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Areas of Natural Occurrence of *Melipona scutellaris* Latreille, 1811 (Hymenoptera: Apidae) in the state of Bahia, Brazil

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ABSTRACT

The bee *Melipona scutellaris* is considered the reared meliponine species with the largest distribution in the North and Northeast regions of Brazil, with records from the state of Rio Grande do Norte down to the state of Bahia. Considering the importance of this species in the generation of income for family agriculture and in the preservation of areas with natural vegetation, this study aimed at providing knowledge on the distribution of natural colonies of *M. scutellaris* in the state of Bahia. Literature information, interviews with stingless bee beekeepers, and expeditions were conducted to confirm the natural occurrence of the species. A total of 102 municipalities showed records for *M. scutellaris*, whose occurrence was observed in areas ranging from sea level up to 1,200-meter height. The occurrence of this species in the state of Bahia is considered to be restricted to municipalities on the coastal area and the Chapada Diamantina with its rainforests. Geographic coordinates, elevation, climate and vegetation data were obtained, which allowed a map to be prepared for the area of occurrence in order to support conservation and management policies for the species.

Key words: Stingless bee beekeeping, urucu bee, stingless bees, distribution.

INTRODUCTION

The species *Melipona scutellaris*, locally known as “Uruçu do Nordeste” or “Uruçu verdadeira”, was one of the first bee species domesticated by Potiguara, Kiriri, Xucuru, Pataxó, Paiaku, Tupicuruba and Aymoré indians. The Portuguese colonizers, who enjoyed honey of this species, soon learned rearing techniques that led urucu to become one of the most frequently reared species of stingless bees in the Northeast and, consequently,

the subject of hunting in order to extract honey (Kerr et al. 1996, Imperatriz-Fonseca et al. 2007).

Mariano Filho (1911) stated that this species was distributed from the Amazon Region down to the state of Bahia. Schwarz (1932) referred to *M. scutellaris* and reported the states of Bahia and Pernambuco as areas of occurrence, where this species was found by Ducke. In the same study, in an analysis of the distribution proposed by Drory, which included the state of Ceará, Schwarz analyzed a colony that was maintained in that state but actually came from the state of Bahia. In another study, Schwarz (1948) reported that *M. scutellaris* distribution would

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extend from Mato Grosso to Pará, and that the bee also occurred in Guyana, Suriname and Panama. Lamartine (1962) studied the distribution of this species and demonstrated that it inhabits the humid region of the Northeast and can be found throughout the Northeastern coast, from the state of Bahia up to Rio Grande do Norte, mainly occupying the Atlantic Rainforest biome, although it might also occur in some inland areas in the states of Pernambuco, Alagoas, and Bahia (Nogueira-Neto 1970, Oliveira et al. 1986). These studies expanded the distribution area for this species. However, it is believed that such reports can be attributed mainly to information from collaborators that would send specimens to taxonomists.

According to Nogueira-Neto (1970), the term “uruçu” designates several bees of the Brazilian fauna, which may be one of the reasons for the equivocal information on the widespread distribution of *M. scutellaris*. Observations made by the author RMOA in the Amazon Region allowed to verify that a large part of the local population is comprised of northeastern people that introduced regional terms during colonization times. An interesting fact also concerns the existence of a species — *Melipona eburnea* — in the Municipality of Careiro-AM, which visually does not differ from *M. scutellaris* and is called “uruçu” by some stingless bee beekeepers. Such similarities can be confirmed in Schwarz (1932) who cited the classification of this species performed by Ducke in 1916, then considered to be *M. eburnea*, a subspecies of *M. scutellaris*, i.e., *M. scutellaris eburnea*.

Santos and Amorim (2007) emphasized that the delimitation of endemic areas depends on the accuracy of phylogenetic information; therefore, it is quite plausible that contradictions will exist when the distribution of a species in a given area is established.

Observations made by RMOA during excursions to Northeastern Brazil confirmed that the species inhabits the coastal strip that extends from Rio Grande do Norte to Bahia and is distributed through the states of Pernambuco, Paraíba, Alagoas and Sergipe. In

the states of Bahia and Pernambuco it can be found inland in humid mountain ranges; the largest rearings are located on the coast and in the highlands, such as Caruaru and Garanhuns in the state of Pernambuco and on the coast of the state of Bahia.

Bahia has a vast expanse of land with rainforests distributed in many regions, especially the coastal area, which spans for 1,000 km where once existed one of the country's largest Atlantic rainforest areas. This coastal area is characterized by ombrophilous and humid forest vegetation, which is the ideal habitat for several bee species including social species of the subtribe Meliponina.

Within this context, *M. scutellaris* stands out because it is the best known and most managed stingless bee species in Bahia, inhabiting biomes with similar characteristics, but in distinct and sometimes little known areas. As the stingless bee beekeeping activity increases in the state and the demand for stingless bee products is on the rise, the pursuit for new information on Northeastern Uruçu has been valued and expanded.

This study aimed at identifying the areas of natural occurrence of *M. scutellaris* L. (Apidae: Meliponina) in the state of Bahia, Brazil, providing background information for future conservation and management strategies for the species.

MATERIALS AND METHODS

A database containing the localities in the state of Bahia with *M. scutellaris* records was organized in an electronic spreadsheet and fed with information obtained by three means: (1) interviews with residents of the region about the existence of the species at the locality for later verification *in locu*; (2) collection of bees in the field at sites previously indicated by stingless bee beekeepers; and (3) literature survey. Field data were collected from 1985 to 2007; specimens were captured with an insect net, killed with ether or ethyl acetate, mounted, maintained in an entomological collection

and later sent for identification to the Entomology Laboratory at *Universidade Federal do Recôncavo da Bahia* (UFRB), Cruz das Almas-BA, Brazil.

Climatic, topographic and vegetation data were obtained from Superintendência de Estudos Econômicos e Sociais da Bahia (SEI 2007) and from Instituto Brasileiro de Geografia e Estatística (IBGE 1992, 2007). Geographic coordinates and elevation data were obtained with a MLRSP 12X GPS receiver and supplemented with information from the SEI database (2002, 2007). The climate classification and division into mesoclimates were made according to the differences in humidity of each locality (IBGE 1981).

Individual lines were constructed from basic units (coordinates) representing the distance among the points. The intersection of these coordinates resulted in a panbiogeographic node that represents the area of occurrence of the species (Morrone 2004, Yanez-Ordóñez et al. 2008).

The information was used to construct maps of occurrence for the species in the state of Bahia using the SPRING 4.1.1 software (Camara et al. 1996).

RESULTS AND DISCUSSION

The occurrence of *M. scutellaris* was recorded in 102 municipalities of Bahia, from a total of 417, corresponding to 24.5%. The climate, elevation range and geographic coordinate data for the natural distribution of *M. scutellaris* in Bahia are summarized in Table I.

DISTRIBUTION AND CLIMATE IN THE AREA OF NATURAL OCCURRENCE

Based on the surveys and visits made, it can be stated that, in general, the species was restricted to the state's humid and sub-humid regions, with the occurrence of forests and contact areas surrounded in some regions by relatively dry areas, which constitutes an ecological barrier among larger forest refuge areas that, according to P.E. Vanzolini (unpublished data), are small survival areas. This distribution can be visualized by marking the geographic coordinates of the municipalities where the species occurs and through the construction of dispersal lines that, according to Morrone (2004),

TABLE I
Natural occurrence of *Melipona scutellaris* in the state of Bahia.

Total number of municipalities	Elevation Variation (m)	Latitude Variation	Longitude Variation	Climates in the area*	Humidity index*	Vegetation in the area*
102	6 to 1040	10°27'59" to 13°56'28"	37°36'35" to 41°23'22"	Humid	40 to 60	Ombrophilous forest
				Humid	40 to 60	Ombrophilous forest/Seasonal forest
				Humid to sub-humid	20 to 60	Ombrophilous forest/Seasonal forest
				Humid to sub-humid	0 to 40	Seasonal forest
				Humid to sub-humid	0 to 40	Seasonal forest/Deciduous forest
				Sub-humid	+ 20 to - 20	Seasonal forest/Deciduous forest
				Sub-humid	+ 20 to - 20**	Seasonal forest/Deciduous forest
				Sub-humid	+ 20 to - 20**	Deciduous forest Forest/caatinga interface
				Sub-humid to Semi-arid	0 to - 20**	Forest/caatinga interface

* Source: IBGE 1992, ** Negative values are in accordance with Thornthwaite's water balance determination rules (IBGE 1981).

can determine the path followed by a species. Humid climate localities showed the highest number of colonies; in areas of sub-humid climate the number of colonies was smaller, especially when they reach the transition border between the forest and the caatinga or the cerrado.

The characteristic for the regional climate type and its mesoclimate variations are based on

formulas that take into account a maximum humidity condition (IBGE 1981). Some municipalities show both regional and local climate variations, with variations in humidity index, which will allow the existence of a vegetation typical of high humidity indices. Based on these data, the geographic limits were defined for the distribution of the species in the state (Table II).

TABLE II
Geoclimatic boundaries of occurrence of the stingless bee *Melipona scutellaris* in the state of Bahia, Brazil.

Municipality	Boundary	Elevation (m)	Latitude	Longitude	Climate
Senhor do Bonfim	North	533	10°27'59"	40°09'34"	Sub-humid to dry and semi-arid
Camamu	Southeast	34	13°56'28"	39°07'19"	Humid
Salvador	East	24	12°58'12"	38°30'46"	Humid
Conde	Northeast	66	11°48'31"	37°36'43"	Humid
Lafaiete Coutinho	South	558	13°39'25"	40°12'46"	Sub-humid to dry and semi-arid
Lençóis	West	748	12°33'42"	41°23'31"	Humid - humid to sub-humid and sub-humid to dry
Barra da Estiva	Southwest	1.026	13°36'50"	41°19'22"	Sub-humid to dry and semi-arid
Morro do Chapéu	Northwest	1040	11°32'57"	41°09'02"	Sub-humid to dry and semi-arid

Source: SEI 2007.

In the municipality of Serra Preta (12°09'37"S and 39°19'54"W) both reared and forest colonies were found, confirming reports of old local residents on the occurrence of *M. scutellaris*. Most of the area in this municipality is located in the dry zone; however, there are continuous mountain ranges with the predominance of semi-deciduous forest vegetation with a high humidity index (SEI 2007). Between Serra Preta and Ipirá (12°09'30"S and 39°44'14") (40 Km apart from each other) there have been reports by residents of the region about the species being found in their mountain ranges, leading to the assumption that the humid forests that once existed there allowed the occurrence of urucu in the region since rearings of the species can be found in the municipality of Baixa Grande (11°57'35"S and 40°10'05"W) (sub-humid and dry climate), which lies at 50 Km from Ipirá on the same road (BA 052 = Estrada do Feijão).

The fact that the current plant formation was observed in the municipalities along this route allows the statement to be made that there was a continuity of the seasonal forest currently very anthropized and with a strong presence of the Caatinga-Seasonal Forest interface in Anguera (12°09'04"S and 39°14'47"W), Ipirá and Baixa Grande (11°57'35"S and 40°10'05"W).

The municipality of Morro do Chapéu is the northwest border of occurrence of the species in the state, as the local forest contains colonies both in stingless bee beekeeping facilities and under natural conditions. The habitat where the species occurs comprises the entire mountain range that goes from Morro do Chapéu (11°33'00"S and 41°09'22"W) to Senhor do Bonfim (10°27'41"S and 40°11'22"W), especially the municipalities of Pindobaçu (10°44'30"S and 40°21'39"W), Saúde (10°56'28"S

and 40°25'08"W), Mundo Novo (11°51'32"S and 40°28'21"W) and Tapiramutá (11°50'50"S and 40°47'29"W), whose area showed the highest number of observed colonies and is characterized by sub-humid and sub-humid to dry climates. The western border is the municipality of Lençóis (12°33'47"S and 41°23'24"W), where the species is well known and intensively reared, with distribution along the ranges of Andaraí (12°48'26"S and 41°19'53"W), Itaetê (12°59'11"S and 40°58'21"W) and Barra da Estiva (13°37'34"S and 41°19'37"W); the latter is considered the southwest border.

The regions located in the middle of the area, consisting mainly of the municipalities of Castro Alves (12°45'56"S and 39°25'42"W), Santa Teresinha (12°46'19"S and 39°31'24"W), Amargosa (13°09'49"S and 39°36'17"W) and those in the Jequiriçá River valley are characterized as places where the species is present in high areas with humid to sub-humid climate. The state's southern border is Lafaiete Coutinho (13°39'21"S and 40°12'45"W), which lies near Maracás (13°26'28"S and 40°25'51"W) and Planaltino (13°15'32"S and 40°22'08"W); this route may indicate the linkage between the Coast and the Plateau through Itaetê. The strip that comprises Jandaíra (11°33'51"S and 37°47'04"W) to the northeast and Camamu (13°56'41"S and 39°06'14"W) to the southeast are the sites with the highest concentrations of colonies and rearings, comprising areas with humid and humid to sub-humid climates and the existence of forests at sea level with precipitations above 1,500 mm/year.

The municipalities of the occurrence of urucu are connected between one another possibly following a typical vegetation associated with those localities (Seasonal or decidual forest) (Fig. 1). This observation is in accordance with the characteristics of forest areas, which show favorable conditions of food, humidity and temperature, as well as allow a better distribution of the species in strips which, in some places, are represented by transition areas.

Transition zones located on the interfaces between biomes represent biotic hybridization events caused

by ecological changes that allow a mixture of different biotic components and where several species can be maintained (Morrone 2004). In the case above, the hybrid zones are the seasonal and decidual forests that possess favorable characteristics for the development of the species under threshold humidity conditions.

The distribution of free-living insects results from factors such as latitudinal gradient (richness and abundance decrease with the elevation), the effect of habitat and favorable conditions (mesic habitats have higher richness and abundance than xeric ones due to the presence of higher humidity and temperature conditions at any elevation), and precipitation amount and frequency (Martins 1985, Carneiro et al. 1995). In general, the distribution of terrestrial animals in the continents is correlated with great plant formations, or with temperature and humidity, or with a combination of both facts (P.E. Vanzolini, unpublished data).

Areas that interface with different climate types such as areas with the joint occurrence of seasonal forest and caatinga determine conditions that show the lowest numbers of colonies found. The abundance and diversity of food sources act as relevant variables in the determination of richness of local bee faunas (Oliveira and Silveira 2007).

VEGETATION IN THE AREA OF NATURAL OCCURRENCE

An analysis of the type of vegetation found in the habitats where *M. scutellaris* occurs in the state of Bahia revealed that the species became adapted to the vegetation of humid and sub-humid forests known as Ombrophilous and Seasonal Forest with its variations, decidual and semi-decidual, and trees with large hollows in all locations where the bee exists, even in municipalities with the predominance of transitional vegetation (contact).

Studies conducted in Pernambuco showed the relationship between *M. scutellaris* and the humid forest whose conditions are ideal for the bees to build their nests (Lamartine 1962, M.G. Almeida, unpublished data). In Bahia, Alves et al.

(2005) observed the nest building adaptation of *M. scutellaris* in coconut tree hollows located in the state's coastal region.

Martins (1985) explained that the degree of air humidity is a crucial factor in the formation of floristic and especially faunistic landscapes in the same region, leading to the assumption that the species started to spread from the coast towards mountainous areas following the humid vegetation that existed in those areas.

These conditions may have favored the stingless bee dispersal that, according to Kerr and Maule (1964), began in regions with humid climates in South America, where the highest diversity of meliponine species can be found.

According to M.F.F. Costa Pinto (unpublished data), the mountainous areas of the plateau do not belong to any defined phytogeographic domain and are better classified as a vegetation mosaic that forms small-sized xerophytic communities, which

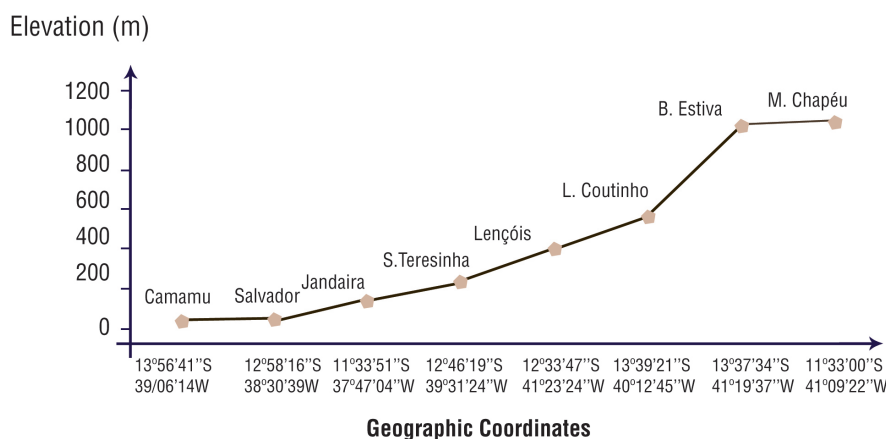


Fig. 1 - Areas of natural occurrence of *Melipona scutellaris* in the state of Bahia, Brazil. SPRING software v. 4.1 (Camara et al. 1996).

makes the nest building of *M. scutellaris* more difficult, since these bees use cavities in usually large trees for their nests.

In municipalities such as Itaetê, where the elevation at some points reaches 800m, although for the most part it is around 300m, and the predominant vegetation shows xerophyllous characteristics, nests were found only in mountainous seasonal forest areas. In the municipality of Santa Inês (13°17'32"S and 39°49'08"W), which sits in a low-lying area and whose vegetation is mostly xerophyllous, *M. scutellaris* can be found in caatinga-seasonal forest transition sites in the most humid areas.

The occurrence of higher nest concentrations in low-lying regions is probably due to the hot and humid climate found in such places, which provides greater colony internal temperature control, and

also because it facilitates the formation of humid forests and greater tree growth with sufficient tree hollows to build nests.

A study carried out by Silveira et al. (2002) reported that several *Melipona* species depend upon forest environments and are not found in open environments, except in forest margins. An exception is *M. quinquefasciata*, which occupies cerrado and forest savanna plant communities in Chapada do Araripe (Lima-Verde and Freitas 2002).

Therefore, it is possible that numerous species, including *M. scutellaris* that 500 years ago had a widespread distribution in the coastal region originally covered with the Atlantic Rainforest, are now confined to one or a few isolated forest refuges (Silveira et al. 2002). G.A. Carvalho (unpublished data) considered that Chapada Diamantina had denser forest areas than

can be found today due to the existence of humid forest remnants around the municipality of Lençóis.

This fact demonstrates the occurrence of this species in highland environments where forest corridors existed in the past, such as the mountain ranges of Ipirá, Anguera, Serra Preta, Milagres (12°52'12"S and 39°51'32"W), Irajuba (13°15'05"S and 40°05'04"W), Itaetê, Nova Itarana (13°01'37"S and 40°04'16"W) and Marcionílio Souza (13°00'11"S and 40°31'50"W).

NATURAL OCCURRENCE BOUNDARIES

According to the natural occurrence boundaries for the urucu bee in Bahia, it can be observed that the species has a wide distribution in the state, spanning 400 km on the north-south and east-west axes (considering the municipality of Santa Teresinha as the center) (Fig. 2).

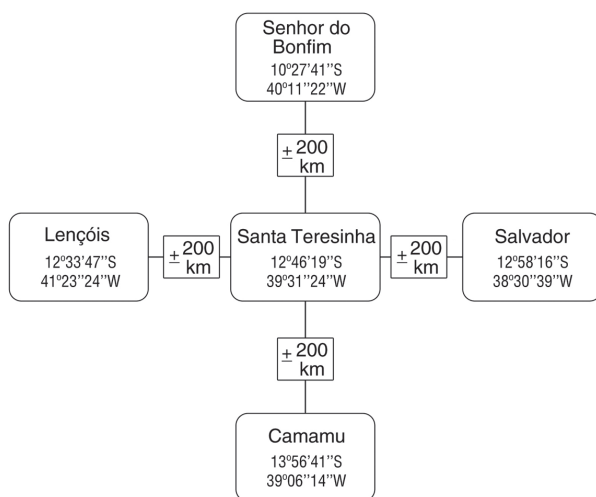


Fig. 2 - Occurrence boundaries for the species *Melipona scutellaris* in the state of Bahia considering the approximate distance between bordering municipalities.

ELEVATION OF AREAS OF OCCURRENCE

The data obtained demonstrate a wide elevation distribution of *M. scutellaris* in the state, with occurrences from the sea level on the coast to the heights of Chapada Diamantina (Fig. 3).

Considering the elevation variation in localities with *M. scutellaris* records, three distinct groups of populations of the species can be separated in the state of Bahia as proposed by M.F.F. Costa Pinto (unpublished data) (Table III).

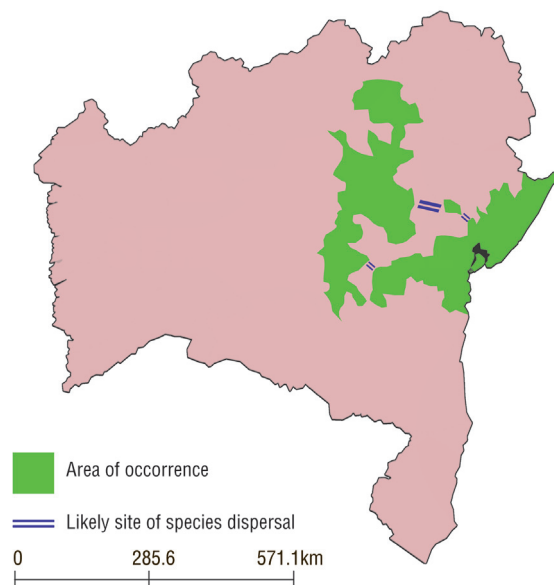


Fig. 3 - Gradient of elevation distribution of *Melipona scutellaris* in the state of Bahia, Brazil.

TABLE III
Variation in elevation, number of municipalities and groups related to *Melipona scutellaris* (Apidae: Meliponina) found in the state of Bahia, Brazil.

Elevation (m)	Number of municipalities	Groups *
0 to 100	36	Sea Level
Between 100 and 600	56	Intermediate
Above 600	10	High Ranges

* Groups proposed by M.F.F. Costa Pinto (unpublished data).

Observations on the development of colonies in the areas visited confirm differences according to the elevation. Colonies that inhabit areas of lower elevations, consequently with a smaller amplitude of daily temperature, showed higher numbers of individuals, while colonies in areas of higher elevations showed smaller populations and the frequent formation of an involucre.

Kerr et al. (1996) stated that the isolation and specialization of meliponines seems to be mostly the result of behavior peculiarities, especially regarding the thermoregulation factor, and an important trait that it is determinant in defining habitats for these species.

As the elevation gradient increases, a reduction can be observed in the number of colonies found in the field, especially in seasonal forest areas and on the interfaces between vegetation types, where a smaller number of nesting sites was observed.

Ortiz-Mora and van Veen (1995) confirmed the hypothesis formulated by Roubik (1989) that meliponines demonstrate a certain tolerance to cold and that the distribution of meliponines is frequently more affected by a lack of suitable nesting sites than by climatic reasons.

GENETIC DIVERSITY

An analysis of the collected individuals shows morphological differences between workers of populations from different elevations. Workers from coastal colonies have a dark thorax (melanotic), while the opposite occurs in mountainous regions, where workers have a light thorax. Such variation might be associated with the humidity in these areas which, according to Martins (1985), influences the pigmentation of animals, with a tendency to enhance color.

J.M.F. Camargo (unpublished data) studied the geographic distribution and differentiation of *Melipona seminigra* and acknowledged that despite variations in integument color patterns and pubescence, all individuals belonged to the same species. Roubik (1992) cited that dark- or light-colored *M. fasciata* subspecies can be readily distinguished; the same occurs with forms of *M. panamica* from Costa Rica and Panama.

Nunes et al. (2007) used morphometric characters of the wings and observed the existence of phenotypic genetic variation in *M. scutellaris* populations at different elevations. Molecular

studies using the RAPD technique conducted by M.F.F. Costa Pinto (unpublished data) with *M. scutellaris* specimens confirmed that, despite being visually different, the species found in the entire state of Bahia is *M. scutellaris*, with the same number of chromosomes and similar genetic characteristics. However, there is the formation of distinct groups due to a lack of gene flow among all populations, thus creating genetic distances.

P.E. Vanzolini (unpublished data) clarified that, in spite of the degree of divergence reached when a given species becomes isolated, this fact per se is not sufficient to prevent populations to cross normally in nature. Colonies brought from regions of higher elevations and introduced into the coastal region of Bahia hybridized normally with colonies from low-lying places. This fact may be used in the future in breeding studies on these populations. Moure (1971) studied *Melipona marginata* and concluded that, despite the color parallelism and microtasseling of the mesepisternum seen between the two varieties on a geographic basis, the two forms could not be close to each other since one was from the mountains and the other, melanotic, occurs on the coast of the state of Paraná, which is not the case of *M. scutellaris* in Bahia.

Therefore, it can be seen that the more distant the populations, the smaller the gene flow rate becomes among them, leading to higher genetic divergence. M.F.F. Costa Pinto (unpublished data) considered that the high genetic distance calculated among populations of *M. scutellaris* is a factor that indicates that the elevation is interfering with the gene flow among the populations, showing that vertical migration in this species is difficult and making the exchange of genetic material harder among populations of different elevations in the state of Bahia.

Kerr et al. (1996) stated that current meliponines form a more isolated and specialized group whose individuals depend on the climatic and floristic characteristics of their respective regions

of origin. Since bees are typically good fliers, it is reasonable to think that they would not have any problems in crossing geographic barriers or in departing from areas where the climate or the vegetation are inhospitable. However, the distribution data suggest that many groups of bees are not particularly good at crossing barriers (UFV 2007). For most bees, dispersal and expansion towards nearby land masses must have occurred slowly, following the vegetation, or by means of human transport.

This expansion suffers the influence of natural causes that contribute to reduce the number of species and areas of occurrence, such as fires and the attack of enemies, as well as anthropic practices such as deforestation, implementation of crops, increases in human occupation areas and the action of honey extractors that accelerate the process of reduction in the number of colonies. Therefore, in order to protect these bees, extensive and continuous vegetation areas should be preserved and management techniques should be adopted to warrant the gene flow among populations (Kerr et al. 2001, M.F. Ribeiro, unpublished data).

In this respect, stingless bee beekeeping could be an important tool since it allows the exchange of genetic materials (queens, brood disks and colonies) among stingless bee beekeepers along the elevation gradient within the area of natural occurrence in the state of Bahia, especially on the coast and in plateau ranges, mainly those associated with humid forest areas.

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RESUMO

A abelha *Melipona scutellaris* é considerada a espécie criada de meliponíneo com maior distribuição no norte e nordeste do Brasil, com ocorrência registradas desde o Estado do Grande do Norte até o Estado da Bahia. Considerando a importância desta espécie na geração de renda para agricultura familiar e na manutenção de áreas com vegetação natural, este trabalho teve como objetivo conhecer a distribuição de colônias naturais de *M. scutellaris* no Estado da Bahia. Informações de literatura, entrevistas com meliponicultores e expedições foram realizadas para confirmar a ocorrência natural da espécie. Um total de 102 municípios apresentou registro de *M. scutellaris*, cuja ocorrência foi observada em áreas desde o nível do mar até 1.200 metros de altitude. A ocorrência desta espécie no Estado da Bahia é considerada como restrita a municípios da área costeira e da Chapada Diamantina, onde existem matas úmidas. Dados de coordenadas geográficas, altitude, clima e vegetação foram obtidos, possibilitando elaborar o mapa da área de ocorrência, subsidiando políticas de conservação e manejo da espécie.

Palavras-chave: Meliponicultura, abelha urucu, abelhas sem ferrão, distribuição.

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