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Analysis of the Hive Yield of Three Species of Bees for Honey Production in Eastern Honduras

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Authors' contributions

This work was carried out in collaboration among all authors. Authors FTM and JATM designed the study, and wrote the protocol. Authors EPL and FTM elaborated the sampling, installation of hives and the collection of field data. Authors FTM and JATM performed the statistical analyses. Authors FTM, JATM and MDBC elaborated the analysis and discussion of the work. All authors read and approved the final manuscript.

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ABSTRACT

Objectives: The analysis of the performance of honey production hives of three species of honeybees was carried out.
Study Design: Three harvests per year of honey per hive of each species the first was on March-April, the second was on June-July, and the third was on November -December, with a sampling of ten hives per species, data were evaluated by ANOVA analysis, and Duncan mean separation test developed by SAS/STAT program.
Place and Duration of the Study: This research was developed in the department of Paraíso, municipality of Danlí, Honduras, Central America, in Cerro El Águila, latitude 13°56'59" N, and longitude 86°13'59" W, the sampling was carried out in 2020.
Methodology: The qualitative variables were evaluated for each species by *In Situ* observation that characterized the honeycombs of the three species, and the data were subjected to an analysis of variance and Duncan's mean separation, where the dependent variable is the average yield of Kg of honey/hive.

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Results: According to the ANOVA, there are significant differences in: the harvest of the three species of bees ($p<0.0001$), for the three annual harvests ($p=0.0024$), and by hives ($p<0.0001$) and in the analysis of separation of means the three averages of honey yield observed are not homogeneous ($P>0.05$), the *Apis mellifera* produces 63.1 kg/hive-year, the *Tetragonisca angustula* obtained an average of 0.679 kg / hive-year*, and Melipona beecheii* obtained 13.19 kg/hive-year.
Conclusion: In the three species is observed that they have differences in the structures of the construction of their hives, their entrance, the construction of their cells, production and storage of honey and pollen, birth of queens, and method of defense; and when evaluating the average annual yield by species, by harvest, and by hives, is found that the three variables evaluated of bees are different averages of honey production.

Keywords: Bees; Apis mellífera; hives; Melipona beecheii; honey; Tetragonisca angustula.

1. INTRODUCTION

Beekeeping could provide more diversified productions such as natural foods rich in vegetable protein, vitamins, and minerals. Today they are lost or ceased to be produced due to ignorance or technological insufficiencies, especially in the fields of Latin America, and Africa, pollen, honey and royal jelly, products that could or reverse the hunger of these peoples [1]. In Honduras the production of honey has experienced a gradual development in recent years, unfortunately it is mostly only for the local market. There are some 3 800 beekeepers, many of them constituted in companies dedicated to the production, processing, and marketing of honey, are grouped in 122 associations of producers, and all these in turn in the ANAPIH [2]. Contreras describes that itis important to analyze meliponiculture, not only as an economic activity that can provide resources to local populations, but as a biocultural heritage of relevance for the maintenance of the ecosystem [3]. In addition, he mentions that the native human-bee relationship and its upbringing implies a network of knowledge and knowledge that are part of the worldview of the peoples.

The study aims to give an essential contribution to the country to characterize honey production in yield per hive-year, observing three varieties of bees, two native to Mesoamerica, as well as making their contributions regarding food security, the rural economy and human health, since information is limited, knowing that there are many producers of melipona bees in the country today, and that it has been an ancient activity recorded since the times of the heyday of the Mayan civilization; López cites that archaeological evidence suggests that it is in the region of the Yucatan Peninsula where meliponiculture originated, approximately 1400-1900 years ago, and where its products, such as wax and honey, came to represent one of the pillars of the Mayan civilization [4]. By estimating the productions of these three species, and characterizing their hives, data that will be available to produce honey of different native species of bees of Honduras, technifying them at home, to improve efficiency in productivity, and to be able to give added value to beekeeping products, this item has special importance for the economy of the country, also helping the conservation of biodiversity and the general habitat.

Honey is a sweet, unfermented substance produced by bees from the nectar of flowers or secretions on or from living plants; that they collect, transform, and combine with specific substances and that they finally store and mature in honeycombs. It is composed of water, fructose, and glucose, as well as acids, minerals, amino acids, proteins, enzymes, aromas, proteins, and other substances [5]. Likewise, the content of hydroxymethylfurfural (HMF) should be values ≤ 40 mg/Kg and the diastatic activity not less than 8 units of diastase (DN) [6]. Ureña cites that the most common components found in honey are water (17.1%), sugars (82.4%), proteins (0.1%) and other components that include vitamins, minerals, aromatic substances, and organic acids, among others (0.4%). In addition, five biologically active enzymes are found in it: invertase, diastase, glucooxidase, catalase and an acid phosphatase [7].

In what represents the productivity of honey in our region, propitiatory dates, and diversity of offerings in the Madrid Codex (Fig. 1), which reflects that it is an ancient activity in the Mesoamerican region, the management of stingless bees, which were sacred to the Mayan civilization. This has beenone of the most developed cultural areas in the breeding of native stingless bees (Hymenoptera: tribe Meliponini),

also known as melipona bees; In the Yucatan Peninsula through the Mayan culture, he stood out in this activity called meliponiculture, whose antiquity can be traced back to the pre-Columbian period [8].

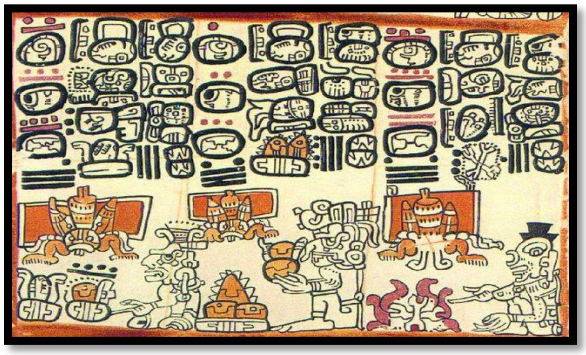

Fig. 1. Madrid codex. Mayan polymeniculture [9]

The best known and studied bee in our environment are the bees of the species: Apis Mellífera Africanized bee introduced in America to increase honey production. But not everyone knows about native bees such as the jimerito *(Tetragonisca angustula*) and the royal bee jicote (*Melipona beecheii*) (Fig. 2), which produce an excellent quality of honey, produced entirely for medicine and supplementary food. The biological characteristics of the three varieties of bees studied are found: the size of the bee in *the Aphis mellífera* the size is usually 20 to 30 mm in length and robust, the *Tetragonisca angustula* is smaller measures 2 to 8 mm in length and thin and the *M. beecheii* is slightly larger can reach 8 to 25 mm in length and robust, as shown in Fig. 2 [10].

Fig. 2. Tetragonisca angustula (a) photo by CPT, Aphis melífera (b), Melipona beecheii (c) Wikipedia

To systematically unify the name of this species we will give the scientific name that is *T. angustula*, its abdomen is yellowish brown, a thorax, and dark head bright. This species of bee, we can find it throughout our country in heights ranging from 600 to 1 800 meters above sea level in different formations of wooded environments, and to the surprise of many can also be found in urban areas where they are established in buildings, tubes, cemeteries, and any space that you find wide for their nests (Fig. 2). They form quite numerous populations with a large number of workers that are reported more than 5000 individuals depending on the space of the hive, they are very docile bees that can be easily managed by the whole family, since they do not have a stinger [11].

Bees do not store honey in honeycombs, instead store the honey in amphorae (pots), which must be broken or crushed to extract the honey. Breeding honeycombs composed of wax have overlapping disc shapes separated from each other by earwax pillars, forming spaces that allow the circulation of bees (Fig. 3). As for the physicochemical characteristics of the honey of this species we can highlight, which has a humidity of 30%; acidity 70 %; sugars 50%, pH of 3-3,5, degrees °Brix 79%, a clearly crystalline color, and acidic flavors [12].

Another type of Melipona bee or native is the *Melipona beecheii*, but larger in the Mesoamerican region, known as real honey jicote bees, they are dark in color with light stripes on the abdomen almost the size of honey Apis. Looking inside these hives we can see a lot of similarity with the involucre of the breeding honeycombs and the honey pots of the jimeritos, the only difference is in the size. Its entrance to the nest is built with a mixture of mud and resin called batumen or geopropolio of circular shape where only one bee fits at a time and that will have a permanent guardian bee. Breeding honeycombs built with earwax are disc-shaped placed on several floors with space between the levels for bee circulation (Fig. 3). Their honeys have different uses in home medicine, for bronchitis and stomach infections [13]. The characteristics of the honey of this species are, humidity 30%, sugars 60%, pH 3.6, acidity 75%, soluble solids 74.6%, Degrees °Brix 81%, amber color, acid flavor, light cloudy appearance, and texture of moderate viscosity [14].

Africanized bees' species as well as the native bees, they are considered as the main pollinators of some wild and cultivated plants (flowering plants or angiosperms). In this way, they help the conservation of ecosystems and improve the

quality and quantity of agricultural products. Most bees are hairy-bodied and have a feathery appearance; they carry an electrostatic charge with which they attract small pollen particles. All of this helps the pollen stick to your body. With their legs they transfer pollen to pollen baskets that can be of two types: cups or corbiculas. The physicochemical characteristics of the honey produced by *A. mellífera* in terms of humidity has 25%, Degrees °Brix 77.9, total solids 83.45%, sugars 69.1%, acidity 40% with pH 3.8, light color and viscosity and flavors different sweet types [15].

2. MATERIALS AND METHODS

This research was developed in the department of Paraíso, municipality of Danlí, Honduras, Central America, in Cerro El Águila, latitude 13° 56' 59" N, and longitude 86° 13' 59" W, with an average height of 1400 m.a.s.l., which is a mountainous area with a rich diversity of fauna and flora, the sampling was carried out in 2020, evaluating the productivity of three species of bees which are: *Apis mellíferas* bees European or Africanized, bees native to the region *Tetragonisca angustula* better known as jimerito, and *Melipona beecheii* known as royal jicote or morito , from which three harvests were obtained for each species of bee, the first harvest and honey harvest was made in the months of March and April taking advantage of the flowering of coffee, the second in June and July with the flowering of citrus, oaks, oaks, and medicinal flowers; the third was held between november and december as native plants and wildflowers bloom.

2.1 Achievement of Melipona Bees in the Field

To make the achievement of colonies of meliponas or native bees, they can be extracted directly from the trees of the forest, without forgetting that most of these species have the need to house trunks, coconuts, cavities that have left other animals, caverns, bricks of houses, different places that offer it a safe cavity and where they can build their nest, in our case, logs were used to house the hives of royal jicote, where we used two types of dry trees, the guamo (*Inga feuilleei*), and the oak *Quercus Robur* (Fig. 4-a).

The colonies of Melipona bees will always form their colonies of access to the nest what we call entrance, this will be protruding from the trunk and there we will see the flow of bees at the entrance and exit, this entrance can be up, down or in the middle of the nest, here the person who is going to make the capture must be malicious with some experience and who knows very well what direction it may be towards the nest so as not to deteriorate it, the way in which we can have access to the nest, handling very carefully so as not to damage the nest when extracting it. Once we have the nest extracted, the largest number of bees and the queen in our trunk in the case of the royal jicote, we proceed to take out the reserves of honey and pollen, which at no time should go to the trunk, since this can bring pests to the hive, before obtaining the colonies you must have the site in the place where it will be placed or housed, It should be a quiet place, shaded and away from strong winds and bases protecting bees from pest attacks.

Fig. 3. Types of beehives used. *Melipona beecheii* in the wooden box (a), *Aphis mellífera* (b), *Tetragonisca angustula* hive in pumpkin (c)

2.2 Method of Obtaining Native Bees Using Traps

To obtain native bees we also use traps, the first thing we must do is clean the containers with water, then we will use an attractive solution that is composed of 70% alcohol, where wax and propolis of the same bees are dissolved so that it adheres inside the trap. With this substance we must impregnate the container well, drain the residues of this attractant well and put the containers to dry in the sun for 15 days to ensure that the aroma of alcohol escapes completely: this type of traps must be placed in very strategic places where the swarms of meliponas or native bees can possibly arrive, these were placed in trees, preferably where we know that there were nests of bees, in the case of *T. Angustula* bees. Pumpkin (*Lagenaria siceraria)* better known as jicaros were used in our country as shelters for all the hives used (Fig. 4-c), since it is a type of natural container, and this species works very well.

2.3 Installation of *Apis mellifera* Hives

Ten hives were installed with two raises or frame boxes each, ten frames per box, these were located at two meters between hives and in the same area, and each hive had 20 frames, of which 60% were with children and pollen and 40% of honey, this in relation to the harvest time. From the hives observed, average records of the honey production of each hive were made, in three different harvests that were made in the year, which were extracted from the honeycombs and centrifuges, to then weigh the honey produced.

2.4 Field Work

Once the hives were installed through direct observation of the three species studied, 10 hives were evaluated for each species of bees placed randomly at different points, and the productive cycle of one year of each hive was observed, making three harvests per species, without altering the natural conditions of the area where all the hives were installed.

2.4.1 Characterization of hives by species

The following qualitative variables are evaluated for each species:

Nature of the entrance of the nest, real cells, location of the real cell, honeycomb shape, method of harvesting pollen, rate of production of queens, and method of defense, which were determined by observation of the hives of each species, and the reality is analyzed in its natural context and as it happens, taking out and interpreting phenomena according to what was observed by the researchers who were in the field.

2.4.2 Honey production yield

Quantitative analysis: the yield in kg of honey of annual production per hive of each species was determined, as well as the yield in weight in Kg of honey per harvest considering three annual harvests for each of the species.

To determine the harvest time, it depends a lot on the flowering season, considering also that if there is a lot of rain the bees do not work at their usual pace, so they were harvested in non-rainy weather, and in high flowering time, in the case of Apis mellifera, when the first 4 rises are full and the honey is ripe in the hive, it is time to make the collection of the honey, which was carried out in the evening, then the honey was transferred to the processing plant to centrifuge and strain it, to then be weighed; in the case of stingless bees, when the honey is ready, the bees usually shake outside the hive, and with the flowering period, we realize that the hive is ready to make the harvest, which was checked by direct review of the honeycombs, then we open the hive to extract the honey, by means of a syringe the honey was removed from each hive, with great care not to damage the wax of the honeycombs, always in the afternoon, and later this honey was weighed by each hive, in the case of the hive, these are washed with clean water in case honey is spilled and resealed with clay to avoid attacks of other insects.

2.5 Statistical Analysis

The samples were subjected to an analysis of variance, where the dependent variable is the average yield of Kg of honey per hive, evaluating as the main factor the three species of bees, and as a subfactor three harvests per year, evaluating in blocks ten that represent the hives by species. In addition, analysis was made of separation of Duncan's stockings by harvest (first, second and third), and by each hive evaluated (block). The statistical program SAS was used to analyze the data by means of a univariate analysis.

3. RESULTS AND DISCUSSION

3.1 Characterization of Hives by Honeybee Species

From the observation of the hives of the three species we denote that *the A. mellifera* does not make any entry into the nest, in exchange the *T. angustola* and the M. beecheii elaborates an entrance of wax to the nest, with respect to the real cells, the *A. mellifera* and the *T. angustola* are large, and the M. beecheii does not have specialized cells; as far as the location of the real cell is concerned, in Apis *M.* they place them near the brood chamber and pollen, in the *T. angustola* it is near the periphery of the honeycomb, and in the M. beecheii they are intermingled in the honeycomb with the cells of workers and males; in the case of honey deposits to Apis M. the shape of the honeycomb is hexagonal, in the case of the other two species they store honey in honeycomb in a spherical shape, called pots; propolis in the case of Apis M. needs traps to collect it, in the case of stingless bees, they store it in spherical pots; In the reproduction of queens it is denoted that in *A. mellifera* and M. beecheii are frequent, contrary *to T. angustola* are very rare new queens; and the method of defense only *A. mellifera* has a sting that has a poison that can harm humans and animals, while the other two species jimerito and jicote morito have no defense system, which makes them more vulnerable to attack by other insects, that is why they are better known as melipona bees (Table 1 and Fig. 5); this characterization of the hives is in accordance with what is described in the species [16] *T. angustola* and *M. beecheii*, which have been domesticated and adapted for a long time in Mesoamerica.

Fig. 4. Extraction of Honey from hives
***Melipona beecheii* in trunk (a), Honey harvest *M. beecheii* (b), *Tetragonisca angustola* hive in pumpkin (c)**

Table 1. Summary of characteristics of the hive

Feature	*Aphis mellífera* European-africanized	*Tetragonisca angustula* Jimerito	*Melipona beecheii* Royal jicote
Nest entry nature	They do not perform any specialty at the entrance of the nest, it is directly.	Usually made of earwax.	Usually made of mud. Nest entrances frequently Radial.
Real cells	Large specialized real cells.	Real specialized cells larger than workers and males	No specialized real cells
Location of the actual cell.	The cells are located near the brood chamber and pollen.	Near the periphery of the honeycomb. It does not include those that make cells in clustered form.	Interspersed in the honeycomb with cells of workers and males.
Honeycomb deposit form.	Hexagonal	Spherical, honey pots.	Spherical, honey pots.

Feature	*Aphis mellífera* European-africanized	*Tetragonisca angustula* Jimerito	*Melipona beecheii* Royal jicote
Harvest pollen. Hive división	Trap is needed for collection Once per year	This accumulates in the spherical pots. Once per year	This accumulates in the spherical pots. Once per year
Method of defense	It has a stinger with poison that harms humans and animals.	It does not harm any harm to a person or has a specific method of defense. No sting.	It has sticky substances, but it does not harm people. No sting.

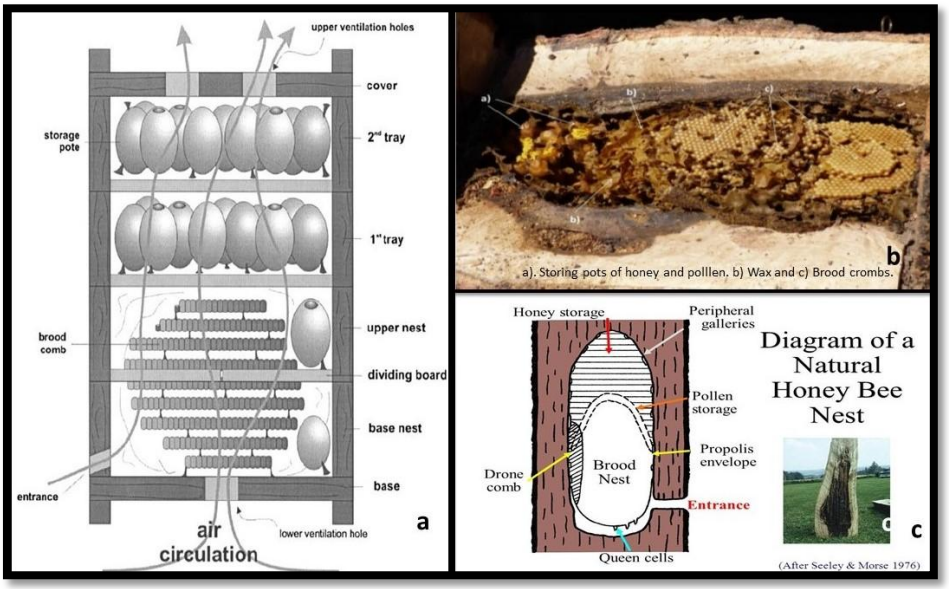

Fig. 5. Beehive structure
***Melipona beecheii* [17] (a), *Tetragonisca angustula* [18] (b), *Apis mellifera* (Photo of Roney Hadland) (c)**

3.2 Statistical Analysis on Yields per Hive and per Harvest

Through the help of SAS, it is found that there are significant differences in the average honey in kg/hive between the three species of bees evaluated (P<0.0001), there are also significant differences between the three annual harvests in kg/hive (P = 0.0024) and evaluating the interaction of species and harvest we have that there are also significant differences between the averages of honey yield per hive (P<0.0001).

3.3 Stocking Separation Analysis

According to Duncan's mean separation analysis, it is denoted that the three average honey yields in kg/hive of the three observed bee species are not homogeneous at a significance level of (P<0.05), then the honey production in kg/year per bee species are different.

When evaluating the harvest by species of bee by Duncan's mean separation test it is necessary that the average honey production averages in kilograms of the three species are different; for *T. angustula* in the analysis of its three annual harvests (first, second and third) in kg are homogeneous (P >0.05), that is, the honey yield of the average harvest in the three annual seasons are the same; similar happens with the species *M. beecheii*, its average yield is homogeneous in the three annual harvests, only in *A. mellifera* the honey yield of the three crops are not homogeneous (P<0.05), so the average harvest of honey obtained from this species are different.

3.4 Hive Analysis

In the ANOVA it is denoted that there are significant differences in the average honey in kilograms between the 90 hives/crops evaluated, thirty of each species of bees that were measured (P<0.0001).

Fig. 8(a) denotes the grouping of the three sets by species and separating from each other by their productive performance and holding the groups of hives by species together in their honey yields.

In Fig. 8(b) to evaluate the harvest of the ninety hives by this test it is necessary that the *A. mellifera (Am)* the honey yield in kg/harvest maintains an equality in all its hives, in two segments, the blue and green, denoted in graph b (P>0.05), and different from the second group of the other species, *M. beecheii(Mb);* in the brown segment it is denoted that the set of stockings of the hives M. beecheii are equal (P >0.05), and different from the group of hives of the species *T. angustula(Ta);* similarly in the red segment demarcates a homogeneity between the productive yield the hives of the species *M. beecheii and T. angustula* (P>0,05), with one exception of its set that is the hive MbX, because it is the hive that has the highest yield of its specie.

In this graph it denotes the averages of honey in Kg. for each of the three species of bees and the three annual harvests per species (P>0.05), where the native bees evaluated tend to raise the average gradually in the three harvests, not so with the *A. mellifera*, which showed that in the second harvest the highest average was obtained, and the last harvest had the lowest yield.

In the case of the bees *T. angustula* Nates-Parra describes that it can be obtained from 500ml to 1 liter / year (0.704 – 1.408 Kg / year.) , in our samples the average values obtained are 2,037 kg honey / hive-year, slightly higher than the average of Nates; as for [19] *the M. beecheii*, he comments in his study carried out in Cuba that the annual production per hive is 10.5 kg / year, being able to reach 13.5 kg/year; when compared with our averages, we denote the closeness of the averages, our average is 13.19 kg honey/ hive-year, which remains in this close range of productive yield [20].

The bee *A. mellífera* as [21] found in the Altiplano Ecuador a yield of 25.08 Kg / harvest-hive, and in our case we obtained averages of 20.9 kg honey / hive / harvest, and 63.1 Kg of honey / hive-year; in the same way in the state of Veracruz, Mexico production data is presented where it specifies that: the technical level produces between 60 to 70 kg, semi-technified between 30 to 45 kg, and non-technified between 25 to 30 kg of honey per hive per year [22], performance that is similar with our averages of Kg. honey/hive are within this range of a hive of technical level of this work, which states that in both research works cited in different places they are within the similar range of our yields per annual hive in this species.

In what corresponds to the medicinal value of honey, this food is of utmost importance, for its infinity of properties that it has, it already offers new opportunities for rural income for the added value it can generate, García suggests that for the use of honey as a nutraceutical the content of phenolic acids is considered, flavonoids, ascorbic acid, proteins, carotenoids, and certain enzymes such as glucose oxidase and catalase. Its antimicrobial action against *Helicobacter pylori* is well documented. In addition to the formation of peroxide, glucose oxidase acts on fibroblasts and activators of epithelial cells. It has bactericidal properties against pathogenic and enteropathogenic bacteria [23]. In relation to cosmetic applications, it has great nourishing and antiseptic effects on the skin, which is why it is used in a variety of beauty products that are found especially in beauty centers [24] comments that for all this honey represents a range of opportunities for the development of new products, mainly native species. Also the entry of cheap honeys into the country in the coming years will be an enormous challenge for beekeepers, there is food insecurity, since only a small number of families have the opportunity to fully cover all the links of what food security entails; it is necessary to focus on those areas, where families are in food uncertainty, (rural areas) working families, who struggle day by day, but that the socioeconomic conditions do not favor them, since although their income improves, the prices of basic basket, public services, and transport; they increase, they do not have access to quality education, that makes illiteracy levels continue to increase, therefore there is no improvement in technologies applied to the countryside, to their coffee farms, to their small business [25], for the above the production of honey becomes an alternative to improve family income, improving access to and availability of food, generating income through the production and processing of beekeeping products; Bees are part of the biodiversity on which we all depend to survive, they provide high-quality foods.

Table 2. Factorial arrangement for ANOVA of honeybee yield. Honey yields in Kg per hive for each of the three species are presented, and the three annual harvests that were made, in addition data from ten hives per species were observed for analysis

Factor	Harvest	Blocks									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Tetragonisca angustola	**First**	0.40	0.52	0.30	0.45	0.46	0.48	0.49	1.00	1.20	1.00
	Second	0.35	0.45	0.22	0.25	0.26	0.35	0.46	0.59	1.00	0.90
	Third	1.00	1.00	0.80	0.85	0.70	0.40	0.89	0.90	1.50	1.20
Melipona beecheii	**First**	2.20	2.90	2.30	3.00	4.00	4.60	4.90	3.00	4.00	5.00
	Second	3.00	4.20	4.00	3.60	2.00	2.50	3.00	4.00	5.00	10.00
	Third	5.00	3.00	3.60	4.60	6.00	5.20	5.80	6.00	4.50	11.00
Apis mellifera	**First**	19.00	21.00	21.00	19.00	17.00	25.00	19.00	21.00	23.00	21.00
	Second	25.0	23.00	21.00	25.00	32.00	32.00	21.00	32.00	25.00	17.00
	Third	19.00	21.00	17.00	15.00	13.00	21.00	15.00	17.00	19.00	15.00

Table 3. Analysis of variance

Source of variation	Gl	Sum squares	Square of the mean	F-value	Pr > F
Species	2	7059.426676	3529.713338	692.13	<.0001
Harvest	2	73.218196	36.609098	7.18	0.0024
Species*Harvest	4	277.678524	69.419631	13.61	<.0001

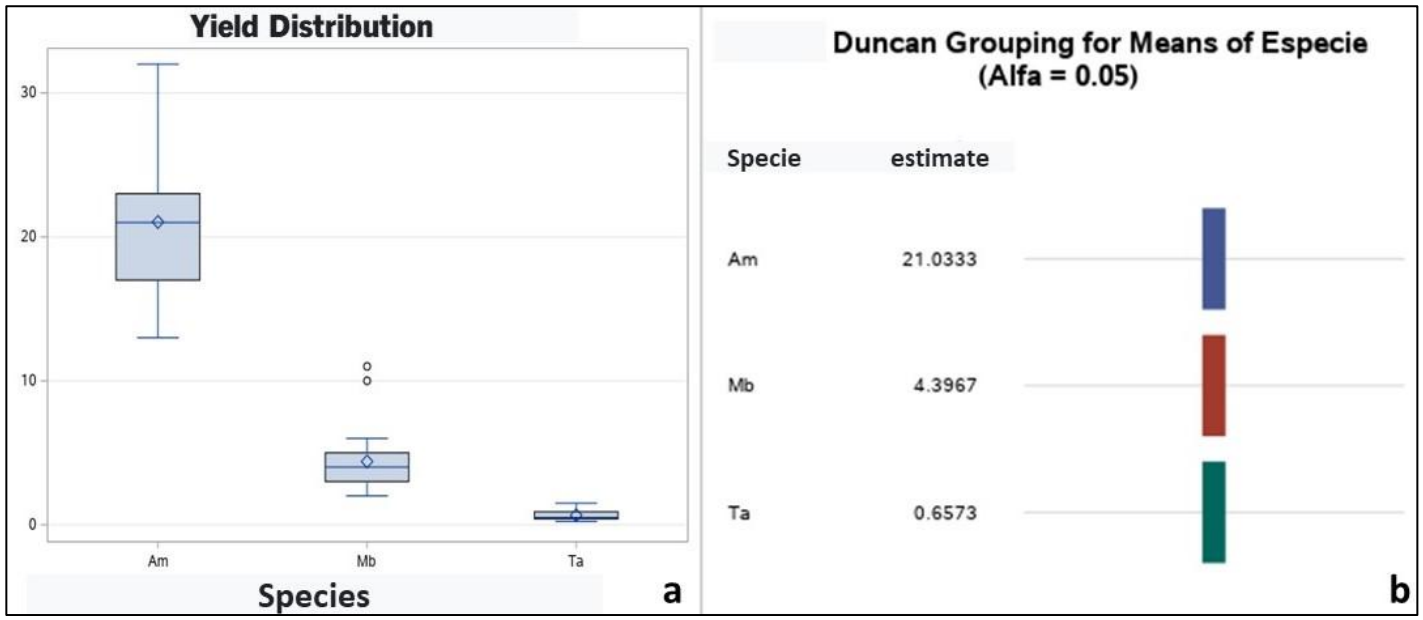

Fig. 6. Distribution of yields by species (a); Test of Separation of means by species (b)

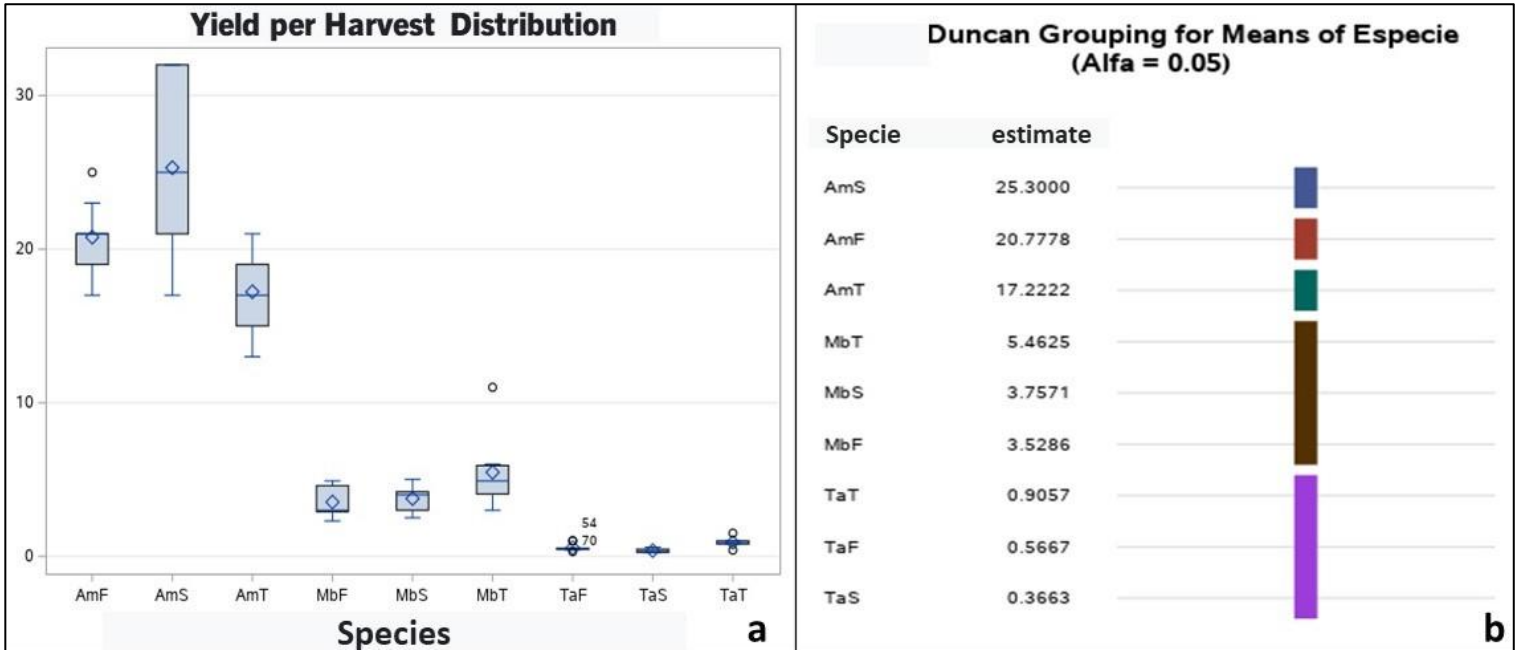

Fig. 7. Distribution of yield by harvest (a); Analysis of separation of means per harvest of each species of bee (b)

Table 4. Analysis of variance of hives/harvest

Source of variation	GL	Sum of squares	Square of the mean	F-value	Pr > F
Model	29	7291.125662	251.418126	26.04	<.0001
Error	60	579.262533	9.654376		
Total	89	7870.388196			

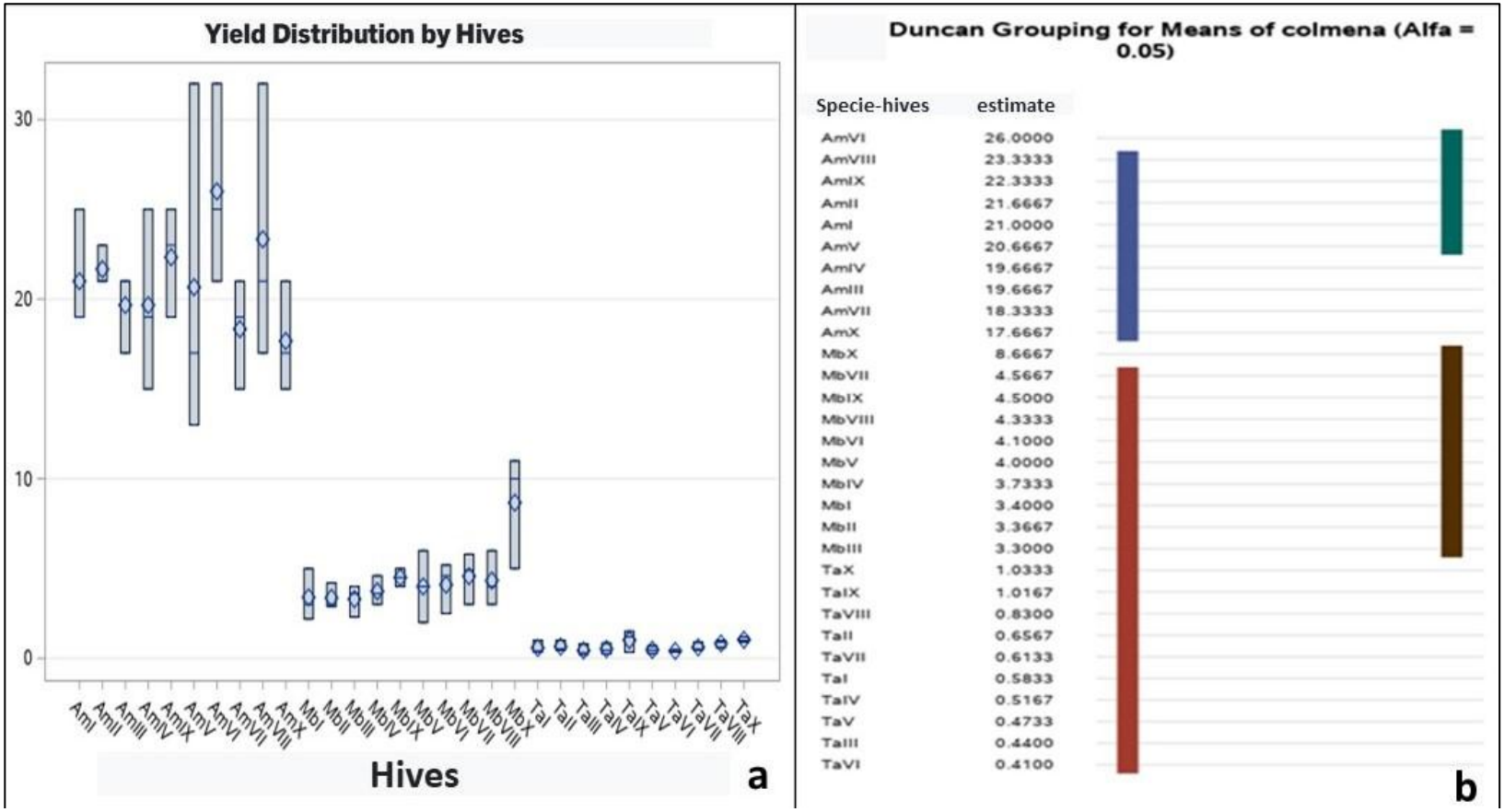

Fig. 8. Yield distribution by hive (a); Separation analysis of hive/harvest stockings (b)

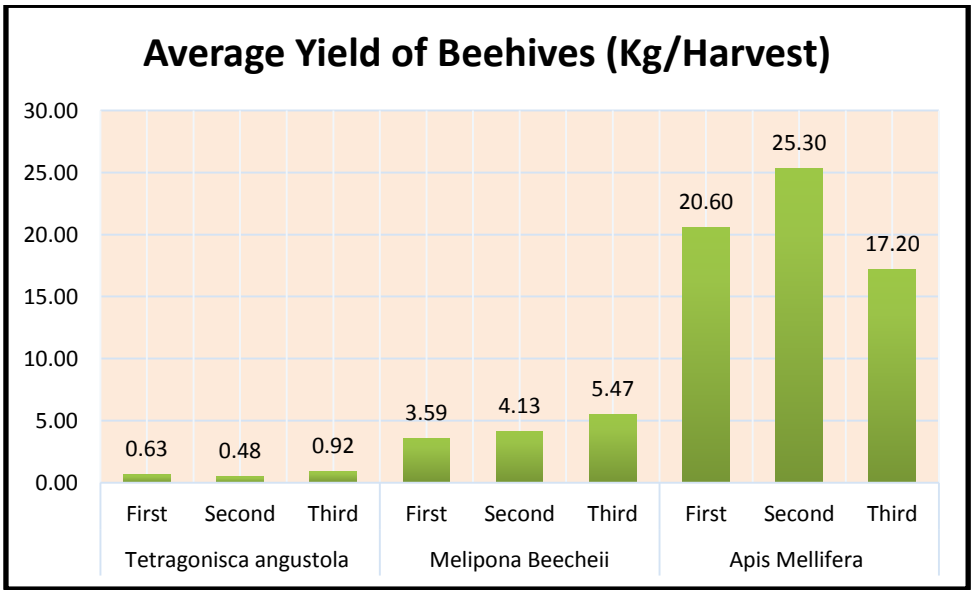

Fig. 9. Average harvest per species

The growing agriculture is a threat to native species, given that in many cases it contributes to the destruction of the natural habitat of these species, Martínez describes that the transformation of the natural environment to move to the agricultural exploitation of the soil has caused a very negative effect on the bee wildlife: on the one hand, the most favorable places for nesting have been destroyed, and on the other, the plant species that provided the original food source have been eliminated [26].

According [26], to Climate Change affects beekeeping mainly indirectly, however, a direct impact lies in the alteration of the behavior and physiology of bees, they adapt to cope with environmental conditions; so it is important to take mitigation measures to reduce the impact of Climate Change on Beekeeping, however, they must be aimed at a common good, since the survival of man affects the different ecological systems, in such a way that the actions to be taken to face Climate Change.

4. CONCLUSION

In the characterization of the hives of the three species, it is observed that they have differences in the structures of the construction of their hives, their entrance, the construction of their cells, production and storage of honey and pollen, division of hives, and their methods of defense. To evaluate the average annual yield of the three species it is found that *Apis mellifera produces* the most honey with 63.1 kg/hive-year, *and Melipona beecheii* obtained the second-best average honey yield with 13.19 kg/hive-year, and *Tetragonisca angustula* obtained the lowest average with 0.679 kg/hive-year, which are non-homogeneous averages, so the productivity in honey yield per species is different in kg/hive-year.

When evaluating the hives of the three annual harvests of the species *T. angustula* it is determined that the honey yields of the harvest are the same; a similar case happens with the specie *M. beecheii*, its average yield is similar in the three annual harvests, that is, in these two species the harvest season does not influence the honey production yield when three harvests are made per year; and only in the *A. mellifera* the honey production yield of the three crops are different for the three harvests, obtaining higher honey production in the second annual harvest elaborated in the months of June and July, and the lowest average for the last harvest that was made between November and December.

In the productive analysis of the ninety hives evaluated, thirty for each species, it is necessary that *the A. mellifera* the honey yield in kg/harvest of all its hives are similar, and different from the group of hives of the *M. beecheii; and a homogeneity was found between the productive yield of the hives of the species M. beecheii and T. angustula,* only with one exception of its set of hive X of the specie *M. Beecheii,* since it is the hive that obtained the highest yield of its specie.

The production of honey in our region offers an opportunity for economic income for rural areas, since it has been an ancient rural activity since pre-Columbian times mainly in stingless bees because it is part of the biocultural heritage of Mesoamerica, and this activity helps to conserve ecosystems and maintain the biodiversity of native flora; In addition, this item contributes to the food security of producers and consumers, since hives offer very high quality foods with nutraceutical and functional properties, bioactive and important antioxidants, because consuming honey and its derivatives has high benefits for the quality of human life, which must be studied to give added value through the creation of new products, in the same way the pharmaceutical and food industry could evaluate its sweetening and preservative properties.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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