doi: 10.12741/ebrasilis.v14.e978
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EntomoBrasilis
e-ISSN 1983-0572
EntomoBrasilis Update Check

## General Entomology

# Checklist of bee species (Hymenoptera: Apoidea: Anthophila) in the urban areas of Cerrado biome in Barreiras, Bahia, Brazil

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***EntomoBrasilis 14: e978 (2021)***

**Edited by:**
*Alberto Moreira Silva-Neto*

**Article History:**
*Received: 30.x.2021*
*Accepted: 11.xi.2021*
*Published: 19.xi.2021*

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**Funding agencies:**
*Without funding declared*

**Abstract.** In a global context, few studies have investigated the effects of urbanization on apifauna, as well as the importance of green areas in urban centers for the conservation of local bee fauna. In Brazil, this line of research is still quite recent, with most studies carried out in regions with a predominance of the Atlantic Rainforest phytogeographic domain. For the Brazilian state of Bahia, such research is still scarce and, especially, if we consider the large territorial dimension that this state denotes. In the area that covers the Cerrado, few studies have been carried out that inventory the urban apifauna. In this paper we present a list of bee species recorded in urban areas of the city of Barreiras, Bahia, Brazil, which represent the first apifauna inventory in the Western region of Bahia. Specimens were collected fortnightly from November 2019 to April 2020, using two sampling methods: colored water traps (ARCAs/pantraps) and entomological net, in two remnants of vegetation used as sampling points. A total of 749 specimens were sampled, distributed in four families, 18 tribes, 29 genera, and 45 species. A total of 369 (49.3%) specimens were collected using the entomological net and 380 specimens (50.7%) by using the ARCAs. Our results showed that the area with the highest level of urbanization had bioindicator species of degraded environments, which benefit from urbanization, and despite the urban growth, the fragments found in the matrix can serve as a refuge for bee fauna, as long as they are well planned.

**Keywords:** ARCAs; Biodiversity; Inventory; Neotropical; Urban fauna.

Over time, bees have developed an intrinsic relationship with the phanerogam flora, from which they obtain the resources necessary for the survival of their populations (*e.g.*, nectar, oils, resins, and pollen). In addition to obtaining shelter from predators and environmental weather. The main ecological importance of these insects is the performance of cross-pollination, thus, ensuring the reproduction of angiosperms, maintenance of gene flow, and plant genetic diversity (Aizen *et al.* 2009; Santiago *et al.* 2009; dos Santos *et al.* 2020; Pires & Maués 2021).

Despite the accumulated knowledge about the importance of bees and other insects as pollinators (Klein *et al.* 2007; Kremen *et al.* 2007; Aizen *et al.* 2009; Kwapong *et al.* 2010; Potts *et al.* 2010, 2016), these animals are enduring strong environmental pressure, especially due to the loss of their habitats and various other misuses of the soil, which poses a serious threat (Beringer *et al.* 2019; Sánchez-Bayo & Wyckhuys 2019). The combination of several factors contribute to the threat that bees face, causing progressive decline. These factors include inadequate management of soil, climatic variations, the advance of agriculture, excessive use of agrochemicals, indiscriminately and/or without criteria to protect pollinators, the action of pathogens and habitat destruction by deforestation, and fires and urbanization intensified by population increase, causing the loss of large forest areas, places that previously served as shelter for these pollinators (Cham *et al.* 2019; Sánchez-Bayo & Wyckhuys 2019).

The process of urbanization, as one of the many anthropomorphic activities, changes the landscape drastically and irreversibly, increasing the proportion of buildings and decreasing areas of forest remnants (Fortel et al. 2014). Urbanization has a tendency to modify the space and thus threaten biodiversity and the ecosystem services it provides (Fortel *et al.* 2014; Araújo *et al.* 2016; Dos Santos *et al.* 2020).

In a global context, few studies have investigated the effects of urbanization on apifauna, as well as the importance of green areas in urban centers for the conservation of local bee fauna (Grandolfo *et al.* 2013; Araújo *et al.* 2016; Cardoso & Gonçalves 2018; De Santis & Chacoff 2020). In Brazil, this line of research is still quite recent, with most studies carried out in regions with a predominance of the Atlantic Rainforest phytogeographic domain (Aidar *et al.* 2013; Araújo *et al.* 2016; Cardoso & Gonçalves 2018; Santana & Oliveira 2010). For the State of Bahia, such research is still scarce and, especially, if we consider the large territorial dimension that this state denotes, which encompasses the convergence of three phytogeographic domains (Atlantic Rainforest, Caatinga, and Cerrado). In the area that covers the Cerrado, few studies have been carried out that inventory the urban apifauna (Antonini *et al.* 2006; Santiago *et al.* 2009; Aidar *et al.* 2013; Grandolfo *et al.* 2013; Leão-Gomes & Nemesio 2020). Despite the great anthropomorphic pressure exerted by agribusiness and considering the real geographic gap in relation to its biodiversity, it is still possible to find fragments of natural vegetation that can play a key role in maintaining regional biodiversity in Cerrado (Joner 2012; Grandolfo *et al.* 2013).

It is known that urbanization causes the loss of natural habitats, as well as promoting the reduction of food sources, nesting sites, number of floral visitors and, therefore, of pollinators. To minimize these impacts on fauna and flora, as well as promoting human well-being, urban environments must provide the configuration of green patches within the urban matrix. This needs to be done in order to conserve the biodiversity of the pollinators, as well as allowing the mobility of individuals between the fragments of forest areas in the urban matrix and adjacent natural fragments (Martins *et al.* 2017; De Santis & Chacoff 2020).

With the increase in urbanization, more studies are needed to understand the dynamics of the bee communities that inhabit this perimeter so that we can contribute to the preservation and/or conservation of Brazilian apifauna (Sirohi *et al*. 2015). Given this context cited above, the purpose of this paper is to know the species of bees residing in the urban perimeter of Barreiras, Bahia, Brazil.

## MATERIAL AND METHODS

The study was carried out in the municipality of Barreiras, Bahia, located in the extreme west of Bahia state, Brazil, at an altitude of 454 m. For the development of the research, two sampling points were chosen within the municipality to carry out the collections which have typical Cerrado vegetation, and subhumid tropical climate according to the Köppen classification (Pina *et al*. 2016). The first collection point was the Exhibitions Park Engenheiro Geraldo Rocha (Area I) (12°08'34" S; 45°00'10" W) with a total area of 44 ha (SEMATUR 2020), and the second study site was at Mimo Mountain range (Area II) (12°08'48" S; 44°57'40" W) (Figure 1), with a total area of 5.900 ha, which were equidistant at approximately 4.5 km.

The two collection points are within the limits of the city's urban perimeter and have different use of occupations. Area I, despite being an environmental protection area, has undergone several changes over time in its natural vegetation with some unsuccessful recovery attempts (SEMATUR 2020). Area II is in a better state of conservation than the first area, but it suffers from fires during dry periods, which changes the original configuration of the flora.

The bees were collected fortnightly, from November 2019 to April 2020, in climatic conditions suitable for bee activity (minimum of 15 °C, light wind and no rain).

Two sampling methods were used: I) actively using entomological nets along the established area, and II) through passive collection using Colored Water Traps (ARCAs or pantraps) in the following colors: blue, white, and yellow (Santana & Oliveira 2010; Moreira *et al.* 2016). Having a grand total of 24 collections over the sampling period.

Afterwards, the bees were sorted, mounted on entomological pins, and sent to the Laboratory of Bionomy, Biogeography and Insect Systematics (BIOSIS-UFBA), located in the Institute of Biology, Universidade Federal da Bahia (IBIO-UFBA), where the insects were identified by a taxonomist (FFO) and later deposited in the BIOSIS reference collection. The classification used in this work follows the proposal by Michener (2007), with small modifications according to Moure *et al*. (2012) (*e.g.*, Oxaeini).

## RESULTS AND DISCUSSION

The bee community was represented by 45 species, 29 genera, 18 tribes, and four families, with a total of 749 individuals sampled. A total of 369 (49.3%) specimens were collected using the entomological nets and 380 specimens (50.7%) by using the ARCAs (Table 1).

Among the five families with occurrence registered in Brazil, four of them were sampled in the present study, namely Andrenidae, Apidae, Halictidae, and Megachilidae. In Andrenidae, two tribes were found: Calliopsini and Oxaeini. For Apidae, a larger number of tribes were present: Apini, Bombini, Centridini, Ceratinini, Emphorini, Ericrocidini, Eucerini, Euglossini, Exomalopsini, Meliponini,

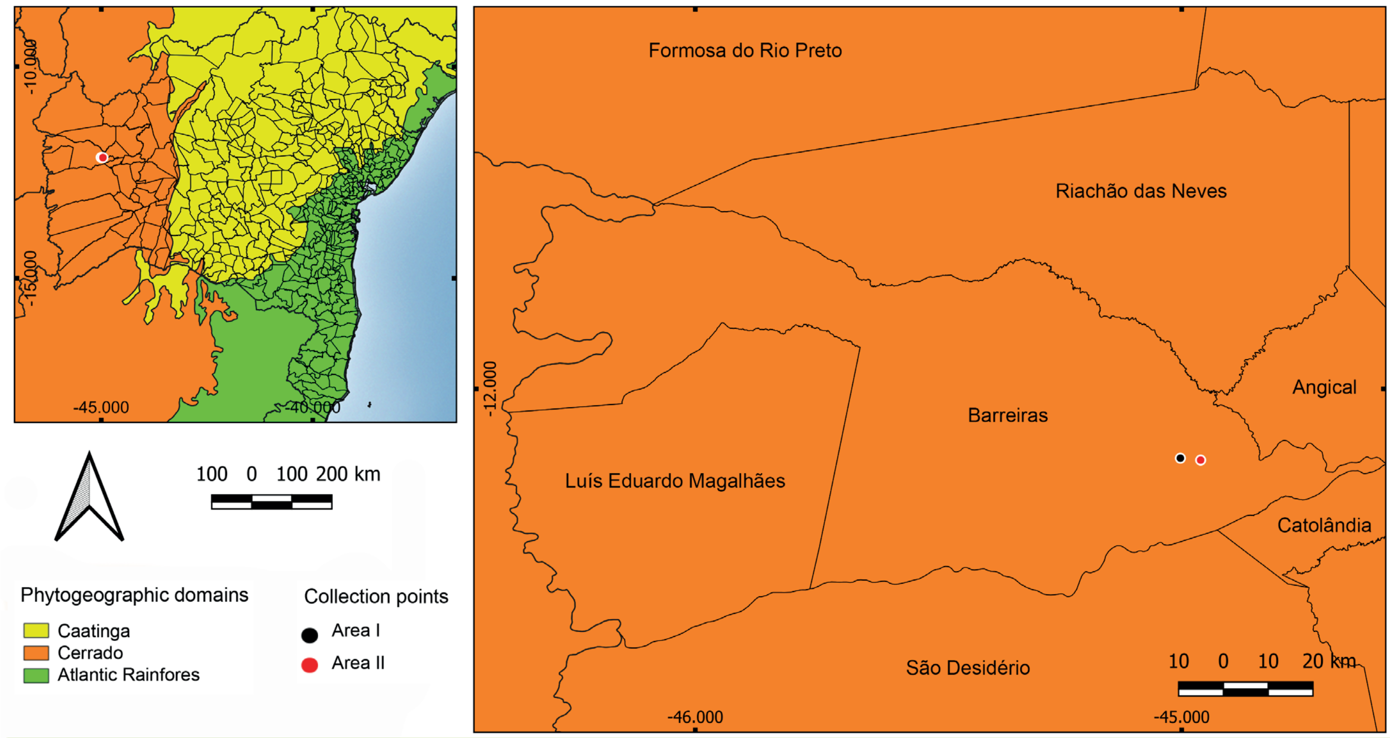


**Figure 1.** Sampling points in the Municipality of Barreiras, Bahia, Brazil. Area I - Park Engenheiro Geraldo Rocha and Area II - Mimo Mountain.

**Table 1.** List of bee species, collection methods and number of individuals sampled in two areas in the municipality of Barreiras, Bahia, Brazil.

| TÁXON | Area I Method | | Area II Method | | TOTAL | RA* (%) |
|---|---|---|---|---|---|---|
| | Passive | Active | Passive | Active | | |
| **Andrenidae** | | | | | | |
| **Calliopsini** | | | | | | |
| *Acamptopoeum prinii* (Holmberg) | - | - | - | 1 | **1** | 0.13 |
| *Callonychium* (*Callonychium*) *brasiliense* (Ducke) | 1 | - | - | - | **1** | 0.13 |
| **Oxaeini** | | | | | | |
| *Oxaea flavescens* Klug | - | - | - | 1 | **1** | 0.13 |
| **Apidae** | | | | | | |
| **Apini** | | | | | | |
| *Apis mellifera* Linnaeus | 21 | 120 | 78 | 99 | **318** | 42.47 |
| **Bombini** | | | | | | |
| *Bombus* (*Thoracobombus*) *brevivillus* Franklin | - | 1 | - | - | **1** | 0.13 |
| **Centridini** | | | | | | |
| *Centris* (*Centris*) *aenea* Lepeletier | - | - | - | 3 | **3** | 0.40 |
| *Centris* (*Hemisiella*) *tarsata* Smith | - | - | - | 1 | **1** | 0.13 |
| *Centris* (*Hemisiella*) *trigonoides* Lepeletier | - | - | - | 2 | **2** | 0.27 |
| *Centris* (*Melacentris*) *obsoleta* Lepeletier | - | 1 | - | - | **1** | 0.3 |
| **Ceratinini** | | | | | | |
| *Ceratina* (*Crewella*) sp. 1 | 2 | 2 | - | - | **4** | 0.53 |
| **Emphorini** | | | | | | |
| *Ancyloscelis* aff. *apiformis* (Fabricius) | 20 | - | - | - | **20** | 2.67 |
| *Diadasina riparia* (Ducke) | 15 | 4 | - | 1 | **20** | 2.67 |
| *Melitoma segmentaria* (Fabricius) | 7 | 1 | - | - | **8** | 1.07 |
| *Melitoma* sp. 1 | 1 | - | - | | **1** | 0.13 |
| *Melitomella murihirta* (Cockerell) | 75 | 1 | - | - | **76** | 10.16 |
| *Ptilothrix plumata* Smith | 1 | - | - | - | **1** | 0.13 |
| **Ericrocidini** | | | | | | |
| *Mesoplia* sp. 1 | 1 | - | - | - | **1** | 0.13 |
| **Eucerini** | | | | | | |
| *Melissoptila uncicornis* (Ducke) | 2 | - | 1 | - | **3** | 0.40 |
| **Euglossini** | | | | | | |
| *Eulaema* (*Apeulaema*) *nigrita* Lepeletier | - | 1 | - | 1 | **2** | 0.27 |
| **Exomalopsini** | | | | | | |
| *Exomalopsis* (*Exomalopsis*) *auropilosa* Spinola | - | - | 1 | 1 | **2** | 0.27 |
| **Meliponini** | | | | | | |
| *Frieseomelitta varia* (Lepeletier) | - | - | 3 | 14 | **17** | 2.27 |
| *Geotrigona mombuca* (Smith) | - | - | - | 4 | **4** | 0.53 |
| *Oxytrigona* sp. 1 | 1 | 2 | 6 | 5 | **14** | 1.88 |
| *Scaptotrigona* aff. *depilis* (Moure) | - | 3 | - | - | **3** | 0.40 |
| *Scaptotrigona postica* (Latreille) | 4 | 3 | 12 | 1 | **20** | 2.67 |
| *Scaptotrigona* sp. 1 | - | 2 | - | - | **2** | 0.27 |
| *Tetragonisca angustula* (Latreille) | 1 | 6 | 2 | 7 | **16** | 2.14 |
| *Trigona* sp. 1 | 8 | 8 | 13 | 28 | **57** | 7.62 |
| *Trigona* sp. 2 | - | - | 2 | 5 | **7** | 0.93 |
| *Trigona spinipes* (Fabricius) | 17 | 5 | 39 | 19 | **80** | 10.69 |
| **Tapinotaspidini** | | | | | | |
| *Paratetrapedia* sp. 1 | - | **-** | 1 | - | **1** | 0.13 |
| **Xylocopini** | | | | | | |

*to be continued*

**Figure 1.** *Continue...*

| TÁXON | Area I Method | | Area II Method | | TOTAL | RA* (%) |
|---|---|---|---|---|---|---|
| | Passive | Active | Passive | Active | | |
| *Xylocopa* (*Neoxylocopa*) *frontalis* (Olivier) | - | - | - | 2 | **2** | 0.27 |
| *Xylocopa* (*Neoxylocopa*) *grisescens* Lepeletier | - | - | - | 3 | **3** | 0.40 |
| *Xylocopa* (*Neoxylocopa*) *hirsutissima* Maidl | - | - | - | 1 | **1** | 0.13 |
| *Xylocopa* (*Schonnherria*) *muscaria* (Fabricius) | - | - | - | 1 | **1** | 0.13 |
| **Halictidae** | | | | | | |
| **Augochlorini** | | | | | | |
| *Augochlora* (*Oxystoglossella*) *aurinasis* (Vachal) | 2 | - | 3 | 1 | **6** | 0. 80 |
| *Augochlora* (*Oxystoglossella*) sp. 1 | 2 | - | 11 | 2 | **15** | 2.00 |
| *Augochlora* (*Oxystoglossella*) sp. 2 | - | - | 1 | - | **1** | 0.13 |
| *Augochlorella tredecim* (Vachal) | 15 | - | - | 1 | **16** | 2.14 |
| **Halictini** | | | | | | |
| *Dialictus opacus* (Moure) | 2 | - | 2 | - | **4** | 0.53 |
| *Dialictus* sp. 1 | 2 | - | - | - | **2** | 0.27 |
| *Dialictus* sp. 2 | - | - | 1 | - | **1** | 0.13 |
| *Dialictus* sp. 3 | 1 | - | - | - | **1** | 0.13 |
| **Megachilidae** | | | | | | |
| **Anthidiini** | | | | | | |
| *Dicranthidium arenarium* (Ducke) | - | - | 3 | 4 | **7** | 0.93 |
| **Megachilini** | | | | | | |
| *Megachile* (*Pseudocentron*) sp. 1 | - | - | - | 1 | **1** | 0.13 |
| **TOTAL** | **201** | **160** | **179** | **209** | **749** | **100%** |

*RA- Relative abundance.

Tapinotaspidini, and Xylocopini. For Halictidae, two tribes were counted (Augochlorini and Halictini), and for Megachilidae two tribes were counted as well: Anthidiini and Megachilini (Table 1).

Among all the tribes, the most abundant was the Apini, followed by Meliponini (both characterized by the eusocial habit) and the Emphorini, the latter having a solitary habit but building their nests aggregated in the ground, having been quite attracted by the ARCAs. The most abundant species (relative abundance) were the exotic Africanized *Apis mellifera* Linnaeus (n = 318), followed by the native *Trigona spinipes* (Fabricius) (n = 80) and *Melitomella murihirta* (Cockerell) (n = 76) (Table 1).

The findings of this research reveal that urban growth is a serious threat to biodiversity, impacting the loss of habitats and reducing the number of pollinators, which can generate long-term effects such as increased temperature, soil compaction, and soil and air pollution (Geslin *et al.* 2016). However, these effects are felt by bees in different ways depending on the group, where some can be strongly benefited by the effects of urbanization, to the detriment of others (*e.g.*, Fortel *et al.* 2014; Sirohi *et al.* 2015; Martins *et al.* 2017; Normandin *et al.* 2017).

Apidae is the most present family in several studies, both nationally and internationally. It is coherent to highlight it as the most represented in this study as well, what corresponds to the normal biodiversity of this family (Santiago *et al.* 2009; Martins *et al.* 2013; Fortel *et al.* 2014; Sirohi *et al.* 2015; Normandin *et al.* 2017; De Santis & Chacoff 2020).

The sampling of the Euglossini tribe was not satisfactory compared to other studies performed in Brazil. Only two individuals were collected (Table 1), possibly because the method of collection using scent baits that commonly attract males from this tribe was not used, which justifies its low representativeness in the present study (Grandolfo *et al.* 2013). As for the habits of bees, a greater richness of solitary species was found (approximately 73%), reinforcing the scientific findings of studies carried out around the world (*e.g.*, Normandin *et al.* 2017; De Santis & Chacoff 2020). However, more richness is expected for solitary bees, as around 85% of the bee fauna corresponds to solitary bees (Batra 1984).

As for the Meliponini tribe, with social habits, greater abundance was recorded for the place with the lowest degree of urbanization, not corroborating the findings of Araújo *et al.* (2016) for urban areas in Minas Gerais (Atlantic Rainforest area). Most of the work on urban apifauna inventories has focused its efforts on the Meliponini tribe due to its high adaptability to areas with intermediate and high degrees of anthropization (Aidar *et al.* 2013; Araújo *et al.* 2016; de Araujo & Witt 2020).

The use of more than one sampling method together is indicated by the literature for a more complete sampling, enabling the sampling of rarer species or species that are difficult to collect with an entomological net (Sakagami *et al.* 1967; Krug & Alves-dos-Santos 2008; Santana & Oliveira 2010; Teixeira 2012). The use of the entomological net in synergy with the ARCA is already a routine methodology in apifauna inventories, a methodology also used for the present study (Fortel *et al.* 2014; Sirohi *et al.* 2015; Normandin *et al.* 2017), although the ARCAs are more efficient in collecting small to medium sized bees, which have greater difficulty escaping the trap. The use of ARCAs has gained notoriety for the inventory of bee fauna in Brazil, but for the Cerrado, specifically for the western region of Bahia, there is still no record of inventories using this type of trap (Santana & Oliveira 2010; Moreira *et al.* 2016).

The effect of urbanization can generate negative impacts leading to the loss of natural habitats, as well as the reduction of food sources and nesting sites, so it is important to have urban planning in order to mitigate these effects (Martins *et al*. 2017; De Santis & Chacoff 2020). Thus, as noted by Fortel *et al.* (2014) and Araújo *et al.* (2016), the place with the highest level of urbanization was characterized by less biodiversity.

Bearing in mind the configuration and characteristics of urban spaces, the overlapping of permeable and impermeable areas, decrease in the supply of foraging resources, and habitat fragmentation subject bee populations to anthropogenic pressure, what together corresponds the serious consequences generated by urbanization. Urban centers can serve as a refuge for certain groups of pollinators, disfavoring species that nest in the soil and favoring those that nest in pre-existing cavities, as is the case of *Eulaema* (*Apeulaema*) *nigrita* Lepeletier. In Fortel *et al.* (2014), which used the same methodology we adopted (ARCAs and entomological nets), and in Cardoso & Gonçalves (2018) and Nelson *et al.* (2021) which used only one of the methods, being the entomological nets and ARCAs, indicated different bee species can function as bioindicators of disturbed areas, as observed also for *Eulaema* (*Apeulaema*) *nigrita* by Grandolfo et al. (2013). However, in the present study, only two females of *Eulaema* (*Apeulaema*) *nigrita* were sampled (Table 1), despite the majority of species of this tribe have the characteristic of flying long distances and being widely distributed in the Americas from the south of the United States of America (Texas) to Argentina, with greater diversity in the Neotropical region (Michener 2007; Moure *et al*. 2012).

The Halictidae bees also has a wide distribution worldwide, having different levels of sociability and collected in the urban areas of South America, North America, Canada, and France (Santiago *et al.* 2009; Martins *et al.* 2013; Fortel *et al.* 2014; Normandin *et al.* 2017; De Santis & Chacoff 2020). This family were poorly represented in the present study, with few specimens from the Augochlorini and Halictini tribes. In our case, the occurrence of these tribes has been related to more preserved habitats, even in studies related to the effects of urbanization on bees in different parts of the world (Fortel *et al.* 2014; Normandin *et al.* 2017). The Augochlorini tribe is well represented in tropical forest areas and Halictini has been commonly sampled in southern and southeastern Brazil.

Similarly, for Megachilidae, we sampled individuals belonging to two tribes, Anthidiini and Megachilini (Table 1), which were represented by a few specimens. Those in this family have the habit of a solitary life, using pieces of leaves and plant debris also using preexisting holes in tree trunks to build their nests. Species of this family were found in apifauna inventories in areas that suffer less anthropogenic influence (Santiago *et al.* 2009; Sirohi *et al.* 2015).

The Africanized bee, *A. mellifera* (Apini tribe), was the most abundant species, as well as in other studies carried out in Brazil, due to its great adaptive capacity and generalist habits, in addition to its extremely populated nests (one of the most populous of all bee species), which can be housed in different types of substrates. Furthermore, they can be kept in rational breeding, greatly increasing the population in certain areas. In some urban apifauna inventories, this species is sometimes not included in the results, precisely because it is so easily found and it is an exotic species. However, it is a species that is already integrated and adapted to Brazilian ecosystems, whose pollination services should not be neglected (Martins *et al.* 2017; De Santis & Chacoff 2020).

The species of the Centridini are very diverse solitary bees, having a habit of collecting floral oils. Its presence is more commonly observed in more preserved areas, such as Area II, which has forest remnants of its original biome. In studies carried out in urban areas of temperate regions, mentioned above (Martins *et al.* 2017; De Santis & Chacoff 2020; Santiago *et al.* 2009), several species of this tribe were sampled, with few individuals collected. In the present study, the tribe was represented by the genus *Centris*, with only four species recorded, and few specimens collected (Table 1). Similarly, species from this tribe have already been sampled in inventories carried out in Urban Parks in Iporá, Goiás, in the Cerrado (Santiago *et al.* 2009).

The Emphorini bees occurs in the Americas from southern Canada to Argentina, inhabiting the most diverse biomes, with the species collected in this study were mostly associated with Area I. The species *Melitoma segmentaria* (Fabricius) was also sampled in urban habitats in São José dos Pinhais, Paraná, Brazil, and *Ancyloscelis apiformis* (Fabricius) in the urban perimeter of Salvador, Bahia, in the Atlantic Rainforest domain (Santana & Oliveira 2010; Martins *et al.* 2013).

The results showed that, despite the urban growth, the fragments found in the matrix can serve as a refuge for bee fauna, as long as they are well planned. Our results support research in the field of urban bee ecology in Cerrado, filling a gap in knowledge, which may be the first step in the construction of an instrument for understanding the urban bee fauna for the far west of Bahia, another gap identified during the review of literature.

## ACKNOWLEDGEMENTS

We are grateful to the Universidade Estadual da Bahia (UNEB), Campus IX (Barreiras - where the first author of this article graduated). This paper configures a partnership between the Universidade Federal da Bahia (UFBA) and UNEB to carry out a Final Course Paper (TCC) project, through the Laboratory of Bionomy, Biogeography and Insect Systematics (BIOSIS), of the Institute of Biology (IBIO-UFBA), coordinated by the fourth author of this article.

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