



RESEARCH ARTICLE - WASPS

Assemblages of Social Wasps (Hymenoptera, Vespidae, Polistinae) in the *Veredas* of Central Brazil

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Abstract

Social wasps are widely distributed in Brazil, and their distribution is closely related to the type of habitat and vegetation structure. *Veredas* (palm swamps) occur on moist soils and are characterized by an almost total predominance of buriti palms (*Mauritia flexuosa*). The insect fauna of these environments is poorly known, especially in Central Brazil. Some data on the diversity of the social wasps are available for the state of Mato Grosso, although its *Veredas* have not been surveyed up to now. In the present study, we investigated the wasp species composition in six *Vereda* environments over a 24-month sampling period, between August 2017 and July 2019. The specimens were collected using a sweep net, which was deployed along 200-m transects that were subdivided into 10 plots of 3 m². To attract the wasps, we used a backpack sprayer to spray each plot with insect attractant made from five spoonfuls of granulated sugar and one spoonful of salt, dissolved in 5 liters of water. After spraying the plot, we waited 10 minutes before initiating the surveys, which lasted 10 minutes per plot, for a total of 200 minutes of sampling per palm swamp. A total of 1072 social wasp specimens were collected, representing 11 genera and 37 different species. The most abundant species were *Polybia* cf. *ruficeps xantops* (Richards, 1978), *Agelaia pallipes* (Olivier, 1792); *Polybia rejecta* (Lepelletier, 1836), and *Mischocyttarus mato Grossoensis* Zikán, 1935, which together accounted for 57% of the specimens collected over the 24 months of the study period. The total species richness estimated for the *Vereda* environments was 39.88 ± 0.627 , approximately 41% of the 88 wasp species of the subfamily Polistinae found in the Cerrado of eastern Mato Grosso.

Introduction

The social wasps of the subfamily Polistinae are highly diversified in the Neotropic region. A total of 381 species are known to occur in Brazil, of which, more than 100 are endemic (Somavilla et al., 2021). Social wasps are an important component of tropical ecosystems due to their ubiquity and species diversity, as well as their complex relationships with other organisms (Somavilla & Fernandes, 2020). These wasps

are characterized by varying levels of eusociality, complex niche architecture, and aggressive nest defense behavior (Carpenter, 1991; Wenzel, 1998; Pickett & Carpenter, 2010; Piekarsky et al., 2018).

Wasps are important pollinators, which overlap with bees in terms of the resources exploited and represent a meaningful component of the pollinator community (Santos et al., 2010; Clemente et al., 2012; Brock et al., 2021). Although the exact role of social wasps as predators and pollinators



is still poorly understood. Some studies indicate they may contribute effectively to the control of the populations of organisms that are considered to be agricultural pests and also that they may contribute to pollination (Prezoto et al., 2019; Southon et al., 2019).

Given their abundance and ecological importance, social wasps have been and continue to be the subject of ecological studies in different regions and environments (Diniz & Kitayama, 1998; Souza & Prezoto, 2006; Silva et al., 2011; Da Silva et al., 2019; Clemente et al., 2020; Ferreira et al., 2020). In Brazil, these environments include the Cerrado savanna (Souza et al., 2012; Souza et al., 2020; Vicente et al., 2020), Atlantic Forest (Grandinete & Noll, 2013; Togni et al., 2014; Ribeiro et al., 2019; Souza et al., 2021), the semi-arid Northeast (Santos et al., 2020), the Amazon Forest (Silveira, 2002; Silveira et al., 2012; Somavilla & Oliveira, 2017; Graça & Somavilla, 2018; Somavilla et al., 2020; Gomes et al., 2020), and the Pantanal wetlands of Mato Grosso (Almeida et al., 2014). In the most recent study of the social wasps of the Brazilian state of Mato Grosso, Ferreira et al. (2020) recorded 43 species. However, many regions or specific environments are still in need of research, as in the case of eastern Mato Grosso, where the most recent study was published 20 years ago (Richard, 1978; Carpenter & Marques, 2001). More than 40 years ago, Richards (1978) recorded a total of 88 species of social wasp in eastern Mato Grosso. While the region clearly has a high species richness, the number of species may be underestimated due to the lack of inventories in the region, in particular, in *vereda* environments.

The *vereda* (palm swamp) is a phytophysiology of the central Brazilian Cerrado biome, which is characterized by a predominance of buriti palms (*Mauritia flexuosa*) and an understory of shrubs and herbs, located on hydromorphic soils and in swampy or waterlogged areas, which typically form at the source of the region's watercourses (Ferreira, 2003). Wetland environments, such as *veredas*, are important for the conservation of the biodiversity of the Cerrado biome, mainly due to their 'sponge effect', buffering the effects of torrential local downpours, storing carbon in the soil, filtering allochthonous waste (e.g.: agricultural fertilizers and pesticides), and providing traditional communities with natural resources, such as fibers and fruit (Rosolen et al., 2015).

The *veredas* are important, sensitive environments that are protected under Brazilian law (CONAMA resolution number 303 of March 20th, 2002), although these palm swamps have nevertheless been suffering changes caused by different types of land use, such as cattle pasture, river impoundments, and cash cropping. These impacts cause the destruction of the natural vegetation, which affects hydrological parameters, increasing soil erosion, and changing the morphological and chemical properties of the soils of these environments (Ferreira & Troppmair, 2004).

Data on the biodiversity of the *veredas* are still very scant, in particular in the case of the invertebrates, a scenario

exacerbated by the fact that anthropogenic shifts in natural environments have negative impacts on the distribution and diversity of the resident organisms (Guimarães et al., 2002). In this context, the present study inventoried the social wasp species found in six *veredas* of the eastern extreme of the Brazilian state of Mato Grosso.

Material and Methods

Study area

The study area comprises six *veredas* located in the municipality of Nova Xavantina in Mato Grosso state, in the Araguaia-Tocantins River basin of central Brazil (Table 1; Figures 1, 2). These *veredas* are located within the transition zone between the Amazon and Cerrado biomes, which means that, while the vegetation associated with the *veredas* is composed of species commonly found in the Cerrado, plant species typical of the Amazon biome are also common in some areas, forming distinct patches within the savanna landscape (Marques et al., 2019). The region's climate is *Aw* in the Köppen classification system (Peel et al., 2008), with two well-defined seasons, dry and rainy.

Table 1. *Veredas* and code: VA = Botina stream, VD and VE = Chupador stream, VC = Areal stream, VF = Coronel Vanique stream, and VB = Queixada stream. Geographic coordinates, altitude, and area of the *Veredas* surveyed in eastern Mato Grosso, Brazil.

Vereda	Latitude (S)	Longitude (W)	Altitude	Area (ha)
VA	14°45'52"	52°33'02"	490 m	6.0
VB	14°45'41"	52°33'58"	490 m	6.2
VC	14°49'03"	52°34'35"	540 m	5.5
VD	14°50'47"	52°30'52"	550 m	4.0
VE	14°49'42"	52°30'59"	550 m	5.0
VF	14°47'09"	52°36'19"	390 m	3.0

Sampling of social wasps

The samples were collected in six *veredas* over a 24-month period from August 2017 to July 2019. Each *vereda* was sampled on a total of 24 days, with 2 hours of sampling per day, i.e., 48 hours per *vereda*, and an overall total of 288 hours. The specimens were collected using a sweep net, which was deployed along transects of 200 m in length, which were subdivided into 10 plots of 3 m². To attract the wasps, we used a backpack sprayer to spray each plot with insect attractant (5 spoonfuls of granulated sugar plus one spoonful of salt, dissolved in 5 liters of water). We waited for 10 minutes after this spraying before initiating the surveys, which lasted 10 minutes per plot, for a total of 200 minutes of sampling per *vereda*. This collection protocol was modified from Noll and Gomes (2009).

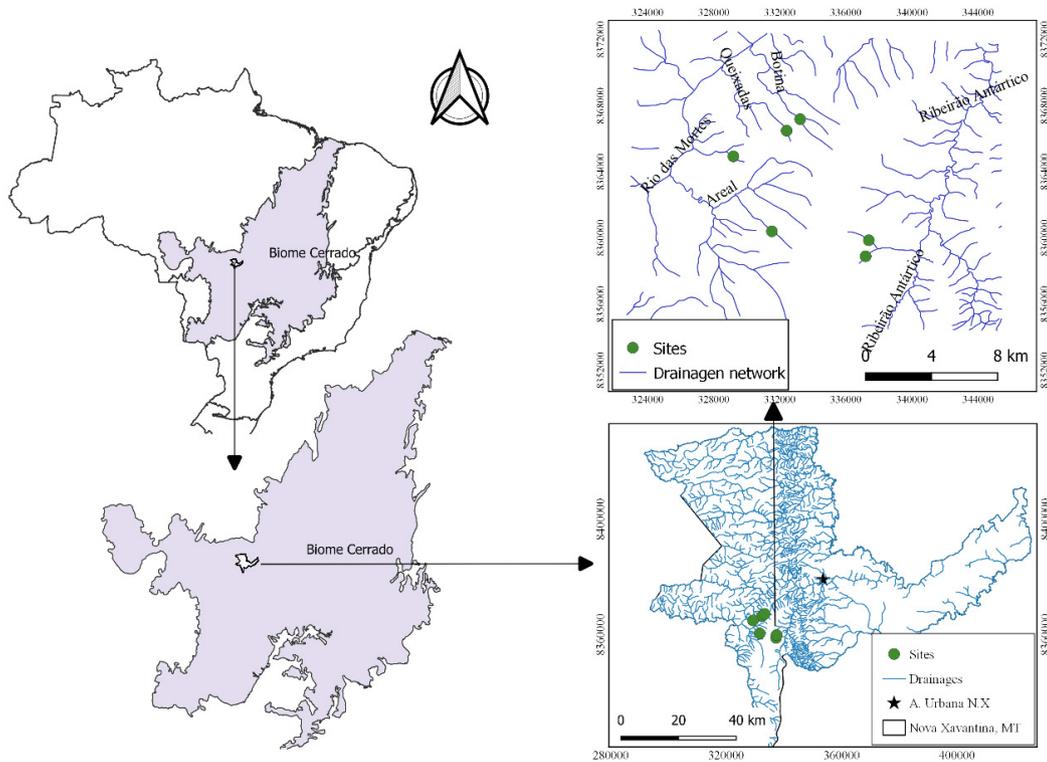


Fig 1. Location of the six study *Veredas* in the Cerrado–Amazon transition zone in the municipality of Nova Xavantina, in Mato Grosso state, central Brazil. The *Veredas* are identified according to the catchment in which they are located. Botina stream, and Chupador stream I and II, Areal stream, Coronel Vanique stream, and Queixada stream.

Preparation of the wasp specimens

The wasp specimens were sorted, pinned, packed in entomological boxes, and identified using dichotomous keys (Carpenter & Marques, 2001; Somavilla & Carpenter, 2021). Samples of each potential species were sent to Dr. Sérgio R. Andena, a specialist in the taxonomy of the social wasps, to confirm their identification. The wasp specimens were deposited in the bee and wasp collection of the Laboratory of Neotropical Bees and Wasps, on the Cáceres campus of Mato Grosso State University (UNEMAT), under the curation of Dr. Evandson J. Anjos Silva.

Data analysis

To evaluate sampling efficiency, we compiled a species accumulation curve using the nonparametric first-order Jackknife estimator, run in the EstimatesWin7.5.0 (Colwell, 2013) software. The constancy (C) of each species was calculated by: $C = px (100 / N)$, where C = constancy and p = the number of samples in which a given species was collected, and N = total number of samples collected. The sampling unit in this study were the 24 months of fieldwork. The species were classified as constant (present in > 50% of the samples), auxiliary (25–50%) or accidental, when < 25% (Silveira-Neto et al., 1976, 1995; Dajoz, 1983).

Results

During the present study, we recorded 37 species of wasp of the subfamily Polistinae (Table 2). The species richness of the six *veredas* estimated by the Jackknife procedure was $S = 38.88$, $SD = 1.59$, and $CI = 0.627$, and the general index of wasp diversity was $H' = 3.319$.

The most abundant species were *Polybia* cf. *ruficeps xantops* (Richards, 1978), *Agelaiia pallipes* (Olivier, 1792); *Polybia rejecta* (Lepeletier, 1836), and *Mischocyttarus mattogrossoensis* Zikán, 1935 which together accounted for 57% of all the specimens collected during the 24 months of the study period. The estimated species richness for the *vereda* environments was 38.88 ± 0.627 , approximately 41% of the 88 species of polistine wasps known to occur in the Cerrado of eastern Mato Grosso.

Based on the analysis of the frequency of records (Table 2), as proposed by Silveira-Neto et al. (1976, 1995), eight (21.62% of the total) of the species were classified as constant, being the most abundant and widespread in the samples. A further 13 species (35.13%) had intermediate abundance, and were thus classified as accessory species. The remaining 16 species (43.24% of the total) were the least abundant, with between one and seven specimens being collected in no more than three samples. These species were classified as accidental.



Fig 2. Landscape features of the six study *Veredas* in the Cerrado–Amazon transition zone in the municipality of Nova Xavantina, in Mato Grosso state, central Brazil. Botina stream, Chupador stream I and II, Areal stream, Coronel Vanique stream, and Queixada stream.

The species accumulation curve (Figure 3) indicates that the sampling efficiency of the present study provided a reliable estimate of the social wasp species richness found in the palm swamps of eastern Mato Grosso. Specifically, the observed species richness represented 93% of that estimated by the Jackknife procedure.

Discussion

The social wasp species richness observed and estimated in this study in the *Veredas* of central Brazil, just one of the vegetation types of the Cerrado biome, are highly similar to the previous estimates for the Cerrado as a whole

$N = 36, 38, 19, 31, 38, 33$ successively according to the authors (Diniz & Kitayama, 1998; Souza & Prezoto, 2006; Santos et al., 2009; Silva et al., 2011; Souza et al., 2014; Vicente et al., 2020). The species richness registered in the *Veredas* of Mato Grosso is higher than the richness registered in the Pantanal of Poconé (northern Pantanal), that has ($N=15$) species recorded (Almeida et al., 2014).

Ferreira et al. (2020) recorded 43 wasp species representing 10 genera in areas of forest, the Cerrado/Amazon transition zone, and the Cerrado savanna, based on specimens collected at 42 sampling points in eight municipalities in the state of Mato Grosso. However, in the present study in only six points in a single phytophysiognomy of the Cerrado biome,

Table 2. Abundance of the social wasp species of the subfamily Polistinae recorded between August 2017 and July 2019 in the six study *Veredas* in the Cerrado–Amazon transition zone in the municipality of Nova Xavantina, in Mato Grosso state, central Brazil. VA = Botina stream, VD and VE = Chupador stream, VC = Areal stream, VF = Coronel Vanique stream, and VB = Queixada stream, Ct% constancy.

Taxon / Vereda	VA	VD	VE	VF	VB	VC	N	Ct %
Agelaia								
<i>Agelaia pallipes</i> (Olivier, 1792)	37	70	32	15	0	2	156	C
Brachygastra								
<i>Brachygastra augusti</i> (de Saussure, 1854)	5	1	1	13	3	20	43	C
<i>Brachygastra bilineolata</i> (Latreille, 1824)	1	0	0	0	0	2	3	Ad
<i>Brachygastra moebiana</i> (de Saussure, 1867)	1	1	3	2	6	4	17	Ac
<i>Brachygastra smithii</i> (de Saussure, 1853)	4	0	0	2	2	1	9	Ac
<i>Brachygastra</i> sp.1	3	0	1	1	2	1	8	Ac
Chartergellus								
<i>Chartergellus communis</i> (Richards, 1978)	9	0	0	0	0	4	13	Ac
Chartergus								
<i>Chartergus globiventris</i> (de Saussure, 1853)	0	0	0	1	0	0	1	Ad
Mischocyttarus								
<i>Mischocyttarus collares</i> Ducke, 1904	3	6	13	1	3	0	26	C
<i>Mischocyttarus cerberus</i> Ducke, 1898	1	0	0	0	0	0	1	Ad
<i>Mischocyttarus mattogrossoensis</i> Zikán, 1935	29	5	14	49	0	42	139	C
<i>Mischocyttarus</i> (<i>Megacanthopus</i>)	0	0	4	0	3	0	7	Ad
<i>Mischocyttarus</i> (<i>Kappa</i>)	0	0	2	0	0	1	3	Ad
<i>Mischocyttarus</i> (<i>Mischocyttarus</i>)	0	0	1	0	0	0	1	Ad
<i>Mischocyttarus drewseni</i> de Saussure, 1857	0	1	0	0	0	0	1	Ad
<i>Mischocyttarus</i> sp.1	0	0	2	0	0	2	4	Ad
Parachartergus								
<i>Parachartergus fraternus</i> (Gribodo, 1892)	0	7	3	9	0	1	20	Ac
Polistes								
<i>Polistes canadensis</i> (Linnaeus, 1854)	0	0	0	1	0	2	3	Ad
<i>Polistes geminatus</i> Fox, 1898	0	0	4	3	0	1	8	Ac
<i>Polistes satan</i> Bequaert, 1940	1	0	0	0	0	7	8	Ad
<i>Polistes subsericeus</i> (de Saussure, 1854)	1	0	0	13	2	20	36	C
Polybia								
<i>Polybia cf ruficeps xantops</i> (Richards, 1978)	137	1	9	5	2	62	216	C
<i>Polybia erythrothorax</i> Richards, 1978	0	0	0	0	1	4	5	Ad
<i>Polybia ignobilis</i> (Haliday, 1836)	0	6	0	1	13	5	25	Ac
<i>Polybia jurinei</i> (Haliday, 1836)	0	0	1	2	0	0	3	Ad
<i>Polybia liliacea</i> (Fabricius, 1804)	0	1	0	3	1	0	5	Ad
<i>Polybia occidentalis</i> (Olivier, 1791)	3	48	15	18	6	15	105	C
<i>Polybia rejecta</i> (Lepeletier, 1836)	6	49	23	2	13	0	93	C
<i>Polybia sericea</i> (Olivier, 1792)	2	0	0	4	0	5	11	Ac
<i>Polybia belemensis</i> Richards, 1970	4	2	1	1	4	10	22	Ac
<i>Polybia parvulina</i> Richards, 1970	0	6	2	1	0	3	12	Ac
<i>Polybia rufitarsis</i> Ducke, 1904	0	1	0	0	0	0	1	Ad
Protopolybia								
<i>Protopolybia chartergoides</i> Gribodo, 1891	14	0	0	0	0	6	20	Ac
<i>Protopolybia sedula</i> (de Saussure, 1854)	2	0	0	1	13	8	24	Ac
<i>Protopolybia</i> sp.1	0	0	0	3	0	0	3	Ad
Pseudopolybia								
<i>Pseudopolybia vespiceps</i> de Saussure, 1864	0	2	0	0	0	0	2	Ad
Synoeca								
<i>Synoeca surinama</i> (Lepeletier, 1836)	3	1	0	3	9	0	16	Ac
Total	266	208	133	154	83	228	1072	

we sampled 37 species from 11 genera, six species less, but one more genus. That is, the *Vereda*, which indicates clearly that these environments are rich in social wasp species. It is important to note, however, that only 15 species were found in common between the two studies, which may in part be related to the differences in the geographic distributions of the species.

The predominance of species of the tribe Epiponini was expected, given that this tribe has at least 246 species distributed among its 19 genera, which are almost exclusively endemic to the Neotropical region (Somavilla et al., 2021). Epiponini species are widely distributed throughout Brazil, where they have been recorded in all geographic regions (Locher et al., 2014; Somavilla et al., 2015; Aragão & Andena, 2016; Somavilla et al., 2021).

Biogeographic reconstructions indicate that the Amazon region is the principal source of Epiponini diversity (Menezes et al., 2020). According to Marques et al. (2019) recent redefinition of the limits of the Cerrado and Amazon biomes, the *Veredas* surveyed in the present study are located within the Amazon/Cerrado transition zone, which may have contributed to the Epiponini diversity recorded in this study.

The greater abundance of some of the Epiponini species recorded in the present study may be related to the size of their colonies, which may include thousands of individuals, and the more diurnal habits of some taxa, in addition to more random factors, such as the presence of nests of two of the four most abundant species in the vicinity of some of the transects, which may have facilitated the collection of specimens during

foraging. Epiponini species provided more than 70% of the specimens collected in many other Brazilian studies (Diniz & Kitayama, 1998; Carpenter & Marques, 2001; Elpino-Campos et al., 2007; Santos et al., 2009; Silva et al., 2011, Togni et al., 2014; Somavilla et al., 2021). However, some Epiponini species (Almeida et al., 2014) were less abundant in our study, with the number of individuals ranging from one to nine, an abundance similar to that recorded by Elpino-Campos et al. (2007), Lima et al. (2010), Simões et al. (2012), and Locher (2014).

The least abundant species belonged to the tribes Mischocyttarini and Polistini, as observed in previous studies (Diniz & Kitayama, 1994; Souza & Prezoto, 2005; Elpino-Campos et al., 2007; Santos et al., 2009; Simões et al., 2012; Silveira et al., 2008; Silva & Silveira, 2009; Almeida et al., 2014). The reduced abundance of these two tribes was expected, given that their species build nests that contain no more than a few dozen or hundreds of individuals (Carpenter & Marques, 2001; O'Donnell, 2020; Somavilla et al., 2021).

The most abundant species in our study was *Polybia cf. ruficeps xanthops* (n = 216 individuals), although more than 80% of the individuals were collected from only two of the six study *Veredas*. We believe that the abundance of the species at these two sites may have been related to the proximity of nests to the study plots in these two *Veredas*. A much lower abundance of this species has been recorded in previous studies of social wasps (Richards 1978; Diniz & Kitayama, 1998; Elpino-Campos et al., 2007; Gomes & Noll, 2009; Tanaka-Junior & Noll, 2011).

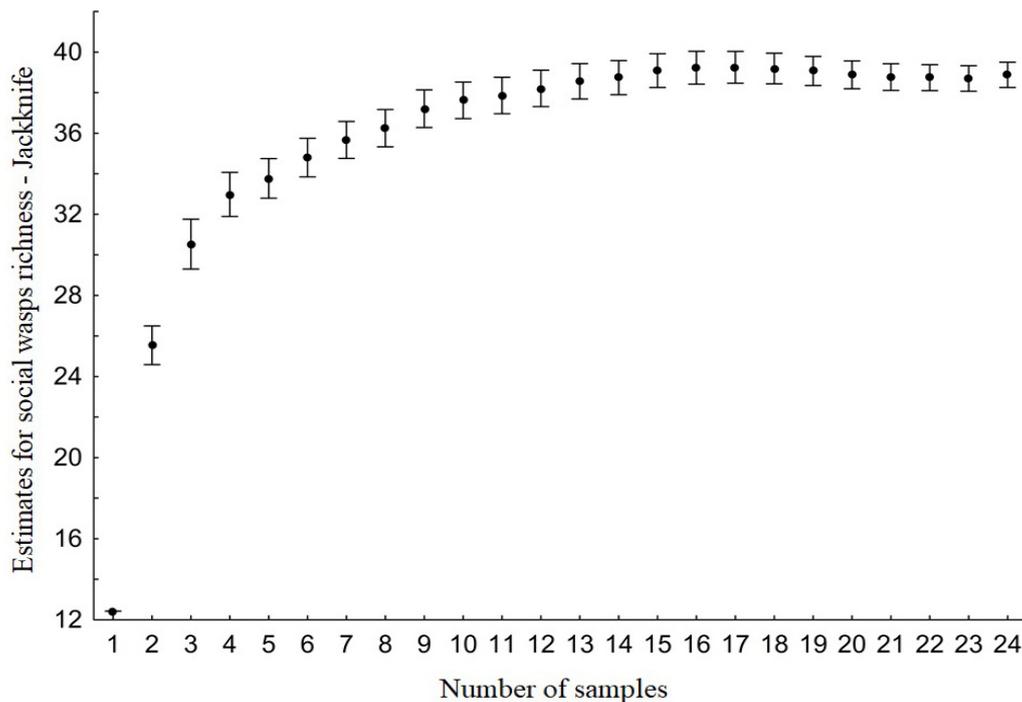


Fig 3. Species accumulation curve of the social wasps and the estimated species richness of the six study *Veredas*, in the Cerrado–Amazon transition zone, estimated from the 60 plots sampled monthly between August 2017 and July 2019, in the municipality of Nova Xavantina, in eastern Mato Grosso state, Brazil.

The results of the present study indicate that social wasps of all three tribes, i.e., Epiponini, Mischocyttarini, and Polistini, can be classified as constant, accessory or accidental, which is consistent with previous studies (Togni et al., 2014; Souza et al., 2014; Souza et al., 2016; Santos et al., 2020). The accidental species were the most numerous overall, followed by the accessory taxa, with the constant species being the least common. These findings contrast with those of Togni et al. (2014), who recorded relatively more constant species and fewer accessory taxa. Drawing on the conclusions of Santos et al. (2007), Togni et al. (2014) suggested that the greater abundance of constant species may be accounted for by the complexity of the dense rainforest habitats they surveyed. In this case, the difference found in the present study may be accounted for by the distinct characteristics and the area of the *Veredas* surveyed, which varied in size from three to 10 hectares, and were divided into three distinct vegetation zones – seasonally and permanently flooded grassland, and a central zone dominated by buriti palms, *Mauritia flexuosa* L.f. (Santos & Munhoz, 2012).

This implies that the classification of almost half of the species collected in the *Veredas* as accidental may reflect their sporadic forays into these swamps in search of some specific resource that is abundant in the *Vereda*, most likely, water. Auad et al. (2010) and Souza et al. (2014) obtained results similar to those of the present study, with a predominance of accidental species, which they attributed to the type of environment, habitat use, and the size of the areas sampled.

The present study is the first systematic, standardized, and long-term inventory of the social wasp communities of the *Veredas* of Central Brazil. The data are an important contribution to the understanding of the geographic distribution of Brazilian wasps.

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Authors' Contribution

Lourivaldo A. Castro, Main author, performed all steps; Project idealization, proposal formatting and methodology, field steps, data analysis, writing and submission of the text in a journal.

Evandson José A. Silva, Co-author, participated in project formatting, methodology and manuscript.

Sergio R. Andena, Co-author, participated in the design of the project, methodology and species identification.

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