NESTING ECOLOGY OF STINGLESS BEES (Hymenoptera, Meliponina) IN URBAN AREAS: THE IMPORTANCE OF AFFORESTATION

ECOLOGIA DA NIDIFICAÇÃO DE ABELHAS SEM FERRÃO (Hymenoptera, Meliponina) EM ÁREAS URBANAS: A IMPORTÂNCIA DA ARBORIZAÇÃO

Isabel Farias AIDAR[1]; Alexandre Oliveira Resende SANTOS[1]; Bruno Ferreira BARTELLI[1]; Giselle Alves MARTINS[2]; Fernanda Helena NOGUEIRA-FERREIRA[1,3]

1. Programa de Pós-Graduação em Ecologia e Conservação dos Recursos Naturais, Instituto de Biologia, Universidade Federal de Uberlândia - UFU, Uberlândia, MG, Brazil. aidar.if.bio@gmail.com; 2. Graduanda em Ciências Biológicas - UFU, Uberlândia, MG, Brazil; 3. Docente do Instituto de Biologia -UFU, Uberlândia, MG, Brazil.

ABSTRACT: Studies on nesting ecology have proven to be extremely important for stingless bees conservation. This kind of study is scarce in urban landscapes. Our study aimed to analyze the abundance, density, diversity, spatial distribution and nesting habits of species belonging to the Meliponina subtribe in an urban area of the Uberlândia municipality, Minas Gerais state. We checked potential nesting sites by searching for nests from October 2009 until April 2010. We collected six worker bees from each detected nest to identify species, and estimated diversity and analyzed the spatial distribution pattern of the nests using the Shannon–Wiener and Nearest Neighbor index, respectively. We found fifty nests belonging to seven species, with *Nannotrigona testaceicornis* being the most abundant species (44%). The density of nests was 2.17 nests/ha, the Shannon–Wiener diversity index was H'=1.58 and the clumped distribution was the detected dispersal pattern. The height of the nests in relation to the ground varied from 0 to 12 m: *Trigona spinipes* had the highest nests and the highest variation for this parameter. Hollow trees were the preferred substrate occupied by the observed bees species (70%): *Caesalpinia peltophoroides* was the preferred plant species for nesting. Our results suggested that urban landscapes can sustain a high diversity of stingless bees, and maintaining trees species and urban forestry projects are important tools for the conservation of this group of animals. This type of study provides relevant information to the development of management and conservation plans for Meliponina species.

KEYWORDS: Diversity. Nesting Habits. Nesting Substrate. Nest founding. Hollow trees.

INTRODUCTION

Pollinators' dependence on, and consequently their adherence to flowers (especially for bees), was one of the main factors leading to the diversification of Angiosperms (ERIKSSON; BREMER, 1992). There are nearly 20,000 cataloged bee species, with most of them being solitary, whereas other species live in colonies, having varied levels of social organization (MICHENER, 2007). Amongst social bees, the stingless bees play an important role in the pollination of cultivated (HEARD, 1999) and native (MICHENER, 2007) plant species. These bees belong to the subtribe Meliponina, which comprises approximately 400 species belonging to nearly 50 genera (SILVEIRA et al., 2002). Meliponina species have a worldwide distribution and can be found in the Americas, in south-eastern Asia, Africa, the island of Madagascar and Australia (SILVEIRA et al., 2002).

There are different nesting habits amongst the Meliponina. Most preferentially use hollows in trees, although some species can nest in termite mounds or ant nests (abandoned or active) and abandoned bird nests, whilst other species form exposed or semi-exposed nests in tree branches or cracks in rocks (CAMARGO, 1989). Moreover, nests of distinct species have been found in buildings and other human constructions (TAURA; LAROCA, 1991; SOUZA et al., 2005), a phenomenon probably caused by habitat fragmentation, which has constantly diminished the number of available nesting sites, these being essential for the survival of these insects (BROSI et al., 2007).

In the Triângulo Mineiro region (Minas Gerais state, Brazil), where soils have been subject to highly intensive exploitation due to the establishment of pastures and monocultures, most of the native vegetation has been replaced by agricultural activity following the Brazilian economic expansion of the 1960s and 1970s (ROSA; SCHIAVINI, 2006). Therefore, the division of large areas of native vegetation into fragments of distinct size, as well as urbanization, has forced the fauna to survive in disturbed areas such as pastures, crop fields and urban areas. These localities can show distinct ecological features, acting both as sheltering areas or species source sites for remnant and native areas, acting as a reciprocal system (GASCON et al., 1999).

Bees and aspects of their ecology have been mainly studied in natural landscapes due to their higher abundance, diversity and relevance in these

Received: 18/09/12
Accepted: 03/03/13

environments. In this context, knowledge of bee fauna present in urban landscapes is fairly limited, especially regarding abundance and diversity patterns of these insects (HERNANDEZ et al., 2009). In Brazil, studies in urban areas are also limited, especially concerning exploitation of resources by bees (AGOSTINI; SAZIMA, 2003) and their nesting habits.

In this sense, although studies on the nesting ecology of stingless bees in urban areas are scarce, they are extremely important, since they can provide relevant information on diversity of dweller species, nest density and other aspects important to management plans and the conservation of these species (TEIXEIRA, 2003). In this context, our study aimed to expand available knowledge on the ecological aspects of stingless bees in urban areas by performing analyses of the abundance, diversity, density, spatial distribution and nesting habits of these bees.

MATERIAL AND METHODS

Study area

This study was carried out on Umuarama *campus* at Universidade Federal de Uberlândia (UFU), which is located in Uberlândia municipality, Minas Gerais state (18º 53' 01"S and 48º 15' 34"W). The *campus* covers approximately 23 hectares and includes several constructions such as houses, classroom buildings, commercial rooms and traffic routes. The climate is Tropical Savanna (Aw megathermic), according to Köppen (1948), characterized by dry winters and rainy summers. The average annual temperature is 23−25º C and annual rainfall varies from 1160 to 1460 mm/year (ALVES; ROSA, 2008).

The vegetation of the *campus* is fairly sparse, represented by a high floristic diversity and comprising mainly typical Cerrado trees, with the most abundant species being *Caesalpinia peltophoroides* (Benth.) and *Tabebuia ocracea* (Cham.) Standl. (FALEIRO; AMÂNCIO-PEREIRA, 2007). In addition, the *campus* hosts introduced species, especially *Tecoma stans* (L.) Kunth.

Data gathering and analysis

From October 2009 until April 2010, we inspected potential nesting sites (constructions, gardens and trees) across the entire *campus* (Figure 1) during the hours of highest bee activity. For each nest found, we recorded the occupied substrate and the height of the entrance from the ground. Six worker bees from each nest were collected and then sacrificed in a chamber containing ethyl acetate. Thereafter, for identification purposes, the collected bees were pinned and then stored in the Entomological Collection of the Museu de Biodiversidade do Cerrado (MBC), on the Laboratório de Ecologia e Comportamento de Abelhas (LECA) at the Instituto de Biologia (INBIO) of UFU. We took a picture of each nest entrance to aid species identification.

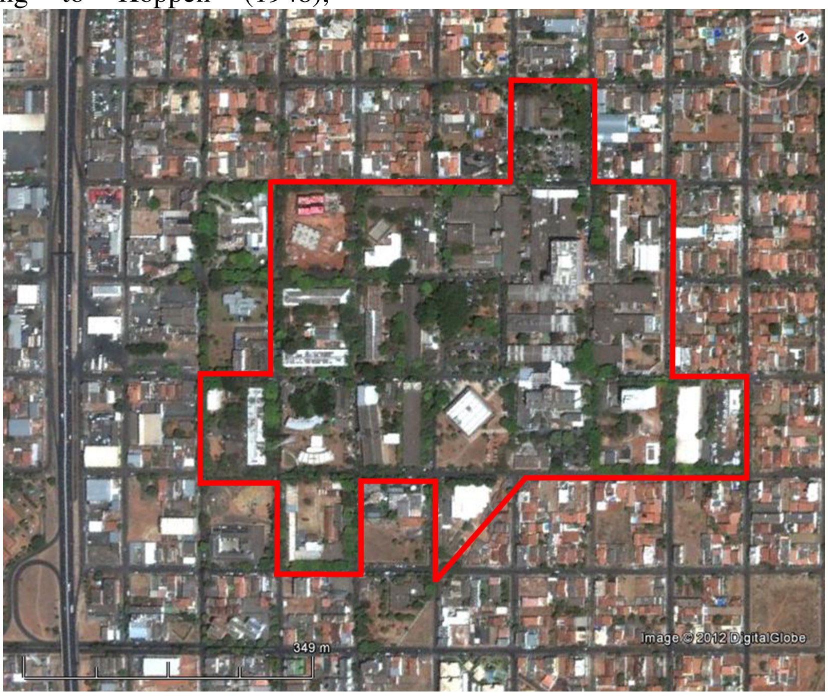

Figure 1. Area in Umuarama *campus* where the potential nesting sites were inspected (delimited in red).

We calculated the Shannon–Wiener (H') and Pielou (J') indices to estimate, respectively, diversity and equability in the study area (KREBS, 1999). The nests' spatial distribution was confirmed by calculating the Nearest Neighbor index (R) (CLARK; EVANS, 1954). The precise location of each nest was mapped with ArcView GIS to determine patterns of nest dispersion.

RESULTS

We found fifty nests of stingless bees belonging to seven distinct species in the study area. The most abundant species was *Nannotrigona testaceicornis* Lepeletier, 1836 followed by *Scaptotrigona* aff. *depilis* Moure, 1942 and *Tetragonisca angustula* Latreille, 1811. The less abundant species was *Trigona hyalinata* Lepeletier, 1836, which was represented by a single nest (Figure 2). The nest density was 2.17 nests/ha and the Shannon–Wiener diversity index and Pielou's evenness were, respectively, H'=1.58 and J'=0.81, indicating high uniformity of species in the area. The clumped distribution was the dispersion pattern of the encountered nests (R=0,83; z=-2,34; p<0,05; n=50) (Figure 3).

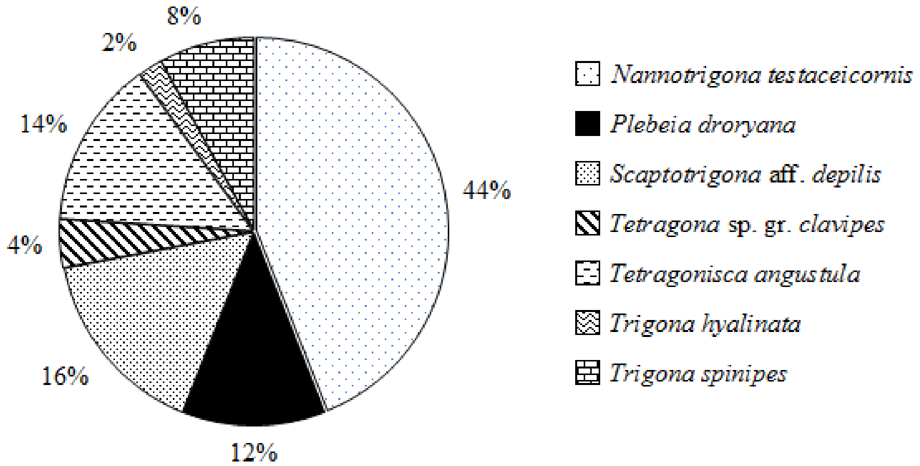

Figure 2. Relative abundance of nests of stingless bees species found on Umuarama *campus* at Universidade Federal de Uberlândia, Uberlândia-MG.

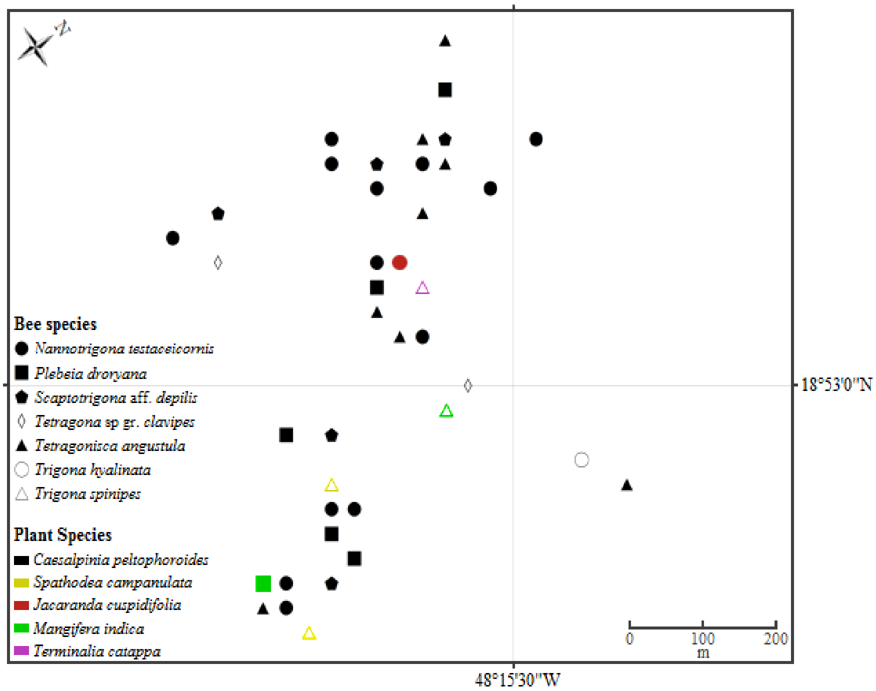

Figure 3. Spatial distribution map of nests of stingless bees and their respective plant species used for nesting substrate (except for *T. hyalinata* that were found in a wall), on Umuarama *campus* at Universidade Federal de Uberlândia, Uberlândia-MG.

The height of nests in relation to the ground varied from 0 to 12m. Despite the different number of nests found for each species, *Trigona spinipes* Fabricius, 1793 showed the highest variation for this parameter, whereas *Tetragona* sp. gr. *clavipes* Fabricius, 1804 exhibited the lowest variation. *T. spinipes* presented the highest average height and *Plebeia droryana* Friese, 1900 the lowest (Table 1).

Table 1. Number of nests (N), height of nest entrance from the ground (meters) and substrate used for nesting by Meliponina species found on Umuarama *campus* at Universidade Federal de Uberlândia, Uberlândia-MG.

Observed species	N	Height[1]	Substrate[2]			
			Constructions	Tree Forks	Hollow trees	Ground
Nannotrigona testaceicornis	22	2.12 ± 0.84	1 (4.50)	0	20 (91)	1 (4.50)
Plebeia droryana	6	0.72 ± 1.04	3 (50)	0	2 (33)	1 (17)
Scaptotrigona aff.*depilis*	8	1.80 ± 0.64	0	0	8 (100)	0
Tetragona sp.gr. *clavipes*	2	1.23 ± 0.66	0	0	2 (100)	0
Tetragonisca angustula	7	1.10 ± 0.77	4 (57)	0	3 (43)	0
Trigona hyalinata	1	5.25	1 (100)	0	0	0
Trigona spinipes	4	8.96 ± 3.01	0	4 (100)	0	0

[1]Average ± standard deviation;[2]Number of nests (relative abundance).

In general, the preferred substrates occupied by the observed bees species were hollow trees (70%), followed by constructions (18%), tree forks (8%) and the ground (4%). The distinct substrates used by each sampled species are shown in Table 1. Of the plant species used for nesting, *Caesalpinia peltophoroides* Benth. (Fabaceae) was predominant, being used by all bee species (Table 2).

Table 2. Number of observed nests (relative abundance) in distinct plant species used for nesting by Meliponina species found on Umuarama *campus* at Universidade Federal de Uberlândia, Uberlândia-MG.

Observed Species	Cp	Sc	Jc	Mi	Tc
Nannotrigona testaceicornis	18 (90)	1 (5)	1 (5)	0	0
Plebeia droryana	1 (50)	0	0	1 (50)	0
Scaptotrigona aff. *depilis*	8 (100)	0	0	0	0
Tetragona sp. gr. *clavipes*	2 (100)	0	0	0	0
Tetragonisca angustula	3 (100)	0	0	0	0
Trigona spinipes	1 (25)	1 (25)	0	1 (25)	1 (25)

Cp: *Caesalpinia peltophoroides*; Sc: *Spathodea campanulata* Beauvois (Bignoniaceae); Jc: *Jacaranda cuspidifolia*, Mart. (Bignoniaceae) Mi: *Mangifera indica*, L. (Anacardiaceae); Tc: *Terminalia catappa*, Linn. (Combretaceae).

DISCUSSION

Our results suggested that the Umuarama *campus* of UFU supports a large number of nests and a high richness of stingless bee species. This is because nests of eight Meliponina species were previously recorded in a 29.6 hectare natural area of cerrado *sensu stricto* (SERRA et al., 2009), values that are similar to what we found in our study.

Although, when comparing our data with the results of other surveys conducted in urban areas, the Umuarama *campus* presents intermediate values for number of nests and diversity of Meliponina species (Table 3). For instance, the values referring to density and richness of stingless bees found at Umuarama *campus* are lower than those shown by data collected from the *campus* of Escola Superior de Agricultura Luiz de Queiroz of the Universidade de São Paulo (ESALQ-USP) (CARVALHO; MARCHINI, 1999). The differences found between the distinct surveys conducted to date might be related to many factors, such as plant species composition, availability and variety of substrates and food resources, degree of human disturbance of the area and the composition of stingless bee communities in the study area. In the study carried out at ESALQ-USP, for example, although the sampled area was smaller than ours, approximately 50% of the nests found belonged to *Tetragonisca angustula*, a species well adapted to adverse nesting conditions (NOGUEIRA-NETO, 1970).

Table 3. Size of sampled area, number of nests (N), number of species and nesting substrate used by stingless bees in different studies conducted in urban landscapes.

Studies	Area size (ha)	N	Richness	Nesting substrate (%)				
				C	TF	HT	G	TN
Present study	23	50	7	18	8	70	4	0
CARVALHO; MARCHINI, 1999	18	97	10	82.47	NA	NA	NA	NA
MATEUS et al., 2009	13.7	111	18	43.24	0	47.74	0	9.02
NETTO et al., 2007	NA	51	6	78.43	0	19.61	1.96	0
NUNES; SANTOS, 2009	NA	31	7	3.22	0	87.10	6.45	3.22
SOUZA et al., 2005	57	94	5	NA	NA	NA	NA	NA
SOUSA et al., 2002	132.58	35.88*	4	77.35	7.40	8.07	0.55	6.63
TAURA; LAROCA, 1991	5.7	28.33*	5	13.16	2.63	84.21	0	0

C: Constructions; TF: Tree forks; HT: hollow trees; G: Ground; TN: Termite nests; NA: Information NOT AVAILABLE in the paper; *Average values obtained per sampling in a specific time span.

The high occurrence of nests in urban landscapes demonstrates the adaptation of many Meliponina species to living in human-disturbed areas. Although these landscapes show considerable density values of this group, the importance of conserving natural areas is unquestionable, since these areas still shelter a higher diversity of stingless bees (AGUIAR; MARTINS, 2003; ANDENA et al., 2005). Furthermore, the importance of preserving natural areas is also underlined by the fact that they are able to offer a larger array of the resources necessary for the survival of these bees, as well as for the persistence of species that are restricted to particular substrates and are sensitive to disturbances, such as bees belonging to *Melipona* Illiger, 1806 genus (SILVEIRA et al., 2002).

In terms of nesting habits, the height of the nest entrance varied greatly amongst species. The data gathered in our study for each species were similar to those found by Souza et al. (2005) when comparing common species, except for *Plebeia droryana*. The height at which bees build their nests might be mainly related to the kind of substrate used for nesting and its availability in the environment. The high values recorded for *Trigona spinipes*, for instance, are associated with the habit of this species of building aerial nests in tree forks, making them inaccessible to many predators. This feature, combined with the lack of human interest in exploiting products from this species, is probably making its success in urban landscapes possible (ALMEIDA; LAROCA, 1988).

Half of the studies analyzed found that stingless bees preferentially used constructions as a substrate for nesting (Table 3). This might be related to the fact that nesting spots are a limiting factor to the expansion of bee populations, making any available and reasonably safe nesting spot an acceptable locality for nesting (CAMARGO, 1989). On the other hand, hollow trees were the most utilized substrate in our study and also in another three, emphasizing the importance of forestry projects in urban areas for the maintenance of stingless bees in these localities (BRUN et al., 2007).

Concerning the preferred substrate used by each sampled species, an analysis of the common species showed that our results are similar to those found on the *campus* of Universidade Federal de Juiz de Fora (SOUSA et al., 2002) and in an urban area of Cataguases-MG (NETTO et al., 2007), except for *Nannotrigona testaceicornis*. In our study, this species preferentially built their nests in tree hollows rather than constructions.

Therefore, the preference of *N. testaceicornis* for hollow trees, the occurrence of *Tetragona* sp. gr. *clavipes* and *Scaptotrigona* aff. *depilis* only in this kind of substrate, and the occurrence of *T. spinipes* only in tree forks, serves to emphasize the importance of maintaining tree species and forestry projects in urban areas, since these bee species rely upon the presence of trees for constructing their nests.

The preference for *Caesalpinia peltophoroides* (also known as "sibipiruna") as a plant species for nesting could be explained by its abundance, as it represents 41.76% of plant species in the *campus* (FALEIRO; AMÂNCIO-PEREIRA, 2007). It is a tree frequently used as an ornamental plant in urban forestry programs by its rapid growth, foliage structure that provides good shade and a deep root system that does not damage the pavement (CAVALHEIRO, 1995). In addition, the preference for *C. peltophoroides* might be related to the thick branches (30–40 cm diameter, LORENZI, 2000) that are characteristic of this species, allowing the formation of voids that are essential for stingless bees to build their nests. This would reinforce the indication of *C. peltophoroides* in urban forestry projects.

However, a study carried out in the cities of São Carlos (SP) and Rifaina (SP) reports mortality of bees caused by "sibipiruna" (DEL LAMA; PERUQUETTI, 2006). It is suggested that mortality occurs due to the presence of a toxic substance in the nectar. This feature is not unique to *C. peltophoroides,* since there are known to be 14 plant species belonging to 11 families whose nectar is toxic to bees (ADLER, 2000). The toxicity of "sibipiruna" plants varied temporally and spatially and the susceptibility of bee species and individuals to its effects has also proved to be highly variable (DEL LAMA; PERUQUETTI, 2006).

In addition, it is noteworthy that most of the bees found dead showed solitary behavior (DEL LAMA; PERUQUETTI, 2006). Many studies have highlighted the importance of solitary bees in the maintenance of natural ecosystems, not only because of the larger number of species this group holds, but also because of the great number and specificity of interactions this group of bees can establish with plants (MICHENER, 2007). Meanwhile, these species represent an important component of the urban bee fauna (SILVA et al., 2007). Therefore, the use of "sibipiruna" for landscaping must be carefully considered, and studies on interactions should be expanded to other species commonly used in urban forestry programs.

The spatial distribution pattern of stingless bee nests might be related to several factors, such as density and distribution of suitable substrates, predation, competition (for food and/or nesting spots) and characteristics of the species, such as the distance to founding a new nest (near or away from parental nest) (HUBBELL; JOHNSON, 1977; JONGJITVIMOL et al., 2005; SERRA et al., 2009). In the study area, the clumped distribution of nests could be associated with the distribution of tree species, and especially to the "sibipiruna", which is concentrated around the campus buildings (FALEIRO; AMÂNCIO-PEREIRA, 2007).

Umuarama *campus* of UFU could eventually, in comparison with surrounding areas, be regarded as a vegetation "island" because of the large number of trees. However, the need to expand the infrastructure of the *campus* has led to the replacement of trees by new buildings and large parking lots, strongly affecting stingless bee populations (NOGUEIRA-FERREIRA, pers. inf.). Another factor that must be taken into consideration is indiscriminate tree pruning. Some months after the development of this study, many Meliponina nests were found on the floor near to the pruned trees. Better management of tree pruning is therefore vital in order to prevent reduction of stingless bee populations in urban areas.

This study leads to an improvement in knowledge about the nesting ecology of stingless bees in urban landscapes. Reveals the abundance, diversity, density, spatial distribution and nesting habits of stingless bees on *campus* at UFU. The information gathered highlights the relevance of urban forestry as a conservation policy for stingless bees. The importance of understanding the plant species that are managed in urban forestry projects is also noteworthy, as are the ecological interactions that these species establish with not only bees, but also all the other groups of animals related to urban landscapes.

ACKNOWLEDGMENTS

The authors thank Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financial support, Dra. Silvia Regina de Menezes Pedro for the identification of bees collected in this study, Prof. Dr. Ivan Schiavini for identifying plant species and Msc. Camila Nonato Junqueira for preparing the spatial distribution map of nests. Data from this work was made available for public access through the Dryad repository platform in the following address: http://dx.doi.org/10.5061/dryad.k54hk.

RESUMO: Estudos sobre ecologia de nidificação tem se mostrado extremamente necessários para a conservação de espécies de abelhas sem ferrão. Em ambientes urbanos, estudos desse tipo são escassos. O presente trabalho teve como objetivo analisar a abundância, densidade, diversidade, distribuição espacial e os hábitos de nidificação de espécies da subtribo Meliponina em uma área urbana do município de Uberlândia-MG. No período de outubro de 2009 a abril de 2010, os possíveis locais de nidificação foram vistoriados. Seis operárias de cada ninho foram coletadas para identificação das espécies e os índices de Shannon-Wiener e do vizinho mais próximo foram aplicados para estimativa da diversidade e análise do padrão de distribuição espacial dos ninhos, respectivamente. Foram encontrados 50 ninhos de abelhas sem ferrão pertencentes a sete espécies, sendo *Nannotrigona testaceicornis* a mais abundante (44%). A densidade de ninhos foi de 2,17 ninhos/ha, o índice de diversidade de Shannon-Wiener foi H'=1,58 e a distribuição espacial dos ninhos ocorreu de forma agregada. A altura da entrada dos ninhos em relação ao solo variou, de modo geral, de 0 a 12 m, sendo *Trigona spinipes* a espécie com os ninhos mais altos e com a maior variação. O tipo preferencial de substrato ocupado pelas espécies encontradas foram ocos de árvores (70%), sendo *Caesalpinia peltophoroides* a espécie vegetal mais utilizada. Os resultados obtidos sugerem que ambientes urbanos podem apresentar uma alta diversidade de abelhas sem ferrão e que a manutenção de espécies arbóreas e projetos de arborização são importantes para a conservação de espécies desse grupo de animais. Trabalhos nesse sentido fornecem informações relevantes para a elaboração de planos de manejo e conservação de espécies de Meliponina.

PALAVRAS-CHAVE: Diversidade. Hábitos de nidificação. Substratos de nidificação. Fundação de ninho. Ocos de árvores.

REFERENCES

ADLER, M. S. The ecological significance of toxic nectar. **Oikos**, Rio de Janeiro, v. 91, p. 409-420. 2000.

AGOSTINI, K.; SAZIMA, M. Plantas ornamentais e seus recursos para abelhas no campus da Universidade Estadual de Campinas, estado de São Paulo, Brasil. **Bragantia**, São Paulo, v. 62, n. 3, p. 335-343. 2003.

AGUIAR, A. J. C.; MARTINS, C. F. The bee diversity of the Tabuleiro vegetation in the Guaribas Biological Reserve (Mamanguape, Paraíba, Brazil).In: MELO, G. A. R.; ALVES-DOS-SANTOS, I. (Eds.). **Apoidea Neotropica: homenagem aos 90 Anos de Jesus Santiago Moure**. Criciúma: Unesc, 2003. p. 209-216.

ALMEIDA, M. C.; LAROCA, S. *Trigona spinipes* (Apidae, Meliponinae): taxonomia, bionomia e relações tróficas em áreas restritas. **Acta Biológica Paranaense**, Curitiba, v. 17, n. 1, p. 67-108. 1988.

ALVES, K. A.; ROSA, R. Espacialização de dados climáticos do Cerrado mineiro. **Horizonte Científico**, Uberlândia, v. 8, p. 1-28. 2008.

ANDENA, S. J.; BEGO, L. R.; MECH, M. R. Comunidade de abelhas (Hymenoptera, Apoidea) de uma área de Cerrado (Corumbataí, SP) e suas visitas às flores. **Revista Brasileira de Zoociências**, Juíz de Fora, v. 7, n. 1, p. 55-91. 2005.

BROSI, B. J.; DAILY, G. C.; SHIH, T. M.; OVIEDO, F.; DURÁN, G. The effects of forest fragmentation on bee communities in tropical countryside. **Journal of Applied Ecology**, London, v. 45, n. 3, p. 773-783. 2007.

BRUN, F. G. K.; LINK, D.; BRUN, E. J. O emprego da arborização na manutenção da biodiversidade de fauna em áreas urbanas. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 2, n. 1, p. 117-127. 2007.

CAMARGO, J. M. F. Comentários sobre a sistemática de Meliponinae (Hymenoptera, Apidae). In: XIV SIMPÓSIO ANUAL ACIESP, 1989, São Carlos. **Anais**... São Carlos, 1989. p. 41-61.

CARVALHO, C. A. L.; MARCHINI, L. C. Abundância de ninhos de Meliponinae (Hymenoptera: Apidae) em biótopo urbano no município de Piracicaba-SP. **Revista de Agricultura**, Piracicaba, v. 74, n. 1, p. 35-44. 1999.

CAVALHEIRO, F. Urbanização e alterações ambientais. In: TAUK-TORNISIELO, S. M.; GOBBI, N.; FOWLER, H. G. (Eds.). **Análise ambiental: uma visão multidisciplinar**. São Paulo: UNESP, 1995. p. 88-97.

CLARK, P.; EVANS, F. Distance to nearest neighbor as a measure of spatial relationships in populations. **Ecology**, Ithaca, v. 35, n. 4, p. 445-453. 1954.

DEL LAMA, M. A.; PERUQUETTI, R. C. Mortalidade de abelhas visitantes de flores de *Caesalpinia peltophoroides* Benth (Leguminosae) no estado de São Paulo, Brasil. **Revista Brasileira de Entomologia**, São Paulo, v. 50, n. 4, p. 547-549. 2006.

ERIKSSON, O.; BREMER, B. Pollination systems, dispersal modes, life forms, and diversification rates in Angiosperm families. **Evolution**, St. Louis, v. 46, p. 258-266. 1992.

FALEIRO, W.; AMÂNCIO-PEREIRA, F. Arborização viária do *Campus* Umuarama da Universidade Federal de Uberlândia, MG. **Revista Científica Eletrônica de Engenharia Florestal**, Garça, v. 6, n. 10, p. 1-17. 2007.

GASCON, C.; LOVEJOY, T. E.; BIERREGAARD, R. O; MALCOLM, J. R.; STOUFFER, P. C.; VASCONCELOS, H.; LAURANCE, W. F.; ZIMMERMAN, B.; TOCHER, M; BORGES, S. Matrix habitat and species persistence in tropical forest remnants. **Biological Conservation**, Washington, v. 91, p. 223-229. 1999.

HEARD, T. A. The role of stingless bees in crop pollination. **Annual Review Entomology**, Palo Alto, v. 44, p. 183-206. 1999.

HERNANDEZ, J. L.; FRANKIE, G. W.; THORP, R. W. Ecology of urban bees: a review of current knowledge and directions for future study. **Cities and the Environment**, Los Angeles, v. 2, n. 1, p. 1-15. 2009.

HUBBELL, S. P.; JOHNSON, L. K. Competition and nest spacing in a tropical stingless bee community. **Ecology**, Ithaca, v. 58, n. 5, p. 949-963. 1977.

JONGJITVIMOL, T.; BOONTAWON, K.; WATTANACHAIYINGCHAROEN, W.; DEOWANISH, S. Nest dispersion of a stingless bee species, *Trigona collina* Smith, 1857 (Apidae, Meliponinae) in a mixed deciduous forest in Thailand. **The Natural History Journal of Chulalongkorn University**, Bangkok, v. 5, n. 2, p. 69-71. 2005.

KREBS, C. J. **Ecological Methodology**, 2nd.ed. California: Benjamin Cummings, Menlo Park, 1999. 620 p.

KÖPPEN, W. **Climatologia: un estudio de los climas de La Tierra**. México: Fondo de Cultura Econômica, 1948. 479 p.

LORENZI, H. **Árvores Brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil**. Nova Odessa: Instituto Plantarum, 2000. 368 p.

MATEUS, S.; PEREIRA, U. C. R.; CABETTE, H. S. R.; ZUCCHI R. Locais de nidificação das abelhas nativas sem ferrão (Hymenoptera, Apidae, Meliponinae) do Parque Municipal do Bacaba, Nova Xanvantina-MT. **Mensagem Doce**, São Paulo, v. 100, p. 60-62. 2009.

MICHENER, C.D. **The bees of the world**. Baltimore: The Johns Hopkins University Press, 2007. 953 p.

NETTO, P. S., GUIMARÃES, T. S.; FARIA-MUCCI, G. M. Levantamento da fauna urbana de meliponídeos (Hymenoptera; Apoidea; Apidae) em Cataguases–MG. In: VIII CONGRESSO DE ECOLOGIA DO BRASIL, 2007, Caxambu - MG. **Anais**... Caxambu - MG, 2007.

NOGUEIRA-NETO, P. Características de algumas espécies domesticáveis. In: ______. **A criação de abelhas indígenas sem ferrão**. São Paulo: Editora Chácaras e Quintais, 1970. p. 74.

NUNES, M. R.; SANTOS, M. E. S. Hábitos de nidificação de abelhas nativas e Princípios de Conservação em áreas de Caatinga no Povoado de Limoeiro em Campo Formoso, BA. In: IX CONGRESSO DE ECOLOGIA DO BRASIL, 2009, São Lourenço - MG. **Anais**... São Lourenço - MG, 2009.

ROSA, A. G.; SCHIAVINI, I. Estrutura da comunidade arbórea em um remanescente florestal urbano (Parque do Sabiá, Uberlândia, MG). **Bioscience Journal**, Uberlândia, v. 22, n. 1, p. 151-162. 2006.

SERRA, B. D. V.; DRUMMOND, M. S.; LACERDA, L. M.; AKATSU, I. P. Abundância, distribuição espacial de ninhos de abelhas Meliponina (Hymenoptera,Apidae, Apini) e espécies vegetais utilizadas para nidificação em áreas de cerrado do Maranhão. **Iheringia**, Porto Alegre, v. 99, n. 1, p. 12-17. 2009.

SILVA, C. I.; AUGUSTO, S. C.; SOFIA, S. H.; MOSCHETA, I. S. Diversidade de abelhas em *Tecoma stans* (L.) Kunth (Bignoniaceae): importância na polinização e produção de frutos. **Neotropical Entomology**, Lodrina, v. 36, n. 3, p. 331-341. 2007.

SILVEIRA, F. A.; MELO, G. A. R.; ALMEIDA, E. A. B. **Abelhas brasileiras: sistemática e identificação**. Belo Horizonte: Fundação Araucária, 2002. 253 p.

SOUSA, L. A.; PEREIRA, T. O.; PREZOTO, F.; FARIA-MUCCI, G. M. Nest foundation and diversity of Meliponini (Hymenoptera, Apidae) in an urban area of the municipality of Juiz de Fora, MG, Brasil. **Bioscience Journal**, Uberlândia, v. 18, n. 2, p. 59-65. 2002.

SOUZA, S. G. X.; TEIXEIRA, A. F. R.; NEVES, E. L.; MELO, A. M. C. As abelhas sem ferrão (Apidae: Meliponina) residentes no Campus Federação/Ondina da Universidade Federal da Bahia, Salvador, Bahia, Brasil. **Candombá- Revista Virtual**, Salvador, v. 1, n. 1, p. 57-69. 2005.

TAURA, H. M.; LAROCA, S. Abelhas altamente sociais (Apidae) de uma área restrita em Curitiba (Brasil): Distribuição dos ninhos e abundância relativa. **Acta Biológica Paranaense**, Curitiba, v. 20, p. 85-101. 1991.

TEIXEIRA, A. F. R**. Ecologia das abelhas eussociais do gênero *Frieseomelitta* Von Ihering, 1912 (Apidae; Meliponina)**. 2003. 107 f. Dissertação (Mestrado em Ecologia e Biomonitoramento) - Instituto de Biologia, Universidade Federal da Bahia, Salvador, 2003.