



## REVIEW

## Social Wasps (Hymenoptera, Polistinae) from the Brazilian Savanna

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### Abstract

The present study was developed aiming to evaluate the richness and biogeography of social wasp species in the Brazilian savanna, Cerrado. In order to do so, we gathered data from specialized literature and field samplings performed at Sempre-Vivas National Park, northeastern Minas Gerais state. 18 genera and 137 species were recorded, with 4 endemic species of the *Mischocyttarus* genus. The results showed that Cerrado houses 40% of Brazilian Polistinae fauna and that Sempre-Vivas National Park is responsible for around 29% of this value, which makes it an important refuge for conservation of social wasps from Cerrado, as well as Mato Grosso state, due to its large number of restricted occurrence and endemic species. Nonetheless, there are Brazilian states and conservation units still lacking information for the taxon, making a bigger sampling effort in the Cerrado biome necessary, as it has been rapidly deteriorating due to human action.

### Introduction

The Brazilian savanna, Cerrado, has an area of over two million square kilometers, about 24% of Brazilian territory. This biome encompasses the whole area of Distrito Federal, almost the entire territory of Goiás and Tocantins states, and approximately 60% of Maranhão, Mato Grosso do Sul and Minas Gerais states (IBGE, 2019). Cerrado is considered a hotspot for biodiversity conservation (Myers et al., 2000; Klink & Machado, 2005). It is also the richest savanna regarding biological diversity, with around 4400 endemic species of plants, more than 800 species of birds, almost 70 genus of mammals and about 300 species of amphibians and reptiles (IBGE, 2019).

Cerrado is represented by 11 phytophysionomies, which are: riparian forest, gallery forest, dry forest and Cerradão, which constitute the forest formations; Cerrado

sensu strictu, Cerrado Park, Palmeiral and Vereda, which constitute the savannic formations; and rough field, rupestrian field and clean field, representing the field phytophysionomies (EMBRAPA, 2019). Rupestrian field and dry forest can still be associated to other biomes (Oliveira-Filho, 2006).

Despite its importance, Cerrado suffers substantial menace by anthropic action, being the most strongly explored savannic phytophysionomy for diverse purposes and land use, with only a small percent still preserved. It is estimated that more than 50% of its total area has been substituted by agricultural crops in the last decades, rates that can bring the biome to extinction by 2030. Thus, the creation of compensation tools is of urgency, in order to attract the attention of the private sector and to subsidize the biome conservation (Ratter et al., 1997; Klink & Machado, 2005; Sano et al., 2008; Grandinete & Noll, 2013).



Among the conservation strategies, biodiversity inventories must be mentioned, as they provide biological diversity data for the definition of suitable conservation policies (Drummond et al., 2005), besides offering knowledge about different biotic groups and their biogeographical aspects (Elpino-Campos et al., 2007). In this sense, social wasps constitute an insect group of considerable evolutive interest, due to its social behaviour (Wilson, 1971), in addition to providing different ecological roles, such as pollination and floral visiting (Clemente et al., 2013; Prezoto et al., 2019).

Nevertheless, biogeographic knowledge of social wasps is still fragmented and in need of data like that provided by biodiversity inventories, specially concerning to Cerrado (Souza & Zanuncio, 2012; Barbosa et al., 2016; Souza et al., 2017). To that end, Simões et al. (2012) developed an inventory of social wasps from Cerrado in Minas Gerais state, with a great number of species, including those of ample geographic distribution, as well as those of rare occurrence. Additionally, some other studies provide data about the biogeography of social wasps from Cerrado (e.g. Diniz & Kitawama, 1994, 1998; Silva-Pereira & Santos, 2006; Elpino-Campos et al., 2007; Santos et al., 2009; Silva et al., 2011; Simões et al., 2012; Grandinete & Noll, 2013; Raw, 2016; Auko et al., 2017; Vicente, 2019).

In view of the above and the high capability of environments more ecologically complex, like Cerrado, of supporting a large richness of social wasps (Santos et al., 2009), the present study was developed. Our aim is to evaluate the richness and geographic distribution of social wasps in Cerrado, through data from specialized literature and the inventory of social wasps from Sempre-Vivas National Park, northeastern Minas Gerais state, Brazil. We also aim to verify the occurrence of endemism and to determine priority areas for conservation of Polistinae fauna in this biome.

## Material and Methods

The present study is based on data found in specialized literature and in novel data about social wasps in Cerrado, obtained from a study conducted at Sempre-Vivas National Park (PARNA Sempre-Vivas). This conservation unit is about 1.200 km in length and is located at the Espinhaço mountain range, that covers the municipalities of Bocaiúva, Olhos d'Água, Buenópolis and Diamantina, northeastern Minas Gerais state (43° 46' 37,12''S; 17° 48' 22,17''W), with altitudes between 1,200 and 1,500 meters high (ICMBIO, 2019).

The vegetation of the park is considered preserved and it is inserted in the Cerrado biome, where different phytophysognomies can be found. The climate of the region is mesothermal, with humid summers and dry winters; average temperature is 18.79°C and average precipitation is of 112.64 mm a year (ICMBIO, 2019). As previously mentioned, rupestrian fields and dry forest can be associated to other biomes, therefore only studies in which these phytophysognomies are related to Cerrado were considered in this work.

The field work was developed in four campaigns in the period between October 2018 and April 2019. There were ten consecutive sampling days in the summer, seven consecutive days in the spring and four days in the fall, with a total sampling effort of twenty-one days.

Samplings were concentrated in areas of riparian forest, rupestrian field and Cerrado strictu sensu. Specimen collection was executed by active search method (Souza & Prezoto, 2006), which consists of collecting the foraging animals with an entomological net. The search for colonies was conducted by observing holes and surfaces on rocks and tree trunks, abaxial faces of leaves, abandoned termite colonies, among other substrates that could house the colonies. The search path was based on preexistent trails, and the search was conducted from 9 am to 5 pm.

The collected specimens were sacrificed, stored in 70% alcohol and transported to the IFSULDEMINAS Campus Inconfidentes zoology lab, where they were fixed in dry medium, labeled, identified and incorporated to the collection of the system <http://splink.cria.org.br/>. For species identification purposes, the material was sent to Dr Orlando Tobias da Silveira, Museu Paraense Emílio Goeldi, Pará state. The study was authorized by SISBIO - Number 63930-1.

Data from other inventory studies and new records or description of species of social wasps conducted in Cerrado areas was also collected (Table 1, Fig. 1). In addition, the book *The social wasps of the Americas excluding the Vespinae* (Richards, 1978), which compiles information about the occurrence of social wasps in diverse areas, including Cerrado, was also used.

In Lima et al. (2010) and Tanaka and Noll (2011), studies conducted in different municipalities of the São Paulo state, some areas are found in transition ranges between Atlantic forest and Cerrado. However, these areas were considered part of Atlantic domain (Fig 1). Therefore, there is no information on Polistinae fauna from São Paulo state in Cerrado areas.

**Table 1.** List of inventories of social wasps (Polistinae) in Cerrado areas, published by state.

| Author and year              | State              | Number of species |
|------------------------------|--------------------|-------------------|
| Diniz & Kitawama, 1994       | Mato Grosso        | 30                |
| Diniz & Kitawama, 1998       | Mato Grosso        | 36                |
| Silva-Pereira & Santos, 2006 | Bahia              | 11                |
| Elpino-Campos et al., 2007   | Minas Gerais       | 29                |
| Santos et al., 2009          | Bahia              | 19                |
| Silva et al., 2011           | Maranhão           | 31                |
| Simões et al., 2012          | Minas Gerais       | 32                |
| Grandinete & Noll, 2013      | Mato Grosso do Sul | 22                |
| Raw, 2016                    | Distrito Federal   | 56                |
| Raw, 2016                    | Goiás              | 19                |
| Auko et al., 2017            | Mato Grosso do Sul | 37                |
| Vicente, 2019                | Minas Gerais       | 37                |

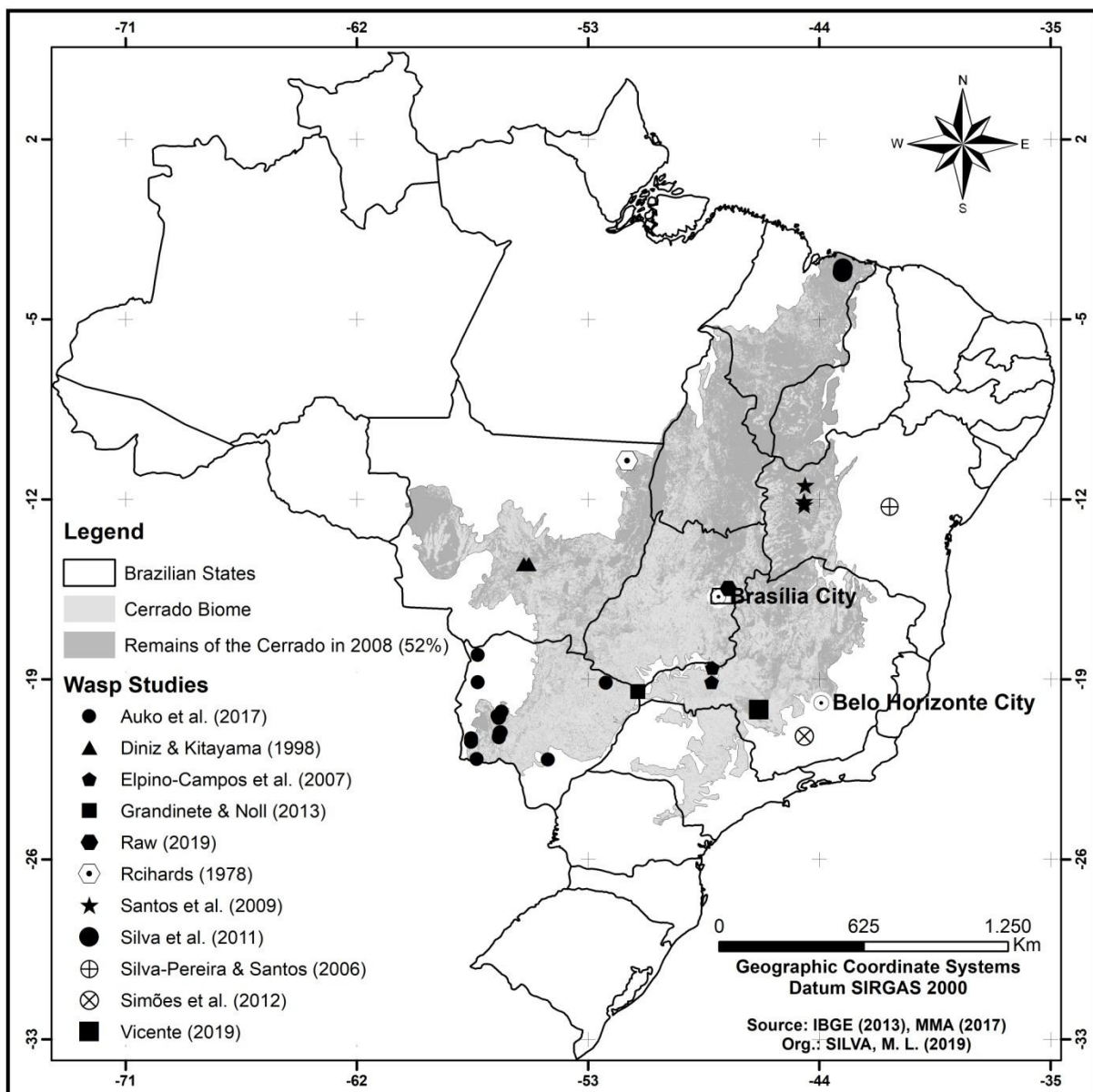


Fig 1. Geographic location of social wasp inventories published for areas of Cerrado biome.

The studies of Silva-Pereira and Santos (2006), Simões et al. (2012) and Auko et al. (2017) were used in this work, because the study areas occur in Cerrado enclaves associated to Atlantic Forest and Caatinga (dos Santos et al., 2015; Carvalho, 2017).

Fauna similarity analysis was conducted through the similarity index of Jaccard, which indicates the resemblance between environments, based on the number of common species. We used binary data (presence/absence) for the species. Therefore, the most diverse genera were used, as less abundant species do not affect significantly the resultant standards of multivariate analysis (Ferreira et al., 2008). The resultant index was utilized to analyze the groups, by means of UPGMA method (Unweighted Pair Group Method with Arithmetic mean). All data was processed on PAST 3.25 software (Hammer et al., 2001).

## Results

Were registered 137 species of social wasps, distributed in 18 genus for Cerrado of 8 states (Table 2).

There are 4 species of occurrence restricted to Cerrado: *Mischocyttarus chapadae*, *M. tertius*, *M. melanoxanthus* and *M. campestris*.

In the similarity Jaccard indexes (Tables 3, 4 and 5) it is emphasize I - In *Polistes*: Distrito Federal+Mato Grosso (0.619); Distrito Federal+Mato Grosso do Sul (0.557); Bahia+Mato Grosso do Sul (0.556); II - In *Polybia* Distrito Federal+Minas Gerais (0.533) and Bahia+Mato Grosso do Sul (0.500); III - In *Mischocyttarus* no areas came close to 0.500, with the closest value being Distrito Federal+Mato Grosso with 0.382.

At PARNA Sempre-Vivas 39 species were catalogued, distributed in 11 genus (Table 2) and 102 colonies, with emphasis for *Mischocyttarus saussurei*.

There is no information about Polistinae in Cerrado areas for São Paulo, Piauí and Tocantins states (Fig 1).

## Discussion

Polistinae fauna in Cerrado corresponds to 40% of Brazilian richness, data obtained from the sampling effort of 13 studies. It is highlighted that this effort is considerably lower than that for the most well sampled Brazilian biome for social wasps, the Atlantic Forest, as already discussed for Minas Gerais state (Barbosa et al., 2016; Souza et al., 2017), which shows a need for a bigger sampling effort for Cerrado.

*Mischocyttarus chapadae* has an impar record in Chapada dos Guimarães municipality, Mato Grosso state (Richards, 1978); *M. tertius*, which was only recorded in Ribeirão Cascalheira municipality, Mato Grosso state (Richards, 1978); *M. melanoxanthus* was also found in Ribeirão Cascalheira (Richards, 1978) and in Distrito Federal (Raw, 2016); finally, *M. campestris* has a single record in Distrito Federal (Raw, 1985). According to Carpenter and Marques (2001), this genus makes up around 25% of Polistinae, with 117 species being recorded in Brazil. Furthermore, it possesses small and cryptic colonies, which makes the field observation difficult (Souza et al., 2015). These are some of the factors that help the understanding of the high range of endemism in the group.

Among the 137 species of social wasps reported for Cerrado, 27 (including 3 of 5 endemic species of the biome) are restricted to Cerrado areas of Mato Grosso state (Table 2). This data results from the effort of only two studies (Table 1) and it can be a reflection of the high proximity to the Amazonic biome, which shelters 20 of those 27 species (Silveira et al., 2012; Somavilla et al., 2013). Such information displays the need for further studies concerning the group in that state.

Similarity Jaccard indexes (Tables 3, 4 and 5) have shown that the similarity analyzed in Cerrado areas of the states can be considered low. Knowing that values higher than 0.5 indicate high similarity, the presented results are considered exceptions, which are: I - In *Polistes*: Distrito Federal+Mato Grosso (0.619); Distrito Federal+Mato Grosso do Sul (0.557); Bahia+Mato Grosso do Sul (0.556); II - In *Polybia* Distrito Federal+Minas Gerais (0.533) and Bahia+Mato Grosso do Sul (0.500); III - In *Mischocyttarus* no areas came close to 0.500, with the closest value being Distrito Federal+Mato Grosso with 0.382, which can be considered low, although Mueller-Dumbois and Ellenberg (1974), claim that this index in rare occasions reaches values higher than 0.6, and must usually be superior to 0.25. The low similarity observed for this genus is, probably, due to its restricted occurrence, as it was already discussed on this study, and also reported in other studies that showed the *Mischocyttarus* species restricted to other biomes (Richards, 1978; Souza et al., 2006; Prezoto et al., 2009; Souza et al., 2017; 2018).

Although there is a difference of sampling effort among the Brazilian states, the similarity analysis is relevant for evaluating the geographic distribution of the species and to

support strategies of conservation biology, as an example, the creation or maintenance of conservation units, what justifies the presentation of the species list by states.

The low similarity found for *Mischocyttarus*, *Polistes* and *Polybia* in Distrito Federal (DF) and Goiás (GO) is probably a result from the difference of sampling effort between the states. Although DF is located within Goiás state, Raw (2016) conducted a study that gathered data of samplings from 1976 to 1998 in the Brazilian capital city, while in Goiás state the sampling effort is considerably smaller (Raw, 2016) and the data is sporadic and comes from material stored in biological collections (Richards, 1978).

The differences of the fauna composition may be, also, a product of the sampling effort, strongly different among the Brazilian states inserted in the Cerrado biome.

High similarity found among some states (Tables 3 and 4) for the *Polybia* and *Polistes* genus is resultant from the fauna constitution, of about 85% of species widely distributed in different ecosystems and states of Brazil (Richards, 1978; Souza & Zanuncio, 2012), unlike what is seen for *Mischocyttarus*, for which presents a more restricted occurrence.

The number of species registered for PARNA Sempre-Vivas makes up about 29% of social wasp fauna from the Brazilian savanna. *Mischocyttarus iheringi* is registered for Cerrado areas inside PARNA Sempre-Vivas limits, but it also occurs in other biomes (Richards, 1978; Souza et al., 2018).

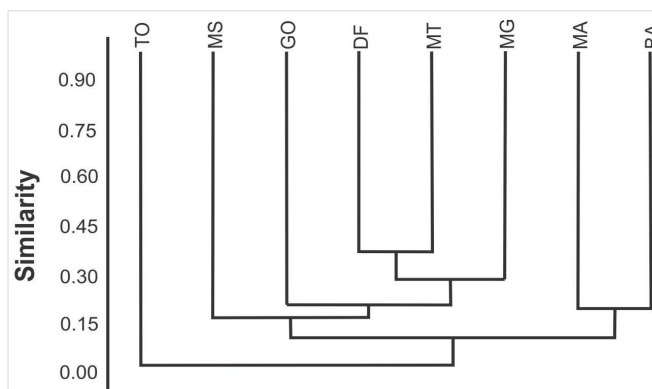


Fig 2. Dendrogram drawn from the similarity Jaccard index among known areas, based on data from species of the *Mischocyttarus* genus.

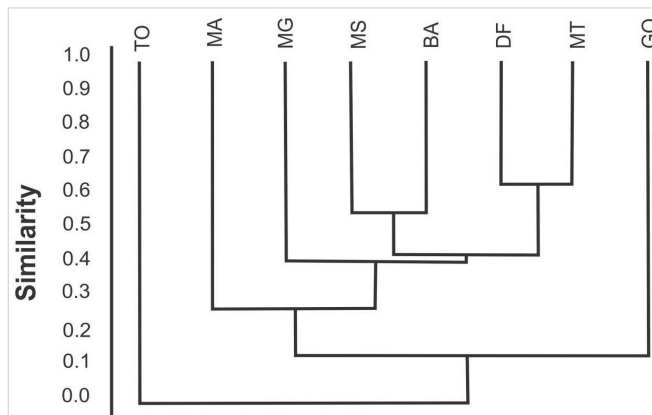
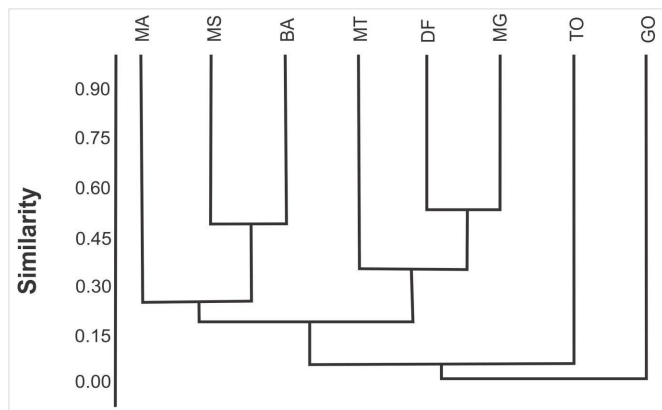


Fig 3. Dendrogram drawn from the similarity Jaccard index among known areas, based on data from species of the genus *Polistes*.



**Fig 4.** Dendrogram drawn from the similarity Jaccard index among known areas, based on data from species of the *Polybia* genus.

Except for Raw (2016), PARNA Sempre-Vivas shows a bigger richness when compared to other studies developed in Cerrado (Table 1), what makes this unit conservation an important instrument for the protection of vespids from the Brazilian savanna biome.

**Table 3.** Similarity matrix (Jaccard) of species from the *Polybia* genus for the 8 studied states (BA = Bahia; DF = Distrito Federal; GO = Goiás; MA = Maranhão; MG = Minas Gerais; MS = Mato Grosso do Sul; MT = Mato Grosso; TO = Tocantins).

|           | BA    | DF    | GO    | MA    | MG    | MS    | MT    | TO    |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>BA</b> | 1,000 |       |       |       |       |       |       |       |
| <b>DF</b> | 0,429 | 1,000 |       |       |       |       |       |       |
| <b>GO</b> | 0,067 | 0,200 | 1,000 |       |       |       |       |       |
| <b>MA</b> | 0,167 | 0,294 | 0,059 | 1,000 |       |       |       |       |
| <b>MG</b> | 0,333 | 0,400 | 0,143 | 0,294 | 1,000 |       |       |       |
| <b>MS</b> | 0,556 | 0,571 | 0,000 | 0,333 | 0,467 | 1,000 |       |       |
| <b>MT</b> | 0,300 | 0,619 | 0,364 | 0,273 | 0,417 | 0,400 | 1,000 |       |
| <b>TO</b> | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 1,000 |

**Table 4.** Similarity matrix (Jaccard) of species from the *Polistes* genus for the 8 studied states (BA = Bahia; DF = Distrito Federal; GO = Goiás; MA = Maranhão; MG = Minas Gerais; MS = Mato Grosso do Sul; MT = Mato Grosso; TO = Tocantins).

|           | BA    | DF    | GO    | MA    | MG    | MS    | MT    | TO    |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>BA</b> | 1,000 |       |       |       |       |       |       |       |
| <b>DF</b> | 0,077 | 1,000 |       |       |       |       |       |       |
| <b>GO</b> | 0,000 | 0,154 | 1,000 |       |       |       |       |       |
| <b>MA</b> | 0,333 | 0,000 | 0,000 | 1,000 |       |       |       |       |
| <b>MG</b> | 0,250 | 0,533 | 0,067 | 0,083 | 1,000 |       |       |       |
| <b>MS</b> | 0,500 | 0,308 | 0,000 | 0,167 | 0,500 | 1,000 |       |       |
| <b>MT</b> | 0,071 | 0,353 | 0,000 | 0,083 | 0,333 | 0,286 | 1,000 |       |
| <b>TO</b> | 0,000 | 0,091 | 0,000 | 0,000 | 0,083 | 0,167 | 0,083 | 1,000 |

Concerning to the states lacking of information about its polistinae fauna, it is mentioned the conservation units Ema National Park (GO), Jalapão National Park (TO), Chapada das Mesas National Park (MA), Grande Sertão Veredas National Park (MG), Sete Cidades National Park and Nascentes do Rio Parnaíba National Park (PI), as well as the Mosaic of Conservation Units of São Paulo Cerrado, which encompasses Aimorés Wildlife Refuge (RVS) and Leopoldo Coutinho Area of Relevant Ecologic Interest (ARIE), located between the municipalities of Bauru, Pederneiras and Agudos, central-western São Paulo (Decree nº 63.893, 2018). Therefore, these areas must be considered priorities for studies, since they may still reveal a large number of endemic species.

Cerrado constitutes an essential biome for Polistinae fauna in Brazil as, aside from its social wasp richness, it has endemic species of *Mischocyttarus*. Sempre-Vivas National Park has proved to be an important refuge for certain Polistinae species, as well as Mato Grosso state. In contrast, other states and conservation units lacking information on the group indicate an urgent need for sampling those regions, in face of the reduction of natural areas that Cerrado, the Brazilian savanna, has been suffering by anthropic action.

**Table 5.** Similarity matrix (Jaccard) of species from the *Mischocyttarus* genus for the 8 studied states (BA = Bahia; DF = Distrito Federal; GO = Goiás; MA = Maranhão; MG = Minas Gerais; MS = Mato Grosso do Sul; MT = Mato Grosso; TO = Tocantins).

|           | BA    | DF    | GO    | MA    | MG    | MS    | MT    | TO    |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>BA</b> | 1,000 |       |       |       |       |       |       |       |
| <b>DF</b> | 0,231 | 1,000 |       |       |       |       |       |       |
| <b>GO</b> | 0,125 | 0,267 | 1,000 |       |       |       |       |       |
| <b>MA</b> | 0,200 | 0,067 | 0,000 | 1,000 |       |       |       |       |
| <b>MG</b> | 0,200 | 0,333 | 0,167 | 0,059 | 1,000 |       |       |       |
| <b>MS</b> | 0,143 | 0,200 | 0,100 | 0,143 | 0,250 | 1,000 |       |       |
| <b>MT</b> | 0,118 | 0,381 | 0,222 | 0,056 | 0,240 | 0,167 | 1,000 |       |
| <b>TO</b> | 0,000 | 0,000 | 0,167 | 0,000 | 0,000 | 0,000 | 0,063 | 1,000 |

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**Author’s contribution**

We, the authors, affirm that each one of us contributed to idealizing, writing and formatting the present manuscript.

**Table 2.** Species of social wasps recorded in Cerrado areas in Bahia (BA), Goiás (GO), Maranhão (MA), Minas Gerais (MG), Mato Grosso do Sul (MS), Mato Grosso (MT), Tocantins (TO) and Distrito Federal (DF) states, further data from Sempre-Vivas National Park (SV).

| Species of social wasps                                 | BA | DF | GO | MA | MG | MS | MT | TO | SV |
|---|----|----|----|----|----|----|----|----|----|
| <i>Agelaia angulata</i> (Fabricius, 1804)               | 0  | 0  | 1  | 0  | 1  | 0  | 1  | 0  | 0  |
| <i>Agelaia angulicollis</i> (Spinola, 1851)             | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Agelaia cajennensis</i> (Fabricius, 1798)            | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  |
| <i>Agelaia flavipennis</i> (Ducke, 1905)                | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Agelaia fulvofasciata</i> (Degeer, 1773)             | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Agelaia multipicta</i> (Haliday, 1836)               | 0  | 0  | 1  | 0  | 1  | 1  | 1  | 0  | 1  |
| <i>Agelaia myrmecophila</i> (Ducke, 1905)               | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Agelaia lobipleura</i> Richards, 1987                | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Agelaia pallipes</i> (Olivier, 1791)                 | 0  | 1  | 0  | 1  | 1  | 1  | 1  | 0  | 0  |
| <i>Agelaia testacea</i> (Fabricius, 1804)               | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Agelaia vicina</i> (de Saussure, 1854)               | 1  | 0  | 1  | 0  | 1  | 0  | 0  | 1  | 1  |
| <i>Angiopolybia pallens</i> (Lepelletier, 1836)         | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Angiopolybia paraensis</i> Spinola, 1851             | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Apoica arborea</i> (de Saussure, 1854)               | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  |
| <i>Apoica flavissima</i> Van der Vecht, 1973            | 0  | 0  | 1  | 1  | 0  | 1  | 1  | 0  | 1  |
| <i>Apoica gelida</i> Van der Vecht, 1973                | 0  | 0  | 1  | 0  | 1  | 0  | 1  | 0  | 1  |
| <i>Apoica pallida</i> (Olivier, 1791)                   | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Apoica pallens</i> (Fabricius, 1804)                 | 1  | 1  | 1  | 0  | 1  | 1  | 1  | 0  | 1  |
| <i>Apoica thoracica</i> du Buysson, 1906                | 0  | 1  | 1  | 0  | 0  | 0  | 0  | 1  | 0  |
| <i>Brachygastra augustii</i> (de Saussure, 1854)        | 0  | 1  | 1  | 0  | 0  | 1  | 1  | 0  | 0  |
| <i>Brachygastra albula</i> Richards, 1978               | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Brachygastra bilineolata</i> Spinola, 1841           | 0  | 0  | 1  | 1  | 0  | 0  | 1  | 0  | 0  |
| <i>Brachygastra fistulosa</i> Naumann, 1968             | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  |
| <i>Brachygastra lecheguana</i> (Latreille, 1824)        | 1  | 1  | 1  | 0  | 1  | 1  | 1  | 0  | 1  |
| <i>Brachygastra moebiana</i> (de Saussure, 1867)        | 0  | 1  | 1  | 0  | 0  | 1  | 1  | 0  | 0  |
| <i>Brachygastra moulae</i> Richards, 1978               | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  |
| <i>Brachygastra scutellaris</i> (Fabricius, 1804)       | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Chartergellus communis</i> Richards, 1978            | 1  | 1  | 1  | 1  | 1  | 0  | 1  | 0  | 1  |
| <i>Chartergus artifex</i> (Christ, 1791)                | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Chartergus globiventris</i> de Saussure, 1854        | 1  | 0  | 1  | 1  | 0  | 0  | 0  | 0  | 0  |
| <i>Chartergus chartarius</i> (Olivier, 1791)            | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Chartergus metanotalis</i> Richards, 1978            | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Charterginus fulvus</i> Fox, 1904                    | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Clypearia angustior</i> Ducke, 1906                  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Clypearia humeralis</i> Richards, 1978               | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Epipona media</i> Cooper, 2002                       | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Epipona tatus</i> (Cuvier, 1797)                     | 0  | 1  | 1  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Marimbonda albogrisea</i> Richards, 1978             | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Metapolybia cingulata</i> (Fabricius, 1804)          | 1  | 1  | 1  | 1  | 0  | 0  | 1  | 0  | 0  |
| <i>Metapolybia suffusca</i> (Fox, 1898)                 | 0  | 0  | 1  | 1  | 0  | 0  | 1  | 0  | 0  |
| <i>Metapolybia unilineata</i> (R. von Ihering, 1904)    | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus annulatus</i> Richards, 1978          | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Mischocyttarus bahiae</i> Richards, 1978             | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus campestris</i> Raw, 1985 *            | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus cassununga</i> (R. von Ihering, 1903) | 1  | 1  | 0  | 0  | 1  | 0  | 0  | 0  | 1  |
| <i>Mischocyttarus cerberus</i> Ducke, 1918              | 1  | 1  | 0  | 1  | 1  | 1  | 1  | 0  | 1  |
| <i>Mischocyttarus chapadae</i> (Fox, 1898) *            | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |

**Table 2.** Species of social wasps recorded in Cerrado areas in Bahia (BA), Goiás (GO), Maranhão (MA), Minas Gerais (MG), Mato Grosso do Sul (MS), Mato Grosso (MT), Tocantins (TO) and Distrito Federal (DF) states, further data from Sempre-Vivas National Park (SV). (Continuation)

| Species of social wasps                                 | BA | DF | GO | MA | MG | MS | MT | TO | SV |
|---|----|----|----|----|----|----|----|----|----|
| <i>Mischocyttarus confusus</i> Zikán, 1935              | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus drewseni</i> de Saussure, 1857        | 1  | 1  | 1  | 0  | 1  | 0  | 1  | 0  | 1  |
| <i>Mischocyttarus flavicornis</i> Zikán, 1935           | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 1  | 0  |
| <i>Mischocyttarus frontalis</i> (Fox, 1898)             | 0  | 0  | 1  | 0  | 0  | 1  | 0  | 0  | 0  |
| <i>Mischocyttarus giffordi</i> Raw, 1985                | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 1  |
| <i>Mischocyttarus imitator</i> (Ducke, 1904)            | 0  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus ignotus</i> Zikán, 1949               | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  |
| <i>Mischocyttarus iheringi</i> Zikán, 1935              | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  |
| <i>Mischocyttarus injucundus</i> (de Saussure, 1854)    | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus labiatus</i> (Fabricius, 1804)        | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Mischocyttarus lecointei</i> (Ducke, 1904)           | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus latior</i> (Fox, 1898)                | 0  | 1  | 0  | 0  | 1  | 1  | 1  | 0  | 1  |
| <i>Mischocyttarus marginatus</i> (Fox, 1898)            | 0  | 1  | 1  | 0  | 1  | 0  | 1  | 0  | 1  |
| <i>Mischocyttarus mattogrososensis</i> Zikán, 1935      | 0  | 1  | 0  | 0  | 1  | 1  | 1  | 0  | 1  |
| <i>Mischocyttarus metathoracicus</i> (Saussure, 1854)   | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Mischocyttarus melanoxanthus</i> Richards, 1978 *    | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Mischocyttarus omicron</i> Richards, 1978            | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Mischocyttarus rotundicollis</i> (Cameron, 1912)     | 0  | 1  | 1  | 0  | 1  | 0  | 1  | 0  | 1  |
| <i>Mischocyttarus socialis</i> (de Saussure, 1854)      | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  |
| <i>Mischocyttarus surinamensis</i> (de Saussure, 1854)  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Mischocyttarus tertius</i> Richards, 1978 *          | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Mischocyttarus timbira</i> Silveira, 2006            | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  |
| <i>Mischocyttarus tricolor</i> Richards, 1945           | 0  | 0  | 0  | 0  | 1  | 1  | 0  | 0  | 0  |
| <i>Mischocyttarus xavante</i> (Ducke, 1905)             | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 0  | 0  |
| <i>Parachartergus fraternus</i> (Gribodo, 1892)         | 0  | 1  | 1  | 1  | 1  | 0  | 1  | 0  | 1  |
| <i>Parachartergus pseudapicalis</i> Willink, 1959       | 1  | 0  | 1  | 0  | 1  | 0  | 1  | 0  | 0  |
| <i>Parachartergus smithii</i> (de Saussure, 1854)       | 0  | 0  | 1  | 1  | 0  | 1  | 1  | 0  | 0  |
| <i>Polistes actaeon</i> Haliday, 1836                   | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  |
| <i>Polistes bicolor</i> Lepeletier, 1836                | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Polistes billardieri</i> Fabricius, 1804             | 0  | 1  | 0  | 0  | 1  | 1  | 1  | 0  | 0  |
| <i>Polistes brevifissus</i> Richards, 1978              | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Polistes canadensis</i> (Linnaeus, 1758)             | 1  | 0  | 0  | 1  | 1  | 1  | 1  | 0  | 0  |
| <i>Polistes carnifex</i> (Fabricius, 1775)              | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Polistes cinerascens</i> de Saussure, 1854           | 0  | 1  | 0  | 0  | 1  | 0  | 0  | 0  | 1  |
| <i>Polistes davillae</i> Richards, 1978                 | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Polistes erythrocephalus</i> Latreille, 1813         | 0  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Polistes ferreri</i> de Saussure, 1853               | 0  | 1  | 0  | 0  | 1  | 1  | 1  | 0  | 1  |
| <i>Polistes geminatus geminatus</i> Fox, 1898           | 0  | 1  | 0  | 0  | 1  | 0  | 1  | 0  | 0  |
| <i>Polistes goeldii</i> Ducke, 1904                     | 0  | 1  | 0  | 0  | 1  | 0  | 1  | 0  | 0  |
| <i>Polistes lanio</i> (Fabricius, 1775)                 | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  |
| <i>Polistes melanossoma</i> de Saussure, 1853           | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Polistes niger</i> Brethes, 1903                     | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Polistes occipitalis</i> Ducke, 1904                 | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| <i>Polistes pacificus liliaciosus</i> de Saussure, 1854 | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| <i>Polistes satan</i> Bequaert, 1940                    | 0  | 1  | 1  | 0  | 1  | 0  | 0  | 0  | 1  |
| <i>Polistes simillimus</i> Zikán, 1948                  | 1  | 0  | 0  | 0  | 1  | 1  | 0  | 0  | 1  |

**Table 2.** Species of social wasps recorded in Cerrado areas in Bahia (BA), Goiás (GO), Maranhão (MA), Minas Gerais (MG), Mato Grosso do Sul (MS), Mato Grosso (MT), Tocantins (TO) and Distrito Federal (DF) states, further data from Sempre-Vivas National Park (SV). (Continuation)

| Species of social wasps                                  | BA        | DF        | GO        | MA        | MG        | MS        | MT        | TO       | SV        |
|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-----------|
| <i>Polistes subsericeus</i> de Saussure, 1854            | 0         | 1         | 0         | 0         | 1         | 1         | 1         | 1        | 1         |
| <i>Polistes thoracicus</i> Fox, 1898                     | 0         | 0         | 0         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polistes versicolor</i> (Olivier, 1792)               | 1         | 1         | 0         | 0         | 1         | 1         | 0         | 0        | 1         |
| <i>Polybia bifasciata</i> de Saussure, 1854              | 0         | 0         | 1         | 0         | 1         | 0         | 0         | 0        | 0         |
| <i>Polybia bicyttarella</i> Richards, 1951               | 0         | 0         | 0         | 1         | 0         | 0         | 0         | 0        | 0         |
| <i>Polybia chrysothorax</i> (Lichtenstein, 1796)         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 0        | 1         |
| <i>Polybia dimorpha</i> Richards, 1978                   | 0         | 0         | 0         | 1         | 0         | 0         | 0         | 0        | 0         |
| <i>Polybia dimidiata</i> (Olivier, 1792)                 | 0         | 1         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia emaciata</i> Lucas 1879                       | 0         | 1         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia erythrothorax</i> Richards 1978               | 0         | 0         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia fastidiosuscula</i> de Saussure, 1854         | 0         | 1         | 0         | 0         | 1         | 0         | 0         | 0        | 1         |
| <i>Polybia flavifrons hecuba</i> Richards, 1951          | 1         | 1         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia gorytoides</i> Fox, 1898                      | 0         | 0         | 0         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia ignobilis</i> (Haliday, 1836)                 | 1         | 1         | 0         | 0         | 1         | 1         | 1         | 0        | 1         |
| <i>Polybia jurinei</i> de Saussure, 1854                 | 0         | 1         | 0         | 1         | 1         | 1         | 1         | 0        | 1         |
| <i>Polybia liliacea</i> (Fabricius, 1804)                | 0         | 1         | 0         | 0         | 0         | 1         | 1         | 0        | 0         |
| <i>Polybia micans</i> Ducke, 1904                        | 0         | 0         | 0         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia minarum</i> Ducke, 1906                       | 0         | 0         | 0         | 0         | 1         | 0         | 0         | 0        | 0         |
| <i>Polybia occidentalis occidentalis</i> (Olivier, 1791) | 1         | 1         | 0         | 0         | 1         | 1         | 1         | 0        | 1         |
| <i>Polybia paulista</i> H. von Ihering, 1896             | 1         | 1         | 0         | 0         | 1         | 1         | 1         | 0        | 1         |
| <i>Polybia platycephala sylvestris</i> Richards, 1978    | 0         | 0         | 0         | 1         | 1         | 0         | 1         | 0        | 0         |
| <i>Polybia quadricincta</i> de Saussure, 1854            | 0         | 0         | 1         | 0         | 1         | 0         | 1         | 0        | 0         |
| <i>Polybia rejecta</i> (Fabricius, 1798)                 | 0         | 1         | 1         | 1         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia ruficeps xanthops</i> Schrottky, 1902         | 0         | 1         | 0         | 1         | 1         | 1         | 1         | 0        | 1         |
| <i>Polybia scrobalis</i> Richards, 1970                  | 0         | 1         | 0         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia scutellaris</i> (White, 1841)                 | 0         | 0         | 0         | 0         | 1         | 0         | 0         | 0        | 0         |
| <i>Polybia sericea</i> (Olivier, 1792)                   | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 0        | 1         |
| <i>Polybia singularis</i> Ducke, 1909                    | 0         | 0         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Polybia striata</i> (Fabricius, 1787)                 | 0         | 0         | 1         | 0         | 1         | 0         | 1         | 0        | 0         |
| <i>Polybia tinctipennis</i> Fox, 1898                    | 0         | 0         | 1         | 0         | 0         | 0         | 0         | 0        | 0         |
| <i>Protonectarina sylveirae</i> (de Saussure, 1854)      | 1         | 1         | 0         | 0         | 1         | 1         | 0         | 0        | 1         |
| <i>Protopolybia acutiscutis</i> (Cameron, 1907)          | 0         | 0         | 0         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Protopolybia chartergoides</i> (Gribodo, 1891)        | 0         | 0         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Protopolybia exigua exigua</i> (De Saussure, 1854)    | 1         | 1         | 0         | 1         | 0         | 1         | 1         | 0        | 1         |
| <i>Protopolybia minutissima</i> (Spinola, 1851)          | 0         | 0         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Protopolybia sedula</i> (de Saussure, 1854)           | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 0        | 1         |
| <i>Pseudopolybia compressa</i> (de Saussure, 1854)       | 0         | 0         | 1         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Pseudopolybia vespiceps</i> (de Saussure, 1863)       | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 0        | 0         |
| <i>Synoeca chalibea</i> Saussure, 1852                   | 0         | 0         | 0         | 0         | 0         | 0         | 1         | 0        | 0         |
| <i>Synoeca cyanea</i> (Fabricius, 1775)                  | 1         | 0         | 0         | 0         | 1         | 1         | 0         | 0        | 1         |
| <i>Synoeca surinama</i> (Linnaeus, 1767)                 | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 0        | 1         |
| <b>Total of species 137</b>                              | <b>22</b> | <b>56</b> | <b>50</b> | <b>27</b> | <b>53</b> | <b>36</b> | <b>89</b> | <b>5</b> | <b>39</b> |
| <b>Exclusive species for each state</b>                  | <b>0</b>  | <b>6</b>  | <b>5</b>  | <b>6</b>  | <b>8</b>  | <b>2</b>  | <b>26</b> | <b>1</b> | <b>3</b>  |



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