AGRARIAN SCIENCES

Trap nest preference of solitary bees in fragments of the Baturité massif, Atlantic Forest, Brazil

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Abstract: The study investigated native solitary bee species that nest in pre-existing cavities in the Baturité Massif, State of Ceará, Brazil, their preference for nest substrates and aspects of these bee communities. Samples were taken in four distinct areas of the Baturité Massif using three types of trap-nests: dried bamboo internodes, cardboard tubes and rational boxes. Out of the 185 nests offered, 34 were colonized and 24 of them produced 131 bees, belonging to two families (Apidae and Megachilidae) and five genera (*Centris*, *Mesocheira*, *Euglossa*, *Megachile* and *Coelioxys*) from six species, including parasitic ones. Nesting preference was observed to certain types of substrates (χ^2=17.89, p<0.001), with bamboo internodes being preferred by bee to build their nests, while monthly variation in temperature and humidity did not affect bee emergency. Spite of few nests foundations and the few species sampled, this work contributed to an unprecedented knowledge about the species that use pre-existing cavities in the Baturité Massif that may contribute to assist in the maintenance and conservation of this mountainous area and can be useful for pollination services of native and agricultural plants.

Key words: Apidae, emergence, Megachilidae, trap-nest.

INTRODUCTION

The Baturité mountain range or Baturité Massif, located in the State of Ceará, has one of the few remnants of Atlantic Forest reserves in the Brazilian Northeast, with diverse flora and fauna (Santos et al. 2012, Pinheiro & Sousa-Silva 2017). Considered important for the maintenance of biological diversity, the Baturité mountain range preserves a true gene bank of the biodiversity of plants and animals of the region (SEMACE 1992, Silva et al. 2014). Although there is some information about the botanical aspects of this mountain range, little is known about the bee fauna, especially in its higher and humid areas (Westerkamp et al. 2006).

The first survey on bee species in the region of the Baturité Massif was carried out over a hundred years (between 1906 and 1909) by Adolpho Ducke. Ducke's collections were punctual and reported the existence of about 90 species of bees belonging to the families Apidae, Megachilidae, Halictidae, Andrenidae and Colletidae (DUCKE 1907, 1908, 1910, 1911). Westerkamp et al. (2006) studied the passage of this researcher in the Baturité mountain range and updated the scientific names of bee species found by him, along with some casual observations. However, they noted that Ducke's inventory needs more details, confirmation, and amplification of the data and suggested that

not all bee species collected in this area by the researcher are still currently found.

Recently, other studies with bees were carried out in the region. Bezerra (2010) analyzed the bee community structure in a caatinga area of the Baturité Massif and sampled 56 species, represented in 28 genera and four families (Apidae, Halictidae, Andrenidae and Megachilidae) with a total of 2,463 individuals collected. Lima-Verde (2011) investigated the structure of bee communities on the edges of four forest fragments of the Baturité Massif and collected 113 species of bees belonging to the families Andrenidae, Apidae, Colletidae, Halictidae and Megachilidae in a total of 3,053 species of plants. Guimarães (2011) carried out a survey of Euglossini bees in an Atlantic Forest fragment of the Baturité Massif and sampled 1,012 males, belonging to 8 species. These studies show that a century after Ducke's studies, about forty new species records were added to this mountainous area (Bezerra 2010, Guimarães 2011, Lima-Verde 2011).

The knowledge about the species of native bees occurring in the mountain range of Baturité is fundamental to define strategies for their conservation. In this sense, the goal of this study is to contribute to the knowledge about the native solitary, communal and primitively eusocial bees that occur in the Baturité mountain range, State of Ceará, providing information about the structure of solitary bee communities that nest in pre-existing cavities and their preferences for types of substrates used in the construction of their nests.

MATERIALS AND METHODS

Studied area

The study was carried out in four areas in the Atlantic Forest domain, located in the Environmental Preservation Area (EPA) of the Baturité Massif, State of Ceará (Figure 1), from September 2012 to November 2013. These areas hereinafter referred to as A1, A2, A3 and A4. Locally known as: A1 - Alto da Serra Tourist Complex: located in the municipality of Guaramiranga, State of Ceará, between the geographical coordinates 4°15'28.1''S and 38°55'39.8''W and 919 m altitude; A2 - Pousada Café Brasil: located in the municipality of Guaramiranga, State of Ceará, between the geographical coordinates 4°15'20.7''S and 38°57'57.9''W and 888 m altitude; A3 - Remanso Hotel da Serra: located in the municipality of Guaramiranga, State of Ceará, between the geographical coordinates 4°14'33.5''S and 38°55'41.9''W and 830 m altitude and A4 - Chalé Nosso Sítio: located in the municipality of Pacoti, State of Ceará, between the geographical coordinates 4°13'24.6''S and 38°55'41.5''W and 760 m altitude.

Characterization of studied areas

The mountain range of Baturité is about 55 km long and an average width of 30 km. It is located in the northeastern portion of the State of Ceará between coordinates 4° and 4°30' South latitude and 38°45' to 39°15' West longitude. It presents altitudes ranging from 400 to over 1000 m, with a maximum peak of 1,114 m (Pico Alto) (Souza 1997, Fernandes 1998).

This mountainous area concentrates one of the last reserves of Atlantic Forest of Northeastern Brazil, possessing diverse flora and fauna, as well as streams and waterfalls of crystalline waters (Santos et al. 2012). The vegetation typology of the studied area is characterized by the Montane Ombrophilous Forest (Wet Mountainous Forest), configured as separate remnants of Atlantic Forest (Figueiredo & Barboza 1990, Veloso et al. 1991, Fernandes 1998).

The characteristic climate of the Baturité mountain range is Aw', hot and humid, according
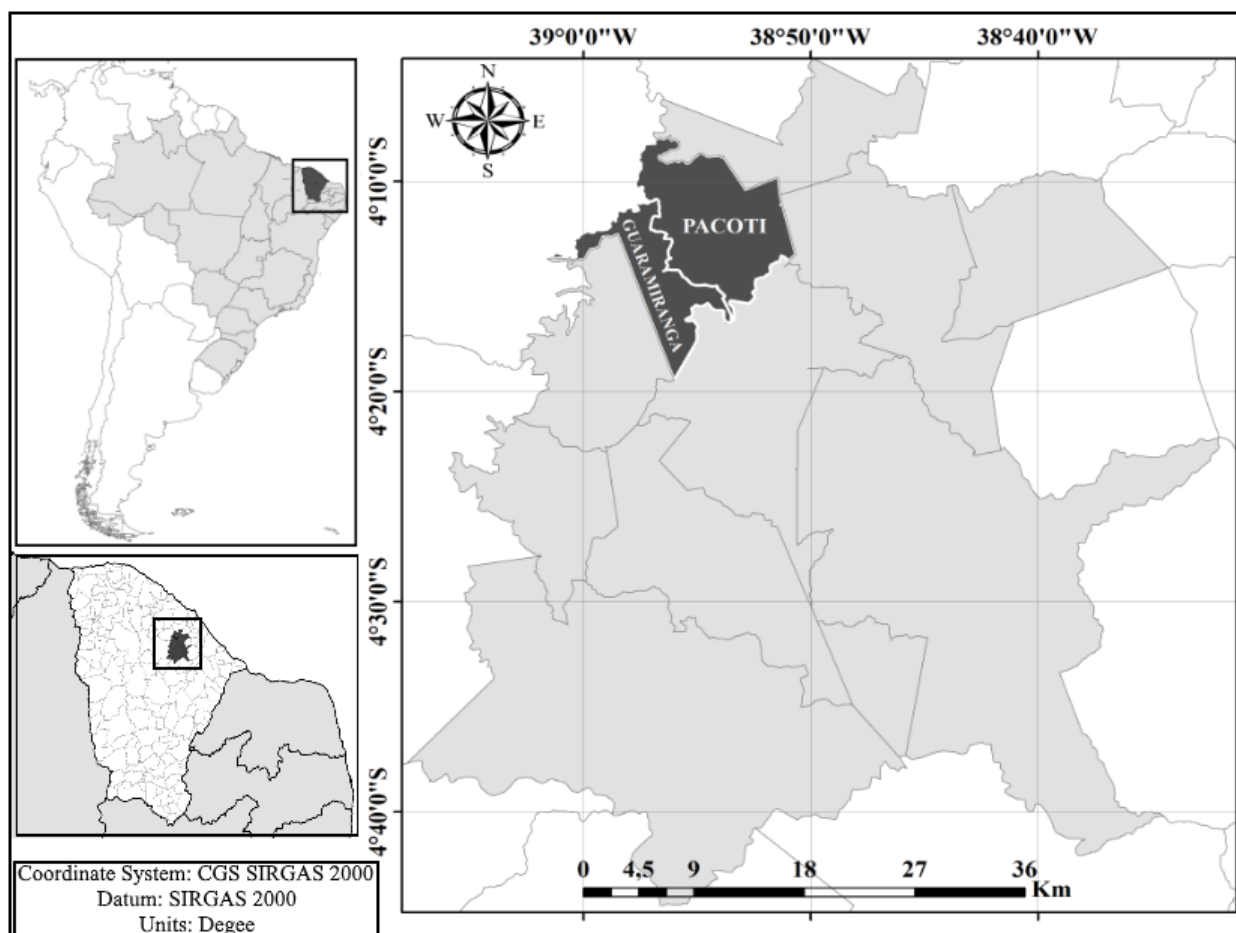
Figure 1. Location of the studied municipalities regarding the nesting biology of solitary bees in the State of Ceará, highlighting the region of the Baturité Massif and the two municipalities studied (Guaramiranga and Pacoti).

to the Köeppen classification system (1948). In the study period, data of temperature and rainfall were collected and compared with the historical records of the last 30 years (1983 - 2013) for the municipality of Guaramiranga (Figure 2). The data were obtained from the website of the Instituto Nacional de Meteorologia (INMET 2015). According to the data acquired, the study was divided into two periods: rainy or humid season (January to July), with average temperature during the study ranging from 20 to 22 °C and total rainfall of 1268.4 mm, and the dry season (August to December), with average temperature during the study ranging from 20 to 21.5 °C and total rainfall of 142.6 mm.

Sampling of bees

Trap-nests (TNs) were used for sampling bees. They were arranged in nesting stations, made with wooden poles and covered with plastic tarpaulin. In each one of the four areas, a nesting station was placed, with the TNs placed on wooden shelves fixed to the support pole, at a distance of 1.3 m from the ground.

For the experimental setup, three types of TNs were made using dry bamboo internodes, tubes made of black paperboard and wooden boxes for solitary bees (Figure 3). Each dry bamboo internode had an open end and another closed by the node itself, with a length of 20 cm and a diameter of the hole varying from

Figure 2. Climatic data of the Baturité Massif observed from September 2012 to November 2013 and historical record of the values of temperature and monthly rainfall of the last 30 years recorded (1983 - 2013) for the municipality of Guaramiranga, State of Ceará, Brazil (INMET 2015).
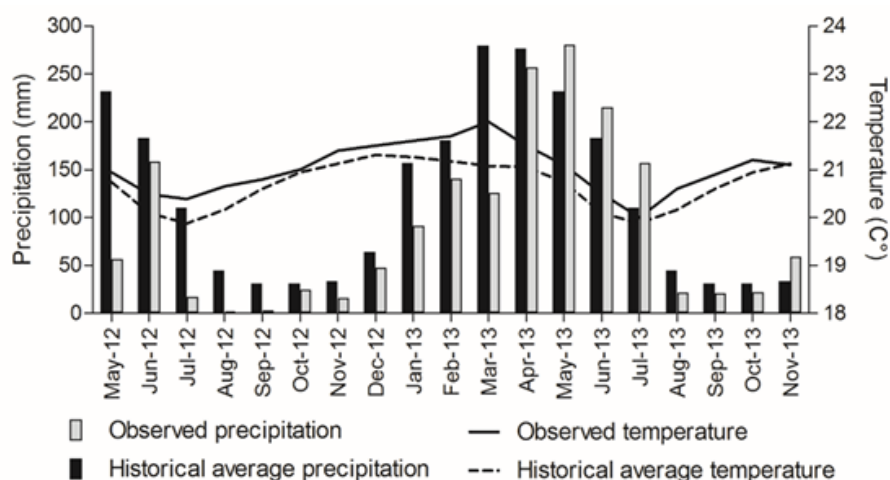
0.5 cm to 3.0 cm, according to the methodology presented by Camillo et al. (1995). These internodes were introduced in building bricks, placed horizontally on the shelf of the station, totaling 18 units made available in each station. The tubes made of black paperboard had one end sealed with the same material and were inserted into blocks of wood. In each block, six holes of 1 cm and six holes of 2 cm were made, totaling 12 holes per block in each station. All tubes were 20 cm in length.

The wooden boxes for solitary bees consisted of four units with external dimensions of 12 cm high x 12 cm wide x 10 cm long; a unit with external dimensions of 15 cm high x 20 cm wide x 22 cm long; a unit with external dimensions of 18 cm high x 14 cm wide x 22 cm long and a unit with external dimensions of 14 cm high x 9 cm wide x 19 cm long. The opening diameters of the boxes were 1.0 cm and 2.0 cm and the thickness of the wood was 1.0 cm. All nesting stations had the same number of trap-nests.

Fortnightly, TNs were evaluated in order to verify their occupation. Nests constructed in bamboo internodes and paperboard tubes, when occupied by bees, were collected after the founding female had completed her reproductive activities of nest construction, labeled and taken

to the laboratory. Nests that contained active females (visual record) or that were not yet with their entrance sealed, indicating that the nest was not finalized, were left in their respective places and collected in the next inspection 15 days later. In the laboratory, the entrances of both types of nests (bamboos and cardboard tubes) were individually connected in transparent PET plastic bottles, sealed with adhesive tape, kept at room temperature and inspected daily until the emergence of individuals.

In the wooden boxes which have also been inspected fortnightly, insofar as the brood cells were sealed, a test tube was placed in the entrance of the box until the individuals emerged. After the first bees had emerged, the boxes were taken to the laboratory, where they were observed daily to evaluate and to record the emergence of individuals.

After the TNs were removed from the studied areas, others of similar size were placed in the same place to keep equal number of nests in the stations.

All specimens collected were killed in a lethal chamber under ethyl acetate vapor, mounted on entomological pins, taken to an oven at 40 °C and properly labeled. The taxonomic identification of bees was carried
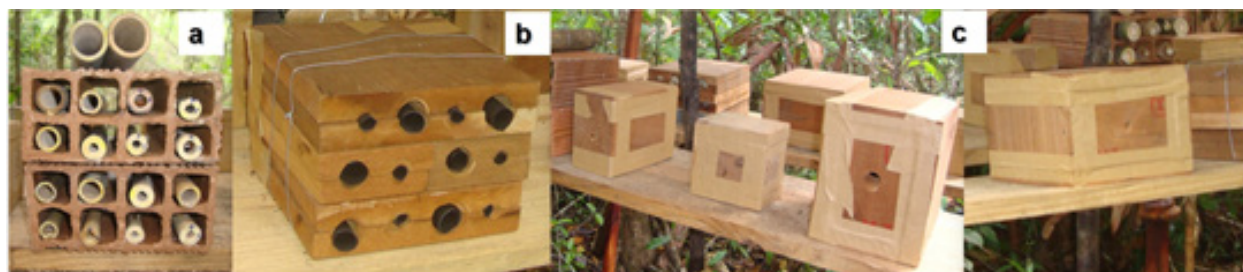
Figure 3. Trap-nests installed in the Baturité Massif, State of Ceará, Brazil: **a)** dry bamboo internodes; **b)** tubes made of black paperboard and **c)** wooden boxes for solitary bees.

out by specialists from the Universidade de São Paulo.

Data analysis

Generalized linear models (GLM) at the significance level of 5% were used to verify whether the environmental variables (temperature, humidity and rainfall) or whether the differences between the studied areas may have influenced changes in the nesting rate in the pre-existing substrates and the number of emerged bees. In order to evaluate the effect of the environmental variables on the number of species of bees nesting and on the number of bees emerging, we measured the deviance caused by the withdrawal of each variable from the model with all the independent variables. A Poisson distribution was used for the number of species of nesting bees and a Normal distribution was used for the number of emergent bees.

To evaluate the degree of similarity between the sampled areas in terms of species composition, a cluster analysis was applied using the Morisita-Horn similarity index (Magurran 2003). The algorithm used for this analysis was the UPGMA. This index considers both the composition and the abundance of species (Magurran 2003). This analysis was performed using PAST software version 2.17c (Hammer et al. 2001).

The diversity of bee species that nested in trap-nests in the sampled studied areas was estimated using the Shannon-Weaver (H') diversity index (Shannon & Weaver 1949, Magurran 2003). This index expresses the proportion of individuals in relation to the total sample and the species richness. The higher the value, the greater the sample diversity. The data obtained in each of the four sampled areas were compared one by one by t-test at a significance level of 5%. The uniformity in the distribution of abundance of individuals in each area was estimated using the Pielou Evenness Index (J'), which refers to the pattern of distribution of individuals among species (Pielou 1975, Magurran 2003).

The degree of species dominance in the areas was measured by the Berger-Parker index, which expresses the proportional importance of the most abundant species in each sample (Berger & Parker 1970, Magurran 2003). All these analyses (Diversity, Evenness and Dominance) were run in the PAST software version 2.17c (Hammer et al. 2001).

The bees preference in the use of substrates (bamboo internodes, paperboard tubes and wooden boxes) and bamboo diameters were investigated using the non-parametric Kruskal-Wallis test, with a post-hoc Mann-Whitney test (Zar 1996).

RESULTS

Out of the 185 nests used monthly, only 34 were colonized and of these only 24 nests registered bee emergence in the four studied areas. At the end of the study, 131 bees emerged, belonging to two families (Apidae and Megachilidae) and five genera (*Centris, Mesocheira, Euglossa, Megachile* and *Coelioxys*) from six species captured (Table I).

In numerical terms, area A2 presented the highest number of species, whereas A3 and A4 presented fewer species. However, the comparison between the indices showed there were no significant differences between areas (p> 0.05). Areas A1 and A4 presented the highest values of evenness, demonstrating that, in these areas, the abundance of individuals is more evenly distributed among species than in areas A2 and A3. The Berger-Parker dominance index

(inverse to Pielou evenness) also revealed lower homogeneity in abundance in area A3, followed by A2, A4 and A1 (Table I).

Evaluating the sampled areas, it was observed that the A2 and A4 locations had the largest number of emerged individuals, 43.5% and 32.1%, respectively. A3 and A1, together, had 24.4% of the total of individuals emerged.

There was no influence of climatic factors on the number of bee species that founded the nests and on the number of bees that emerged (Table II). There was also no significant difference in the number of bee species that founded nests (p = 0.798) and in the number of bees that emerged (p = 0.059) between the studied areas (Table II).

The similarity between the four studied areas, analyzed through the Morisita-Horn index, indicated a high similarity in the composition

Table I. Composition, number and abundance of species (nest founders and kleptoparasites) sampled in the four studied areas; Shannon-Weaver Diversity (H'); Pielou Evenness Index (J') and Berger-Parker Dominance (d) of the studied areas in the period between September 2012 to November 2013, in the Baturité Massif, State of Ceará, Brazil.

Family / Species	A1	A2	A3	A4	Total
Apidae					
Centris (*Hemisiella*) *tarsata* Smith, 1874	5	27	-	22	54
Centris (*Heterocentris*) sp.	3	-	7	7	17
Mesocheira bicolor Fabricius, 1804	-	1	1	-	2
Euglossa pleosticta Dressler, 1982	-	16	-	-	16
Megachilidae					
Megachile (*Austromegachile*) aff. *susurrans* Haliday, 1836	5	11	-	-	16
Coelioxys (*Cyrtocoelioxys*) sp.	6	2	5	13	26
Species abundance	19 (14.5%)	57 (43.5%)	13 (9.9%)	42 (32.1%)	131
Number of occupant species	4	5	3	3	
Shannon Diversity (H')	1.06	1.18	0.90	1.00	
Evenness (J')	0.97	0.73	0.82	0.91	
Berger-Parker Dominance (d)	0.43	0.52	0.54	0.52	

and abundance of species between areas A2 and A4 (73%) and between areas A1 and A3 (70%). However, these two groups of similar areas differ from each other, around 70% (Figure 4).
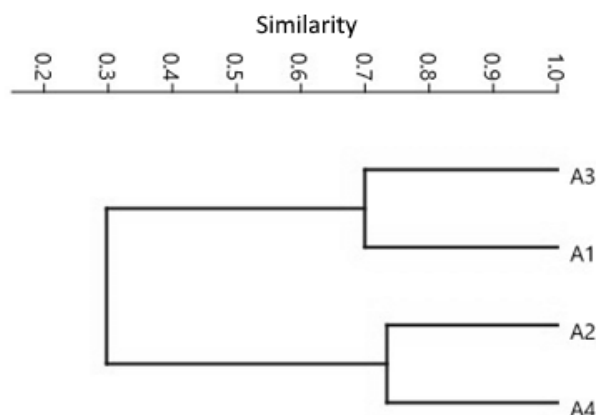
Bees nested in the three types of trap-nests offered. However, preference was given to certain types of substrates (χ^2 = 17.89, p = 0.0001), with bamboo internodes being the most used by bees to construct their nests (p <0.05) corresponding to 82% (n = 28) of the total used. Of the 28 nests constructed in bamboo internodes, total mortality of individuals before reaching the adult phase was 35.7% (n = 10), and it was not possible to know which bee species built those nests. The tubes made of paperboard had less occupation, 12% (n = 4) of the total nests founded. Of all types of wooden boxes tested, those with external dimensions of 12 cm high x 12 cm wide x 10 cm long were the only ones occupied by bees and corresponded to 6% (n = 2) of the total nests used (Table III).

In relation to kleptoparasite bees, it was observed that *Mesocheira bicolor* preferred hosts that nested in bamboo internodes and cardboard tubes and *Coelioxys* (*Cyrtocoelioxys*)

sp. parasitized only nests founded in bamboo internodes. All parasitized nests had a diameter ranging from 0.5 to 0.9 cm in diameter. In the wooden boxes there was no emergence of parasitic bees.

In general, it was observed that bees nested on substrates with a maximum of 1.2 cm in diameter, revealing a higher preference for nesting in holes with smaller diameters, however, this preference varied according to each species (Table IV). In relation to the diameter of the cardboard tubes, the females used only the ones with 1.0 cm for the foundation of their nests. In relation to the diameters of the wooden boxes, the bees occupied both boxes with entrance of 1.0 cm and 2.0 cm diameter. There was no difference in the preference for diameter of nests constructed in bamboo internodes by nesting bees (χ^2 = 12.06, p = 0.098) and by emerging bees (χ^2 = 5.5, p = 0.482).

Centris (*Heterocentris*) sp. and *Megachile* (*Austromegachile*) aff. *susurrans* nested exclusively on bamboo internodes and preferred the mean diameters of 0.97 ± 0.16 cm and 0.78 ± 0.19 cm, respectively. Whereas, *Centris* (*Hemisiella*) *tarsata* used both bamboo internodes (with a mean diameter of 0.8 ± 0.08 cm), and cardboard tubes with 1.0 cm holes to found the nests (Table IV). *Euglossa pleosticta* was the only species that exclusively nested in wooden box and occupied boxes with 1.0 and 2.0 cm diameter holes. In the box with entrance of 2.0 cm, it was observed that this species closed the entire entrance with a resin curtain and left only an opening of about 1.0 cm.

DISCUSSION

This study revealed a high similarity in the community structure among the four areas studied in relation to the fauna of solitary

Figure 4. Similarity (Morisita-Horn index) between the studied areas in the period between September 2012 to November 2013 in the Baturité Massif, State of Ceará, Brazil.

Table II. Results of generalized linear model performed to explain the relation among the environmental variables, number of nesting bee species and number of emergent bee species.

Dependent variables	Independent variables	Deviance	F	p
Number of species of nesting bees	Temperature	0.264	---	0.608
	Humidity	0.461	---	0.497
	Rainfall	0.000	---	0.998
	Area	1.659	---	0.798
Number of bees emerged	Temperature	0.170	0.326	0.570
	Humidity	0.582	1.117	0.294
	Rainfall	0.473	0.908	0.344
	Area	4.986	2.393	0.059

Table III. Species of bees and occupation of different types of trap-nests (GB = Bamboo internodes; TC = Cardboard tubes; CR = Wooden box) in the four studied areas, from September 2012 to November 2013, Baturité Massif, State of Ceará, Brazil.

Species	AREAS											
	A1			A2			A3			A4		
	GB	TC	CR	GB	TC	CR	GB	TC	CR	GB	TC	CR
	N (%)			N (%)			N (%)			N (%)		
Centris (*Hemisiella*) *tarsata* Smith, 1874	-	-	-	2 (50%)	3 (100%)	-	-	-	-	3 (60%)	1 (100%)	-
Centris (*Heterocentris*) sp.	1 (50%)	-	-	-	-	-	3 (100%)	-	-	2 (40%)	-	-
Mesocheira bicolor Fabricius, 1804*	-	-	-	-	1	-	1	-	-	-	-	-
Euglossa pleosticta Dressler, 1982	-	-	-	-	-	2 (100%)	-	-	-	-	-	-
Megachile (*Austromegachile*) aff. *susurrans* Haliday, 1836	1 (50%)	-	-	2 (50%)	-	-	-	-	-	-	-	-
Coelioxys (*Cyrtocoelioxys*) sp.*	1	-	-	1	-	-	2	-	-	3	-	-
Total nests occupied	2 (100%)	-	-	4 (100%)	3 (100%)	2 (100%)	3 (100%)	-	-	5 (100%)	1 (100%)	-
Total species	2	-	-	2	1	1	3	-	-	2	1	-

*Kleptoparasite bee species are not included in the percentage of preference for substrate, as they are not founders.

bees that nest in TNs, suggesting that this fauna is homogeneous across the Baturité Massif. Although there is a greater similarity in the composition and abundance of species between areas A2 and A4 and between areas A1 and A3, the effect of vegetation type, floristic composition, climatic aspects and anthropic pressure are probably similar in these areas, making the bee fauna in these places similar. Gathmann et al. (1994) and Mallinger et al. (2016) pointed out that the floral diversity and abundance of fragments should be taken into account, since an area with a high diversity of mellithophilous flowers can provide greater diversity and abundance of bees in trap-nests, being, therefore, directly proportional aspects. Other studies (Tonhasca et al. 2002, Buschini 2006, De Palma et al. 2016) also show that the equivalence between nesting species diversity results from the level of geographic similarity between habitats. It is noteworthy that another factor that could have influenced this result is the small number of species, since the small numerical differences tend to favor the homogeneity between the areas.

In the Atlantic Forest fragments of the Baturité Massif, it was verified that the bees showed little preference for nesting in trap-nests, presenting low richness and abundance of captured species. Although it is not possible to evaluate the abundance of individuals of each species, it was possible to identify species present in the area, their frequencies, those that most easily accept artificial nests of the types tested and their nesting preferences. The fact that some nested on long substrates such as bamboos and tubes and others in boxes, preferred diameters of nests, depends on the nesting strategy of the species itself and decreases the competition for nesting sites between species, also hindering the supply of a large variety of potential substrates to sample more species.

Moreover, the low variation in diameter and the constant height at which trap-nests were installed may have reduced the occupancy rate of these artificial cavities (Buschini 2006, Viana et al. 2001, Stangler et al. 2016). In this way, the availability of natural potential cavities for nesting and the different micro-habitats are fundamental agents that unite the general community of bees and their respective abundance (Potts et al. 2005, Roberts et al. 2017). A characteristic of bees nesting in cavities refers to fluctuations in individual annual frequencies. These manifestations of bee populations, in turn, may be related to the availability of environmental resources and climatic factors (Frankie et al. 1998, Oertli et al. 2005, Stangler et al. 2015). The lack of a statistical relationship of climatic factors on the population parameters of the community of bees suggests that other factors present in the habitat (food and nesting sites) are the most probable responsible for this low diversity of species. Nevertheless, it is still possible that low rainfall within the studied period had a significant biological effect on the bee fauna, since the year 2012 presented the lowest rainfall of the last 30 years recorded (940.8 mm), with monthly average of 78.4 mm. The year 2013 was characterized by heavy rainfall events, totaling an annual rainfall of 1408.1 mm, with a monthly average of 117.3 mm (Figure 2). The occurrence of an extended drier period followed by intense rainfall events may have greatly impaired the nesting activity in the studied areas. According to Linsley (1958), extreme climatic factors such as the occurrence of few rainfall events or above average rainfall can directly affect the availability of resources for the construction and maintenance of nests, consequently affecting bee abundance.

Table IV. Species of bees and variation in the diameter of the bamboo internodes used in the four studied areas, from September 2012 to November 2013 in the Baturité Massif, State of Ceará, Brazil.

Species	Variation in the diameter of the bamboo internodes				
	AREA				
	A1	A2	A3	A4	x̄ ± SD
Centris (Hemisiella) tarsata Smith, 1874	-	0,8 – 0,9	-	0,7 – 0,9	0,8 ± 0,08
Centris (*Heterocentris*) sp.	1,1	-	0,8 – 1,2	0,8 – 0,9	0,97 ± 0,16
Mesocheira bicolor Fabricius, 1804*	-	-	0,85	-	0,85 ± 0
Euglossa pleosticta Dressler, 1982	-	-	-	-	-
Megachile (Austromegachile) aff. *susurrans* Haliday, 1836	0,65	0,7 – 1,0	-	-	0,78 ± 0,19
Coelioxys (Cyrtocoelioxys) sp.*	-	0,5	-	0,9	0,77 ± 0,23

*Species of kleptoparasite bees.

The high rainfall values in 2013 may have contributed to the low nesting frequency observed, which contributed to the fact that the trap-nests offered were humid or wet, making it difficult for bees seeking dry shelters to lay their eggs. In addition, it is also necessary to consider that low temperatures and high humidity can exert a negative influence on the activity of these individuals, since insects, in general, have low thermoregulatory ability (Stangler et al. 2015).

The low number of nests built in the studied areas may also be related to the good conservation of the vegetation in these localities, since well preserved sites must have a greater number of pre-existing natural cavities, making trap-nests not so attractive to these species (Potts et al. 2005). Other factors such as nesting resources, preference for holes most appropriate to bee size, sampling time (Fortel et al. 2016) and the arrangement of these trap-nests in the studied areas (Morato 2001) may also have influenced the amount of nests and species sampled in this study.

With respect to the preference of bees for the substrates, some factors may be determinant for the use of trap-nests, such as the cavity diameter (Jenkins & Matthews 2004, Garófalo 2008, Campbell et al. 2017). Bamboo internodes were the substrates preferred by bee species for the construction of their nests, possibly due to the diversity of diameters offered. The preference for bamboo internodes for the great majority of species occurs due to variations in the diameter of this type of trap-nest, in order to meet the requirements of the choice of holes by females of several species (Garófalo 2008). It is more likely that bee species prefer cavities where there is a better adjustment of their body and their brood cells, which serves both to reduce the energy expenditure in the nest construction and to hinder the access of parasites inside them (Aguiar & Martins 2002, Macivor 2017).

Thus, the choice of the ideal cavity diameter by species that nest exclusively on bamboo internodes was probably determined by the body

size of the founder female and by the way these females use resources, such as sand and leaves, to construct nests, which most often occupy a good part of the cavities offered (Mendes & Rêgo 2007, Mesquita et al. 2009, Cardoso & Silveira, 2012, Marques & Gaglianone, 2013).

The tubes made of paperboard had a low occupation by the bees, with only *Centris* (*Hemisiella*) *tarsata* nesting in the tubes with a diameter of 1.0 cm in this type of trap. Bees of the genus *Centris* are highly sensitive to disturbances caused by other females or even parasites that may infest the substrate (Velez et al. 2017). In this study, the bamboo internodes were infested with borers, which may have contributed to the increased nesting in cardboard tubes. Furthermore, according to what has been observed in some studies, species of this genus have a preference for founding nests in pre-existing cavities with a diameter varying from 0.8 cm to 1.0 cm, which may have made cardboard tubes attractive to these individuals (Aguiar & Garófalo 2004, Aguiar et al. 2005, Drummont et al. 2008).

The wooden boxes with external dimensions of 12 cm high x 12 cm wide x 10 cm long were occupied exclusively by *Euglossa pleosticta*. This preference may be due to the structure of the nest of species of this genus, in which the arrangement of the brood cells requires a space larger than those provided by the trap-nests made of bamboo or cardboard, demonstrating the importance of offering different types of traps to bees of this genus so that they can choose a certain type or size of artificial cavities offered (Garófalo et al. 1993, Augusto & Garófalo 2004, Aguiar et al. 2005, Freiria 2015).

Species of kleptoparasite bees parasitized only the bees that nested on bamboos and tubes demonstrating that their reproduction is directly associated with the hosts and not to the type of trap-nest.

Although this study showed relevant information on identification and distribution of species of bees that nest in pre-existing cavities in the Atlantic Forest fragments of the Baturité Massif, it was noted that it is difficult to sample the real diversity of the studied area based on the use of trap-nests, probably because of the attractiveness of the local natural nesting sites. The simultaneous use of trap-nests with other sampling methods such as pantraps, entomological nets and scent traps would certainly achieve a greater representativeness of the bee fauna.

CONCLUSION

The high similarity in the structure of bee communities among the four studied areas suggests that the Baturité Massif region has low environmental heterogeneity and possibly many options of pre-existing natural substrates for nesting in nature.

The preference for bamboo internodes by most bee species for the construction of their nests evidences the importance of the use of versatile trap-nests like bamboo internodes in trap-nests projects to allow a more representative capture and supply of nesting sites in areas lacking these resources to maintain or increase populations of bees that nest in pre-existing cavities.

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