)	0	0	0	0	1	0	0
Total of 1 specie	0	0	0	0	1	0	0
Metapolybia cingulata (Fabricius, 1804)	1	0	0	0	1	1	0
Metapolybia docilis Richards, 1978	0	0	0	0	0	1	0
Total of 2 species	1	0	0	0	1	2	0
Mischocyttarus artifex Ducke, 1914	0	0	0	0	0	1	0
Mischocyttarus annulatus Richards, 1978	0	0	0	0	1	0	0
Mischocyttarus atramentarius Zikán, 1949	0	0	0	1	1	1	0
Mischocyttarus bahiaensis Zikán, 1949	0	0	0	0	1	0	0
Mischocyttarus buysoni (Ducke, 1906)	0*	0*	0*	0*	0*	0*	0*
Mischocyttarus cerberus Ducke, 1898	1	0	0	1	0	1	0
Mischocyttarus confusus Zikán, 1935	0	0	0	1	0	1	0
Mischocyttarus giffordi Raw, 1985	0	0	0	0	0	0	1
Mischocyttarus ignotus Zikán, 1949	0	0	0	0	0	1	0
Mischocyttarus ihering Zikán, 1935	0	0	0	0	0	1	0
Mischocyttarus mirificus Zikán, 1935	0	0	1	0	0	1	0
Mischocyttarus nomurae Richards, 1978	1	0	0	0	0	0	0
Mischocyttarus saussurei Zikán, 1949	0	0	0	0	0	1	0
Mischocyttarus tricolor Richards, 1945	0	0	0	1	0	1	0
Mischocyttarus ypiranguensis da Fonseca, 1926	1	0	0	0	0	1	0
Mischocyttarus bertonii (Ducke) 1908	1	0	0	0	0	1	0
Mischocyttarus flavoscutellatus Zikán 1935	0	0	0	0	1	1	0
Mischocyttarus frontalis (Fox, 1898)	0	0	0	0	1	0	0
Mischocyttarus funerulus Zikán, 1949	0	0	0	0	0	1	0
Mischocyttarus latior (Fox, 1898)	0	0	1	1	0	1	0

Table 02. Species of social wasps recorded in different ecosystems: SSF (Seciduous seasonal dry forest), HAF – (High-altitude fields), CR- (High-altitude fields), CE – (Cerrado), OF- (High-altitude fields), SRF – (Seasonal semideciduous rain forest), CMF – (Complex Mixed Forest). (Presence 1/Absence 0). (Continuation)

Species of social wasps (109)	SSF	HAF	CR	CE	OF	SRF	CMF
Mischocyttarus drewseni de Saussure, 1857	1	1	1	1	1	1	1
Mischocyttarus labiatus (Fabricius, 1804)	0	0	0	0	0	1	0
Mischocyttarus mattogrossensis Zikán, 1935	0	0	0	1	0	0	0
Mischocyttarus rotundicollis (Cameron, 1912)	1	1	1	1	0	1	1
Mischocyttarus montei Zikán 1949	1	0	0	0	0	0	0
Mischocyttarus punctatus (Ducke, 1904)	0	0	0	0	1	0	0
Mischocyttarus araujoi Zikán, 1949	0	0	0	0	0	1	0
Mischocyttarus bahiae Richards, 1945	0	0	0	0	1	0	0
Mischocyttarus cassununga (R. von Ihering, 1903)	1	1	1	1	0	1	1
Mischocyttarus consimilis Zikán, 1941	0	0	0	0	0	1	0
Mischocyttarus fluminensis Zikán, 1949	0	0	0	0	1	0	0
Mischocyttarus marginatus (Fox, 1898)	0	0	1	1	0	0	0
Mischocyttarus mourei Zikán, 1949	0	0	0	0	0	1	0
Mischocyttarus nomurae Richards, 1978	1	0	0	0	0	0	0
Mischocyttarus paraguayensis Zikán, 1935	0	0	0	0	0	1	0
Mischocyttarus wagneri (du Buysson, 1908)	0	0	1	0	1	1	0
Mischocyttarus parallellogrammus Zikán, 1935	0	0	0	0	0	1	0
Total of 37 species	9	3	7	10	10	24	4
Parachartergus fraternus (Gribodo, 1892)	1	0	1	1	0	1	0
Parachartergus pseudapicalis Willink, 1959	0	0	0	1	0	0	0
Parachartergus smithii (De Saussure, 1854)	1	0	0	0	0	0	0
Parachartergus wagneri du Buysson, 1904	0	0	1	1	0	1	0
Total of 4 species	2	0	2	3	0	2	0
Polistes actaeon Haliday, 1836	0	0	0	1	1	1	0
Polistes billardieri Fabricius, 1804	0	1	1	1	0	1	1
Polistes canadensis (Linnaeus, 1758)	0	0	0	0	1	0	0
Polistes carnifex (Fabricius, 1775)	0	0	0	0	1	0	0
Polistes cavapytiformis Richards, 1978	0	0	0	0	1	0	0
Polistes cinerascens de Saussure, 1854	0	1	1	1	0	1	1
Polistes davillae Richards, 1978	0	0	1	0	0	0	0
Polistes ferreri de Saussure, 1853	0	0	1	1	0	1	0
Polistes geminatus Fox, 1898	0	0	0	1	0	0	0
Polistes goeldii Ducke, 1904	0	0	0	1	0	1	0
Polistes lanio (Fabricius, 1775)	0	0	1	1	0	1	0
Polistes melanossoma Saussure, 1853	0	0	0	0	1	0	0
Polistes occipitalis Ducke, 1904	0	0	0	0	1	0	0
Polistes pacificus pacificus Fabricius, 1804	0	0	0	0	0	1	0
Polistes pacificus flavopictus Ducke, 1918	0	0	0	0	0	1	0
Polistes satan Bequaert, 1940	0	0	0	1	0	0	0
Polistes simillimus Zikán, 1948	1	1	1	1	0	1	1
Polistes subsericeus de Saussure, 1854	0	0	1	1	0	1	0
Polistes versicolor (Oliver, 1792)	1	0	1	1	1	1	0
Total of 19 species	2	3	8	11	7	11	3

Table 02. Species of social wasps recorded in different ecosystems: SSF (Seciduous seasonal dry forest), HAF – (High-altitude fields), CR- (High-altitude fields), CE – (Cerrado), OF- (High-altitude fields), SRF – (Seasonal semideciduous rain forest), CMF – (Complex Mixed Forest). (Presence 1/Absence 0). (Continuation)

Species of social wasps (109)	SSF	HAF	CR	CE	OF	SRF	CMF
Polybia bifasciata de Saussure, 1854	0	0	0	1	0	1	0
Polybia brunnea (Curtis, 1844)*	0*	0*	0*	0*	0*	0*	0*
Polybia emaciata (Saussure, 1854)*	0*	0*	0*	0*	0*	0*	0*
Polybia signata Ducke, 1910	0	0	0	0	1	0	0
Polybia quadricincta de Saussure, 1854	0	0	0	1	0	1	0
Polybia jurinei de Saussure, 1854	1	0	1	1	1	1	0
Polybia dimidiata (Olivier, 1792)	0	0	0	0	1	0	0
Polybia rejecta (Fabricius, 1798)	0	0	0	0	1	0	0
Polybia bistriata (Fabricius, 1804)	0	0	0	0	0	1	0
Polybia erythrothorax Richards, 1978	0	0	0	1	0	0	0
Polybia fastidiosuscula de Saussure, 1854	0	1	1	1	0	1	1
Polybia flavifrons Smith, 1857	0	0	0	1	0	0	0
Polybia occidentalis (Olivier, 1792)	1	0	1	1	1	1	0
Polybia paulista H. von Ihering, 1896	0	1	1	1	0	1	1
Polybia platicephala Richards, 1978	0	1	1	1	1	1	1
Polybia ruficeps Schrottky, 1902	1	0	0	1	0	0	0
Polybia scutellaris (White, 1841)	0	1	1	1	0	1	1
Polybia liliacea (Fabricius, 1804)	0	0	0	0	1	1	0
Polybia striata (Fabricius, 1787)	0	0	0	1	1	0	0
Polybia ignobilis (Haliday, 1836)	1	1	1	1	1	1	1
Polybia lugubris de Saussure, 1854	0	0	0	0	0	1	0
Polybia minarum Ducke, 1906	0	1	1	1	0	1	1
Polybia punctata DuBuysson, 1908	1	1	1	0	0	1	1
Polybia chrysothorax (Lichtenstein, 1796)	0	1	1	1	1	1	1
Polybia sericea (Olivier, 1792)	1	1	1	1	1	1	1
Total of 25 species	6	9	11	16	11	16	9
Protonectarina silverae (de Saussure) 1854	1	1	1	1	0	1	1
Total of 1 specie	1	1	1	1	0	1	1
Protopolybia exigua (De Saussure, 1854)	1	0	0	0	0	1	0
Protopolybia sedula (De Saussure, 1854)	1	0	1	1	0	1	0
Total of 2 species	2	0	1	1	0	2	0
Pseudopolybia vespiceps (De Saussure, 1863)	0	0	0	1	0	1	0
Total of 1 specie	0	0	0	1	0	1	0
Synoeca cyanea (Fabricius, 1775)	0	0	0	1	1	1	1
Synoeca surinama (Linnaeus, 1767)	1	0	0	0	0	0	0
Total of 2 species	1	0	0	1	1	1	1
Total spp.	35	19	35	53	39	68	21
spp. exclusive	6	0	1	7	17	16	1

* Species with occurrence registered in literature by without information by ecosystems

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