Article

Bee characterization in the sierra central-north region of Veracruz: context and transhumance

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Abstract

This article presents the result of an investigation carried out from August 2015 to November 2016, to characterize the beekeeping production and transhumant activity of the municipalities of Misantla, Yecuatla, Colipa, Juchique de Ferrer and Tenochtitlan. Interviews are conducted with specialists, experts and honey producers. It is found that the beekeeping activity is carried out for at least 500 families with an average experience of 22 years, with semi-extensive transhumant systems with an average production of 24 kg of honey per beehive, of which 9% have more than 500 beehives working under semi-technified schemes. Among these systems, only 10% of beekeepers have invested in the differentiation of beehive products. The volume of honey generated with production systems of a queen bee per beehive is at least 90 t year^{-1}, with an economic value of $174 000 (US $). It has been found that 90% of beekeepers in the study region transhuman between places in that region and 23% of them do it to another entity. On the other hand, it was also found that access and permission to land are factors that define transhumant routes and identification of suitable areas for apiaries settlement. This research provides a map of areas used as apiaries settlements, as research work, their results deserve the attention of future research to identify spatial zones through systems of geo-positioning, as well as a transhumance program for these locations based on calendars of flowering.

Keywords: apiaries, beehive, bees, honey.

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Introduction

The central-northern mountain region of the State of Veracruz has a territorial diversity in ecosystems, and ample agricultural activity in the cultivation of coffee, fodder, citrus, among other smaller-scale crops which offer high possibilities for the exercise of the apicultural activity. The beekeeping activity is immersed with the flowering seasons characterized by the variations of the climate and flora of each region which allows beekeeping to become the third largest source of foreign exchange in the agricultural sector of Mexico; however, said biotic potential, it contrasts with the low level of honey production compared to the international order (Magaña and Leyva, 2011).

In this sense, the beekeeping practices within which transhumance stands out are important, as a production strategy in that sector. Honey production in the central-northern mountain region of the state of Veracruz has generated an activity of high economic value in the last decade as shown in Figure 1 with a production in 2016 of 82 t, which can be favored in production yield with the use of information that supports the decisions of beehive settlements in better areas of pecoreo.

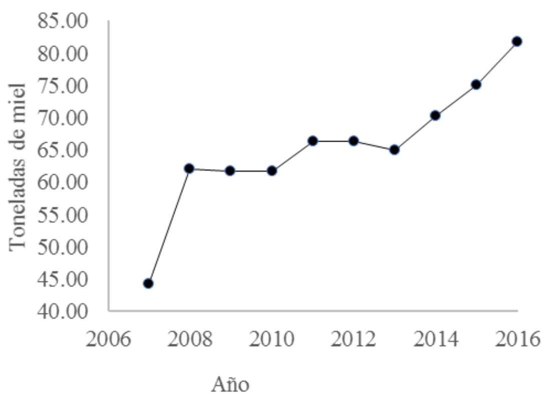

Figure 1. Production in tons of honey in the region of Misantla, Veracruz. Source: SAGARPA (2010).

The transhumance activity is closely linked to the environment and natural resources of the area that the producer uses to install his apiaries, so that knowledge of spatial and temporal vegetation is important to plan the management and mobility of beehives. However, it should be recognized that flowering areas have been modified in the last decade by different factors, including clandestine logging or the increase in intensive crop extension, which modify biotic systems with an impact on low yields of honey production by beehive (Bellarby *et al.*, 2008; SAGARPA, 2010).

Although the beekeeping activity in Mexico is not different from that carried out in other parts of the world, the task of previously identifying areas with apicultural aptitude is not a common activity in Mexico, but rather is carried out by family-hereditary knowledge. Transhumance, in this sense, is considered as a strategic action of the beekeeper to increase the yields of honey production (Zoccali *et al.*, 2017), in balance with the biotic resource of the environment (Solomon, 1971; Roubik, 1995).

The choice of the area for the settlement of the beehives considers, in addition to the technical-financial ones the beehive selectivity for a certain type of flora of botanical species producing nectar and pollen, morphologically suitable for exploitation by bees (González and Sánchez, 2008). Abou-Shaara *et al*. (2013) report that the risks of an inappropriate decision of apiary location, result in lower yield of honey production from the beehive, therefore, transhumance involves investing time resources and logistics infrastructure to the dynamics of this activity that seeks an environmental balance to maximize honey production based on the density of honey and nectarine flora and minimize the bee's path in its pecoreo, however, in recent years, drastic changes due to the variation of the natural environment and actions of human intervention, makes the location of such places for the settlement of beehives more complicated.

This research describes the beekeeping and transhumant activity carried out in the central-northern region of the state of Veracruz, delimited to the municipalities of Misantla (19° 55' 51.86'' north latitude 96° 51' 6.09'' west longitude); Yecuatla (19 º51' 57'' north latitude 96º 46' 36'' west longitude; Colipa (19º 55' 25'' north latitude 96º 43' 38'' west longitude; Juchique (19º 50' 25'' north latitude 96º 41' 41'' west longitude) and Tenochtitlan (19º 48' 27'' north latitude 96º 54' 39'' west longitude). The border of these municipalities covers 1 159 km^2, with an approximate population of 101 613 inhabitants (INEGI, 2010).

Materials and methods

The research is cross-sectional and descriptive, supported by primary and secondary sources with technicians and experts in the beekeeping sector, honey producers, representatives and former representatives of beekeeper's associations in the study region. The primary information is collected supported by personalized unstructured interviews and a diagnostic questionnaire, to collect both production yields by season and harvest, as well as the elements to migrate.

To reduce the ambiguity of the information, the Delphi method was used in a panel of 7 experts made up of beekeepers in the study region with a proven track record as a bee producer. From a registered population of 52 members in the Misantla Beekeepers Association (AAM, by its acronym in Spanish), 35 beekeepers were interviewed, while those not registered in the AAM, were identified by the linear snowball technique during the period of 2015 and 2016.

With this technique, the range of interviews with beekeepers in the region with low incidence or difficult access was broadened, with the purpose of identifying the specific feature of the study population for categorization as a beekeeper. In both cases, the study variables related to the honey production chain: age, main economic activity, experience in the field, number of beehives per apiary, as well as access to settlement areas and their transhumance.

The data collected through questionnaires were treated by elementary statistical processing for quantitative representation. The responses of unstructured interviews conducted in a personalized way, were processed in frequency to reduce them to descriptive categories and express them as a percentage. This data analysis is performed with the intention of interpreting the important findings of beekeeping and transhumance practice to characterize beekeeping in this study region. Based on these objectives, the study variables of this research were described by means of measures of central tendency and proportion values, as the case may be.

For georeferencing settlement sites were visited apiaries *in situ*, supported with a GPS device model Garmin X15. The georeferenced points were processed in the Qgis Las Palmas software, in version 2.18, free licensed software. Figure 1 describes the areas with apicultural aptitude currently used by beekeepers in the study region.

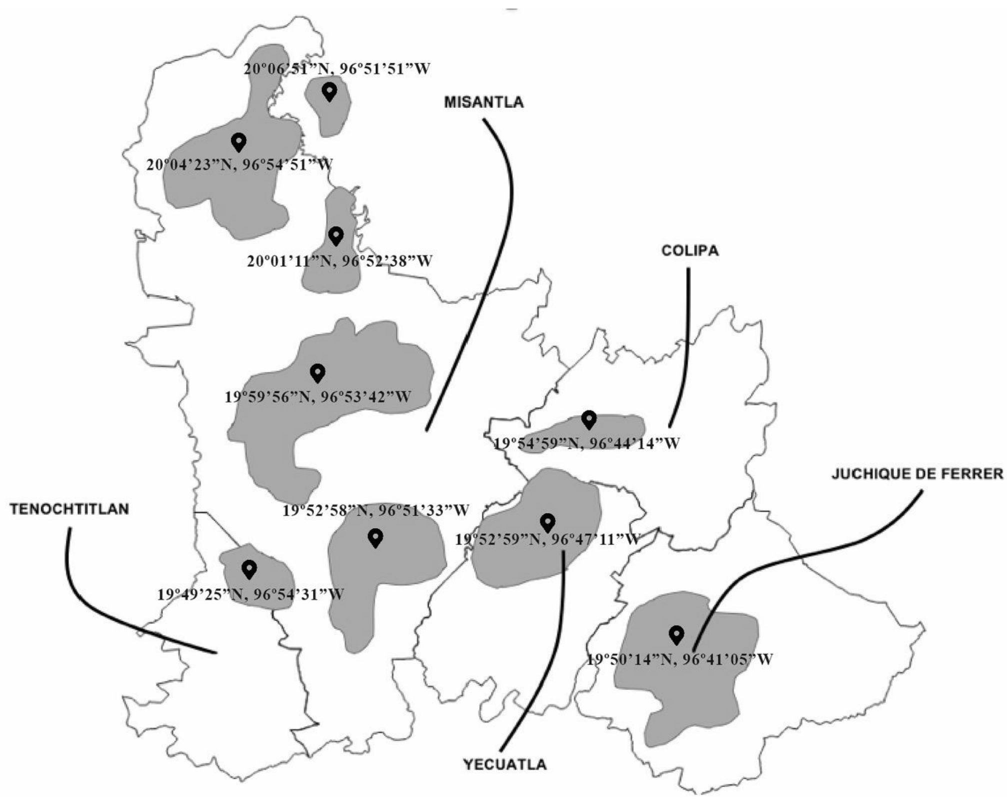

Figure 1. Areas identified with beekeeping attitude by beekeepers in the intermunicipal region of Misantla. Source: own design based on field research conducted from August 2015 to November 2016.

Results

The natural components of the study region generate a warm tropical climate, warm sub-humid, temperate humid and warm thermal regime with rainfall that varies on average of 2 036 mm per year. The average annual temperature ranges from 22.7 °C, with relative humidity of 35% to 40%. The coldest months are December and January, the most intense heat occurs from April to August. Frosts are usually recorded occasionally in the months of December. Special meteorological phenomena such as cyclones, thunderstorms and nortes, which regularly cause heavy rains, are recorded in the months of September and October (INEGI, 2015).

The study region is characterized by a semi-regular topography in hills and slopes greater than 45 degrees of inclination, which allows the practice of agricultural activities with a barrier of humid tropic trees. The dominant productive system is the cattle rancher and its pastures are mixed with areas dedicated mainly to the production of citrus fruits (mandarin, orange, lemon, grapefruit and tangerine) that covers large areas, mainly in the south of the municipality of Misantla, with a large presence of coffee plantations mostly in mountain areas.

The intermunicipal zone has a hydrology framed by the Nautla River basin in which the Bobos River, Nautla River, Misantla River, Colipa River and Juchique River extend that make these lands suitable for agricultural activities (INEGI, 2015), while the sources of water from springs and streams, which descend from its hills, create their own setting for apicultural practice.

The beekeeper carries out agricultural activities and has beekeeping as a second source of income, placing his beehives geographically in his region trying to cover as much flowering as possible. Normatively in the Apicultural Law No. 830 of the state of Veracruz, an apiary must comply with a minimum of 20 beehives, even though it is common to observe apiaries installed with just two beehives or less than 15.

To achieve the best production yields, the beekeepers try to place the apiaries at a distance between 200 m with respect to the pedestrian crossings, public places and room houses to keep distance to people and pets; while among apiaries, beekeepers in the study region report placing them 1 km away to avoid congestion and competition among the pecoreadoras for the floral supply, which presumes to cause the low yield of honey production.

Figure 2 shows a stratum of 5 categories: 1-50 beehives, 51-100 beehives, 101 to 300 beehives, 301 to 500 beehives and more than 500 beehives from a total of 120 beekeepers between associates and independents in the region study. This categorization is carried out for future studies of this production system, of which 85% of the apiaries are in common lands and 15% in communal lands.

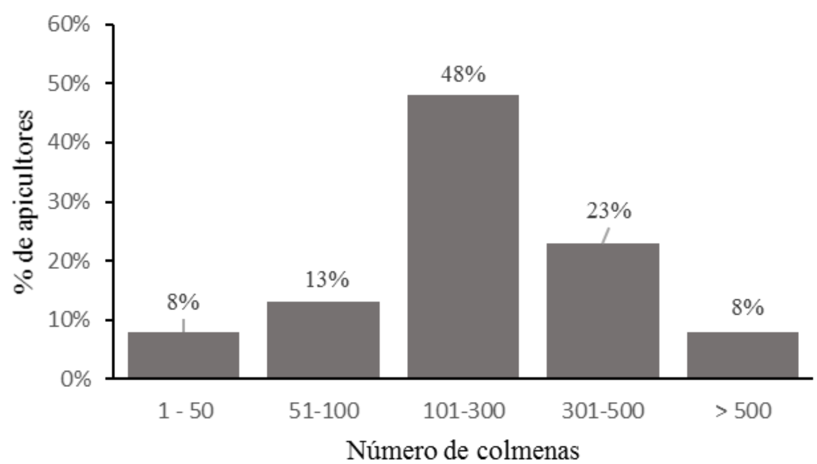

Figure 2. Stratification of beekeepers of the AAM according to the number of beehives. Source: own design based on field research conducted from August 2015 to November 2016.

Figure 3 describes that the access roads to apiaries in the study region, in general, 57% are rolled, 29% paved roads in regular traffic conditions, 7% roads and the rest are real roads.

Producers of the study region, as well as Visscher and Seeley (1982); Seeley (1995) and Beekman and Ratnieks (2001) report that 10 000 to 120 000 bees live and work in a colony that require large nectar and pollen supplies of honey flowers. In this regard, the literature reports that colonies can be fed routinely covering an area between 5-10 km^2; however, in extreme conditions, much larger ranges have been reported (Erickson *et al*., 1978). This event is observed in commercial places: ice cream shop, bakeries, coffee shops, in each city of the municipalities under study.

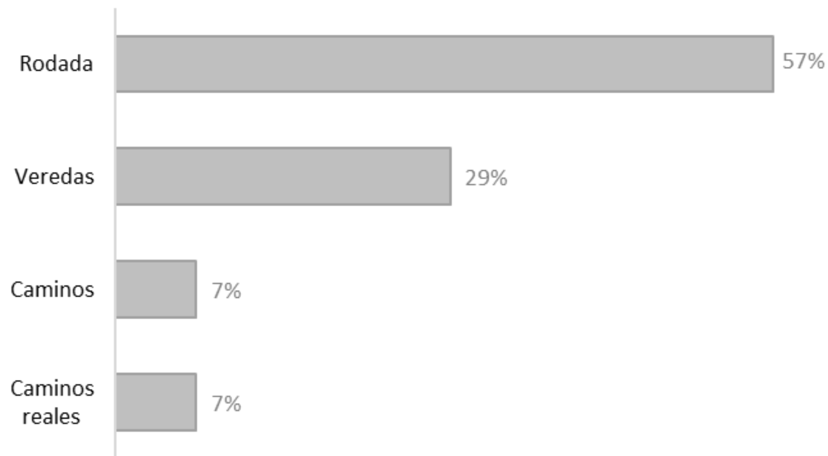

Figure 3. Accessibility to areas of apiary settlements in the study region. Source: design based on field research conducted from August 2015 to November 2016.

Beekeepers in the study region report working on a production system of a queen bee per beehive with *Apis mellifera* and with subspecies originating in Europe, Asia and those genetically modified, of which 73% of the producers carry out the 'traditional exploitation' focused to the production of honey, wax and cores and 27% the 'integral exploitation' that seeks to obtain additional income from obtaining other products such as pollen, royal jelly, propolis, apitoxin, monofloral honeys, organic, in addition to pollination services. According to their infrastructure and production level, they are occasionally supported by people with purely agricultural activity, who assist the beekeeper for an extraordinary income to that of his activities in the field.

The change in land use, the lack of training and organization of beekeepers, as well as the sporadic presence of diseases such as *varroasis*, coupled with intermediary and competition in the national market, has caused instability of the apicultural sector of the region, which somehow this activity is no longer attractive in a formal way (Contreras *et al*., 2016). At least 90% of beekeepers are low-income farmers who supplement with beekeeping and generally, even if they work between 15 and 80 beehives, they lack some type of administration of their activities. This profile of beekeeper does not make records of production, nor of production expenses and income.

Between 4% and 10% are beekeepers who have invested in the differentiation of the product, strategies and marketing channels of honey. The average age of beekeepers directly involved in the beekeeping activity is 52 years. Figure 4 shows that 22% of beekeepers in the study region are between 26 and 35 years old, 32% are aged between 36 and 45, 19% represent beekeepers aged between 46 and 55, 23% of they are between 56 and 65 years old and only 4% represent a population between 66 and 75 years old.

The average experience of beekeepers is 22 years; however, the experience within the activity is not necessarily an indicator of the degree of specialization and professionalization of the beekeeping chain. It can be observed in this proportion of ages, that the age range of 36 to 45 years of the beekeeper is the most frequent, which somehow demonstrates that the interest in the beekeeping practice remains in force in this agricultural sector.

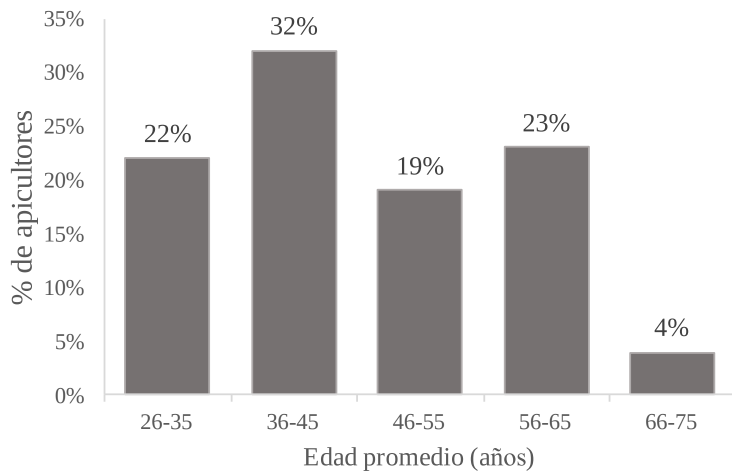

Figure 4. Average age of beekeepers in the region. Source: field research conducted from August 2015 to November 2016.

According to Reyes *et al*. (2014) and Magaña *et al*. (2016), the yield of honey production per beehive is subject to a number of factors such as the strength of the beehive nuclei; a good source of food; the application of good apicultural practices, among other factors such as temporality which is manifested in the volume of nectar and pollen flow, given this by the availability of the honey and nectariferous flora of the area where the apiary sits, in such sense, the lack of disposition of honey and polynifer flora, promotes transhumance, practiced properly in different areas of the study region.

To identify new sites, the beekeeper travels considerable distances in his vehicles so that he visually locates land according to his experience and subsequently meet with the owner and reach an agreement for the placement of his beehives. In this sense, 100% of the beekeepers interviewed agree on the importance of having tools that expedite them to locate optimal areas to install their apiaries.

When the beekeeping activity is the main economic activity of income, there is a direct relationship with the total number of beehives per beekeeper with an average of 172 beehives, from 101 to 300 beehives. In contrast when it is not their main economic activity, beekeepers work with 15 to 30 beehives, so they seek to diversify their economic income activities, while those who work with 31 and up to 80 beehives, the product of the honey harvest, it represents between 60% to 75% of the family's income.

Beekeeping presents the main source of economic income for producers who have more than 500 beehives (8% in the study region), which implies a greater movement of resources to a greater number of beehives. On the other hand, the producers that have a small number of beehives, this activity generates low income and production costs that exceed the income from the sale of the products of the beehive, however, they maintain the activity as a family tradition for the private and family consumption. It is have found that, in a general way, beekeepers agree that the level of technology involved in their beekeeping practice is related to the economic level of each beekeeper, since this is not their family income agricultural activity, but rather complementary.

Some researchers such as Contreras *et al*. (2013); Martínez *et al*. (2017); Vélez *et al*. (2016), report that beekeepers in Mexico are classified into three groups: technified, semi-technical and traditional. Among the first are beekeepers with more than 100 beehives (2% of national producers) that incorporate cutting-edge technological advances and even generate their own technology according to the characteristics of the region. They manage a diversified beekeeping and practice transhumance in search of blooms and better spaces to place their apiaries. Within this category it was observed that 9% of the producers in the study region are technified.

The second category is made up of beekeepers with different degrees of technification and generally have between 60 and 100 beehives (7% of the national producers) which in the case of the study area represents 36% of the producers. Finally, the third group practices beekeeping as a complementary activity to other tasks or as a hobby. These do not incorporate technology and most of them employ rudimentary techniques (91% of national producers), this category is represented by 55% in the study region.

Figure 5 shows the percentage comparative trend at the national and regional level of the categorization of beekeepers according to their production system. Regarding the yields of honey production per beehive, even though 40 kg beehive^{-1} are reported by beekeepers in the study region, the AAM reports honey crops on average of 24 kg beehive^{-1}, with volumes from only 15 kg beehive^{-1} up to 27 kg beehive^{-1}.

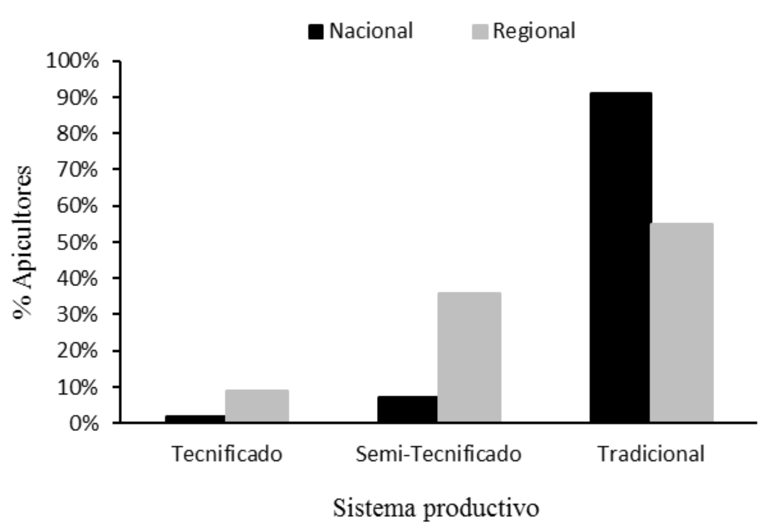

Figure 5. Percent comparison of the categorization of the beekeeping production system. Source: own design with data from SAGARPA (2010) and field research.

Transhumant beekeeping in the region includes at least 80 beekeepers among associates and independents. These beekeepers are predominant in the intermunicipal region of Misantla and constitute a pattern of peasant production, where family inheritance has been the engine that has maintained this agricultural activity. The route they carry out for transhumance in the study region is in response to territorial physical obstacles and the adaptation required with climatic and flowering, sociocultural and institutional conditions.

Between 75% and 90% of beekeepers who practice beehive mobilization have already defined transhumant routes and specific areas for this practice. Of this proportion, only 23% of these mobilize their beehives to other entities in order to harvest honey of different characteristics. Table 1 shows the proportion of beekeepers who practice local, regional and state transhumance. These transhumant beekeepers consider that there are areas with better production conditions within the study region that have not been exploited; however, they do not enter them since they do not have accessibility and permissibility information to these areas, leaving the opportunity to explore potential areas for beekeeping.

It can be seen in Table 1 that the greatest transhumance, corresponding to 43%, is carried out in the study region, which corresponds to a mobility of between 1 500 and 2 000 beehives, while 34% of beekeepers transhuman inside from its own municipality, which represents a mobility of 1 000 to 1 200 beehives. Transhumance to other regions is made specifically to the Altiplano de Puebla and mangrove areas in the south of the state of Veracruz, which represents the mobility of 1 800 to 2 500 beehives. In either case, the transhumance takes advantage of the flowering calendar of these regions and the number of beehives, is determined by the experience of each beekeeper or by the result of the production of honey from the past period.

Table 1. Local, regional and state transhumance of beekeepers in the intermunicipal region of Misantla.

Origin of beekeepers in the study region	Transhumance to other regions (%)	Regional Transhumance (%)	Local transhumance (%)
Juchique de Ferrer	4	12	10
Yecuatla	5	10	8
Colipa	3	2	6
Tenochtitlan	0	0	1
Total beekeepers in the study region	23	43	34

Source: field research conducted from August 2015 to November 2016.

According to AAM data, transhumant beekeepers use trucks of 1.5 to 5 t to move their beehives to settlement areas. These beekeepers move from 45 to 90 beehives per trip in their own vans. For the mobilization of beehives, at least 90% of these hire 1 to 3 temporary employees for the installation of apiaries. On the other hand, the AAM reports that ‘beekeeping in the intermunicipal region of Misantla is carried out in a sedentary, semi-extensive and extensive way’.

The Sedentary form is characterized by beekeepers for personal-family consumption with fixed apiaries with no more than 19 beehives. The semi-extensive way is to move their beehives -less than 80 beehives- between places already known, without complicating logistical problems in their mobilization. Finally, in the Extensive form -with more than 100 beehives-, in addition to locating their apiaries in places of their region, they transhuman to places outside the municipality or the state always looking for settlement points to have new sources of supply for their apiaries.

Discussion

This article presents findings of beekeeping production and transhumant activity of the municipalities of Misantla, Yecuatla, Colipa, Juchique de Ferrer and Tenochtitlan. It is have found, like Saul da Rosa *et al*. (2014), that honey production in this intermunicipal region, is an agricultural activity that is carried out informally and secondarily as a complement to family income. In this context, beekeepers in this research agree that the economic utility of this agricultural practice is determined, on the one hand, by the technological level involved in their apicultural practice in the honey production process; likewise, by the mechanisms of commercialization of the products obtained in said honey production, as mentioned in (Simone *et al*., 2016).

These aspects are coincident with Saeed-Khan *et al*. (2009), who report that the costs of production and the income received from the sale of honey denote the lucrative benefit of this activity, which can be reversed by the appropriate technological application in beekeeping practices. Carreck *et al*. (1997) report that the relationship between agriculture and beekeeping is highly interdependent and that the interaction of farmers and beekeepers in a mutual benefit is needed, for food production and honey production.

This benefit motivates the beehives to move to suitable settlement sites for the bees pecoreo and take advantage of the available flowering. Although the beekeeper has a calendar of flowering of the crops in the region, unfortunately this consultation tool has not been updated for more than thirteen years, since the flowering seasons of today have changed considerably in their calendar. Since there is no precise selection technique to determine the appropriate areas to locate the apiary, the beekeeper uses his experience without assessing whether that area will be adequate for the production of honey in the next production period.

The beekeeper remedies this problem by consulting with other producers the seasonality of flowering in areas previously used for exploitation or with farmers in the area of interest in order to reduce the costs involved in access, the permits of the owners in the installation points and thus avoid the proximity of apiaries to areas of urban population. This experience translates it to perform short transhumance and take advantage of local and regional flowering. This apiary management scheme, to take advantage of the apicultural flora available in each region, is recommended by (Fagúndez *et al*., 2016).

As a transhumance strategy, beekeepers have a map that has been updated with information from their own members to identify the apiaries settlements by beekeeper to install their beehives and not interfere with the pecoreo areas that were already assigned to the apiaries installed. However, these maps do not show the areas with potential for flowering supply, so the location decision is made by talking directly with the owners of the plots, analyzing visually whether the area is suitable or not, according to their criteria and experience.

In this sense, the very ignorance of the density of flora between the seasons of the year and the ignorance of the flowering phenology, presents the transhumance activity as a situation of 'good luck', which makes it an economically expensive activity by obtaining low yields of honey production per beehive and apiary, below the regional average of 24 kg of honey per beehive.

Conclusions

Beekeeping in the Sierra Norte-Central region of Veracruz faces a panorama of opportunities and challenges, originated mainly from the demands of the market, as well as the need to strengthen the economy and the organization of beekeeping producers as the main axes of action that promote the millenary activity of beekeeping.

The survival and adaptation strategies implemented by beekeepers in the study region are as diverse as the uncertain changes in climate and floral phase shift, caused to a greater or lesser extent by the invasion of intensive cultivation areas in areas that could not be imagined in the past for commercial exploitation, adding to this the unregulated growth of urban stain. All of them have in common a gap related to the use of technologies, such as the geo-positioning systems available on their cell phones, which do not use it for this purpose in their beekeeping practice.

However, the strategies that have been identified and reported by several beekeepers with more than 150 beehives are: diversification, transhumance, intensification and strengthening of cores.

The challenges for Veracruz honey in the current context are to ensure the quality and traceability of honey, obtain designations of origin to improve the price of specific honey of a type of flora and offer a product that supports the sustainable management of native forests and cultivated. In this sense, in addition to the yields of honey production per beehive, it is relevant to identify the flowering areas that provide the supply of nectar and pollen to bees for the production of honey.

As well as, a better strategy is required to carry out beekeeping transhumance activities such as the use of geographic information systems (GIS) aimed at precision beekeeping.

Identifying spatial areas for the settlement of apiaries, as well as a transhumance program between these potential points of apiary settlements, has motivated this research so that, supported by mathematical programming, routing techniques and GIS, a map of interest is presented beekeeping for the location of apiaries in the north-central region of the state of Veracruz.

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