

Nesting behavior of stingless bees

Comportamento da nidificação de abelhas melíponas

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Abstract

Native bees, besides excellent producers of honey, lend a great legacy to humanity through their ability to pollinate plants and the consequent preservation of ecosystems. In this interspecific relation, bees are benefited by plant species by the provision of food (nectar and pollen), besides using their branches and trunks for lodging. However, the anthropogenic action has jeopardized the survival of stingless bees, causing irreversible environmental damage in the preservation of natural resources. This study aimed to identify the nesting habits of native bees under natural conditions. Random trails in the Curimataú micro-region of Paraíba allowed identifying nesting sites of indigenous species in their natural habitat. Sixty honeycomb nests were identified in 12 different plant species, being *Commiphora leptophloeos* the most preferred host (46.66%), with 55% of the entrance holes pointed to magnetic orientations between the Northeast and Northwest; a greater choice by host trees (85%); preference for nesting in host plants with a circumference of 0.98 m in diameter, entrance hole of nests of 7.77 mm in diameter, and height from the ground of 1.52 m. The obtained data showed little variety of stingless bee species in the Curimataú region of Paraíba, especially *Melipona subnitida*. The species *Melipona asilvae*, *Melipona scutellaris*, *Partamona seridoenses*, and *Plebeia* sp. should receive special attention not to become extinct in this region.

Keywords: Curimataú. Natural habitat. Nesting. Preference. Stingless bees.

Resumo

As melíponas, além de excelentes produtoras de mel, prestam um grande serviço à humanidade através da sua capacidade de polinizar plantas e sua consequente preservação de ecossistemas. Nessa relação interespecífica harmônica, as abelhas são beneficiadas pelas espécies vegetais pelo provimento do alimento (néctar e pólen), além de utilizarem seus galhos e troncos para se alojarem. Porém, a ação antrópica predatória tem colocado em risco a sobrevivência das melíponas, causando danos ambientais irreversíveis e comprometendo a preservação dos recursos naturais. Este trabalho objetivou identificar os hábitos de nidificação das abelhas nativas em condições naturais. Por meio de trilhas

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aleatórias na microrregião do Curimataú paraibano foi possível identificar os pontos de nidificação das espécies de meliponíneos em seu *habitat* natural. Foram identificados 60 ninhos de melíponas nidificando em 12 espécies vegetais diferentes, sendo a *Commiphora leptophloeos* a hospedeira de maior preferência (46,66%), com 55% dos orifícios de entrada apontados para orientações magnéticas entre o Nordeste e Noroeste; com maior escolha por hospedeiras (árvores) [85%]; apresentando preferência por nidificação em vegetais hospedeiros com circunferência de 0,98 m de diâmetro, orifício de entrada dos ninhos com 7,77 mm de diâmetro e uma altura do solo de 1,52 m; Os dados obtidos revelam pouca variedade de espécies melíponas na região Curimataú paraibano, com destaque para *Melipona subnitida*. As espécies *Melipona asilvae*, *Melipona scutellaris*, *Partomona seridoenses* e *Plebeia* sp. devem ter uma atenção especial para não entrarem em extinção nessa região.

Palavras-chave: Curimataú. *Habitat* natural. Melíponas. Nidificação. Preferência.

Introduction

Meliponines, also known as stingless or indigenous bees, inhabit the Earth about 125 million years.⁽¹⁾ Meliponiculture is an ancient activity that has been practiced since the dawn of civilizations in ancient Egypt.⁽²⁾ In Brazil, the rearing of honey bees was initiated by indigenous⁽³⁾ even before the discovery and introduction of *Apis mellifera* L. (Hymenoptera: Apidae).

Bees provide a great service to humanity through their ability to pollinate, as they are insects specialized in plant pollination,⁽⁴⁾ contributing to the preservation of ecosystems and generating an increase in the production of commercial plant species.⁽⁵⁾ In addition, they are the main pollinating agents on the planet. Approximately 80% of the world's cultivated plant species are estimated to be pollinated by some bee species, 19% by flies, 6.5% by bats, 5% by wasps, 5% by beetles, 4% by birds, and 4% by butterflies and moths.⁽⁶⁾

The indiscriminate use of pesticides has endangered fauna and flora due to their harmful effects on pollinating insects of agroecosystems.⁽⁷⁾ One of the major consequences of this practice is the direct reduction of the bee population, as well as indirect effects of economic losses resulting from the decline of these pollinators.⁽⁸⁾

Anthropogenic action, i.e., the predatory action of humans over decades has caused irreversible environmental damage in the preservation of natural resources. Advances in agricultural frontiers have increased the rates of deforestation and indiscriminate use of pesticides, making it difficult to fix native bees in their habitats. As a result, stingless bees are in an accelerated process of disappearance, mainly caused by the loss of environmental quality related to the clearing of native forests.⁽⁹⁾ Therefore, the degradation and destruction of the environment seem to be the main factor of

biodiversity decline.⁽¹⁰⁾ Other factors, however, have been causing concern in the preservation of these species, such as global warming.⁽¹¹⁾

An imminent and compromising threat to the future of meliponiculture is attributed to “honey hunters,” people who irregularly exploit the trade of indigenous bee honey. These people cut down the trees in search of native bees, rudely remove the honey, destroy the honeycomb frames of beehives, and throw the remaining ones on the ground, which are eaten by ants. It rapidly leads to the decimation of stingless bees^(12, 13) by the destruction of their nests through this indiscriminate and predatory action practiced by honey hunters.⁽¹⁴⁾

The rearing of indigenous bees, often performed empirically by producers, generates a demand for research that contributes to production with appropriate management techniques.⁽¹⁵⁾ This study aimed to identify the nesting habits of stingless bees under natural field conditions regarding their occurrence, location, plant substrates, substrate characteristics, architecture, and nesting preferences, also considering the magnetic orientation in the Curimataú micro-region of Paraíba, besides proposing technical specifications that may be used in the manufacture of standard boxes, orientation of their positioning in relation to the cardinal points, and rational and humanized management of stingless bees in a sustainable way.

Stingless bees are docile bees that live in colonies and are easy to manage.⁽¹⁷⁾ Understanding the nesting process of stingless bees is of fundamental importance for species preservation and careful planning of a sustainable production system, taking into consideration the region of their occurrence and characteristics of the habitat in which they are inserted. Based on this understanding, several authors⁽¹⁸⁻²²⁾ described the preference of different nesting habits for stingless bee species.

The diameter of the tree trunk that house the stingless bee nests gives an idea of the diameter of the pre-existing cavity occupied by the nest and may vary from species to species. Most species depend on these pre-existing cavities, usually in cavities of living or dead trees, to build their nests,⁽²³⁾ and their internal diameter varies with nested species.⁽²⁴⁾

The orientation ability of living beings is a determining factor in species survival, whether in displacement, food collection, or reproduction. Thus, the most varied species develop mechanisms of adaptation to the environment. Among these abilities, the theory of the ability to detect the Earth’s magnetic field for orientation and navigation, commonly accepted by several researchers,⁽²⁵⁻²⁷⁾ is noteworthy, although it is little known in animals.⁽²⁸⁾

The substrate is another parameter that undergoes variations regarding nesting habits of stingless bees. Sometimes, several nesting habits are found within the same genus of stingless bees.⁽²²⁾ The factors that drive the preference of bees for a particular plant source are not known,⁽²⁹⁾ but reports show they are selective in this choice. In general, stingless bees depend on trees for housing and food,^(30, 24) building their nests in pre-existing cavities. The region of occurrence of all species of stingless bees must be respected in a rational exploration, avoiding the degradation of that ecosystem. Understanding the

pattern of their distribution and abundance is considered important⁽³¹⁾ for developing conservation strategies in order to reduce the effects of habitat fragmentation on the genetic and ecological structure of stingless bee populations.

The bees are part of the order Hymenoptera and meliponines are in the superfamily Apoidea, which is subdivided into the families Andrenidae, Anthophoridae, Colletidae, Halictidae, Melittidae, Megachilidae, Oxaeidae, and Apidae. The family Apidae, in its turn, is divided into four subfamilies: Bombinae, Euglossinae, Apinae, and Meliponinae. The subfamily Meliponinae is divided into two tribes: Meliponini and Trigonini. Bees of both tribes can be called meliponines.⁽³²⁾ Fifty-two genera, with a total of 400 species,⁽³³⁾ can be found within the subfamily Meliponinae spread throughout the world, from the state of Rio Grande do Sul in Brazil to central Mexico, Africa, India, Malaysia, Indonesia, and Australia.⁽³²⁾

Brazil is one of the main places of stingless bee occurrence, where they have a great influence on the maintenance of ecosystems. To date, 33 genera of Neotropical meliponines have been described in Brazil, comprising 300 species,⁽³⁴⁾ which may vary between 350 and 400 species.⁽³⁵⁾ However, it is believed that the number of species is much higher, with a high diversity of shapes, size, and nesting habits.⁽³⁶⁾ At least 100 stingless bee species are in danger of extinction due to the destruction of their habitats by humans.⁽³²⁾

The tribe Meliponini is unique of the Americas, in the Neotropical region (from southern South America to the mountains of northern Mexico in Central America), with approximately 26 species and numerous subspecies, and is represented by one genus: *Melipona*. In Brazil, there are about 20 species: *Melipona scutellaris*, *M. mandacaia*, *M. asilvae*, *M. quinquefasciata*, *M. subnitida*, among others.⁽³⁷⁾ In Paraíba, the tribe Meliponini is distributed in the coastal micro-regions, Curimataú, Borborema, and Sertão, with five species: *M. subnitida*, *M. quadrifasciata*, *M. asilvae*, *M. compressipes fasciculata*, and *M. scutellaris*.⁽³⁸⁾

The tribe Trigonini is a very diverse group of stingless bees, encompassing the largest number of genera in the Neotropical region, being possible to find several genera: *Lestrimelitta*, *Hypotrigona*, *Cephalotrigona*, *Oxytrigona*, *Schwarziana*, *Scaura*, *Plebeia*, *Partamona*, *Paratrigona*, *Scaptotrigona*, *Nannotrigona*, *Tetragonisca*, *Trigona*, *Geotrigona*, and *Frieseomelitta*, and numerous species (around 120).⁽³⁷⁾ In Paraíba, thirteen Trigonini species were found into eight different genera: *Frieseomelitta*, *Trigona*, *Scaptotrigona*, *Partamona*, *Tetragonisca*, *Leurotrigona*, *Plebeia*, and *Nannotrigona*.⁽³⁸⁾

Caatinga is a unique biome, located in the semi-arid climate, and is the main existing ecosystem in the Northeast region of Brazil, the natural cradle of stingless bees. This region has a great variety of landscapes with relative biological and endemic richness, governed by seasonal and periodic droughts that are renewed with each rainfall cycle. This biome has been undergoing extensive environmental devastation caused by an anthropogenic process of indiscriminate use of its natural resources.⁽¹⁶⁾

In Paraíba, Curimataú is a micro-region within the Caatinga biome known for the presence of indigenous bees. Municipalities of this locality, such as Araruna, Cacimba

de Dentro, Damião, and Cuité, have a vast predominantly Caatinga area and semi-arid climate, marked by low precipitation, short, poorly distributed rainfall, and with fauna and flora threatened by anthropogenic action. Thus, knowing the nesting habits of stingless bees in this region is essential for meliponiculturists to improve their management techniques. This study aimed to identify the nesting habits of native bees under natural conditions in the Curimataú micro-region of Paraíba.

Material and methods

This study was carried out in the Curimataú region of Paraíba. For sampling purposes, the data were collected from September to November 2016 from four municipalities: Araruna (06°33'30" S and 35°44'30" W), Damião (06°37'54" S and 35°54'18" W), Cuité (06°29'01" S and 36°09'13" W), and Cacimba de Dentro (06°38'21" S and 35°46'42" W), totaling an area of 1,336.9 km². Nesting sites were previously identified through interviews with family farmers living in the collection areas.

A survey of possible nesting sites of native bees in the Curimataú region of Paraíba started via random trails with the assistance of native informers from the region. The botanical identification of host trees was performed by collaborators using the common name of the species and confirmed by a search in specialized websites (Tópicos and Flora do Brasil).

Nesting sites were cataloged by the Global Navigation Satellite System (GPS) using a Garmin® etrex 30 device, allowing identifying their geographical coordinates and magnetic orientation (cardinal and collateral points) of the entrance hole of nests preferred by native bees. Other parameters were evaluated for better characterization and identification of native bee preference when choosing nesting sites. The methodology described by Serra⁽³¹⁾ was used by measuring the diameter of the entrance hole of nests with a Lotus® caliper, tree diameter at the entrance hole location with a Stanley® measuring tape, and the height of the entrance hole of nests in relation to the ground height with a 5-meter Irwin® measuring tape. An entomological net was used for the capture of samples with a hole height higher than 2 meters.

A sample of five native bee specimens was collected at each nesting site by placing them in an acrylic container (50 ml) with a lid containing 30 ml alcohol (70%). The container was duly identified and sent to the Laboratory of Entomology (LE) of the Department of Systematics and Ecology (DES) of the Federal University of Paraíba (UFPB) for taxonomic analysis.

The chi-square test was used for occurrence frequencies of species, while Duncan's test was used after ANOVA to compare means of the diameter of the entrance hole, trunk diameter, and nest height as a function of species and orientation.

Results and discussion

Sixty nests of stingless bees were found in four different municipalities of the Curimataú region of Paraíba (Araruna, Cacimba de Dentro, Damião, and Cuité). Bees

(tribes Meliponini and Trigonini) corresponded to eight different species: *Melipona subnitida* Ducke, 1910, *Melipona asilvae* Moure, 1971 (Hymenoptera: Apidae), *Melipona scutellaris* Latreille, 1811 (Hymenoptera: Apidae), *Frieseomelitta doederleini* Friese, 1900 (Hymenoptera: Apidae), *Frieseomelitta francoi* Moure, 1946 (Hymenoptera: Apidae), *Partamona seridoenses* Pedro & Camargo, 2003 (Hymenoptera: Apidae), *Plebeia* sp., and *Scaptotrigona aff. depilis* Moure, 1942 (Hymenoptera: Apidae). The most frequent species was *M. subnitida* (36.67%), followed by *F. doederleini* (25%), and *Frieseomelitta francoi* Moure, 1946 (Hymenoptera, Apidae) and *S. aff. depilis*, both with 11.67% (Table 1). A study carried out in Serra da Capivara, PI,⁽³⁹⁾ also observed the occurrence of these species.

Table 1. Distribution of frequency and number of species of stingless bees found in the Curimataú micro-region of Paraíba

Tribe	Species	Local name	Number (n)	F (%)
Meliponini	<i>Melipona subnitida</i>	Jandaíra	22	36.67
	<i>Melipona asilvae</i>	Rajada	3	5.00
	<i>Melipona scutellaris</i>	Uruçu	2	3.33
Trigonini	<i>Frieseomelitta doederleini</i>	Mané de Abreu	15	25.00
	<i>Frieseomelitta francoi</i>	Moça Branca	7	11.67
	<i>Partamona seridoenses</i>	Cupira	2	3.33
	<i>Plebeia</i> sp.	Mosquito	2	3.33
	<i>Scaptotrigona aff. depilis</i>	Canudo	7	11.67
Σ			60	100.00
χ^2				50.40
p-value				< 0.01

F=frequency.

Among the 18 native species of bees that inhabit Paraíba,⁽³⁸⁾ eight were found distributed in the collection area (Curimataú micro-region of Paraíba), in which the species at higher occurrence in the study area was *Melipona subnitida*, with 36.67% of the nests. It confirms the predominance of this species in the Curimataú micro-region,⁽³⁸⁾ followed by *Frieseomelitta doederleini* (25%) and *Scaptotrigona aff. postica* Latreille, 1807 (Hymenoptera: Apidae) (11.67%). The bee species *Melipona scutellaris*, *Partamona seridoenses*, and *P. sp.* were the least frequent (all of them with 3.33%) (Table 1). Considering that stingless bee species are under an accelerated process of disappearance⁽⁹⁾ caused especially by the loss of habitat due to deforestation of native forests (their natural environment), their low incidence suggests that an environmental education program be carried out in local communities, particularly with meliponiculturists. In a field research carried out in João Câmara, Rio Grande do Norte, Martins et al.⁽⁴⁰⁾ found seven species of stingless bees, in which *M. subnitida* was more frequent (57.3%), followed by the species *Melipona asilvai* Moure, 1971 (Hymenoptera: Apidae) (17.2%) and *Frieseomelitta dispar* Moure, 1950 (Hymenoptera: Apidae) (13.7%).

Although the hundreds of tree species in the Curimataú region, stingless bees have used a small number of them for nesting, i.e., only 12 species (Table 2). Stingless bee species are selective and opt for specific trees.⁽⁴¹⁾

Table 2. Frequency and number of substrates used as a host in the nesting preference of stingless bees in the Curimataú micro-region of Paraíba

Family	Scientific name	Local name	Number (n)	F (%)
Anacardiaceae	<i>Anacardium occidentale</i> L.	Cajueiro	2	3.33
	<i>Schinopsis brasiliensis</i> Engl.	Baraúna	1	1.67
	<i>Spondias tuberosa</i> Arruda	Umbuzeiro	6	10.00
Euphorbiaceae	<i>Sapium scleratum</i> Ridl.	Burra leiteira	1	1.67
Apocynaceae	<i>Aspidosperma pyriforme</i> Mart. & Zucc.	Pereiro	1	1.67
Fabaceae	<i>Anadenanthera macrocarpa</i> (Bent.) Brenan	Angico	1	1.67
	<i>Poincianella pyramidalis</i> (Tul.)	Catingueira	14	23.32
Malvaceae	<i>Ceiba glaziovii</i> (Kuntze) K. Schum.	Barriguda	1	1.67
Burseraceae	<i>Commiphora leptophloeos</i> (Mart.) J.B. Gillett	Imburana	28	46.66
Mimoseae	<i>Mimosa caesalpinifolia</i> Benth.	Sabiá	1	1.67
Moraceae	<i>Artocarpus heterophyllus</i> Lam.	Jaca	3	5.00
	<i>Ficus carica</i> L.	Figo	1	1.67
Σ			60	100.00
χ^2				158.87
p-value				< 0.01

F=frequency.

This study showed that stingless bees nest in different tree species. However, 69.98% of the nests were observed in only two tree species: *Commiphora leptophloeos* (Mart.) J.B. Gillett, with 46.66%, followed by *Poincianella pyramidalis* (Tul.), with 23.32% (Table 2). Similar data were found in phytosociological studies carried out in a secondary growth Caatinga area in the Seridó region,⁽⁴²⁾ where *Poincianella pyramidalis* had the highest densities and frequencies. The species *C. leptophloeos* has a hollow trunk, an essential condition for nest installation. Similar results in the preference of host plant species with stingless bees in the Caatinga (Seridó, PB, and João Câmara, RN) were observed⁽⁴⁰⁾ for *C. leptophloeos* and *Poincianella pyramidalis*, with a frequency of 75.0%, which is similar to that found in this study (69.98%).

Knowledge on the preference of stingless bees for nesting choices goes beyond a cavity and good flowering. Magnetic orientation, i.e., the direction the entrance hole of nests is facing, should also be taken into consideration.

Stingless bees found in the Curimataú micro-region of Paraíba have a specific preference in the magnetic orientation. Cardinal and collateral points with variable orientation between Northeast and Northwest (Table 3) had a higher choice, with a frequency of 55%.

Table 3. Frequency distribution of the magnetic orientation of the entrance hole of stingless bees in the nesting preference in the Curimataú micro-region of Paraíba

Magnetic orientation	Number (n)	Frequency (F)
North	12	20.00
Northeast	13	21.67
East	5	8.33
Southeast	2	3.33
South	4	6.67
South-west	4	6.67
West	12	20.00
Northwest	8	13.33
Σ	60	100.00
χ^2		17.60
p-value		0.01

The lowest values for magnetic orientation were found for Southeast (3.33%), South (6.67%), and Southwest (6.67%) positions, totaling 16.67% .

In their natural habitat, stingless bees seek to install their nests in camouflaged locations. Most of these bees use cavities in living trees, dead trees, dry trunk, stones, termite mounds, anthills, wall tiles, among others. However, nesting in live tree trunks is predominant.⁽⁴³⁾

The results showed that 85% of stingless bees nest in cavities of living trees, followed by dead trees (6.67%), dry trunks (5.0%), and termite mounds (3.33%) (Table 4). A study carried out in Cataguases, MG, showed that 20 of 21 nests were found in a tree substrate, and only one nest of *T. angustula* was built in a ravine.⁽⁴⁴⁾ It is evident the preferences of stingless bees for live trees to nest.

Only 3.33% of the species nested in termite mounds (Table 4). These termite mounds, in turn, were occupied by *P. seridoenses*, a bee that has a specific nesting habit in termite mounds.⁽⁴⁵⁾

Stingless bees have characteristics that can be influenced at nesting time in relation to the diameter of the entrance hole, trunk diameter, and nest height. Nest hole sizes of the studied stingless bees differed between species (Table 5). However, nest height showed no difference between species.

The diameter of the entrance hole of stingless bee nests may vary when considering the size of each species, i.e., the larger their size is, the larger the entrance hole. Significant

differences in the diameter of the entrance hole were observed when comparing the studied species (Table 5). The largest diameter was observed for *Scaptotrigona* (10.43 mm), with no statistical difference from *M. scutellaris* (9.0 mm), *M. subnitida* (8.45 mm), and *P. seridoensis* (7.50 mm).

Table 4. Frequency distribution of the nesting site of stingless bees in the Curimataú micro-region of Paraíba

Nesting place	Number (N)	Frequency (F)
Living tree	51	85.00
Dead tree	4	6.67
Dry trunk	3	5.00
Termite mound	2	3.33
Σ	60	100.00
χ^2		135.33
p-value		< 0.01

Table 5. Influence of stingless bee species of the Curimataú micro-region of Paraíba during nesting in relation to the diameter of the entrance hole, trunk diameter, and nest height

Stingless bee species	Entrance diameter (mm)	Trunk diameter (m)	Nest height (m)
<i>Frieseomelitta doederleini</i>	7.00 bcde	0.74 c	1.39 a
<i>Frieseomelitta francoi</i>	6.00 de	0.83 bc	2.26 a
<i>Partamona seridoenses</i>	7.50 bcd	1.46 abc	1.84 a
<i>Plebeia</i> sp.	6.50 cde	0.75 c	0.80 a
<i>Scaptotrigona</i> aff. <i>depilis</i>	10.43 a	1.86 a	1.25 a
<i>Melipona asilvae</i>	4.67 c	1.36 abc	2.15 a
<i>Melipona scutellaris</i>	9.00 ab	0.92 bc	0.69 a
<i>Melipona subnitida</i>	8.45 abc	0.83 bc	1.50 a
Mean	7.77	0.98	1.52
p-value	< 0.01	< 0.01	0.15
CV	18.97	39.15	56.69

*Means followed by different letters in the column differ from each other by Duncan's test at 5% probability ($p \leq 0.05$).

Intermediate results for the diameter of the entrance hole were recorded for *P. seridoensis* (7.5 mm), *F. doederleini* (7 mm), and *F. francoi* (6 mm), while the lowest value was found for *M. asilvae* (4.67 mm) (Table 5). Stingless bees typically build their nests in pre-existing native tree cavities, with an internal diameter varying according to the nested species.⁽²⁴⁾

Trunk diameter was influenced by the studied stingless bee species, in which the highest values were found for *S. aff. depilis* (1.86 m), *P. seridoenses* (1.46 m), *M. asilvae* (1.36 m), and *M. scutellaris* (0.92 m), differing from *M. subnitida*, which ranged from 0.74 to 0.83 m (Table 5). Other studies have found different results, with diameter values ranging from 0.39 and 0.50 m.⁽⁴⁰⁾

Trunk diameter may be directly related to the occupation volume used by stingless bees, which may vary regarding the species in relation to their requirements to build their nests. The capacity of the pre-existing cavity may be decisive in choosing the nesting site.⁽⁴⁶⁾ Beehive volume is a determining factor and may vary according to the region.⁽³²⁾ Usually, an *M. subnitida* beehive requires a volume of 15 liters.

Nest height did not change significantly when comparing stingless bee species, although they presented a variation of 0.80 m for *Plebeia* sp. and 2.6 m for *F. francoi* (Table 5), which led to a high coefficient of variation. A significant influence of the host plant species of the Curimataú micro-region of Paraíba was observed in relation to the diameter of the entrance hole and trunk diameter of nests found in their natural habitat (Table 6). Also, no significant difference was observed for nest height.

The largest entrance holes were found in the species *A. heterophyllus* and *F. carica* (11 mm), *A. occidentale* (10 mm), and *C. glaziovii* and *S. sceleratum* (9 mm). The lowest values were observed for *A. macrocarpa*, *A. pyrifolium*, and *S. brasiliensis* (4, 5, and 4 mm, respectively) (Table 6).

Table 6. Influence of the host plant species of the Curimataú micro-region of Paraíba on nesting of native bees in relation to the diameter of the entrance hole, trunk diameter, and nest height

Host plant species	Entrance diameter (mm)	Trunk diameter (m)	Nest height (m)
<i>Anacardium occidentale</i>	10.00 ab	2.25 a	1.43 b
<i>Anadenanthera macrocarpa</i>	4.00 d	0.84 cd	0.56 b
<i>Artocarpus heterophyllus</i>	11.00 a	1.84 ab	1.56 b
<i>Aspidosperma pyrifolium</i>	5.00 cd	0.63 cd	1.57 b
<i>Caesalpinia pyramidalis</i>	7.71 abcd	0.61 cd	1.20 b
<i>Ceiba glaziovii</i>	9.00 abc	0.74 cd	0.92 b
<i>Commiphora leptophloeos</i>	7.46 abcd	0.96 bcd	1.70 b
<i>Ficus carica</i>	11.00 a	2.30 a	0.27 b
<i>Mimosa caesalpiniaefolia</i>	6.00 bcd	0.51 d	0.15 b
<i>Sapium sceleratum</i>	9.00 abc	1.46 abc	0.38 b
<i>Schinopsis brasiliensis</i>	4.00 d	1.27 bcd	3.85 a
<i>Spondias tuberosa</i>	8.00 abcd	0.88 cd	1.97 ab
Mean	7.77	0.98	1.52
p-value	0.01	< 0.01	0.04
CV	22.13	35.28	53.76

*Means followed by different letters in the column differ from each other by Duncan's test at 5% probability ($p \leq 0.05$).

When comparing tree trunk diameter in relation to the influence of host plants (Table 6), it is observed that the largest diameters were presented by *A. occidentale* and *F. carica*, with 2.25 and 2.30 m, respectively, differing statistically from *M. caesalpiniaefolia*, which had the lowest value (0.51 m). A study conducted in the Forest Zone of Pernambuco showed that 50% of stingless bees nest in trees with a diameter lower than 50%, 30% with a diameter between 1 and 1.5 m, and 20% between 2 and 2.5 m.⁽⁴⁷⁾ Diameter variation of trees chosen for nesting of stingless bee species found in the Curimataú region of Paraíba may be related to the size of trees in the study area, with varying characteristics regarding size and architecture.

Nest height showed no significant difference regarding host tree species, even though it showed a maximum amplitude of 3.85 m for *S. brasiliensis* and minimum for *M. caesalpiniaefolia*, with 0.15 m of nest height in relation to the ground. Similar results were found in a survey conducted in Bahia with stingless bees,⁽⁴⁸⁾ in which nest height ranged from 0.5 to 3.8 m. Probably, nest height of stingless bees is not related to the size or type of trees, but rather to nesting characteristics of each bee species. The height of nest entrance hole in host plant species at the highest or lowest positions is due to chance.⁽³¹⁾ Cardinal and collateral points showed no influence on the diameter of the entrance hole, trunk diameter, and nest height (Table 7).

Table 7. Influence of cardinal and collateral points of the Curimataú micro-region of Paraíba in the nesting of stingless bees in relation to the diameter of the entrance hole, trunk diameter, and nest height

Magnetic orientation	Entrance diameter (mm)	Trunk diameter (m)	Nest height (m)
North	7.92 a	1.27 a	0.86 a
Northeast	6.46 a	0.95 a	1.93 a
East	9.20 a	0.89 a	1.60 a
Southeast	7.50 a	0.91 a	2.15 a
South	8.75 a	0.87 a	1.50 a
South-west	7.00 a	0.65 a	1.66 a
West	7.92 a	1.01 a	1.52 a
Northwest	8.50 a	0.82 a	1.60 a
Mean	7.77	0.98	1.52
p-value	0.14	0.49	0.52
CV	18.97	39.15	56.69

*Means followed by different letters in the column differ from each other by Duncan's test at 5% probability ($p \leq 0.05$).

Although not statistically different, the diameter of the entrance hole showed the highest values for points facing East, South, and Northwest, with 9.2, 8.75, and 8.5 mm, respectively. The lowest values were observed for Northeast, Southeast, and Southwest (6.46, 7.5, and 7.0 mm, respectively (Table 7).

Trunk diameter of host trees was not significantly influenced when comparing cardinal and collateral points (Table 7), although the largest diameter was 1.27 m in circumference for North and the smallest circumference was 0.65 m for the southwest. Different results were observed in the Cariri region of Paraíba, where the largest trunk diameters at nest height were facing Southwest, while the lowest values were facing West.⁽⁴⁹⁾

No significant influence of nest height was observed in relation to the influence of cardinal and collateral points, although they varied between 0.86 m for the North and 2.15 m for the Southeast. Stingless bees in the Cariri region of Paraíba⁽⁴⁹⁾ presented a higher height of entrance holes directed to the South, while those directed to the Southwest presented nests closest to the ground.

Conclusion

Melipona subnitida is the most common stingless bee species in the Curimataú micro-region of Paraíba. *Melipona asilvae*, *Melipona scutellaris*, *Partamona seridoenses*, and *Plebeia* sp. presented the lowest frequency in the Curimataú micro-region of Paraíba. Stingless bees with occurrence in the Curimataú micro-region of Paraíba preferentially nest on *Commiphora leptophloeos*, with nest entrance holes directed at a variable angle between Northwest and Northeast at 1.52 m from the ground. The nesting behavior of these species is the reason to review the current model of meliponiculture adopted in this region, especially in relation to the position and height of hives in the meliponary.

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