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GEOSPATIAL ANALYSIS OF APIARIES AND USE OF FLORA FOR HONEY PURPOSES IN TACOTALPA, TABASCO, MEXICO

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Abstract: The present study characterized the beekeepers and the honey flora of the municipality of Tacotalpa, Tabasco. The average age of beekeepers is 50.5 years. The majority of beekeepers are men, with only 10 women involved in the activity. A total of 83 honey species were identified, distributed in 33 botanical families. The most represented families were Fabaceae (12 species), Euphorbiaceae (7 species). The flowering of the species was concentrated mainly between March and June, coinciding with the dry season and the beginning of the rainy season. Regarding honey production, a total of 13,374 liters was reported from 835 hives, with an average of 16 liters per hive. The towns with the largest number of producers were Francisco I. ``*Madero*`` 2nd Section and ``*La Raya Zaragoza*``. It was highlighted that the management of the African bee *(Apis mellifera* scutellata) is predominant, followed by carniola (*Apis mellifera* carnica) and the dark European (*Apis mellifera* mellifera). The fishing area covers approximately 2,827 hectares located on the slopes of the Tacotalpa hills, which maximizes the use of marginal lands and contributes to the conservation of the local biodiversity of the region.

INTRODUCTION

Beekeeping is considered a practice linked to the conservation of biodiversity, because to develop it it is necessary to have large forest masses or production systems that offer significant flowering. It can hardly be developed in grasslands or monocultures that do not flower. In tropical regions it can be of great commercial interest due to the large forest mass.

The southeast of Mexico is characterized by a high diversity of floristics, which allows bees to find their source of nectar and pollen almost all year round. This diverse condition is essential for the health of apiaries and to maintain honey production. The studies by González et al (2023) as well as those by (Martínez and Herrera) 2022 indicate that the flora of Tabasco includes a wide variety of honey species that are used by bees, contributing significantly to the production of high-quality honey.

The honey produced in the Tabasco entity is not only a product, it is part of the complementary base of the economy of many rural families in the region (SADER, 2022). At the same time, a critical component of local ecosystems, since bee pollination is key to the subsistence of many of these ecosystems and agricultural systems. The insect-plant relationship guarantees the production of fruits and seeds, which in turn guarantees the annual propagation of wild species and the production of fruits, maintaining a functional structure of the ecosystems (Rodríguez et al., 2023).

Within the national panorama, the State of Tabasco contributes 0.7% of the country's total honey production, standing out for its beekeeping practices and the quality of its honey (González et al., 2022; Martínez & Herrera, 2023). In terms of production volume, Tabasco reached 407 thousand liters of honey in the last year. This achievement is particularly notable in the municipality of Huimanguillo, which is positioned as the main producer in the state, closely followed by the municipality of Tacotalpa, with productions of 84.4 thousand and 81.3 thousand liters respectively (López et al., 2022; Rodríguez et al., 2022; al., 2023). These municipalities have become fundamental pillars for beekeeping in Tabasco, in the case of Tacotalpa there is a rugged orography and thus a limitation for the management of hives. The following document identifies the current characteristics and conditions of beekeeping in the Sierra de Tacotalpa region, Tabasco, as well as the flora identified for foraging.

METHODOLOGY

The work was carried out directly in the Municipality of Tacotalpa, Tabasco, located in the Sierra region, southeast of the state, bordering to the north with the municipalities of Jalapa and Teapa, to the east with the state of Chiapas, to the south with the municipality of Teapa, and to the west with the municipality of Jalapa (INEGI, 2021). The municipality has a territorial area of approximately 732.45 km², which represents 2.97% of the total area of the state of Tabasco. Tacotalpa has a warm humid climate with rain all year round (Af), characterized by high temperatures and annual precipitation that exceeds 2000 mm (García, 2004). This climate favors exuberant vegetation and high biodiversity and according to Rzedowski, (2006) the predominant type of vegetation is high evergreen forest, which is characterized by the presence of tall trees that maintain their foliage throughout the year.

A census was carried out on the 69 previously identified honey producers to apply a semi-structured interview with 20 items where the infrastructure available to the producers, number of hives and type of box was addressed (Smith et al., 2021). In addition, 12 guided tours were carried out in the bee foraging area to learn about the plant species that beekeepers identify as honey flora.

During the tours, the group of beekeepers pointed out the plants that they consider most important for honey production, and they were identified or collected for taxonomic identification using guides and manuals for local species (Magaña-Alejandro, 2006, Maldonado-Morales, 2016).

Using GPS devices, all identified apiaries were georeferenced. Subsequently, a geospatial analysis was performed using geographic information systems software (Qgis 3.16) to map the foraging areas and evaluate their accessibility and distribution in relation to other apiaries. The quantitative data obtained were analyzed using descriptive and inferential statistical techniques.

RESULTS AND DISCUSSION

The average age of beekeepers is 50.5 years with a minimum age of 22 years and a maximum of 80 years. This suggests a wide age distribution among honey producers, indicating that both young people and older adults participate in bee production in the Tacotalpa municipality, although 49% of beekeepers are over 50 years of age.

The maximum level of education of beekeepers is high school and only 7.6% have it, secondary and primary studies correspond to 26% and 43% respectively, the rest have no studies. This pattern suggests that honey production is accessible to individuals with various educational levels. Regarding sex, we found that only 10 people are female and the rest are male.

Beekeepers have identified a total of 83 honey species, distributed in 33 different botanical families. The families with the largest number of species are Fabaceae (12 species), Euphorbiaceae (7 species), Apocynaceae (6 species), and Rubiaceae (6 species) as shown in Figure 1. These families stand out for their wide distribution and the variety of species they contain, which is consistent with previous studies on honey flora (Smith et al., 2018; Jones & Green, 2020). In Figure 1 we can find the grouping of the number of months in flowering of the botanical families found, ranging from 5 to 4 months.

The flowering period that most combines the family is three months and the Fabaceae family with 12 species is the most represented, followed by Euphorbiaceae (7 species), Apocynaceae (6 species), and Rubiaceae (6 species) respectively.

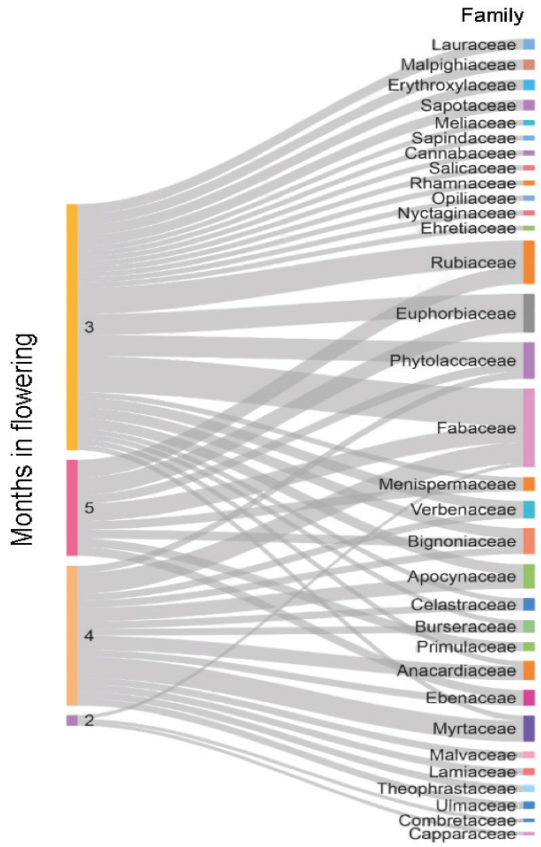

Figure 1: Relationship between the flowering period of the species and botanical families represented as honey flora.

With respect to flowering periods, Table 1 shows a wide variability, with a marked predominance in the months of March to June. This period coincides with the dry season and the beginning of the rainy season in many tropical regions, which favors the flowering of many honey species. Specifically, the month of March is the most frequent month for the start of flowering, followed by April, May and June. This seasonality is crucial for beekeepers, as it determines the optimal periods for honey production (Brown & Wilson, 2019).

The results obtained in this study are comparable with research carried out in other tropical regions. For example, in a study on honey flora in the Yucatan region, Mexico, it was found that Fabaceae and Rubiaceae were also the predominant families, with a similar flowering period, concentrated between March and June (Martínez et al., 2017). Additionally, the presence of species such as: *Mimosa biuncifera* and *Haematoxylum campechianum* both studies highlight the consistency of these species as valuable honey resources.

Bees depend on a variety of flowers for nectar and pollen, and the availability of different species at different flowering periods ensures a constant supply of resources (Klein et al., 2007). In addition, floristic diversity contributes to the production of honey with different organoleptic characteristics and nutritional properties, although producers complain about the price which is paid at 5.50 dollars per liter for wholesale and up to 15 dollars for retail sale.

The communities with the largest number of producers are Francisco I. Madero 2nd Section, (32 producers) and La Raya Zaragoza (18 producers). This suggests that these areas are important honey production centers, which could be due to factors such as the availability of honey flora, traditional knowledge and established beekeeping practices, and the fact that the orography of the land is more accessible.

Regarding production per hive, it can vary significantly depending on factors such as climate, available flora, and beekeeping practices. A study by Jones and Green (2020) indicates that the global average production per hive ranges between 10 and 20 liters per hive annually, with significant variations in tropical and subtropical regions. Brown and Wilson (2019) reported production averages of up to 25 liters per hive in some areas with advanced beekeeping practices and abundant honey flora.

Localities such as Arroyo Seco Miraflores and Tomas Garrido stand out for their high production averages per hive compared to the others as shown in Table 2, which agrees with what was found in the field when they were

Scientific name	Flowering period					Plant Form
	March	April	May	June	July	
Anacardium occidentale						Tree
Metopium brownei						Tree
Spondias mombin						Tree
Plumeria obtusa						Tree
Stemmadenia donnell-smithii						Tree
Tabernaemontana alba						Shrub
Thevetia gaumeri						Shrub
Parmentiera sp.						Tree
Cameraria latifolia						Shrub
Cordia alliodora						Tree
Cordia dodecandra						Tree
Bursera morelensis						Tree
Bursera simaruba						Tree
Trema micrantha						Tree
Capparis sp.						Shrub
Maytenum belizensis						Tree
Maytenum schippii						Tree
Bucida buceras						Tree
Diospyros anisandra Blake						Tree
Diospyros bumelioides						Tree
Rouchefortia sp.						Shrub
Eryrtroxylum obovatum						Shrub
Erytroxylum rotundifolium						Shrub
Alchorneae latifolia						Tree
Croton icche Lundell						Shrub
Croton sp						Shrub
Jatropha gaumeri						Shrub
Sebastiana adenophora						Shrub
Sebastiania adenofora						Shrub
Acacia sp.						Tree
Ateleia cubensis Griseb						Tree
Cassia grandis						Tree
Dyphysa carthagenensis						Tree
Gliricidia maculata						Tree
Haematoxilum campechianum L.						Tree
Haematoxylon brasiletto						Tree
Lonchocarpus sp.						Tree
Lonchocarpus xuul Lundell						Tree
Millera quinqueflora						Tree
Mimosa bahamensis						Shrub
Mimosa biuncifera						Shrub
Pithecelobium albicans						Tree
Vitex gaumeri Greenm.						Tree

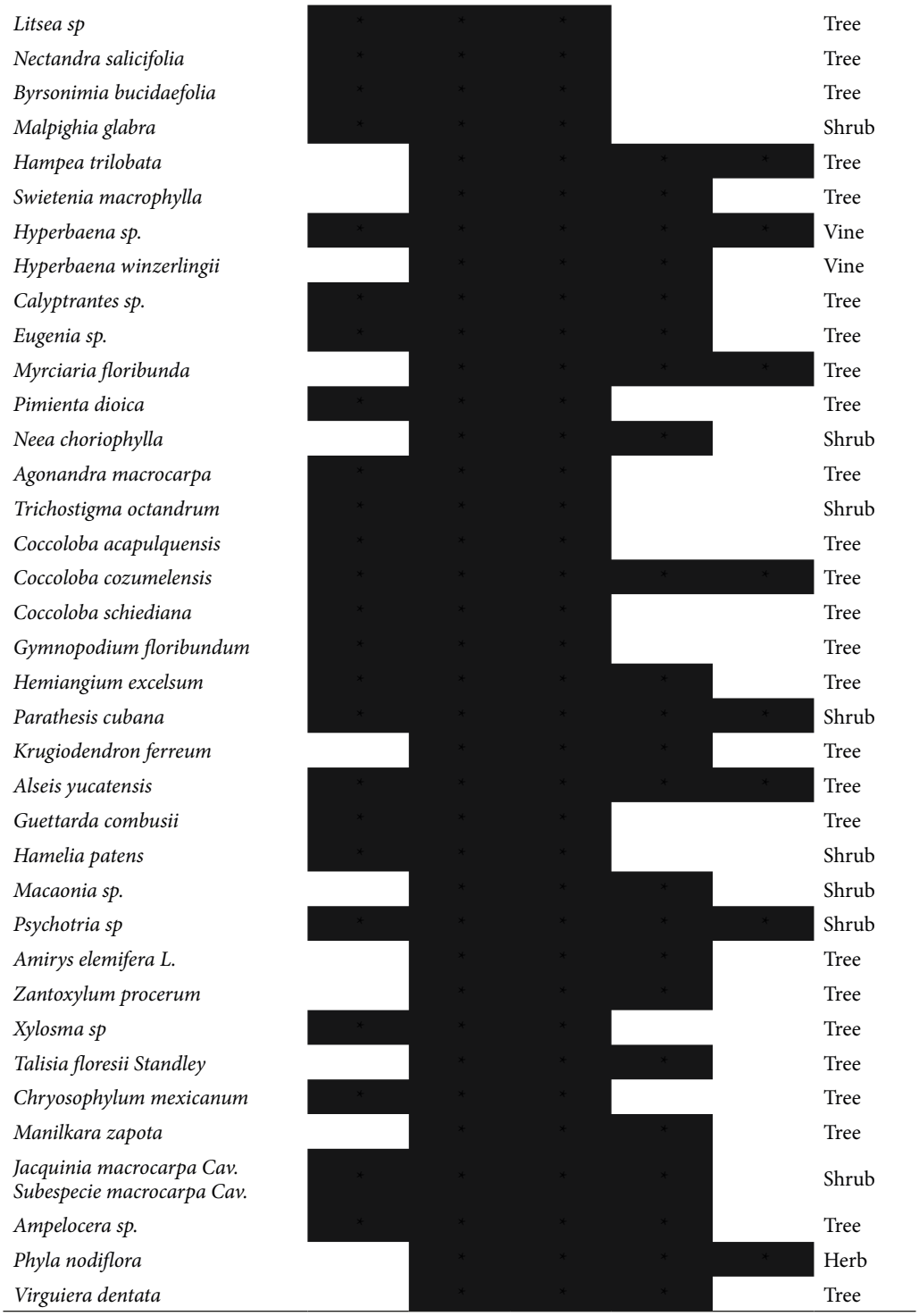

Table 1: Floristic resources for beekeeping described in the guided tours

asked about the practices they carry out in the field. To which they responded that they select colonies using only those due to their high productivity and resistance to diseases, although they also mostly have defensive behavior. They also mentioned that they carry out periodic control of pests and diseases that affect bees. Another of the activities they carry out is the selection of the site where they place the box, trying to do so at the foot of hills or land preferably covered by tree vegetation.

Place	Number of hives	Liters/ produced	Average/ Hive (L)
Arroyo Seco Miraflores	6	95	48
Barreal Cuauhtémoc	14	126	9
Caridad Guerrero	20	400	20
Carlos A. Madrazo	25	500	20
Francisco I. Madero 1ra Sec.	18	143	8
Francisco I Madero 2da. Sec.	165	2675	16
La Pila	30	600	20
La Raya Zaragoza	392	5718	15
Mexiquito	6	100	17
Noypac	15	300	20
Pomoca	19	387	20
Puxcatan	50	1100	22
R/A Gran Poder	15	180	12
Tomas Garrido	22	600	27
Yajalon Río Seco	14	250	18
Zunu y Patastal	24	200	8

Table 2: Estimated production volumes by location in the municipality of Tacotalpa

The total honey production volume for the Municipality of Tacotalpa is 13,374 liters with a quantity of 835 boxes of bees, the main breed of bee managed in Tacotalpa is the African one. (*Apis mellifera* scutellata). This preference is mainly due to its abundant availability in the environment. African bees are known for their defensive behavior and high reproductive capacity, which makes them prolific in warm regions and favors their presence in urban and rural areas. It is common for local beekeepers to be called upon to remove or relocate swarms of wild bees that have settled in urban areas. These beekeepers usually keep the bees as is, without changing the queen, managing them according to established local practices. The second most common breed of bee in Tacotalpa is the Carniola (*Apis mellifera* carnica). This breed was introduced through government support programs, where Carniolan queens were distributed to local beekeepers. The third most prevalent race is the dark European (*Apis mellifera* mellifera). This breed has been introduced mainly through the purchase of queens by beekeepers..

In Tacotalpa, bee breed management practices vary among producers; a total of 36 producers manage two bee breeds, taking advantage of the specific advantages of each breed. On the other hand, 32 producers prefer to manage only one breed, simplifying management and specializing in the characteristics of that breed, and one producer manages three breeds, possibly to diversify the production and benefits of each breed. This diversity in management practices reflects the adaptability of local beekeepers to environmental and economic conditions, as well as the influence of support programs and the availability of breeds on the market.

Figure 2 shows the foraging area of 2,827 hectares located on the slopes of the Tacotalpa hills. This location is due to the fact that the land at these elevations has slopes greater than 60%, which makes it impossible to use it for the agriculture of crops such as corn or grasses. Likewise, these slopes prevent the introduction of cattle. Due to these limitations, beekeepers place their hives at the foot of the hills, taking advantage of the local flowering available in these hills. Furthermore, the floristic diversity present in these hills provides a constant source of nectar and pollen, which is essential for the health and productivity of the hives (Gómez et al., 2023; Hernández & Rodríguez, 2022).

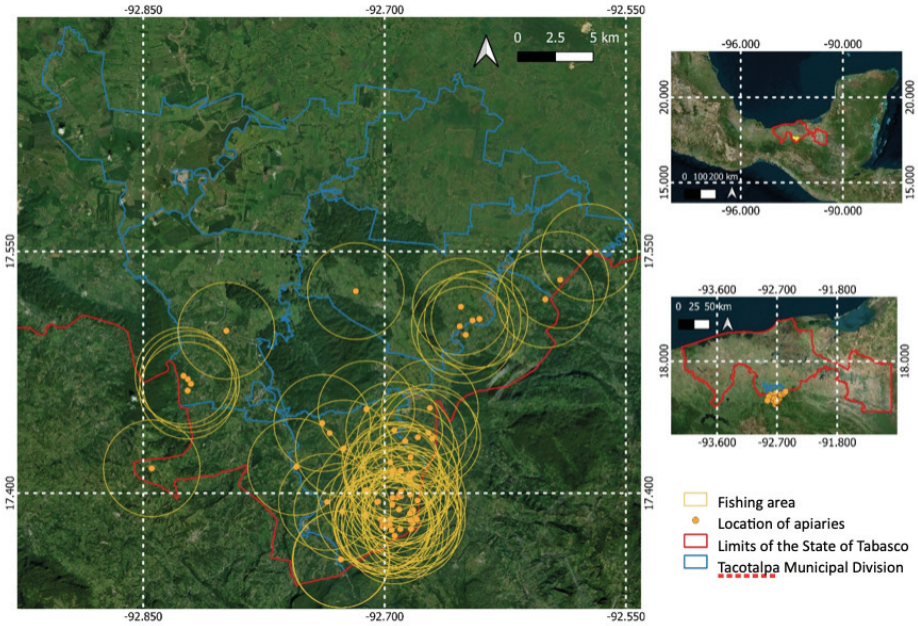

Figure 2: Map of the foraging area and location of the apiaries in the Municipality of Tacotalpa

The use of sloping land for beekeeping not only maximizes the use of marginal lands, but also contributes to the conservation of local biodiversity. Bees play a crucial role in pollinating wild plants, helping to maintain the structure and function of local ecosystems.

This practice also minimizes conflict with other land uses, such as agriculture and livestock, which are not viable in these areas (Martínez & Herrera, 2023; Pérez et al., 2022). The total foraging area covers approximately.

Other studies have highlighted the importance of beekeeping on marginal lands as a sustainable strategy for biodiversity conservation and climate change mitigation. For example, Gómez et al. (2023) demonstrated that placing hives in non-arable areas increases pollination of native plants, which in turn improves the resilience of local ecosystems. Likewise, Martínez & Herrera (2023) found that hives located in areas with high floristic diversity have greater honey production and better hive health.

CONCLUSIONS

In the municipality of Tacotalpa, Tabasco, there are 69 beekeepers, the average age is 50.5 years with a maximum educational level of high school, although the majority of producers have a primary school education.

Producers recognize 83 honey species, distributed in 33 different botanical families. The families with the highest number of species are Fabaceae (12 species), Euphorbiaceae (7 species), Apocynaceae (6 species), and Rubiaceae (6 species).

The volume of honey production for the Municipality of Tacotalpa is 13,374 liters with a quantity of 835 boxes, with an average of 16 liters per box and according to the location of the bee boxes, there is a foraging area of 2,827 hectares.

To maintain an apiary with a production of 16 liters of honey, it is necessary to have a foraging area of approximately 2827 hectares that can sustain around 3,961,940 honey flowers per hectare during a 100-day foraging season. This calculation assumes an average nectar production of 0.5 mg per flower per day.

The management of different breeds of bees in Tacotalpa is a strategy that allows beekeepers to optimize honey production and adapt to local conditions. The predominance of the African bee is due to its availability and adaptation to the warm climate of the region, while the introduction of the Carniolan and European races through support programs and purchases demonstrates the search for better beekeeping practices and genetic diversification to improve disease resistance and production efficiency.

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