

Diversity of Nectar-Producing Plant Species, and their Potentialities on Suburban Farms in Santiago de Cuba, Cuba

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Abstract

Context: Success in beekeeping depends on the existence of plant resources for bee consumption, so research on the flora with uses in apiculture is essential.

Aim: To evaluate the diversity of bee species, and their potentialities, on suburban farms in Santiago de Cuba, Cuba.

Methods: The composition and diversity of bee species were established through sample collection, which included 100 m² (10 x 10) lots. Semi-structured interviews were conducted to determine the potential uses attributed to such species, related to honey production.

Results: A number of 51 species were enlisted, of which three stood out for their abundance and distribution. *Musa*, *Polianthes tuberosa*, *Ipomoea batata*, *Amaranthus dubius*, and *Mangifera indica*. The farms with the largest bee-related flora were La Cecilia, Erick Vega, and La República. *Helianthus annuus* and *Mangifera indica* were the most frequently visited by the bees, with at least less than 50% of the reports issued by the technicians.

Conclusions: The farms included in the study have a stable flora, with a balanced distribution, and a diversity that tends to reduce dominance. Their similarity was low-moderate, thus proving that the bee species range between exclusiveness and the potential adaptation to the conditions of the ecosystems studied. There was an adequate social perception of the nectar-producing plant species on these farms, with a thought potential to offer this service to the ecosystem in their communities.

Key words: beekeeping, agroecosystems, biodiversity, nectar, weeds.

Introduction

Apiculture is known as beekeeping aided by science and technology, whose end is to collect the several products offered by a hive, and is a significant economic activity in quite a few countries (Laura, 2017; Estrada, 2017). This productive activity is one of the few whose almost entire production brings benefits to the environment. Additionally, it has

gained significance today, as bees contribute to the nutrition, health, and the surrounding of humans, providing direct and indirect benefits using their labor (Laura, 2017).

However, Briceño (2018) and Florez & Sepúlveda (2019) noted that beekeeping faces a drop in productivity caused by a reduction in flowering, and a dependency on the climate, under a limited variable

setting. Among these issues are climate change, indiscriminate pesticide use within certain perimeters, and deforestation. Flowers are the main resource used by bees to feed and breed. Apiculture-related plants produce nectar, pollen, and propolis (Montoya et al., 2017). Hence, the flora is the most important input to planning beekeeping, as a source of resources collected and transformed by bees (Florez & Sepúlveda, 2019), and therefore, it is essential.

Knowing the nectar-producing plants of a region permits the better establishment of production areas for proper bee nectar and pollen supply (Potosí & Yepez, 2015). Besides, it permits adapting apiary management to the existing natural potential (Briceño, 2018). Araujo-Mondragón & Redonda-Martínez (2019) argued that in recent years, the study of these plants has been more rigorous, and includes a list of flowers, their common and scientific names, habitats, and factors that impact the production of nectar. They also permit knowing the beekeeping-related ecosystems, and determining, among others, the diversity of flora for sustainable apiculture (Gualpa-Calva et al., 2020).

To identify the possible conservation-restoration needs of ecosystems and adapt apiary management to the naturally available setting, it is important to understand the universe of bee species well. Therefore, the knowledge farmers may have in this respect is a significant tool to get information about the most relevant species in an area (May & Rodríguez, 2012).

The growth of the urban population has led to changes in soil use, with negative impacts on melliferous resources. In that sense, Acuña (2019) and Araujo-Mondragón & Redonda-Martínez (2019) are some outstanding examples. However, Kaluza et al. (2016) demonstrated that patches in the vegetation of urban or suburban areas have supported bee populations by having varied and stratified flora.

In Cuba, particularly, in urban areas of Santiago de Cuba, several studies (Belyani Vargas et al., 2016a; Vargas et al., 2017a; and Vargas et al., 2019) evaluated different plant species groups with very specific functions, regardless of their melliferous potential. Hence, a study to demonstrate the potential of the existing melliferous flora on suburban farms is necessary.

Accordingly, this paper aims to evaluate the diversity of bee species, and their potential, on suburban farms in Santiago de Cuba, Cuba.

Materials and methods

This study was conducted on 10 suburban farms and adjacent communities in the municipality of Santiago de Cuba, between 2017 and 2020. It comprised the

two stages of Cuban agriculture: winter (November-April) and spring (May-October). The weather data collected for the areas (Boniató People's Council) are shown in Figure 1.

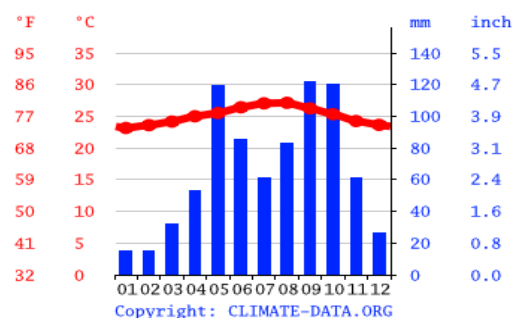


Fig. 1. Weather diagram of Boniató People's Council, farm reference area.

The climate is tropical. The mean temperature is 25.1 °C, with August as the warmest month in the year (27.1 °C, average). The coolest month is January (23.2 °C, average). The total average precipitation value is 792 mm. In winter, the rain is more scarce than in the summer. The driest month is January (15 mm rainfall), whereas September is the wettest (122 mm, average). The days with the least rain values are in February (3.13 days), whereas the rainiest days are recorded in September (19.73 days). The lowest relative humidity is in March (66.64%), and the most humid month is October (84.04%). Overall, there is a 107 mm difference in rainy days between the driest and most humid months. The mean temperatures varied by 4.0 °C throughout the year.

The farms selected by del Toro et al. (2018) were visited, depending on their accessibility, representativeness, production systems, integrity, and diversity of uses, in keeping with the soil and logistics. The names, geographic coordinates, and altitude (m above sea level) of the farms are the following (Table 1):

Table 1. Farms selected and their geographic location

Farms	North lat.	West long.	Ht (m above sea) (m.level)
Erick Vega	20.091236	-75.786977	150
La	20.047084	-75.791690	48
Tres	20.064135	-75.801778	75
La	20.068167	-75.801893	75
La	20.047843	-75.794819	43
Los	20.057827	-75.800777	54
Cascabeles			
La Juliana	20.086979	-75.793355	105
El Sol	20.090400	-75.800728	137
La	20.038776	-75.789878	50
La Cecilia	20.089008	-75.785528	100

Type of soil: Siallitic soft brown without carbonate (all the cases)

1Decimal coordinates

The lots were 100 m² (10m x 10m), according to the method used by Vargas et al. (2016), which has been recommended for natural and production areas (forests, mountains, and city outskirts), as it includes species of different sizes and growth habits. The number of lots per farm varied (41-700), depending on the total farm area; the same lots were used in the two periods.

Then, samples were taken in the presence of farmers, who identified the species with a potential for apiculture based on references made by other people with expertise in beekeeping, and from observing the most commonly visited plant species (*Apis mellifera* (Linnaeus, 1758) and *Melipona beecheii* (Bennet, 1831)). The samples were useful in identifying the common names and the number of individuals of each species.

The number of individuals was determined by counting the representative individuals in each species in the lots. The total of individuals observed in the grass-like species with a creeping or climbing habit was determined by estimate. The quadrant method described by González et al. (2017) was used. A previously set 1m² (1m x 1m) quadrant was used, then the individuals rooted inside the area were quantified. A total of six diagonal quadrants were lifted.

Then the species were identified as described by Vargas et al. (2017b). Initially, the Botanical Dictionary of Cuban Common Names (Roig, 1988) from the Agronomy Department at the University of Oriente, was used. The easily identified species were transported to the Mid-East Herbarium of Ecosystems and Biodiversity (BIOECO) for identification. The scientific names of the species were matched and updated according to Greuter & Rankin (2017). The literature was reviewed to confirm the melliferous activity of the species identified.

The data was used to determine the botanical composition by farm, campaign, and in general terms. Accordingly, floristic lists were made and the total of individuals, families, genera, and species was quantified. The most commonly observed botanical families were taken into consideration as well (especially the ones contributing with at least two different species by farm, and those more inclined to repeat. The repeatability indicator used was the one described by Toro et al. (2018).

Moreover, the heterogeneous composition of bee species was determined, by pooling them in each period, considering the main usefulness of every species, as shown:

(i) plants for nutrition,

(ii) ornamental plants, (iii) medicinal plants,

(iv) fruit species, (v) perennial plants [arboreal and shrub-like], and (vi) weed species.

The evaluation of diversity relied on several indicators, such as alpha (α), species richness (S), Dominance (*Simpson D*), and General diversity (*Shannon H*). Besides, the species were classified according to their percentage of abundance (Abd %), which was matched to the scale described by Vargas et al. (2017a), shown below. The most abundant species in each campaign were shown. These indicators were determined using the Biodiversity Calculator (Danoff-Burg & Chen (2005)).

Level	Range (%)	Classification
1	01 – 20	Scarce
2	21 – 40	Occasional
3	41 – 60	Little frequent
4	61 – 80	Frequent
5	81 – 100	Abundant

The similarity measure was the formation of homogeneous groups, through a multivariate analysis (CLUSTER) to check the number of existing homogeneous groups and the basis of such homogeneity. This analysis was performed with BioDiversity Pro 2 (McAleece et al. 1997). The classifying ranges used by Vargas et al. (2019) were included to assess similarity. (2019).

A semi-structured interview was conducted to measure the social perception to determine the knowledge of the nearby communities about the potential of bee-related plant species and to gather information about this group of plants.

A total of 10 key subjects were selected through the snowball method, as described by Vargas, Pupo, Puertas, Mercado & Hernández (2011). The selection demanded all the participants in the sample were engaged in beekeeping. The responses were pooled by reporter consensus (CI), considering the relative frequency of each opinion over the total number of reporters (N=10) x 100.

Then the information was evaluated according to these parameters: (i) list of well-known bee-related flora; (ii) match percentage between the most commonly known plant species and the ones reported by the farms on every campaign; (iii) reference percentage of most widely known bee-related plant species; (iv) list of most frequently visited plant species by bees; (v) reference percentage of the most commonly visited plants; (vi) reference percentage of nectar-producing plant species availability; and (vii) the percentage of opinions observed to use the nectar-

producing plant species on the farms as a way to increase availability.

Results and discussion

Overall, 30 298 specimens were identified, belonging to 29 botanical families, 45 genera, and 51 species (Appendage 1). The previous reports were higher than the findings reported by Jiménez et al. (2021), upon a characterization of melliferous species in the dry tropical forest, to conserve seven apiaries in Quimis. These authors only reported 1 527 individuals, 16 botanical families, and 31 species. Therefore, this study evidenced that the farms have the potential to enhance bee honey production.

The performance of the botanical composition in each period evaluated is shown in Table 2.

Table 2. Performance of the botanical composition on the two campaigns

Campaigns evaluated	Taxonomic categories			
	TI	BF	G	Spp.
CC	15 899	29	44	49
SC	14 399	28	42	49

Legend: CC: Cold campaign; SC: Spring campaign; TI: Total individuals; BF: Botanical families; G: Genera; Spp.: Species

In each period, the botanical composition tended to a 3.45% decrease in the number of families, as well as in the number of genera (4.55%). The species total was constant between periods, and the total of individuals underwent the greatest variation, with a 9.43% decrease.

In general, the data revealed little variation in the composition of melliferous species between the campaigns.

The drop observed in the number of individuals may be associated with the heterogeneous composition of this group of plants. It may comprise plants for nutrition and weed species. The former group includes several crops whose optimum moment takes place in the cold campaign (very seasonal), ending with the coming of rain. If they remain in the system, the number of individuals will be reduced. The latter comprises annual, seasonal, or perennial species. Though they are favored by the beginning of the rainy season, they are cut by humans to avoid competition, or they grow spontaneously in fallow land.

By farm, the botanical composition of MP varied (Table 3), with a 50% increase in productive lands, whereas another 50% was observed to decrease in the rest. A striking reduction was observed in the total of

individuals between campaigns in 40% of the farms (La Esperanza, Los Juliana, El Sol, and La Cecilia).

Table 3. Botanical composition of nectar-producing plants on the farms selected

Farms	Taxonomic categories							
	Total of individuals		Families		Genera		Species	
	CC	SC	CC	SC	CC	SC	CC	SC
EV	1695	1514	18	19	23	27	26	31
LE	1828	1859	14	13	19	18	22	20
TP	648	1705	18	18	19	22	23	16
LR	840	1152	17	20	21	27	24	31
LC	2690	3119	15	17	19	23	21	25
LCs	2091	1029	19	19	26	24	24	26
LJ	885	1348	19	15	24	18	26	21
ES	1032	918	15	16	22	20	27	22
LS	501	644	14	15	16	19	17	20
LCc	3689	1111	22	14	28	17	31	20

Legend: EV: Erick Vega, LE: La Esperanza, TP: Tres Palmas, LR: La República, LC: La Caballería, LCs: Los Cascabeles, LJ: La Juliana, ES: El Sol, LS: La Sorpresa, LCc: La Cecilia, CC: Cold campaign; SC: Spring campaign

The reduction observed in the number of individuals between campaigns can be explained by a decrease in the number of species from one season to another. The species only observed in the cold campaign are weeds, which are killed by man totally or in part upon the arrival of the rainy season. The 60% increase observed in the number of individuals in the studied ecosystems was linked to an increase in the number of species that occurred when seasons changed. Another element that may have influenced the presence-absence of species or individuals between campaigns is the life cycles (seasonal, annual, perennial) of the different taxa in the groups.

In the suburban ecosystems with a reduction, the behavior observed was as follows. In La Esperanza (Table 4), of the 25 species reported, 17 were common in the two periods, five were present in the cold campaign only, whereas, three were only observed in the spring campaign. It meant a 9.09% species decrease from one campaign to the other.

Table 4 Reduction of species on La Esperanza, Los Cascabeles, and La Juliana

Farms	Total of species	Common species	Exclusively from the C	Exclusively from the
LE	2	17	5	3
LCs	2	25	2	1
LJ	3	16	10	5
ES	3	15	12	7
LCc	3	17	14	3

Legend: LE: La Esperanza, LCs: Los Cascabeles, LJ: La Juliana, ES: El Sol, LCc: La Cecilia, CC: Cold campaign; SC: Spring campaign

Of the 28 bee species found in Los Cascabeles, 25 appeared in the two campaigns, while only two species were observed in the cold campaign, and one in the spring campaign, thus reducing the number of species to 3.70%. In La Juliana, of the 31 species identified, 16 were present in the two seasons. Only 10 appeared exclusively in the cold season and five in the spring season, with a 19.23% species decrease.

In El Sol, 34 species of bee-related plants were identified, of which 15 were found in the two seasons, 12 were observed in the cold season, and seven in the spring season, with an 18.52% species reduction with the coming of the rainy season. In La Cecilia, 17 were found in the two seasons out of the 34 identified, of which 14 were only observed in the cold season and three in the spring. This farm underwent the highest species reduction (41.93%).

The group of beekeeping plants is made of weed species, plants for nutrition, and fruit species, mostly (Table 5). Of them, the weeds were the only group that decreased from one season to the other. The other botanical groups of melliferous plants underwent a slight increase. Overall, among these plants, the most varying botanical groups were the weeds and plants for nutrition. However, the analysis of all the species revealed that only one of them decreased.

Table 5. Botanical groups found in the bee species during the two campaigns

Botanical groups	CC	SC
Weed species	26.6%	25.0%
Ornamental species	4.1%	4.2%
Medicinal species	6.1%	6.1%
Plants for nutrition	22.4%	22.9%
Arboreal and shrub-like plants	14.3%	14.6%
Fruit plants	26.5%	27.1%

Legend: CC: Cold campaign; SC: Spring campaign

The reduction found in the weeds group partially explains the observations in the botanical composition. Meanwhile, the light increase observed in the other botanical groups of melliferous plants might be caused by an increase in the number of individuals reported on most farms. Rojas (2008) noted that these plants in Cuba are mostly represented by wild species. In a study, Montoya et al. (2017) pointed out that weeds were observed to have spread most (50%), and highlighted their relevance in keeping the hive.

Of the families reported, 10 accounted for 34.48%, which showed the largest contribution to the presence of melliferous species on the farms in the study (Table 6).

Anacardiaceae, *Cucurbitaceae*, and *Musaceae* were observed in all the farms in the two seasons, whereas, *Rutaceae* was observed in 90% of the agroecosystems. In turn, *Arecaceae* had a +1 increase, from 90 to 100% distribution on the farms from one campaign to the other. Moreover, *Malvaceae* had a +2 increase, thus increasing from 80 to 100%. *Poaceae* also showed an increase with the season change, though in +3 farms, from 50 to 80%.

Table 6. Presence of botanical families on the farms in the two campaigns

Families	Farms	
	Cold campaign	Spring campaign
<i>Anacardiaceae</i>	100 %	100 %
<i>Arecaceae</i>	90	100 %
<i>Asteraceae</i>	100 %	70 %
<i>Convolvulaceae</i>	100 %	80 %
<i>Cucurbitaceae</i>	100 %	100 %
<i>Fabaceae</i>	100 %	90 %
<i>Malvaceae</i>	80	100 %
<i>Musaceae</i>	100 %	100 %
<i>Poaceae</i>	50	80 %
<i>Rutaceae</i>	90 %	90 %

Fabaceae showed a reduction in -1 farm with the coming of precipitations, which meant a reduction of its representativeness from 100 to 90%. *Convolvulaceae* also showed a reduction, though in -2 farms, thus increasing its representativeness from 100 to 80%. Finally, *Asteraceae* underwent a 100-70% reduction (-3 farms), becoming the one with the highest loss between campaigns. However, the families mentioned above were well-distributed, with a presence in 70% of the farms, at least in one of the periods.

The fact that the botanical families reported were the most widely represented was associated with their high economic interest in farmers. The variety of botanical groups that make the nectar-producing plants on these farms may have also influenced this behavior. Overall, plants for nutrition and weeds make families taxonomic categories and indicators of the botanical composition and increased their presence on the farms.

The families *Asteraceae*, *Fabaceae*, *Rutaceae*, *Convolvulaceae*, and *Malvaceae* were reported by Méndez et al. (2018), Briceño (2018), and Araujo-Mondragón & Redonda-Martínez (2019), as part of the families with the largest contribution to the composition of bee-related plant species, which are more commonly visited by bees, though under different conditions from those in Cuba. Moreover, a greater number of botanical families intervene in the composition and representativeness of bee-related plant species than in other groups found on the farms included in the study, such as perennial plants

(Belyani Vargas et al., 2016a), medicinal and ornamental plants (Vargas et al., 2017 a and b), fruit plants (Vargas et al., 2019), and weeds (Candó-González et al., 2020), as well as plants for nutrition (González et al., 2021), though not comparable, as they qualify under different points of view.

Richness S (Figure 2) varied, with an increase-decrease ratio from one season to the other in 50% of the farms. Upon analysis of the scope of values between 15 and 35 species, the group of nectar-producing plant species was close to stability. The highest richness (31 species) was reported on La Cecilia (cold campaign) and Erick Vega, and La República (spring campaign). The presence of bee-related plant species was reported on all the farms, which is not only important due to the effects this type of vegetation may have on the system but also due to the service it can render to the adjacent systems.

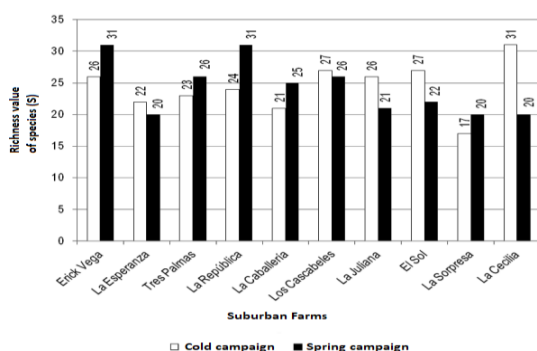


Fig. 2. Richness of bee-related plants on the suburban farms

The dominance values varied when comparing farms, whereas there was a decreasing inter-campaign tendency by agroecosystem (Figure 3). The results were within the range set (0 and 1), below the mean value (0.5000), except for La Esperanza (0.5126) in the cold campaign, and La Juliana (0.6064) and La Cecilia (0.6064) in the spring campaign. In La República, lower values were observed for the two seasons.

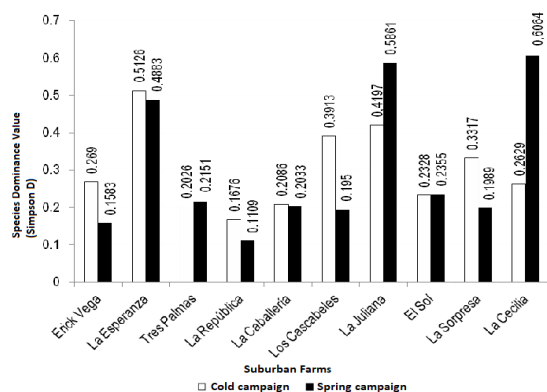


Fig. 3. Nectar-producing plant dominance on the suburban farms in the two seasons

In general, the richness of bee-related plants was adequate, which can be explained by the heterogeneous composition of this group of species. Furthermore, dominance may be considered moderate-low as a result of the increase-decrease ratio in the total species and the number of individuals. Generally, this reduction in the dominance between seasons is considered significant. It means that the diversity value may increase from one season to the other, and therefore, the distribution of individuals in the sample is more balanced. A value increase might entail an opposite behavior. Accordingly, the *Simpson D* index has been influenced by the total of individuals in the sample and the species. Hence, any variation in them may affect dominance.

The species with the highest contribution to dominance underwent a variable behavior on each farm; only Erick Vega with plantain (*Musa* sp.), La Esperanza and La República (*Musa* sp.), and La Caballería (*Polianthes tuberosa*) kept the same species from one season to the other. Furthermore, many of the species not only are repeated on the same farm from season to season, but they also tended to repeat from one system to another in the same season.

Of the total of bee-related species reported, only seven (three species of genus *Musa*, *Polianthes tuberosa*, sweet potato (*Ipomoea batata*), red spinach (*Amaranthus dubius*), and mango (*Mangifera indica*)), accounting for 13.72%, were the most dominant ones. Of them, the three species of the genus *Musa* were the most commonly identified on the farms. Meanwhile, *Amaranthus dubius*, *Mangifera indica*, *Ipomoea batata*, and *Polianthes tuberosa*, were less observed. Although *Mangifera indica* produces seasonal flowering, it remained on the farm throughout the year.

Of the most dominant species reported in the cold season, 60% were occasional, and 20% were the least and little frequently observed specimens. In the spring campaign, the occasional species remained, with 60% dominance, 30% for the frequent ones, and 10% for the less frequent ones. Overall, the representativeness percentage of these species was almost constant from one season to the other, slightly increasing the number of frequent species, with a possible effect on the behavior of diversity.

Of the most dominant species, only *Polianthes tuberosa* was observed on La Caballería in the two seasons, and *Amaranthus dubius* in the cold season on El Sol was not edible species for humans, at least in Cuba. The other species (*Mangifera indica*, *Ipomoea batata*, and the three *Musa* species) are usually used for human nutrition. These are the normal results expected considering that the main role of these farms is the production of food. Hence, their flora is dominated by plants with this purpose,

though they may have other functions in the ecosystem.

In addition to the previous behavior shown in the analyses performed so far, many of the values achieved are also associated with the farmer's will. The human factors determine the purpose of the farm, its position, and its permanence. It does not mean that the adaptative capacity of species (linked to the indexes evaluated), and the farmers' needs are in opposition. Hence, other ecosystem services may be enhanced depending on the completion of production goals (food). Moreover, it permits farm arrangements and designs, which enable, regardless of their main purpose, bee honey production on the farms and their surroundings.

The *Shannon* index was the most varying indicator. Overall, it shows the low values from the two campaigns. However, there was a 60% increase from one season to the other (Figure 4). In all the farms, the values were observed to be below the range set for proper diversity and abundance (1-5). The greatest diversity was observed in La República during the two campaigns, while the lowest occurred in La Esperanza (1.1763) in the cold campaign and La Cecilia (1.0734) in the spring campaign.

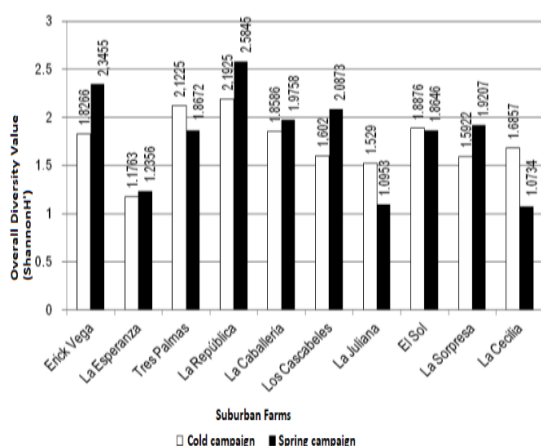


Fig. 4. Overall diversity of bee-related plants on the suburban farms in the two periods studied.

The *Shannon* index is within the range set, in keeping with the *S* and *Simpson D* values observed, and the heterogeneous composition of bee-related plants in suburban systems. The homogeneous distribution of individuals led to the highest values in both periods of La República. It had an effect on the low *Simpson* values for this farm, and because the influence of the most dominant species (*Musa* sp.) in each season was the lowest among all the most influencing species. A different performance was the reason for La Esperanza and La Cecilia to show low diversity values.

Several studies have included these indicators to measure the behavior of nectar-producing plants. The results of this research were not as high as the ones reported by Navarrete et al. (2016). However, in the two cases, they were within the range of proper diversity and abundance. It is important to maintain these levels in the two seasons since it ensures a diversity of bee resources. Diéguez (2017) said that a decrease in the diversity values entails losses of bee resources, and therefore, a change in the honey production potential. Moreover, these results match the reports of Barrantes-Vásquez et al. (2019), showing a uniform distribution of species.

The similarity of these two farms (Figure 5), in terms of nectar-producing plants, led to the formation of two groups in the cold season. One comprised farms Erick Vega-La Sorpresa-La Cecilia (25-50%). The other included La Juliana-La República-Tres Palmas-El Sol-La Esperanza-Los Cascabeles (up to 75%). La Caballería was the only farm that differed from the rest and remained outside the groups.

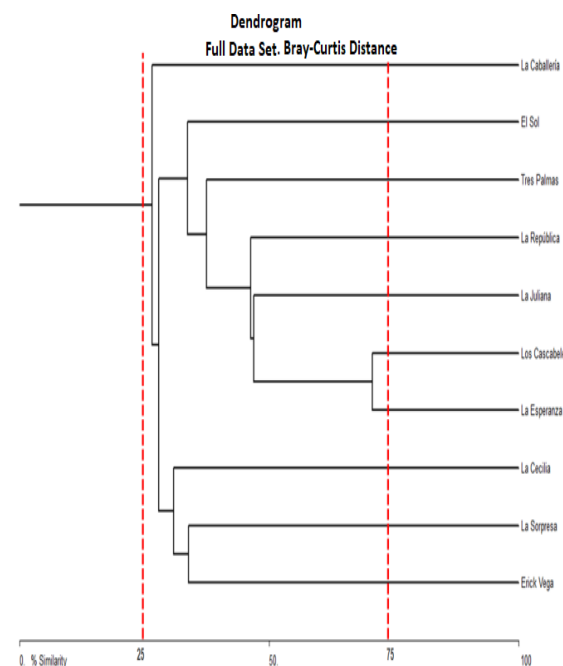


Fig. 5. Dendrogram of the similarity between farms, considering the bee-related plant species in the cold season.

In the spring season (Figure 6), farm similarity was greater, with the formation of three groups, whereas the ecosystems were limited to four agroecosystems outside the groups. The groups made by La Esperanza-La Cecilia, and La República-El Sol showed 50-75% similarity, like La Sorpresa, which remained outside any group. Meanwhile, the Tres Palmas-La Juliana group showed a 25-50% similarity to Erick Vegas and Los Cascabeles, more inclined to stay outside the grouping. Only La Caballería showed a 0-25% similarity, remaining outside groups. Overall, in the two seasons, few similar groups were

formed, taking into account the type of melliferous flora.

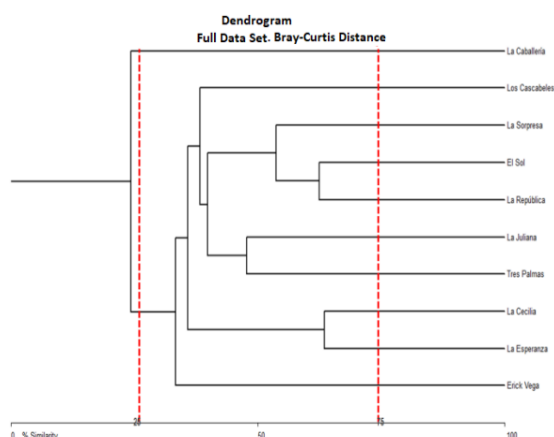


Fig. 6. Similarity dendrogram between farms, taking into account the nectar-producing plant species in the spring season.

In terms of similarity, the groups and farms with values between 0 and 25% qualified as low similarity; between 25 and 50% as moderate similarity; and 50-75% as high similarity. The existence of few heterogeneous groups was caused by the little presence of common species between farms. The ones outside the groups had more exclusive species or an insignificant number of individuals.

The similarity values were associated with the distribution of the most dominant species. The increase of similarity during the beginning of the rainy season was thought to have caused an increase in the number of common species in the samples studied. This demonstrated the permanence of bee-related plants as part of the vegetation of these farms, both spatial and temporal.

These are critical results, since farms can offer an ecosystem service consisting of supplying bee-keeping resources beyond their limits. Pardo & Jiménez (2006) and Reyes-Carrillo et al. (2014) acknowledged the flying range of Hymenoptera may vary (1-10 km), depending on the species. Additionally, the fact that bee-related plant species are present in the two periods, ensures the resources needed by bees to do their job. These farms are spread over extensive areas (7-8 km), ensuring the collection material for bees and beekeepers.

All the plant species were reported to provide resources, and 17 were identified as the most common ones. These 17 species accounted for 34.69% of the 49 existing species in the two periods. The number of percentage groups identified rose to eight (Table 7), most of them reported by 50% or more reporters.

Table 7. Most widely known bee species

No.	Melliferous species	PCR
1	<i>Helianthus annuus</i>	100 %
2	<i>Manihot indica</i>	90 %
3	<i>Cucurbita pepo</i>	90 %
4	<i>Merremia umbellata</i>	70 %
5	<i>Ipomoea purpurea</i>	70 %
6	<i>Turbina corymbosa</i>	70 %
7	<i>Ipomoea batatas</i>	60 %
8	<i>Gouania polygama</i>	50 %
9	<i>Cissus trifoliata</i>	50 %
10	<i>Samanea saman</i>	50 %
11	<i>Coffea arabica</i>	50 %
12	<i>Polianthes tuberosa</i>	50 %
13	<i>Musa paradisiaca</i>	40 %
14	<i>Gliricidia sepium</i>	40 %
15	<i>Cocos nucifera</i>	40 %
16	<i>Carica papaya</i>	30 %
17	<i>Momordica charantia</i>	10 %

Legend: PCR: Reference percentage

A comparison showed a 76.47% coincidence with the reference species, as the most commonly visited by bees (Table 8). Only *Ipomoea batata*, coconut (*Cocos nucifera*), and bitter melon (*Momordica charantia*) were among the most widely known, but not among the most frequently visited species.

Table 8. Most visited melliferous species, according to the reporters

No.	Melliferous species	PCR
1	<i>Helianthus annuus</i>	100 %
2	<i>Manihot indica</i>	50 %
3	<i>Merremia umbellata</i>	40 %
4	<i>Ipomoea purpurea</i>	40 %
5	<i>Turbina corymbosa</i>	40 %
6	<i>Cucurbita pepo</i>	30 %
7	<i>Carica papaya</i>	30 %
8	<i>Cissus trifoliata</i>	20 %
9	<i>Gouania polygama</i>	20 %
10	<i>Polianthes tuberosa</i>	10 %
11	<i>Coffea arabica</i>	10 %
12	<i>Musa paradisiaca</i>	10 %
13	<i>Samanea saman</i>	10 %

Legend: Legend: PCR: Reference percentage

The above can be explained by the fact that most reporters (90%) mentioned that the most frequently visited species can be used as melliferous plants, provided they are present in natural or production areas, including the farms in this research study. According to 50% of reports, many species could be used as melliferous, and 20% said that they are common plants that appear normally at different sites without cultivation. Another aspect that enables nectar-producing plant access and availability is the flying range of bees since the area of these farms is within the sucking extent of these insects. This opinion was given in 10% of the reports. A similar percentage was reported to be present in several locations at different levels of existence.

These results demonstrate that apiculture is influenced by the social context, especially one linked to the knowledge of nectar-producing plants. Toro (n/a.) noted that when beekeepers know the

productive plant species, they must take preservation actions by ensuring the viability of the resource and the cost-effectiveness of the products. They added that knowledge has affected floristic resources, with ensuing consequences for bees and their nutrition. Luna et al. (2019) pointed out that the identification of potential beekeeping areas should be based on social perception studies of the contribution of plant species.

The presence of nectar-producing plants on a certain farm is perhaps associated with their potential to conserve them. Several studies confirm the usefulness of these plants for honey production. Montoya-Pfeiffer et al. (2014) referred to mamoncillo (*Melicoccus bijugatus*), *Ipomoea batata*, and yellow merremia (*Merremia umbellata*) as part of the species identified in the honey samples. Silvino Vargas et al. (2016b) when evaluating the agronomic parameters of these plants referred to Spanish elm (*Cordia gerascanthus*), chewstick (*Gouania polygama*), snake-plant (*Turbina corymbosa*) and various species of genus *Citrus*.

Pérez & Arozarena (2020) pointed out that *Turbina corymbosa*, known in Cuba as snake-plant, is present in the bee-related flora in Cuba since it was first described by Acuña (1970), as part of the 472 frequently-visited botanical species. It is a Class 3 melliferous species with a high contribution to the annual honey production. Its flowers secrete nectar before anthesis, the most appropriate moment to perform a productive evaluation of the species. Its presence throughout the country, in different edaphoclimatic environments has permitted its inclusion within the melliferous species on which Cuban beekeeping rests.

Although *Turbina corymbosa* is a highly seasonal species, its presence in the two seasons was associated with the moment the samples were collected. In the cold campaign, sample collection was performed in March and April, whereas the collection of samples for the spring campaign was conducted in May and June.

Coral vine (*Antigonon leptopus*) was mentioned by Briceño (2018) in the floristic list of plants identified in the apiaries in Yucatan state, Mexico, whereas Peña et al. (2018) reported the presence of bees collecting nectar in avocado (*Persea americana*) and *Mangifera indica*. Acuña (2019) reported the Cuban royal palm (*Roystonea regia*), papaya (*Roystonea regia*), mata ratón (*Gliricidia sepium*), pomegranate (*Punica granatum*), guava (*Psidium guajava*), shepherd's needles (*Bidens alba*), morning glory (*Ipomoea purpurea*), sleepy plant (*Mimosa pudica*), basil (*Ocimum basilicum*), and West Indian elm (*Guazuma ulmifolia*).

In this study, *Ipomoea purpurea* was hard to identify, and therefore, the specialists at BIOECO herbarium were asked to corroborate this species. Moreover, its presence in the two seasons responds to the same causes related to *Turbina corymbosa*. Although morning glory is not a common name for *Ipomoea purpurea*, it was the only vernacular name attributed to the locals where the research was done.

Araujo-Mondragón & Redonda-Martínez (2019) noted that pumpkin (*Cucurbita pepo*) and maize (*Zea mays*) are among the nectar-producing plants in the mid-east region of Pátzcuaro municipality, Michoacán, México. Meanwhile, Morales (2020), said that coffee (*Coffea arabica*) is frequently visited by bees. Cucumber (*Cucumis sativus*) and cardosanto (*Argemone mexicana*) were included by Gualpa-Calva et al. (2020) in the list of nectar-producing plants adjacent to the apiary at Tunshi Experimental Station. All these species are among the 51 reported in this paper.

Also interesting is the fact that all the reporters acknowledged the need to utilize the potential of the nectar-producing plants on the farms to enhance their availability. Overall, the nectar-producing plants identified on the farms have the potential to generate apiculture-related ecosystem services in the communities. Some of the criteria that support this rationale, based on the results, are (i) the species on the farms, which is recognized by the community; (ii) there are adequate diversity and abundance levels; (iii) the nectar-producing plants were observed to maintain stability in the two seasons; and (iv) most of them are within the most widely preferred by the bees.

These results demonstrate the potentialities of these farms for beekeeping, such as (i) the existence of nectar-producing plants on suburban farms; (ii) proper diversity values observed between seasons; (iii) the assurance of collection material for bees does not hinder other ecosystem services provided by the farms; (iv) these species can contribute to the agroecological design of these farms; and (v) the production potential of nectar-producing plants on these farms has been recognized as a social need.

However, it demands certain actions, such as (i) training farmers in nectar-producing plant maintenance and the best ways of conservation; (ii) determining the season with the highest nectar-producing plant flowering on each farm; (iii) enhancing agroecological designs of weed species, as the most contributing group of nectar-producing plants; and (iv) implementing a crop rotation system with a bee-keeping potential (by enabling the ecosystem service provided by the farms beyond their production), with the identification of the best

seasons, flowering stages, and the conditions of every agricultural ecosystem.

Conclusions

The suburban farms studied have a stable composition, with balanced botanical species, particularly the weed species, whereas the *Anacardiaceae*, *Cucurbitaceae*, and *Musaceae* were the families with the greatest contribution. There is a diversity of bee species which tend to decrease in the dry season but showed a better distribution in the spring. Although the occurrence of rain increases similarity, the bee-related flora of these farms is made of species that vary between exclusiveness and the potential adaptation to the conditions of the ecosystems studied, with low-moderate similarity. However, they remain from one campaign to another, ensuring the presence of bee-associated plants, along with the benefits and services they can provide. There was an adequate social perception of the bee-related flora on these farms to provide such ecosystem service, including the need to use the existing potential of these agroecosystems to increase their availability.

Author contribution statement

Belyani Vargas Batis: research planning, analysis of the results, redaction, and review of the manuscript.

Alexis Cuadra Tamayo: analysis of some results, redaction, and final review of the manuscript.

Adriel Plana Quiala: literature search, analysis of some results, final review of the manuscript.

Héctor Valdés Rodríguez: literature search, interviews, final review of the manuscript.

Randy González Amita: interviews, data processing, final review of the manuscript.

Oniel Fuentes Miranda: field work, final review of the manuscript.

Enmanuel de Jesús Acosta Ojeda: correction and final review of the manuscript. Ana M. Lupiáñez Pérez: planeación de la investigación, elaboración de la plantilla, análisis de resultados, redacción del artículo, revisión final.

Conflict of interest statement

Not declared.

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Appendage 1. General list of melliferous species found in suburban farms

Family	Scientific name	Vernacular name	Individuals (total)
Amaranthaceae	<i>Amaranthus dubius</i> Mart. ex Thell.	Bledo	1025
Anacardiaceae	<i>Anacardium occidentale</i> L.	Marañón	13
	<i>Mangifera indica</i> L.	Mango	798
Arecaceae	<i>Cocos nucifera</i> L.	Coco	72
	<i>Roystonea regia</i> (Kunth.) O.F Cook	Palma real	99
Asparagaceae	<i>Polianthes tuberosa</i> L.	Azucena	2206
Asphodelaceae	<i>Aloe vera</i> (L.) Burm. f.	Sábila	8
Asteraceae	<i>Bidens alba</i> (L.) DC.	Romerillo blanco	440
	<i>Helianthus annuus</i> L.	Girasol	634
	<i>Pluchea odorata</i> (L.) Cass.	Salvia	6
Boraginaceae	<i>Cordia gerascanthus</i> L.	Baría	100
Brassicaceae	<i>Raphanus sativus</i> L.	Rábano blanco	952
Byttneriaceae	<i>Guazuma ulmifolia</i> Lam.	Guásima	52
Caricaceae	<i>Carica papaya</i> L.	Fruta bomba	152
Commelinaceae	<i>Tradescantia spathacea</i> Sw.	Cordobán	13
Convolvulaceae	<i>Ipomoea batatas</i> (L.) Lam.	Boniato	3528
	<i>Ipomoea purpurea</i> (L.) Roth.	Campanilla morada	178
	<i>Merremia umbellata</i> (L.) Hall.	Campanilla amarilla	74
	<i>Turbina corymbosa</i> (L.) Raf.	Campanilla blanca	73
Cucurbitaceae	<i>Cucumis melo</i> L.	Melón	48
	<i>Cucumis sativus</i> L.	Pepino	373
	<i>Cucurbita pepo</i> L.	Calabaza	351
	<i>Luffa acutangula</i> (L.) Roxb.	Friega Plato	1
	<i>Momordica charantia</i> L.	Cundeamor	215
Fabaceae	<i>Gliricidia sepium</i> (Jacq.) Kunth.	Piñón florido	1811
	<i>Mimosa pudica</i> L.	Moriviví	123
	<i>Pithecellobium dulce</i> (Roxb.) Benth.	Tamarindo chino	57
	<i>Samanea saman</i> (Jacq.) Merr.	Algarrobo	43
	<i>Tamarindus indica</i> L.	Tamarindo	1
	<i>Vachellia farnesiana</i> (L.) Wight & Arn.	Aroma	355
Lamiaceae	<i>Ocimum basilicum</i> L.	Albahaca blanca	713
Lauraceae	<i>Persea americana</i> Mill.	Aguacate	119
Lythraceae	<i>Punica granatum</i> L.	Granada	3
Malvaceae	<i>Abelmoschus esculentus</i> (L.) Moench.	Quimbombó	288
Meliaceae	<i>Trichilia hirta</i> L.	Jubabán	110
Musaceae	<i>Musa</i> sp.	Plátano burro	7314
	<i>Musa</i> sp.	Plátano fruta	2152
	<i>Musa</i> sp.	Plátano macho	2605
Myrtaceae	<i>Psidium guajava</i> L.	Guayaba	376
Papaveraceae	<i>Argemone mexicana</i> L.	Cardo santo	12
Poaceae	<i>Sorghum halepense</i> (L.) Pers.	Don Carlos	821
	<i>Zea mays</i> L.	Maíz	1120
Polygonaceae	<i>Antigonon leptopus</i> Hook. & Arn.	Coralillo	137
Rhamnaceae	<i>Gouania polygama</i> Jacq.	Bejuco de indio	90
Rubiaceae	<i>Coffea arabica</i> L.	Café	210
Rutaceae	<i>Citrus x aurantium</i> L.	Naranja agria	31
	<i>Citrus x limon</i> (L.) Osbeck.	Limón	31
	<i>Citrus sinensis</i> (L.) Osbeck	Naranja	5
Sapindaceae	<i>Melicoccus bijugatus</i> Jacq.	Mamoncillo	248
Sapotaceae	<i>Pouteria sapota</i> (Jacq.) H. E. M. & S.	Zapote	11
Vitaceae	<i>Cissus trifoliata</i> (L.) L.	Bejuco de ubí	101