Article

Characterization of native bee species and their biocultural relationship in the Oaxacan Mixteca

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Abstract

There are more than 20 000 species of bees, only 5% are social, within these is the Meliponini tribe, for Mexico 46 species of native stingless bees are reported (Arnold *et al*., 2018). These native bees carry out fundamental tasks since they are great pollinators, they are responsible for the maintenance and balance of the ecosystem. Currently there is evidence on the negative effects on bees due to the various actions of man that have caused their decrease, among them traditional agriculture and the extraction of wild nests stand out. The objective of this study was to characterize the native bee species and their biocultural relationship with the community of Peña Flor de Clavo, Santa Lucia Monteverde, Oaxaca, where semi-structured interviews were applied to the inhabitants to know the native bee species, the sources of food, knowledge, uses and practices of local management. A total of 11 species of stingless bees and 10 genera were identified, eight species are recognized locally, which are: *Frieseomelitta nigra*, *Geotrigona acapulconis*, *Melipona fasciata*, *Nannotrigona perilampoides*, *Scaptotrigona hellwegeri*, *Trigona fulviventris*, *Partamona bilineata* and *Trigonisca pipioli* and three species are unknown.

Keywords: food sources, native bees, species characterization.

Reception date: October 2020
Acceptance date: February 2021

Introduction

Bees belong to the Apoidea superfamily of the Hymenoptera order, currently around 20 000 species of bees are known worldwide, of which 400 to 500 species correspond to native stingless bees, grouped within the Meliponini tribe, they are the only group of bees native to America, which has a highly social behavior, live in perennial colonies and their populations vary between about 100 to 100 000 individuals, in addition they are found in the tropical and subtropical regions of Africa, Asia, Australia and America, in the last on the mainland, the meliponinos can be distributed from Mexico to the north of Argentina (Gennari, 2019).

Native bees (*Apis mellifera*) are known for the benefits of their products (honey, pollen, wax, etc.), the result of their breeding since time immemorial, believing that honey was the first substance that man used to sweeten his food (Vásquez *et al.*, 2016). In Mexico since before the arrival of the Spaniards, the Mayans already practiced the breeding of stingless bees in the Yucatan peninsula and part of Central America, where honey was the sweetener for this culture, and they already used wax for payment of tribute and commercialization with other peoples of Mesoamerica (Legorreta, 2016). However, not all cultures have documented this knowledge; in Oaxaca, for example, a greater effort is needed to document the apifauna of the municipalities of the state, since there are few studies with an ecological and ethnoecological approach carried out (Ayala, 1999; Arnold *et al*., 2018).

Currently the fauna of native bees is at risk due to different problems such as: traditional agriculture, application of agrochemicals, climate change, lack of knowledge about their management, introduction of exotic species (*Apis mellifera*), low flowering and hunting of honey has caused the death of native bees, but the main problem is that its great richness of native bee species is unknown (Mérida and Arnold, 2016).

Native stingless bees are of essential importance because they are organisms responsible for the pollination of most species of flowering plants, cultivated and wild, thus playing an ecological, economic, social role and in our food security (Gonzáles *et al*., 2018). FAO (2004) estimates that about 73% of the cultivated plant species in the world and more than 75% of the world's vegetation are pollinated by bees (Arnold *et al*., 2018), despite their importance, the impact on the population of stingless bees has been remarkable, since its cultivation has been gradually displaced by that of honeybees, this due to a greater production of honey and wax (Pérez e*t al*., 2018).

The problem faced by the community of Peña Flor de Clavo, San Sebastian Nopalera with native stingless bees (Meliponini) is due to the fact that, in recent years, the population of these bees has decreased considerably, due to the fact that most of the people they practice traditional agriculture (rose, grave and burn), in which a large part of the habitats is destroyed, that is, mother trees are cut down and thus the food (flower resources) of the pollinators decreases (Arnold *et al.*, 2018).

In addition, the inhabitants use agrochemicals such as fertilizers, insecticides and herbicides in agriculture. The use of these toxic substances in crops has caused the death of native bees and a reduction in the diversity of flowers (Mérida and Arnold, 2016).

The study aims to characterize native bees and their biocultural relationship in the community of Peña Flor de Clavo, San Sebastian Nopalera, Santa Lucía Monteverde, Oaxaca in order to know the diversity of native stingless bees and the species of flowers they use as a source of food to give the proposals of modernization in boxes to conserve the native bee species of the community and develop the activity of meliponiculture, generating sources of employment and economic income for families.

Materials and methods

Description of the study area

The project was carried out in the rural nucleus of Peña Flor de Clavo (Figure 1) belonging to the municipal agency of San Sebastian Nopalera, in the municipality of Santa Lucia Monteverde, Oaxaca, Mexico, it is located in the province of Sierra Madre del South, between a small Valley of the Mixteca Baja with a territorial extension of 15 970.20 ha (PDM, 2016). The municipality of Santa Lucia Monteverde, borders to the north with Santa Catarina Yosonotu and Santiago Nuyoo, to the east with Santa Catarina Yosonotu, Chalcatongo de Hidalgo, Santiago Yosondua and Santa Cruz Itundujia, to the south with Santa Cruz Itundujia and San Andres Cabecera Nueva, to the west with San Andres Cabecera Nueva, Putla de Guerrero and Santiago Nuyoo (INEGI, 2010).

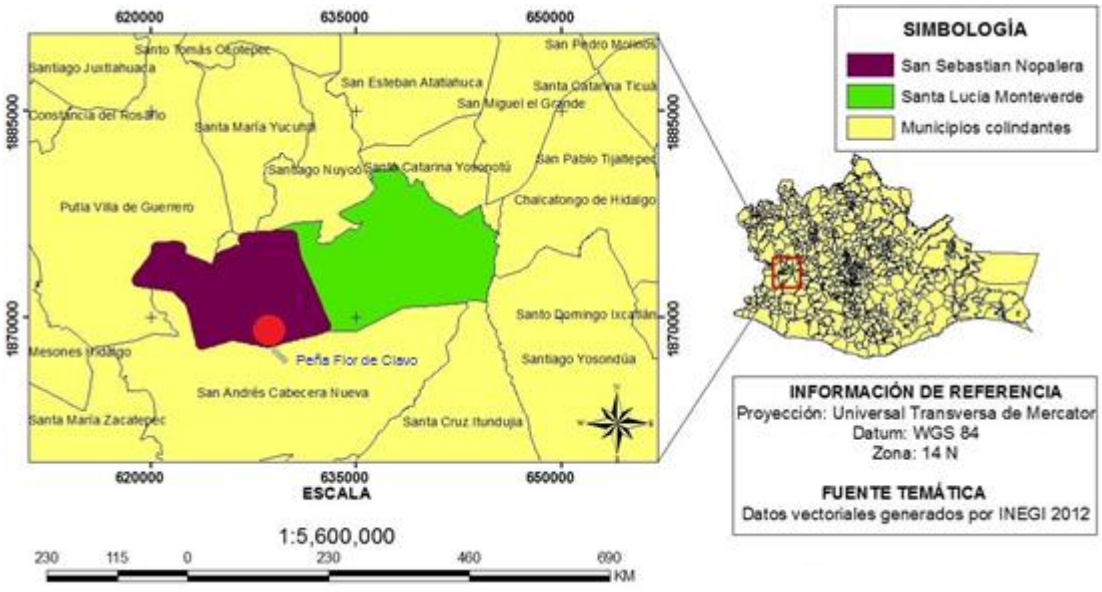

Figure 1. Geographical location of Peña Flor de Clavo, Municipality of Santa Lucía Monteverde, Oaxaca. Elaboration with data from INEGI (2012).

According to García (2004), the prevailing climate in the municipality of Santa Lucía Monteverde is temperate Subhumid with rains in summer and dry in winter, the temperature range oscillates between 12 and 24 °C and precipitation fluctuates between 1 000 and 2 500 mm in said municipality.

Methodology

The type of research was mixed due to the qualitative and quantitative aspects that are presented, the qualitative data are: local knowledge, food sources and the local taxonomy of bees, while, quantitatively, species of bees were identified and quantified without a needle, the characteristics evaluated were bee weight, bee length, beehive type and color (Yániz *et al*., 2017). Qualitative research studies reality in its natural context and how it happens, taking and interpreting phenomena in accordance with the people involved.

This research produces descriptive data: people's words, spoken or written, and observable behavior (Pérez, 2011). The research was based on the ethnographic method described by Munch (2005) as an approach that tries to present episodes that are portions of life documented with a natural language and that they represent as faithfully as possible.

Due to the direct interaction with people to obtain information about native stingless bees, local names, flowers they visit, uses, local practices, current situation and beliefs about native stingless bees. The study population is counted through the numerical conception to which it refers to the number of individuals and families that make up the community (Martínez, 2012). In relation to the research topic, it was all the families that exist in the community of Peña Flor de Clavo.

The research was carried out in the community of Peña Flor de Clavo, this community belongs to San Sebastian Nopalera and we worked with families from the community, with men and women. The characteristics that were taken into account for the application of the questionnaire were the following: Have knowledge about native stingless bees. Living in the community for at least five years; be at least 18 years old and over.

The object of study are the native stingless bees from the community of Peña Flor de Clavo. These bees belong to the meliponini tribe or also known as ANSA, it is the largest tribe that exists in highly social Mexico that can provide different products such as: wax, honey, propolis, among others.

The type of sampling used for this research was quotas, because the 10 families of the community were interviewed, in which the interview techniques and direct observation were applied with their respective instruments that facilitated the research (Rivero, 2008).

1) a semi-structured questionnaire was conducted which consisted of seven questions that were applied to the 10 families of the community in order to obtain information about native stingless bees; 2) the presentation of the preliminary project was made to the authority of the municipal agency of San Sebastian Nopalera, later with the local representative of the community of Peña Flor de Clavo where matters on the research topic were discussed and they were informed that it would be carried out visits in the community; 3) field trip: for the collection of the different species

of native stingless bees (tribe: Meliponini), sites with the presence of numerous species of flowers were resorted, first they were collected in the lowest part of the community (altitude of 853), then in the middle part and in the mountains that are around it (1 000-1 181). An observation guide, field notebook, photographic camera and GPS were used to take the coordinates of each site; 4) the collection technique was extensive and directed, the extensive technique applied the direct search method in the different natural areas of the study place, the second was directed collection, with the help of people from the community different sites where there is a presence of wild nests were used, in both methods the capture with an entomological aerial net was used. The collected specimens were sacrificed in lethal chambers with 70% alcohol.

It is worth mentioning that three sites with blooms of approximately 3 km distance between each site where different species of bees were collected were selected again, the collected species were sacrificed in lethal chambers with ethyl acetate for their subsequent mounting on entomological pins. Each specimen was labeled with the basic data of the site and the label of the taxonomic identification. The specimens were then placed in an entomological box for their taxonomic identification; 5) an Excel database was created for data on longitude, latitude, altitude, collection date, determination date, state, district, region, municipality, locality, site code, genus, species, substrate, collector and determiner for each specimen according to the label.

The collected specimens were deposited in the Bee Collection (ECOAB) of El Colegio de la Frontera Sur, San Cristobal de las Casas Unit, Chiapas. The information from the Excel database was transferred into the FileMaker Pro® program of said institution; 6) scientific identification was carried out according to Ayala (1999) with the help of the taxonomic key found in the document: review of the stingless bees Hymenoptera: Apidae: meliponini and at the facilities of the Colegio de la Frontera Sur (ECOSUR), based in San Cristobal de las Casas.

In identifying bees it was supported by a Nikon SMZ1500 stereomicroscope. For the local identification of these species, a semi-structured interview was conducted in the community based on Robles (2011) to gather information and facilitate identification; and 7) for the list of the bees' food sources, direct dialogue and the interview application were used in order to obtain information on the common names of the flowers visited by the bees present in the study area.

Results and discussion

Diversity of native stingless bee species

In August-December, a total of 119 specimens of stingless bees from the meliponini tribe were collected in the community of Peña Flor de Clavo, San Sebastian Nopalera. The specimens that were collected belong to 11 species that correspond to 10 genera which are *Trigonisca*, *Nannotrigona*, *Scaptotrigona*, *Trigona*, *Geotrigona*, *Melipona*, *Partamona*, *Plebeia*, *Frieseomelitta* and *Lestrimelitta*, of these three are endemic to Mexico, *Melipona fasciata*, *Scaptotrigona hellwegeri* and *Plebeia fulvopilosa*. Likewise, it is interesting to find similar names in other places (state of Guerrero and Michoacan), for example, buzzard to refer to *Frieseomelitta nigra* and ground beehive for *Geotrigona acapulconis* (Arnold *et al*., 2018) (Table 1).

Table 1. List of native stingless bee species.

Scientific name	Common name	Mixtec name
Frieseomelitta nigra	Buzzard bee	Ñuñu tejí
Geotrigona acapulconis	Black beehive, ground beehive	Nu'u tnu
Lestrimelitta niitkib		
Melipona fasciata	Big real cuckoo	Ñuñu na'anu
Nannotrigona perilampoides	Little royal cuckoo, trumpet	Ñuñu yaa nti'i
Scaptotrigona hellwegeri	Cuckoo by mamey	Ñuñu yaa, ñuñu ntika jee'e
Trigona fulviventris	Yellow beehive or ground beehive	Nu'u kua'a
Partamona bilineata	Galindo	Ñuñu taka
Trigonisca pipioli	Suck dirt	Ñuñu chuku, stlakua
Plebeia moureana		
Plebeia fulvopilosa		

In Mexico, 46 species of stingless bees are reported, of which there are 35 in Oaxaca (Ayala, 1999), of these 11 species were registered for the community of Peña Flor de Clavo, one of the characteristics that favored to record this number of species, was the difference in altitudes that the community has, altitude ranging from 853 to 1 181.

Of the 11 species identified, a total of 20 nests were located, being the *Nannotrigona perilampoides* with six nests, five corresponding to *Partamona bilineata* and the species that did not register their nests were *Frieseomelitta nigra*, *Trigona fulviventris* and *Plebeia fulvopilosa* (Figure 2).

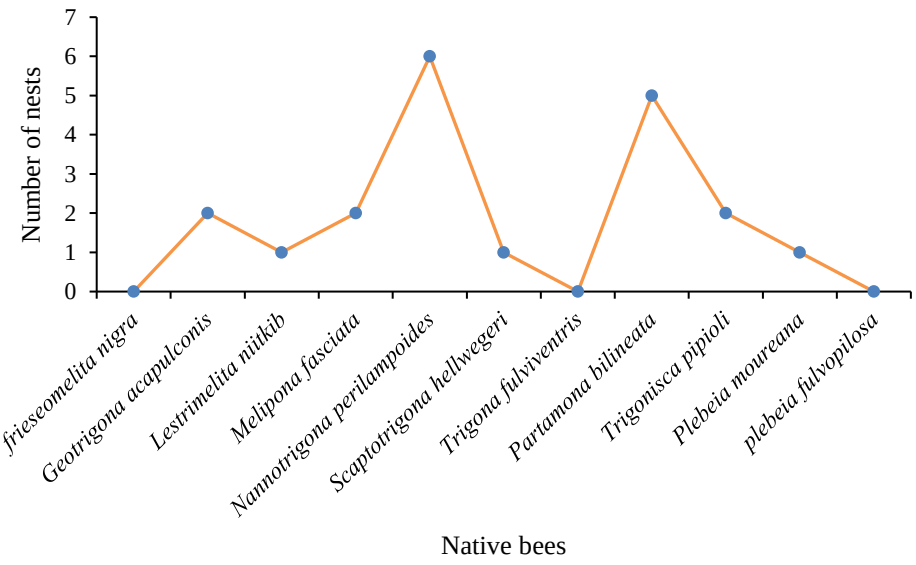

Figure 2. Numbers of nests by species. Elaboration based on field information 2019.

The 20% of those interviewed agree that timi bees of the genus *Bombus* are very good pollinators, in previous years their corn crops were produced more than now. *Bombus* are very effective for the production of native fruits and seeds because they pollinate by means of vibration.

Local names of native stingless bees

90% of the interviewees commented that to differentiate one bee from another is through their nests, the color of each species and the size of the bee. According to these characteristics, people assign the name in Mixtec and the common name of each stingless bee. The smaller and medium-sized bees are called ñuñu, the larger species are known as timí.

Sixty percent of the interviewees named eight different species of bees, which are differentiated by the common name they are assigned: buzzard bee (*Frieseomelitta nigra*), black beehive (*Geotrigona acapulconis*), large royal cuckoo (*Melipona fasciata*), little royal cuckoo (*Nannotrigona perilampoides*), cuckoo by mamey (*Scaptotrigona hellwegeri*), yellow beehive (*Trigona fulviventris*), galindo (*Partamona bilineata*) and muck sucker (*Trigonisca pipioli*), three species are unknown which are: *Lestrimelita niitkib*, *Plebeia moureana* and *Plebeia fulvopilosa*. The common names for each species provide diverse information (ecological and morphological) about the type of bee to which they refer, for example, Nu'u tnu= ground beehive, Ñuñu na'anu= large bee. Thanks to these local names and in the native language (Mixtec), the precise identification (scientific name) of the native bees was achieved, this was possible with the help of the people who accompanied the search for the bees in the field.

Normally, people know all bees as 'ñuñu'= bee with the exception of the bees that live on the ground, which know them as nu'u which means beehive; however, for some people there may be confusion between native bee and *Apis Mellifera* because the African bee is known as ñuñu stila which means bush bee or wild bee. Other characteristics by which community residents recognize stingless bees are behavioral and nesting characteristics (Table 2).

Table 2. Nesting and behavior of native stingless bees.

Scientific name	Common name	Nesting	Conduct
Frieseomelitta nigra	Buzzard bee	In the hollows of the trees	Does not perform aggressive defenses
Geotrigona acapulconis	Black beehive, ground beehive	On the floor	Does not perform aggressive defenses
Lestrimelitta niitkib		In the hollows of the trees, of rocks	They steal honey or nests from other meliponinos
Melipona fasciata	Big real cuckoo	In the hollows of the trees	Does not perform aggressive defenses

Scientific name	Common name	Nesting	Conduct
Nannotrigona perilampoides	Little royal cuckoo, trumpet	In the hollows of the trees, of rocks	Very shy
Scaptotrigona hellwegeri	Cuckoo by mamey	In the hollows of the trees	Aggressive defense
Trigona fulviventris	Yellow beehive or ground beehive	On the floor	Does not perform aggressive defense
Partamona bilineata	Galindo	In abandoned or squirrel nests, on rocks or boulders	Tangles hair and bites with its strong jaws
Trigonisca pipioli	Suck dirt	In the hollows of the trees	Likes to suck people's sweat
Plebeia moureana (Say)		In the hollows of trees, walls of houses, rocks	Shy
Plebeia fulvopilosa		In the hollows of the trees, periquera or termites (chinaco), branches	Shy

Meliponines were found to inhabit aerial nests; that is, they live in the cavities of living and dead trees of different species, for example, in oaks; yellow, black, acorn (*Quercus*), mango (*Mangifera*), cuajinicuil (*Inga*), palo mulato (*Bursera*) to name a few. Sometimes they are usually found on fallen logs, in rock holes and walls, or on the walls of houses. The nests are at varied heights ranging from the base to 30 m high. Only two identified species live in the soil which are the black beehive (*Geotrigona acapulconis*) and the yellow beehive (*Trigona fulviventris*) that can be installed at a depth of 10 cm up to four meters. At the entrances of some nests it can be found with mixtures of wax, earth and sand. The little royal cuckoo or trumpet (*Nannotrigona perilampoides*) is a very shy species of bee. The interviewees commented that the entrance is in the shape of a trumpet, because of this characteristic it is known as a trumpet or little royal cuckoo (Figure 3).

The cuckoo by mamey bee is so called because it is orange in color, the honey has an aroma similar to the mamey sapote. The buzzard bee is known that way because it is black and the tips of its wings are white, a characteristic like the buzzard. The black beehive or ground beehive is identified by its black color and its nesting pattern is on the ground, it regularly makes its nest in the orange-colored earth (mud earth).

Figure 3. Entrance of nests of the *Nannotrigona perilampoides* species. Image taken in field 2019.

The yellow beehive its nesting pattern is on the ground, it regularly lives near large rocks, it is recognized for having an orange abdomen and a black head and thorax. The bee sucks dirt, it is identified by its small size and by the behavior of putting itself on the face, eyes, arms and head (places where there is presence of sweat) of people. Galindo is recognized by its way of nesting, the nest is made of litter and earth, exposed in the trees. The large royal cuckoo can be identified by its orange color, a very tame, large bee.

Power supplies

In the community of Peña Flor de Clavo there is a wide variety of native plant species of importance to bees which are: acorn oak, black oak, pitaya, paloma, crushed grass, cuche grass, manzanillo, wild sunflower, flower horsefly, yellow flower, guapinol, guava, tejoruco, orchids, squirrel cuajinicuil, organ cuajinicuil, cuajinicuil, cuche orange, orange, sapote, mesón zapote, coffee, guanacasle, cuajilote, belly stick, sarsa, shameful, capulin pink, purple capulin, green, black, letter stick, bull thorn, passion fruit, margarita, shrimp, lime, guarumbo, platanar, coconut, guaje, yellow flower, mango, elderberry, palo mulato, lemon, cornfield, beans, nanche , ginger, broomstick, papaya, scourer, chipile, chuparrosa flower, rose apple, blackberry, snake tomato, bird tomato, pipiona, purple flower, venison chiche and *naguta*'*un*. These floral species offer nectariferous and polyniferous resources to bees, since it is considered that these and other associated floristic species are those where bees visit to satisfy their nutritional requirements.

Knowledge, uses and practices of local management of bees

Within the knowledge about the use of the products generated by native stingless bees, honey has been attributed medicinal properties, wax is another product that was used to make candles and pollen is consumed as food. The traditional management of the beehives by the families started

because they went to look for them and to cut the trees it was done with an ax and a machete, later the nests were transferred on the shoulders from 5:00 pm to 7:00 pm, because in the afternoon the workers already return to their nests.

The storage of honey and pollen is called 'kiyi', due to the characteristics similar to those of a clay pot, the brood combs are referred to as 'cake', 'memela' or 'brood' (the pupae and larvae are not consumed as they are very sour, they commented that they only eat the honeycombs of *Apis mellifera* because it is sweet), they call pollen 'flower' since it has colors characteristic of the nanche flower (yellow, red, orange), cerumen, bathumen and involucre, known as 'wax' as shown in Figure 4.

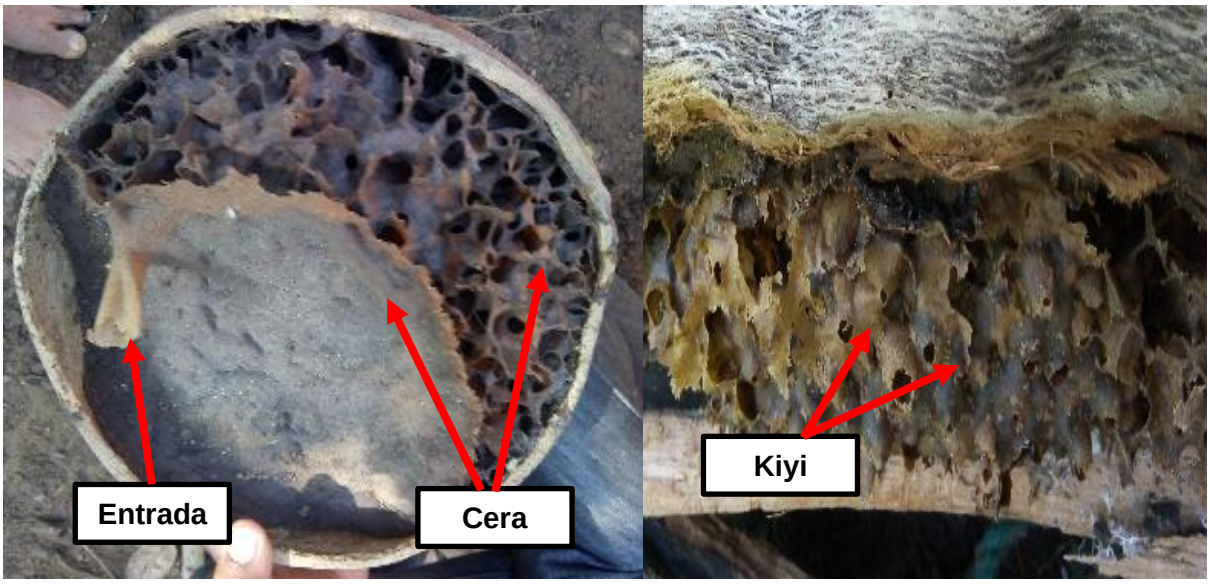

Figure 4. Structure of the meliponines. Image taken in field 2019.

Species that were used in the community

According to the information obtained in the interviews, it was recorded that within the use of stingless bees there were four species: black beehive (*Geotrigona acapulconis*), large royal cucumber (*Melipona fasciata*), yellow beehive (*Trigona fulviventris*) and galindo (*Partamona bilineata*). The species *Geotrigona acapulconis* and *Trigona fulviventris* were the best species to obtain wax.

The *Melipona fasciata* (large royal cuckoo) was one of the species that was extracted a lot of honey for consumption and to cure diseases and the Galindo species, for honey consumption, but the production of this is very scarce. In the community, two types of use of native stingless bees were found: looting of wild nests in the forest for the extraction of honey, management of nests in native logs bringing them home. The two types of exploitation are worrying since it puts at risk, the reduction and the death of the hives by not having knowledge about the management that each species of bee requires.

Technification proposals for bees

To carry out the technification of bees they must be totally native species of the locality in order to avoid various risks such as the introduction of diseases, food competition, the death of hives by not adapting to a different climate, loss of genetic diversity. Reason why species should not be moved far from their place of origin, where the species does not exist. Good native bee species for meliponiculture are: *Frieseomelitta nigra*, *Melipona fasciata*, *Nannotrigona perilampoides* and *Scaptotrigona hellwegeri*. Currently these species are considered of high value for obtaining food resources and usable biological drugs (honey, pollen, resins and propolis).

To carry out the technification of the hives in wooden box type logs (modern hive), a measure that does not fail to calculate the appropriate space for each species of native bee without sting, is to take into account the natural cavity where the colony was housed and increase it a few centimeters in diameter (mainly considering the brood nest), for example, if the diameter of the cavity is 12 cm, add an additional 2 cm or 14 cm.

The reserve area can be the same length as the one in the natural cavity. Also, the thickness of the walls of the box should not be less than 2.5 cm, being better the use of 3 cm (Guzmán *et al*., 2011). The different measures of boxes of intermediate technology for five species of stingless bees, this type of box is more expensive, but the advantage is that it facilitates the work of division and harvest (Table 3).

Table 3. Measurements of intermediate technology boxes.

Species	Common name	High (cm)	Width cm)	Length (cm)	Thickness (cm)
Melipona	Big real cuckoo	9	15	36	2.5
Frieseomelitta	Buzzard bee	12	25	34.5	2.5
Scaptotrigona	Cuckoo by mamey	12	25	34.5	2.5
Nannotrigona	Little royal cuckoo	9	9	25	2.5
Plebeia		9	9	25	2.5

Elaboration based on Enriquez and Yurrita (2006).

The boxes are simpler and cheaper, people with low economic resources can make use of it. However, they have certain advantages and disadvantages. The advantages of using this type of boxes are easy construction, it has fewer cracks where forids, ants, and other pests can enter, the disadvantage is: the size of the box is not adjustable, which is an inconvenience for thermoregulation of the hive and if green wood is used it is deformed (Table 4).

Table 4. Simple box measurements used for different species of stingless bees.

Genus	Length (cm)	Width (cm)	High (cm)	Wood thickness (inch)	Feeder diameter (cm)
Melipona	45	21	17	1	2
Scaptotrigona	38.5	21	17	1	2
Nannotrigona	25	18	17	1	2

Elaboration based on Enriquez and Yurrita (2006).

The measures of boxes used for the different species of stingless bees were presented before interested people in the community, this in order to avoid honey hunting and conserve native species of stingless bees since in Mexico only the Meliponini tribe is the only highly social group that produces.

Conclusions

11 species of stingless bees were registered (24% of the bee fauna corresponds to the national level and 31.4% state level), belonging to 10 genera (*Trigonisca*, *Nannotrigona*, *Scaptotrigona*, *Trigona*, *Geotrigona*, *Melipona*, *Partamona*, *Plebeia*, *Frieseomelitta* and *Lestrimelitta*), of which three are endemic to Mexico (*Melipona fasciata*, *Scatrotrigona hellwegeri* and *Plebeia fulvopilosa*). And locally eight species are recognized (buzzard bee (*Frieseomelitta nigra*), black beehive (*Geotrigona acapulconis*), large royal cuckoo (*Melipona fasciata*), little royal cuckoo (*Nannotrigona perilampoides*), cuckoo by mamey (*Scaptotrigona hellwegeri*), yellow beehive (*Trigona fulviventris*), galindo (*Partamona bilineata*) and suck mugre (*Trigonisca pipioli*). The common name is assigned in Mixtec language by means of the nest structure, the color and the size corresponding to the bee.

Four species are good for meliponiculture (*Frieseomelitta nigra*, *Melipona fasciata*, *Nannotrigona perilampoides* and *Scaptotrigona hellwegeri*). These species can be managed in technical boxes, because they have a high value for obtaining food, pharmaceutical and biological resources. It is worth mentioning that of these species the one that predominates is *Nannotrigona perilampoides*, the others are in lesser proportion.

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