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RESEARCH ARTICLE - WASPS

Influence of Dry Season on Social Wasp Communities (Hymenoptera: Polistinae) in Deciduous Forest

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Abstract

The seasonal deciduous forest, also known as dry forest, is characterized by the deciduity of tree species and two well-defined seasons, which cause drastic changes in its physiognomy. Furthermore, the seasonality of rainy periods directly impacts the forest's biological communities. Social wasps (Vespidae: Polistinae) are well documented. However, some ecosystems in which they occur, such as the deciduous forest, are still subsampled. This study aimed to assess the response of social wasp communities to the dry season in a deciduous forest in the Mata Seca State Park in the North of Minas Gerais, Brazil. Insects were collected over 24 days and divided into four field campaigns, each with six successive days of collection (February, May, July, and November 2021), encompassing one campaign per season. All specimens were sacrificed and stored in 70% alcohol and later dry-mounted for identification. The Kruskal-Wallis (KW) H test was performed to verify the difference between species richness, number of total colonies, and number of colonies of each tribe regarding the collection station. In total, 131 colonies of eight species were located, particularly *Polybia occidentalis* (Olivier, 1791), with 39 colonies, *Polistes versicolor* (Olivier, 1791), with 33, *Mischocyttarus cassununga,* with 21, and *Protonectarina sylveirae* (Saussure, 1854), with 13. Six species, five from the Epiponini tribe, were collected in the four seasons. The responses of social wasps to periods of drought in the deciduous forest vary by tribe. While Epiponini populations can keep colonies active in the dry season, Polistini cannot. Meanwhile, *P. versicolor* responds positively to the onset of the rainy season, increasing its population.

Introduction

The seasonal deciduous forest, also known as dry forest, is a phytophysiognomy that composes the Atlantic Forest Biome (Oliveira-Filho et al., 2006), characterized by the deciduity of tree species that cover about 3.4% of the territory of the state of Minas Gerais (Belém et al., 2021) and located in the transition area between the Cerrado and the Caatinga (Santos et al., 2007a). This phytophysiognomy also occurs in the states of Bahia, Goiás, Tocantins, Mato Grosso, and the Federal District (Haidar et al., 2013).

The dry forest is characterized by two well-defined climatic seasons, one dry and the other rainy, which cause drastic changes in its physiognomy. In the dry season, more than 50% of the vegetation cover is lost; in the rainy season, this vegetation grows back (Belém et al., 2021)

The seasonality of rainy periods directly affects biological communities, altering regional fauna and influencing the population dynamics of insects (Murphy & Lugo, 1986; Melo et al., 2019). In turn, pollination increases in the dry season since the higher incidence of sunlight benefits the action of insects, the absence of rain protects the nectar of flowers, and the low vegetation cover improves visibility (Pezzini et al., 2008). Moreover, climate change affects some species of dung beetles, cicadas, and butterflies, reducing their total richness in the dry season, while ants and bees are unaffected (Neves et al., 2010).

Social wasps are popularly known as *marimbondos* or *cabas* (Noronha et al., 2021) in Brazil. About 381 species of this insect are documented, all representatives of the subfamily Polistinae (Somavilla et al., 2021). Out of these species, 170 have been recorded in the Atlantic Forest (Souza et al., 2020a), 137 in the Cerrado Biome (Souza et al., 2020b), and 81 in the Caatinga Biome (Santos et al., 2021).

Despite the growing number of inventory studies in Brazil since the beginning of the 21st century (Barbosa et al., 2017; Souza et al., 2020a), some ecosystems, such as the deciduous forest, are still subsampled. In the literature, only two studies in Brazil have reported on this forest (Brunismann et al., 2016; Francisco et al., 2018), indicating the need for further information on the occurrence and distribution of social wasps in places with this type of vegetation (Brunismann et al., 2016), especially in Conservation Units, such as the Mata Seca State Park (PEMS).

This study aimed to assess the response of social wasp communities to the dry season in a deciduous forest in the Mata Seca State Park, in the North of the state of Minas Gerais, Brazil.

Materials and Methods

This study was conducted in the Mata Seca State Park (PEMS) in the municipalities of Manga and Itacarambi, located between coordinates 14º97'02'' S – 43º97'02'' W and 14º53'08'' S – 44º00'05'' W (Fig 1), North of the state of Minas Gerais, Southeastern Brazil, totaling an area of 15,360.07 hectares of seasonal deciduous forest, in the transition area between the Cerrado and the Caatinga (Santos et al., 2007a).

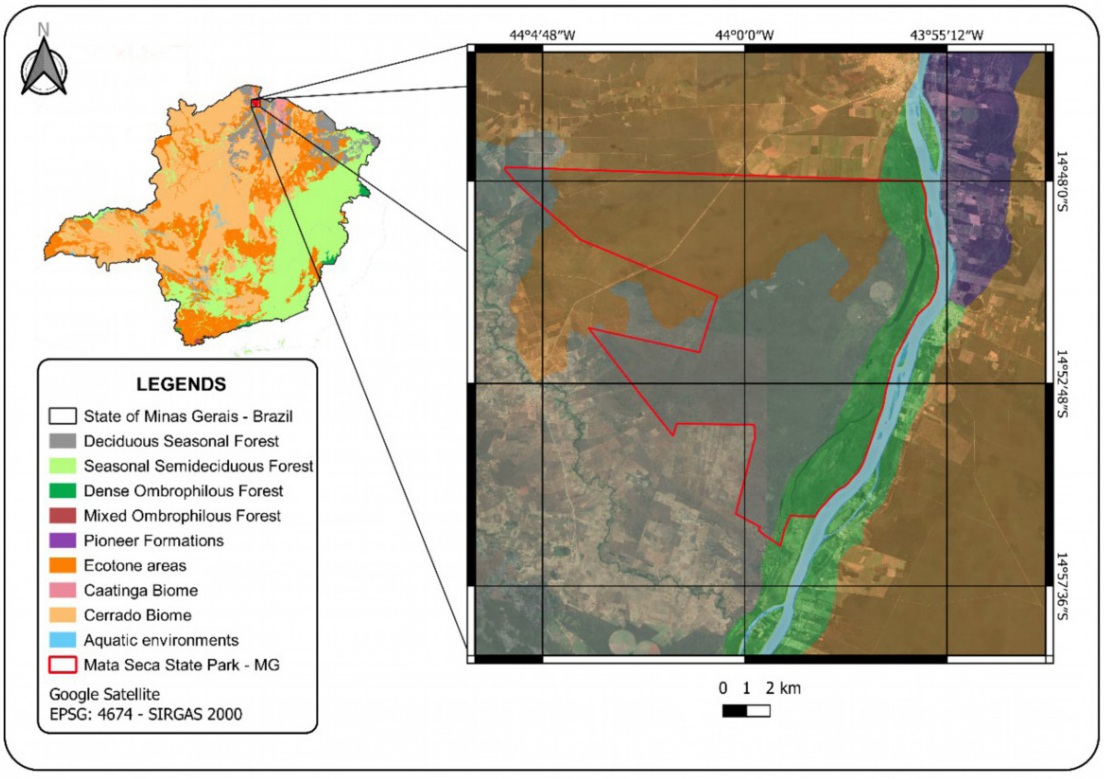

Fig 1. Location of the Mata Seca State Park concerning the territory of Minas Gerais.

This phytophysiognomy presents two well-defined climatic seasons – one rainy and another with a long drought (Fig 2). The tree stratum is mainly deciduous, and more than 50% of trees have no foliage during the unfavorable period (Belém et al., 2021). The average annual temperature in the region is 24 °C, the average annual precipitation is 818 mm/ year, and the altitude is 400-500 m (Madeira et al., 2009; Rodrigues et al., 2013).

Insects were collected over 24 days divided into four field campaigns, each with six successive days of collection (February, May, July, and November 2021), encompassing one campaign per season, with four researchers, totaling 144

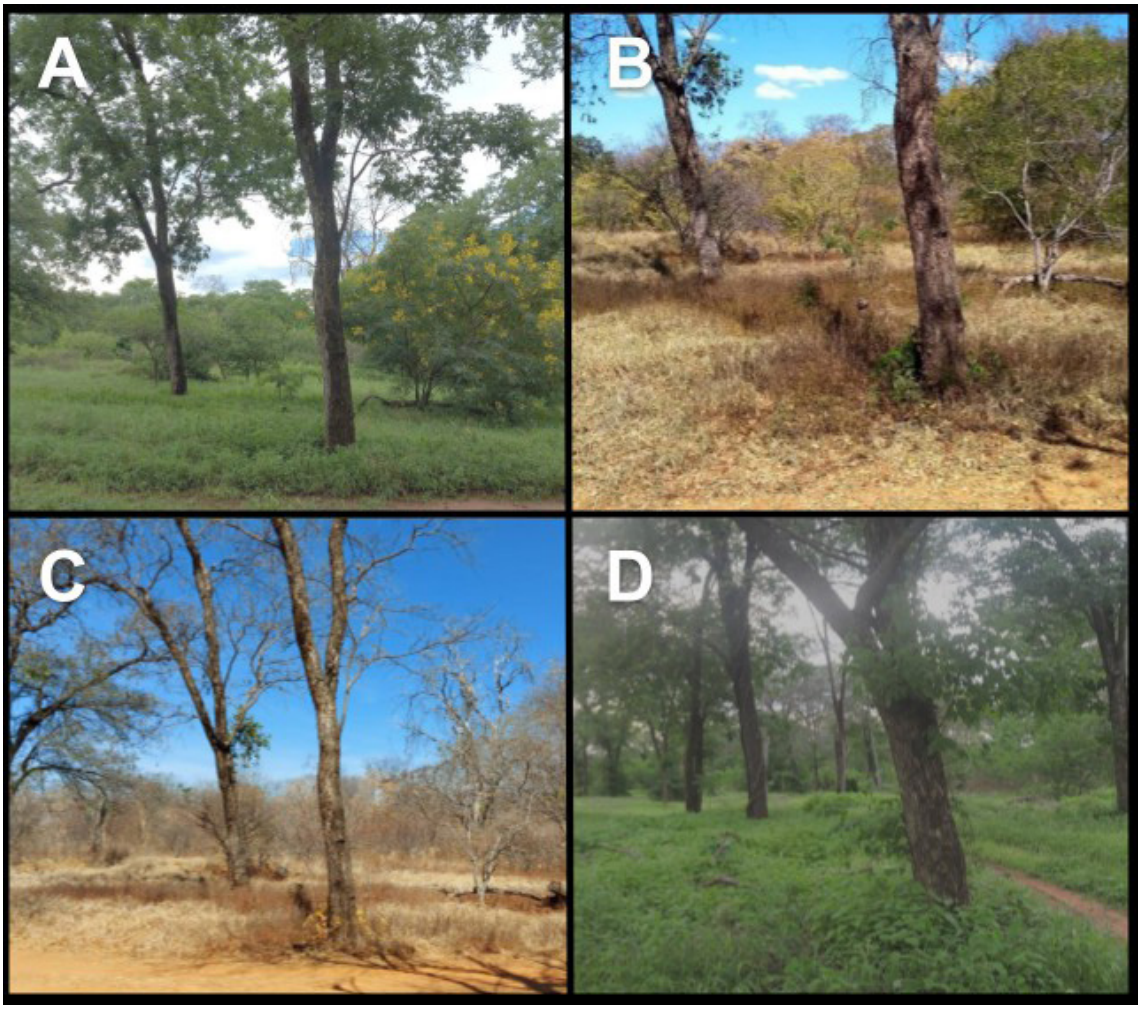

Fig 2. Alteration of the vegetation cover (deciduity) of the seasonal deciduous forest throughout the seasons (A = summer, B = autumn, C = winter, and D = spring) in 2021 in the Mata Seca State Park, Minas Gerais, Brazil.

hours of sampling effort per researcher. The active search methodology (Souza & Prezoto, 2006) was used with the aid of entomological networks to capture social wasps in flight and the colonies, inspecting areas of a rocky outcrop, riparian wetland vegetation, lagoons and banks of the São Francisco River, and along roads, and searching for colonies fixed on the surface or in trunk cavities, in the abaxial surface of coriaceous leaves, in Cactaceae (common in the area), in abandoned termite nests, and human constructions.

All specimens were sacrificed and stored in 70% alcohol and later mounted on an entomological pin for identification using the dichotomous keys Richards (1978) and Carpenter and Marques (2001) compared to the biological collection of social wasps (CBVS) of IFSULDEMINAS, where the specimens are deposited, or sent to Dr. Orlando Tobias da Silveira, Emílio Goeldi Museum, Belém, Pará. The Biodiversity Authorization and Information System (SISBIO) and the State Institute of Forests (IEF) provided the necessary licenses for this study (SISBIO: 76140-1 and IEF: 038/2020).

The Kruskal-Wallis (KW) H test was performed to verify the difference between species richness, number of total colonies, and number of colonies of each tribe concerning the collection station. If a significant difference was observed, the Mann-Whitney U test was conducted using the Past 4.03 program (Hammer et al., 2005). The frequency of each species was estimated by the occurrence of each one per sampling day regarding the total number of days of field collection effort. An accumulation curve was created to assess the sampling effort using the richness observed with a 95% confidence interval under the Bootstrap 1 estimator in EstimateS software 9.1.0 (Cowell, 2013). This estimator uses information from all species collected instead of restricting the analysis to rare species (Santos, 2003).

Results and Discussion

Fourteen species of six genera of social wasps were recorded (Table 1), where *Mischocyttarus* (Saussure, 1853) was richer with five species. Six species, five from the Epiponini tribe, were collected in the four seasons. In total, 131 colonies of eight species were located, particularly *Polybia occidentalis* (Olivier, 1791), with 39 colonies, *Polistes versicolor* (Olivier,

1791), with 33, *Mischocyttarus cassununga* (R. von Ihering, 1903), with 21, and *Protonectarina sylveirae* (Saussure, 1854), with 13 (Table 1).

Polybia occidentalis presented the most colonies, corroborating the report by Brunismann et al. (2016) and Francisco et al. (2018), carried out in a deciduous forest in the Refúgio da Vida Silvestre do Rio Pandeiros, which occupies a transition area between the Atlantic Forest and the Cerrado. This species is part of the guild of social wasps that feed on cacti fruits (Santos et al., 2007b). It is widely distributed in Northeast Brazil, indicating its adaptation to semi-arid environments (Santos et al., 2021). The nests of *P. occidentalis* may contain several cells used to store food such as ants, fragments of flies, and termites (Richards & Richards, 1951; Detoni & Prezoto, 2021), which can be used in unfavorable periods, such as the dry season (Hunt et al., 1987).

Protonectarina sylveirae, found throughout Brazil (Richards, 1978), can also store food (Shima et al., 2003) to use during periods of lower abundance, keeping the colonies active for longer (Jeanne, 1991) – which explains its several colonies in winter (Table 1). During winter, vegetation is almost completely leafless. Although this may have facilitated the location of the nests, it did not influence species registration since the frequency of registration was high (70%) during drought, showing that these wasps remain active even in the dry season.

The social wasp *P. versicolor* is also widely distributed (Richards, 1978), occurring in several biomes, such as the Cerrado and the Atlantic Forest (Souza et al., 2020b), and in various types of substrates, such as leaves, branches, roots, human constructions, and abandoned nests of other social wasps (Oliveira et al., 2010; Jacques et al., 2015). Environmental changes can direct the production of larger female social wasps, which are more likely to survive a season of scarce resources – whether biotic, such as plant biome, or abiotic, such as rain – and thus start a new nest (Gobbi et al., 2006), allowing this species to survive annual environmental changes such as marked loss of leaves and long periods of the drought of deciduous forests.

Five of the six species of the Epiponini tribe occurred in all seasons of 2021. This is due to two conditions: first, these species have a habit of swarm nesting, which provides better chances of dispersing in the search for nesting sites and food; second, they build nests with a protective enclosure, which ensures a more efficient homeothermic control than other tribes have (Andena & Carpenter, 2014; Santos et al., 2020). These species occur in other ecosystems and have a wide geographical distribution (Richards, 1978; Souza et al., 2020b). Moreover, the results suggest that they are better adapted to the abiotic conditions of the deciduous forest, especially the long dry season, than other species recorded in this study.

Mischocyttarus cassununga was the only open nest species found in all seasons. This species occupies different ecosystems (Silveira et al., 2008), has synanthropic behavior (Jacques et al., 2012), and uses different substrates for nesting (Castro et al., 2014). This ecological plasticity explains the presence of the species in this study in both rainy and dry seasons despite not having a protective casing.

No significant difference was observed in species richness ($p = 0.3246$) and the number of colonies (0.3897) when considering all species regarding the seasons nor when analyzing the number of colonies for the Mischocyttarini tribe ($p = 0.2816$). However, a difference was observed for Epiponini ($p = 0.0351$), which had fewer colonies in spring (Table 2), and for Polistini ($p = 0.0146$), with fewer colonies in autumn and winter (Table 2, Fig 3).

Table 2. Comparison between the number of Epiponini and Polistini colonies per season using the Mann-Whitney U test. The values in the table represent the p-value, where $p < 0.05$ indicates a significant difference.

Tribe	Season	Summer	Autumn	Winter	Spring
Epiponini	Summer	-	0,833	0,517	0,044
	Autumn	0,833	-	1	0,030
	Winter	0,517	1	-	0,011
	Spring	0,044	0,030	0,011	-
Polistini	Summer	-	0,353	0,136	0,261
	Autumn	0,353	-	0,405	0,021
	Winter	0,136	0,405	-	0,009
	Spring	0,261	0,021	0,009	-

The Epiponini tribe had fewer nests during spring (Table 2). As aforementioned, *P. occidentalis* and *P. sylveirae,* which had the highest number of colonies in Epiponini, can store resources such as proteins and carbohydrates in their nests (Ihering, 1896; Machado & Parra, 1984), thus improving resistance to unfavorable periods (Jeanne, 1991). Therefore, the species of this tribe are likely to resist the period of scarcity as much as possible (until the end of winter). Still, when resources end, they abandon their nests.

For the Polistini tribe, specifically, *P. versicolor*, the only species of the tribe that had nests in the study area, no colonies were recorded in autumn and winter, the driest periods of the year (Table 1, Fig 3). During the dry season, when the area is practically leafless, the foraging behavior of *P. versicolor* decreases, resulting in fewer resources for the colony and thus affecting the expansion and proper functioning of the nests (Elisei et al., 2010). Furthermore, this species does not accumulate food resources, hindering the maintenance of the colony in unfavorable situations. Instead, individuals leave the nest and concentrate in a safe place, waiting for a favorable environment (Gobbi et al., 2009).

Table 1. Tribes, species, richness (1 = Presence; 0 = Absence), and the number of colonies of social wasps recorded in the PEMS throughout the different seasons.

TRIBE	SPECIES	SEASON							
		SUMMER		AUTUMN		WINTER		SPRING	
		RICHNESS	COLONIES	RICHNESS	COLONIES	RICHNESS	COLONIES	RICHNESS	COLONIES
Epiponini	*Brachygastra lecheguana* (Latreille, 1824)	1	0	1	0	1	0	1	0
	Polybia ignobilis (Haliday, 1836)	1	0	1	0	1	0	1	0
	Polybia occidentalis (Olivier, 1791)	1	15	1	16	1	6	1	2
	Polybia sericea (Olivier, 1791)	1	1	1	0	1	3	1	0
	Protonectarina sylveirae (Saussure, 1854)	1	1	1	3	1	8	1	1
	Protopolybia exigua (Saussure)	1	5	0	0	1	3	0	0
Mischocyttarini	*Mischocyttarus bertonii* Ducke, 1918	1	3	0	0	0	0	0	0
	Mischocyttarus cassununga (R. von Ihering, 1903)	1	10	1	4	1	3	1	4
	Mischocyttarus drewseni Saussure, 1857	1	0	0	0	0	0	1	0
	Mischocyttarus matogrossoensis Zikán, 1935	1	0	0	0	0	0	0	0
	Mischocyttarus consimilis Zikán, 1949	1	0	1	5	1	5	0	0
Polistini	*Polistes cinerascens* Saussure, 1854	1	0	0	0	0	0	1	0
	Polistes ferreri Saussure, 1853	1	0	0	0	0	0	0	0
	Polistes versicolor (Olivier, 1791)	1	9	1	1	0	0	1	23
TOTAL RICHNESS BY SEASON		**14**		**8**		**8**		**9**	
NUMBER OF COLONIES BY SEASON			**44**		**29**		**28**		**30**
TOTAL RICHNESS					**14**				
TOTAL NUMBER OF COLONIES					**131**				
NUMBER OF SPECIES IN COMMON BETWEEN THE FOUR SEASONS					**6**				

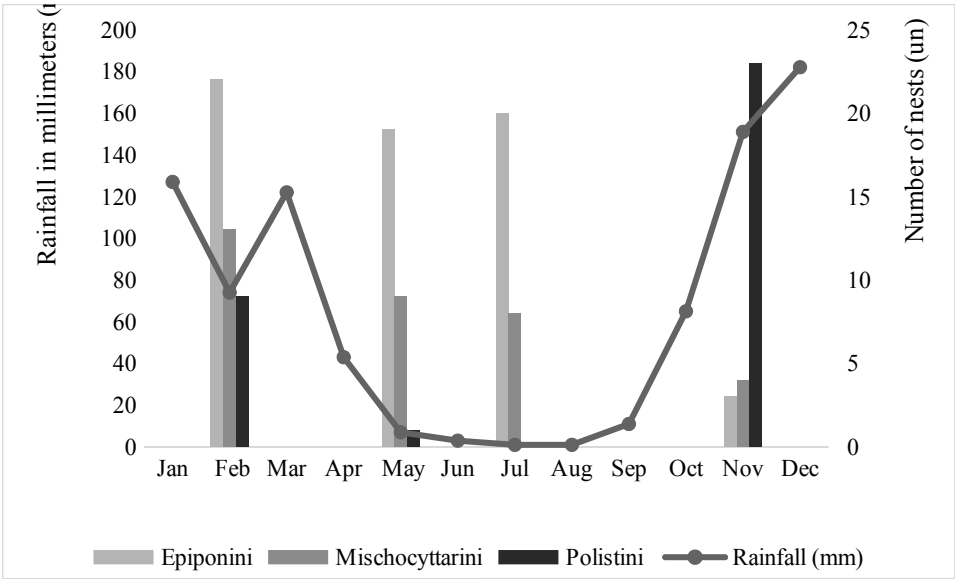

Fig 3. Number of nests of social wasp tribes (Epiponi, Mischocyttarini, and Polistini) as a function of rainfall (millimeters) throughout the seasons (Feb = summer, May = autumn, Jul = winter, Nov = spring) in 2021 in the deciduous forest in the Mata Seca State Park, Minas Gerais.

In the spring, after the dry season, the number of nests of *P. versicolor* increased. This species forms aggregations of queens in hibernation during the intensely dry season, so as soon as the rainy season begins, promoting a rapid replacement of leaves in the dry forest, *P. versicolor* can have a fast ethological response and start their nesting process, increasing the number of colonies (Koeppen, 1931; Gobbi & Zucchi, 1980; Gonzáles et al., 2002, 2004). Moreover, the reproductive females that form the winter cluster are larger and therefore adapted to survive and found colonies after droughts (West-Eberhard, 1969; Sólis & Strassmann, 1990; Dani, 1994), indicating that this species, as well as the five Epiponini species that occur in all seasons, are well adapted to the conditions of deciduous forests.

The species accumulation curve (Fig 4) tends to reach an asymptote. Furthermore, the estimated number of species (BootStrap1 = 19.39) is within the 95% confidence interval, indicating that the sampling effort was sufficient – that is, sampling over a whole year produced results that can be considered a good approximation of the real biotic diversity within the study area.

The responses of social wasps to periods of drought in the deciduous forest vary by tribe. While Epiponini populations can keep colonies active in the dry season, Polistini cannot. Meanwhile, *P. versicolor* responds positively to the onset of the rainy season, increasing its population.

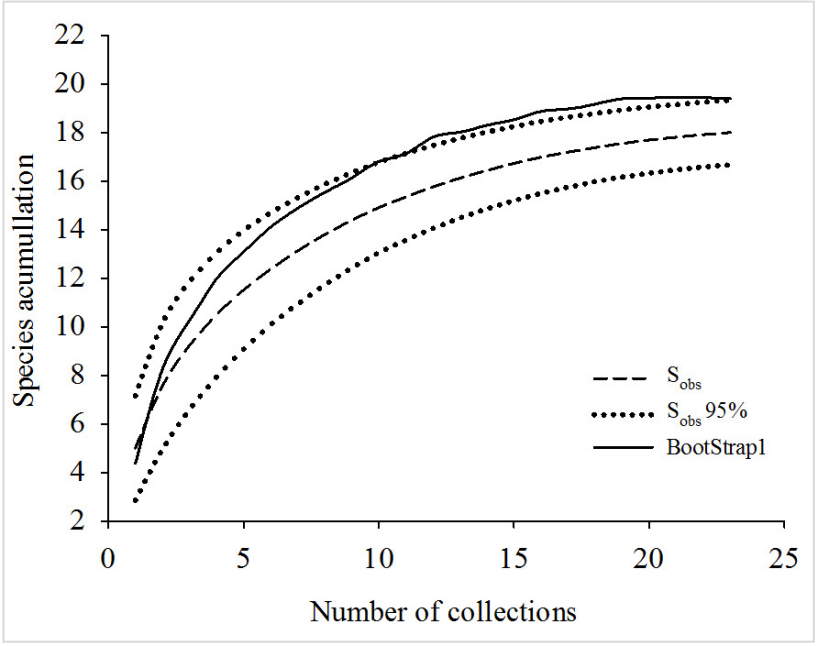

Fig 4. Species accumulation curve for social wasps collected in the Mata Seca State Park using the species richness observed within a 95% confidence interval and estimated species richness (Bootstrap 1).

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Author's Contribution

GCJ: Conceptualization; Formal analysis; Resources; Writing-Review & Editing
LDB: Investigation; Writing-Original Draft
TPG: Investigation; Writing -Original Draft
NAS: Investigation; Formal analysis; Writing-Original Draft
GTGS: Investigation; Writing-Original Draft
OTS: Supervision; Methodology; Writing-Review & Editing
MMS: Supervision; Methodology; Resources; Writing-Review & Editing

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