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Characterization and description of beekeeping agroecosystems in Hopelchén, Campeche, Mexico

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ABSTRACT

Objective: to characterize honey bee (*Apis mellifera*) production systems in the municipality of Hopelchén, Campeche, Mexico.

Design/methodology/approach: the sample was made up by 10% of the beekeepers in Hopelchén, identified through the snowball method. A semi-structured questionnaire was designed with 94 questions grouped into five sections (general information, structure of the systems, product trade, technologies used, and decision making). The questionnaire was applied through the technique of interviewing those responsible for the 118 beekeeping production systems. The information obtained with the questionnaires was analyzed with descriptive statistics.

Results: beekeeping is an important productive activity in the region of Los Chenes and La Montaña in Hopelchén, which are undergoing the process of generational replacement and are currently maintained by young adult producers who are younger than 45 years old. They own 55 hives on average per producer, which are located at a distance of 7.7 km from their households. The main technology is the use of sugar for feed, by 50% of producers, followed by the diagnosis of Varroa infestation and determination of moisture with 35 and 21.5% of beekeepers.

Limitations on study/implications: the limited access to regions with beekeeping potential, as well as the lack of monitoring by outside staff, does not ease open-mindedness of beekeepers toward researchers.

Findings/conclusions: the characterization of beekeeping production systems with high potential allows proposing improvement strategies to promote the development of small-scale producers.

Keywords: Beekeeping, characterization, sustainability.

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INTRODUCTION

In Mexico, an activity of great economic and social relevance is beekeeping, because it generates employment, income and currency (Güemes *et al.*, 2003; Tiatrini, 2002). It is considered to be an important activity of the livestock subsector, and its production volume and level of productivity place Mexico in the sixth place globally; in America, it is third in both categories, as well as in exports (Magaña *et al.*, 2007). This livestock production

activity, in addition to its social and economic importance, is relevant from the ecological point of view due to its positive impact on cross-pollination of wild and cultivated species (SADER, 2016; Martinez-Gonzalez *et al.*, 2018). In addition to honey, beekeeping is a source of other products of excellent quality and uses in agroindustry, such as pollen, royal jelly, wax, propolis and bee venom.

The Yucatan Peninsula is an important region in honey production at the national level, approximately 95% of its production is destined to the international market, and due to its quality conferred by the botanical origin, it is a product accepted in the European and United States market (Güemes-Ricalde *et al.*, 2003). The state of Campeche is positioned in the second place nationally in bee honey production (SIAP, 2023).

It is estimated that approximately 6,226 families from the rural sector depend directly on the beekeeping activity in this state (SADER, 2018), and the highest honey production is concentrated in the municipalities of Campeche and Hopelchén, which contribute more than 75% of the annual state production (SIACON, 2017). Hopelchén has a higher proportion of rural areas and therefore more agriculture and livestock activity. This municipality is divided into two large regions called La Montaña and Los Chenes.

La Montaña represents a higher proportion, with approximately 200,000 ha, and it is located in the southern part of the municipality of Hopelchén. It is considered a high priority conservation area, part of the muffling area of the Calakmul Biosphere Reserve and Mesoamerican-Mexican Biological Corridor (Porter-Bolland *et al.*, 2008). The climate of the municipality of Hopelchén corresponds to warm tropical sub-humid type (García, 1973), the mean temperature and annual precipitation are 26 °C and 1,050 mm, although between both regions there is a moisture gradient that is higher in the La Montaña region, where vegetation is represented mainly by sub-evergreen and deciduous medium forest, while in the region of Los Chenes it is low deciduous forest (Porter-Bolland *et al.*, 2008).

Beekeepers in Campeche have been grouped into 31 organizations and eight honey stockpiling companies operate in the state (Cruz-Zamudio, 2017). However, the organization has had a lower impact as a driving element of beekeeping, probably because the production systems differ and their particular characteristics have not been considered in the elaboration of strategies to potentiate the activity. Organizing among beekeepers is important for the knowledge exchange process and the creation of technical and financial cooperation networks, as well as to represent themselves as a union in the presence of authorities, to gain access to government backing, and to confront threats to their activities (Contreras-Uc *et al.*, 2018).

From this perspective, it is important to understand the structure and management of beekeeping production systems to identify areas of opportunity that allow their development in the short and long term. Therefore, the objective of this study was to characterize the honey bee (*Apis mellifera* L.) production systems in the municipality of Hopelchén, Campeche.

MATERIALS AND METHODS

The study was carried out from March to July in 2022. Of the honey-producing localities, 10% were considered, with a total of 13, from the two geographic regions of

the municipality of Hopelchén, Campeche (Figure 1). In the valley region (Los Chenes), the localities were: Ich ek, El Poste, Katab, Xcalot Akal, Huechil, Bolonchén and Xculoc; and in the region of La Montaña, the localities were: Dzibalchén, Iturbide, Chunchintoc, Ukum, Xmejia and Xmaben.

To determine the sample size, 10% of the beekeepers reported by the local authorities were considered. The selection of producers to be interviewed was according to the criterion of free decision to participate, and the snowball method was used. A sample population of n=118 Beekeeping Production Systems was obtained (Table 1).

A semi-structured questionnaire was designed with 94 questions grouped into five sections: general information, structure of the systems, product trade, technologies used, and decision making. The questionnaire was applied with the technique of interviewing those responsible for each of the beekeeping production systems considered in the study.

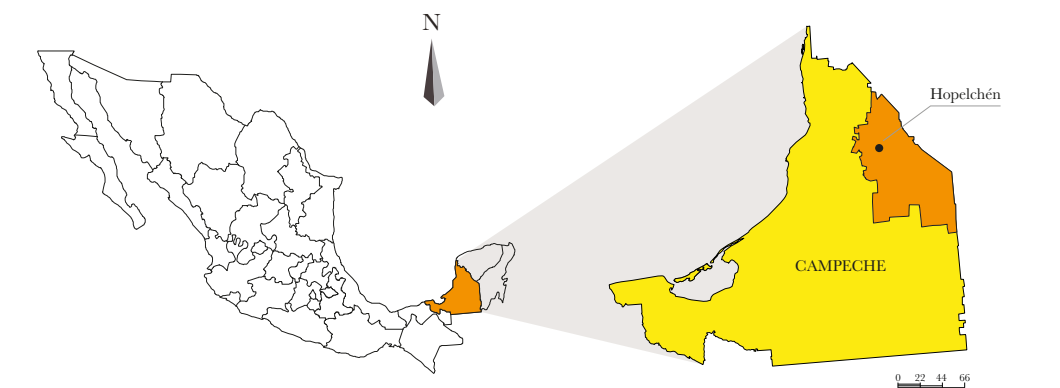


Figure 1. Location of the municipality of Hopelchén, Campeche, Mexico.

Table 1. Localities and number of beekeepers interviewed in the municipality of Hopelchén, Campeche, Mexico.

Region	Location	N	%
La Montaña	Ukum	14	11.86
	Chunchintoc	11	9.32
	Dzibalchen	9	7.62
	Iturbide	11	9.32
	Xmaben	10	8.47
	Xmejia	10	8.47
Los Chenes	Xculoc	9	7.62
	Katab	10	8.47
	Ich ek	7	5.93
	El poste	10	8.47
	Xcalot	10	8.47
	Bolonchen	5	4.23
	Huechil	2	1.69
Total		118	100

The information obtained with the application of questionnaires was arranged in an Excel spreadsheet and analyzed through descriptive statistics.

RESULTS AND DISCUSSION

Age of the beekeepers

The average age of those responsible for beekeeping systems is 44.1 years; 43.8 and 44.3 in the systems of La Montaña and Los Chenes, respectively (Figure 2). At the time when the interview was applied, the youngest age recorded was 18 years and the oldest 85 years. In La Montaña, 29.2% of those responsible are older than 50 years while in Los Chenes 41.5% of those responsible are in that age range.

In this regard, Rogers (2003) pointed out that 114 studies with producers showed that age has an impact on the attitude of older adults toward acquiring new knowledge, implementing new practices, and assuming risks in the production. In this sense, Escamilla *et al.* (2019) mention that age is a defining factor for the adoption of technology and innovation in agriculture and livestock systems, because older producers present resistance to change, while young ones are more innovative.

For both regions, it was seen that beekeeping is an activity that is undergoing a process of generational replacement since a higher proportion of beekeeping systems are kept by young adult producers less than 45 years old, this being the case in 56.9 and 53.7% in La Montaña and Los Chenes, respectively.

Number of apiaries and beehives

In all, the 118 producers interviewed in the two zones own 270 apiaries with a total of 4,825 hives (Table 2). In La Montaña, 156 apiaries were counted and 3,146 hives, corresponding to 20 hives apiary⁻¹. In the same region, on average 2.4 apiaries and 49.1 hives were recorded by producer. In the region of Los Chenes, 114 apiaries were counted and 1,679 hives, corresponding to 14.7 hives apiary⁻¹, and on average 2.2 apiaries and 33.8 hives were recorded per producer.

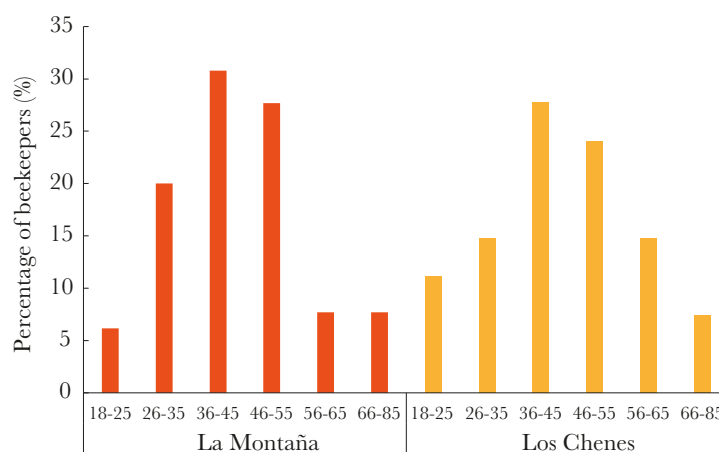


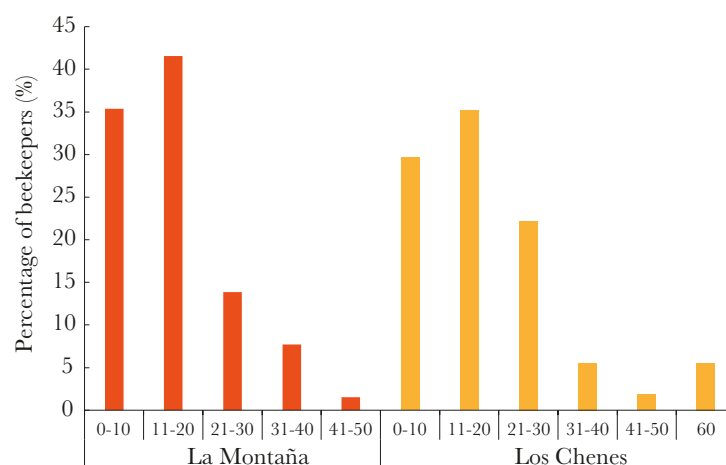
Figure 2. Age of beekeepers in the regions of La Montaña and Los Chenes, Hopelchén, Campeche, Mexico.

Table 2. Number of apiaries and hives belonging to beekeepers in the regions of La Montaña and Los Chenes in the municipality of Hopelchén, Campeche, Mexico.

Region	Location	Apiaries	Hives
La Montaña	Ukum	33	495
	Chunchintoc	26	640
	Dzibalchen	14	244
	Iturbide	17	280
	Xmaben	35	703
	Xmejia	31	784
Los Chenes	Xculoc	14	296
	Katab	25	285
	Ichek	14	302
	El poste	21	273
	Xcalot	16	177
	Bolonchen	20	285
	Huechil	4	61
Total		270	4,825

Years devoted to beekeeping

The family has been devoted to beekeeping 16.8 years on average in the region of La Montaña and 19.7 in Los Chenes. In the region of La Montaña, 41.5% of the families are located within the range of 11 to 20 years, while 35.9% of the families are within the same range in the region of Los Chenes (Figure 3). Likewise, the longest-lived beekeeping systems in La Montaña (1.5%) were found to be within the range of 41 to 50 years of existence, while in Los Chenes 5.5% of the systems have been operating for 60 years. It is important to highlight that 35.3% of the systems considered in La Montaña have existed for less than 10 years, while in Los Chenes 29.6% are under this condition.

**Figure 3.** Years of having been devoted to beekeeping in the regions of La Montaña and Los Chenes in the municipality of Hopelchén, Campeche, Mexico.

Main economic activities

In La Montaña, 56.92% of interview respondents have three economic activities, while for the region of Los Chenes 61.11% of the families reported two economic activities (Figure 4). This phenomenon may be because producers from the two regions consider beekeeping as an alternative source of income due to its inconsistency and risk, but it is also seen as an alternative for the future. Another explanation could be risk management by producers, who make sure to diversify their sources of income throughout the year. The risk is defined as the uncertainty regarding the results that can involve damages or losses.

When the consequences of performing a specific activity are uncertain, especially unfavorable or negative, it is said that such an activity carries a related risk (Elton *et al.*, 2014). The decision of taking that risk is influenced by the characteristics of the person, the situation and often who with and when they interact (Finger and Weber, 2011).

Economic importance of beekeeping

When the importance of beekeeping in the family's income was analyzed, it was seen that it is the main source of income for the region of La Montaña (72.3% of producers), while in the region of Los Chenes it is 66.7% (Figure 5). This could be because producers from both regions consider beekeeping as an alternative source of income with some inconsistency and risk, so producers devote only part of the workday to beekeeping tasks. Producers also mentioned that the growing establishment of farming areas in the municipality results in more deforestation and segmentation of the ecosystem, which increases the distance between the flowering zone and the apiary.

Average education in years

It was found that 88.05% of the family members in the beekeeping systems of La Montaña had access to education, while in the region of Los Chenes it was 95.17%. Average schooling of beekeepers responsible for the systems is 8.4 years and 9.2 years in La Montaña and Los Chenes, respectively. It was also seen that the maximum average

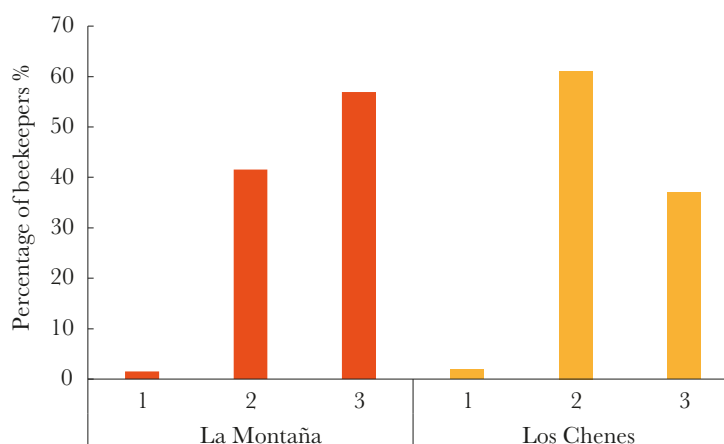


Figure 4. Economic activities of beekeepers from the regions of La Montaña and Los Chenes, municipality of Hopelchén, Campeche, Mexico.

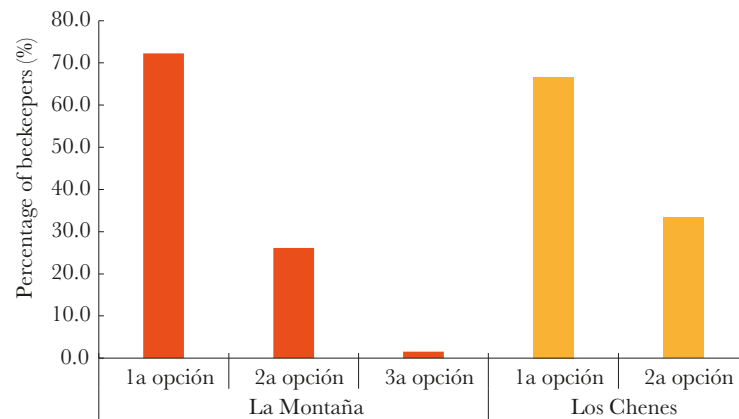


Figure 5. Economic importance of beekeeping for families from the regions of La Montaña and Los Chenes, Hopelchén, Campeche, Mexico.

education reached by any member of the beekeeping family is 11.5 years in La Montaña and 12.5 years in Los Chenes. The range with highest proportion of education by region observed in the families considered in this study was 30.77% for the region of La Montaña within a range of 7 to 9 years of schooling (Secondary), while it was 35.19% between 13 and 17 years (Higher Education) in the region of Los Chenes (Figure 6). This difference could be because the municipal township is located in the region of Los Chenes, so the educational offer is greater.

Distance from the apiary to the household of the beekeeping family

When it comes to the distance at which beekeeping systems are found from the household of those responsible, averages of 8.7 and 6.7 km were recorded in La Montaña and Los Chenes, respectively. Most apiaries are located at less than 10 km from the household of the person responsible, 64.6 and 81.5% in La Montaña and Los Chenes, respectively (Figure 7). Therefore, more proximity to the apiaries results in better and more constant control and care of the systems, since the visits are more frequent;

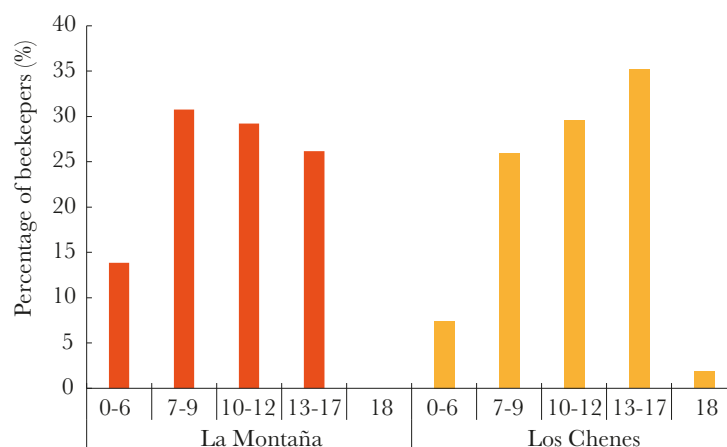


Figure 6. Schooling average of beekeeping families in the regions of La Montaña and Los Chenes in the municipality of Hopelchén, Campeche, Mexico.

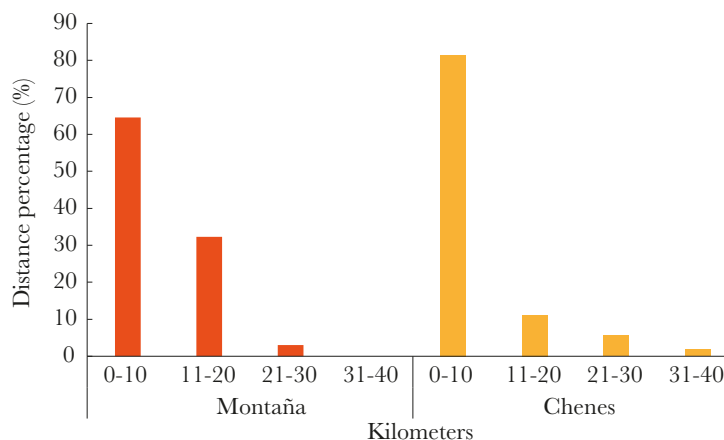


Figure 7. Distance (km) from the apiary to the beekeeper's household in the regions of La Montaña and Los Chenes, Hopelchén, Campeche, Mexico.

inputs, equipment and products can be transported with greater ease and there is more availability and integration of the family nucleus into the system's activities, generating empathy and enjoyment of family members toward beekeeping in the future.

Technologies applied in the apiary

The use of six technologies for preventive and corrective control was observed in all the systems analyzed in the two regions of study. It could be seen that feeding with sugar is the most widely used practice inside the apiaries, with a record of 48.7 (La Montaña) and 49.5% (Los Chenes). It is a useful strategy in the drought season to maintain the hive colonies strong and healthy.

The source from which beekeepers learn technologies varies between regions; in La Montaña the greatest proportion of beekeepers, approximately 37.6%, learn from another producer, while in Los Chenes the greatest proportion (39.4%) learn new technologies on their own. It stands out that in La Montaña the highest proportion (41.4%) of learning about sugar feeding is obtained from the family's father.

Decision making for apiary management

It could be seen that in the two regions the head of the family and person responsible for the beekeeping system makes 90% of the decisions related to apiary management, because he/she contributes resources, carries out management, and has more knowledge about beekeeping. For the remaining 10%, decision making was different between regions. In La Montaña, 6.15% was shared between the man and woman heads of household, 1.53% by another member of the family, and 1.53% by several members of the family. In Los Chenes, 5.55% of the decisions are made by several members of the family, 1.85% by another member of the family, and 1.85% by all the members of the family. With this, a marked tendency toward the head of household can be seen in the two regions, generally the owner or person responsible for the system, just as he/she contributes the resources and has more knowledge about their management.

Table 3. Technologies used by beekeepers from the regions of La Montaña and Los Chenes, Hopelchén, Campeche, Mexico.

Region	Technologies	Producers (%)	Years applying the technology	Where learned *
La Montaña	Sugar feeding	48.7	14.4	a=13, b=7, c=13, d=24, e=3
	Protein feeding	19.3	9.6	a=12, b=1, c=5, d=5, e=0
	Diagnosis of varroa (<i>V. destructor</i>)	38.6	12.0	a=25, b=3, c=1, d=7, e=10
	Varroa traps (<i>V. destructor</i>)	7.6	4.6	a=2, b=1, c=0, d=4, e=2
	Determination of moisture in honey	29.4	19.1	a=7, b=21, c=3, d=2, e=2
	Beetle traps	6.7	4.5	a=2, b=0, c=0, d=4, e=2
Los Chenes	Sugar feeding	49.5	13.2	a=6, b=17, c=14, d=10, e=3
	Protein feeding	30.3	7.9	a=9, b=8, c=2, d=9, e=2
	Diagnosis of varroa (<i>V. destructor</i>)	32.3	13.0	a=10, b=10, c=6, d=4, e=2
	Varroa traps (<i>V. destructor</i>)	15.1	11.6	a=3, b=5, c=3, d=2, e=2
	Determination of moisture in honey	22.2	16.2	a=1, b=17, c=0, d=3, e=1
	Beetle traps	15.1	4.3	a=5, b=2, c=1, d=5, e=2

* Where: a=from another producer, b=on own account, c=another producer, d=from the father, e=did not respond

After performing a general analysis of the data gathered, it could be seen that there is a marked trend in decision making about the apiary management, since the head of the family is the one responsible for this activity with an average of 90.7% of the decisions made, and this is notable taking into account that the average number of members per family is 3.6 (La Montaña) and 3.2 (Los Chenes), with a range of 1 to 10 members. Likewise, the educational level of those members represents 11.5 (La Montaña) and 12.5 (Los Chenes) years on average, which shows that the academic degree has been increasing among the young population, although this does not mean that they are taken into account to participate and make decisions in the system.

This results in a very marked decreasing trend in the application of resources and technologies within the production process, since the number of practices where there was shared decision was 0.32 (La Montaña) and 0.09 (Los Chenes), from within a range of 0 to 9 available practices to be performed in the apiary. Therefore, the application of technologies that could be used in the apiary also decreases when the head of household does not have interest or knowledge of the technologies, so that he/she does not intervene in the process; there was an average of 2.8 (La Montaña) and 3 (Los Chenes) technologies applied from a range of 0 to 7 available ones.

Based on the data gathered, it could be observed that although beekeeping has been growing in development, and since it already represents the main source of income for the great majority of the producers, decision making continues to be markedly by the head of the family; and although there are more members of the families involved in

the apiary activities from an early age, this has not allowed for their participation in decisions and application of technologies to have an influence on the system.

CONCLUSIONS

Knowledge of the characteristics of different types of beekeeping systems present in Hopelchén, Campeche, allows explaining their structure and management, as well as the cultural, technological and economic factors that define them, making it possible to detect important components that could allow promoting their development. The organization among beekeepers is of utmost importance to ease the access to government backing and qualified technical assistance, to promote knowledge exchange, and to approach sustainability. With this, the shortcomings that beekeepers face in production within their apiaries could be minimized, and the economic benefits and sustainability they seek to find in beekeeping could increase.

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