Global Science Research Journals

ISSN: 2408-5480 Vol. 3 (9), pp. 321-329, October, 2015

http://www.globalscienceresearchjournals.org/

Global Journal of Agricultural Economics, Extension and Rural Development

Full Length Research Paper

Apiculture in the humid tropics: Socio-economic stratification and beekeeper production technology along the Gulf of Mexico

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Accepted 13 October, 2015

Beekeeping is an economically productive activity of importance in the primary sector of many developing countries. In Mexico, this activity is an important source of foreign exchange, reaching $90 million (USD) annually from exports of honey. However, beekeeping has not been described, nor is there information on how beekeepers can design strategies and policies to improve performance. Therefore, the objective of the present study was to describe beekeepers in the central region of the state of Veracruz by characterizing socio-economic and production technology characteristics. In autumn 2013 and spring 2014, 88 beekeepers in 19 municipalities were interviewed. Principal components (PC) and Dalenius and Hodges groupings were used for data analysis. Beekeeping in the study area is an extensive activity, where social networks (friends and labor relations) of beekeepers largely defined their knowledge and production technology capacity. Three types of beekeepers were observed (commercial, intermediate, and traditional) for which different production technologies and economic variables were identified. The differences were defined by production scale, economic dependence on the activity and efficiency of the activity. Decision-makers should design policies to help improve the competitiveness of beekeeping in the humid tropics.

Key words: Beekeeping, socio-economic characteristics, typology beekeepers.

INTRODUCTION

Honey production is an international trade activity (Crane, 1999). Currently, 10 countries account for over 70% of the honey sold worldwide, and Mexico ranks eighth (FAO, 2015), after China, Turkey, Argentina, Ukraine, USA, Russia and India, and is the fifth greatest exporter of this product, generating revenues over $90 million (USD) (AUSAID, 2013; FAO, 2015). Beekeeping is one of the most important production activities in Mexico with regard to the number of jobs created and the amount of foreign exchange from honey exports (SAGARPA, 2013).

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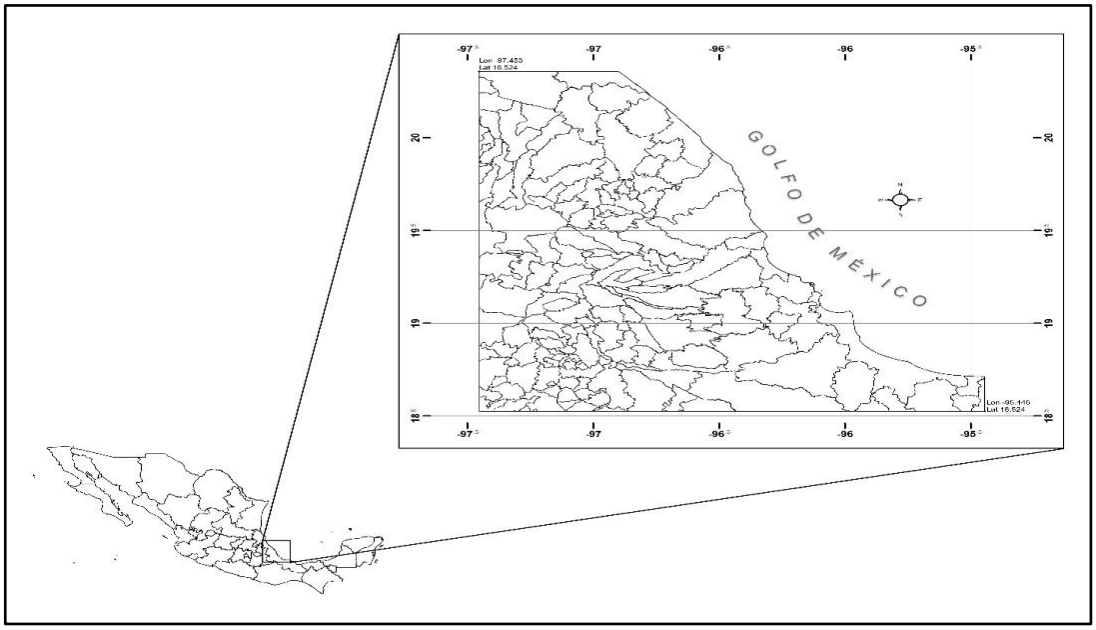

Figure 1: Location of the central apicultural región of Veracruz state, along the Gulf of Mexico.

Beekeeping in Mexico is distributed among five honey-producing regions: North, South, Pacific Coast, Highlands and Gulf. These are defined by the flora, the type of beekeeping practiced (SAGARPA, 2010; García and Meza, 2013)and the level of development of the beekeepers (Contreras-Escareño et al., 2013).

The state of Veracruz lies within the beekeeping region along the Gulf of Mexico, and is the state producing the most honey in this region. The climate diversity in the state promotes heterogeneous vegetation (Soto and Giddings, 2011) and the potential for apiculture. The annual production of honey in the state for 2013 was 4564 tons, which ranks fifth in national production (SIAP, 2015).

Beekeepers in Veracruz practice migratory beekeeping, where hives are transported to melliferous blooms of interest (Crane, 1999). This is a common practice requiring good production practices, high investment, official documentation and constant animal health management. Such issues lead decision-making by beekeepers to differ depending on the type of beekeeping and socio-economic characteristics of each, and on the relative environments in which this activity is practiced.

Generally, when designing policies, beekeepers and their activities are similar across regions of the country, although they can be described and grouped according to similarities. Beekeeping in Mexico is scarce, and most reports are socioeconomic characterizations of beekeeping and beekeepers (Cajero, 1999; Magaña et al., 2007; Rosales et al., 2010; Magaña and Leyva, 2011; Magaña et al., 2012; Pat et al., 2012; Contreras et al., 2013). Vural and Karam (2009), Semkiw and Skubida (2010), Karam et al. (2013), Masuku (2013) and Zalilova and Mannapova (2014) also describe beekeepers based on their socioeconomic characteristics.

Therefore, the objective of this study was to characterize beekeepers in the central region of Veracruz state based on their social, economic and honey production technologies. This work is being realized in order to provide information to decision-makers who will propose different support programs to each group of beekeepers which will increase their competitiveness.

MATERIALS AND METHODS

The study area corresponded to the central beekeeping region of Veracruz (Figure 1), which includes 19 municipalities spanning longitudes -95.115 to -97.453, and latitude 18.524.During autumn 2013 and spring 2014, 88 people were interviewed using a structured questionnaire containing three sections: 1) general information, 2) economic information, 3) production technology information. It was taken as a sample population beekeepers who are issued level record levels of infestation by *Varroa destructor* Anderson & Trueman (2000), (varroa), as issued by the national governing body in the state delegation of SAGARPA.

To estimate the sample size from a population of N=247, a simple random sampling technique was used (Scheaffer et al., 1987)with α=0.95, where:

$$n = \frac{N\sigma^2}{(N-1)D + \sigma^2}$$

N = Number of hives
n = Sample size
σ = Standard deviation
D = Error disposition

Table 1. Weight of each variable on Principal Components 1 and 2

Characteristic	Variable	PC-1	PC-2
Social	Age	-0.016	-0.563*
	Years of study	0.035	0.492*
Economics	Dependence (%)	0.301*	0.109
	Economic expectations	0.181	0.276*
	Dependents	0.148	0.249*
Production technology	Total number of hives	0.396*	-0.157
	Total number of apiaries	0.365*	-0.190
	Total amount of flowering	0.306*	-0.083
	Total honey production (kg)	0.370*	0.025
	Honey production hive^{-1} (kg)	0.232	0.237*
	Beekeeping diversity	0.164	0.338*
	Total wages provided	0.300*	-0.159
	Total equipment owned	0.300*	-0.068
	Total days working in apiculture	0.270*	-0.148
	Percentage explaining each principal component	34.3%	12.6%
	Accumulated percentage	34.3%	46.9%

*Variables with greatest weight on each principal component.

An exploratory data analysis (Tukey, 1977) was performed using Statistica© 7 software (StatSoft, 2007), as well as univariate and bivariate analyses of variance according to variable type and measurement scale. After 14 variables had been identified to hives >0.50 with respect to beekeeping, principal components (PC) analysis was used to reduce the data dimensions (Johnson and Wichern, 2007; INEGI, 2010).Using this technique, 34.3% of the variance for the first component was explained (PC-1) and 12% for the second (PC-2). Variables with the greatest weight on each component could then be identified, eight for PC-1 and six for PC-2 (Table 1).

The technique proposed by Dalenius and Hodges (1959) was used to form three homogenous groups, and a graphic plot was then constructed. Subsequently, an analysis of variance and means comparisons were made to determine the statistical difference among groups according to their variables (Ojeda, 1999). Finally, beekeepers from each group were identified and described based on the characteristics associated with beekeeping.

RESULTS

Social characteristics

The average age of interviewed beekeepers was 50±10.3 years, with 7.9±3.7 years of education; 8% had an undergraduate (five) or graduate (one) degree. In contrast, Adgaba et al. (2014) reported 40.7% of beekeepers had postgraduate studies in Saudi Arabia. The average age of beekeepers in the present study was similar to that in countries such as South Africa and Poland, about 50 years (Semkiw and Skubida, 2010; Masuku, 2013). Although the age of beekeepers was similar, this could be a limitation regarding technological appropriation, since younger beekeepers have greater innovation potential (Damián Huato et al., 2007; Sanjerman-

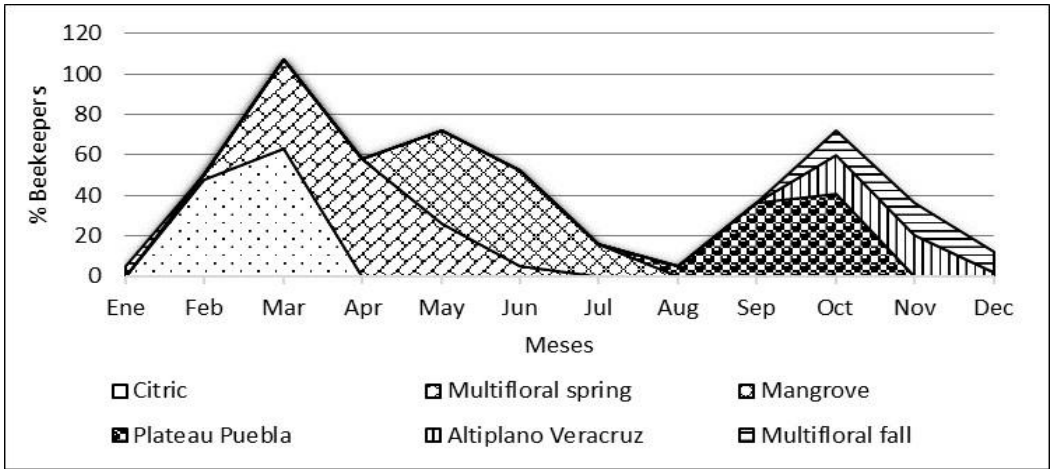

Figure 2: Monthly blooms used by beekeepers.

Jarquin et al., 2014). Beekeeper experience averaged 20.3 years, and in Yucatan 21 (Magaña et al., 2007),and this was superior to the value of 16 years reported for the state of Jalisco (Contreras-Escareño et al., 2013).

Based on the learning process for beekeeping, just over half of beekeepers started their activity after being given advice from a friend (52.1%),from a relative (29.3%), from employment relationships (12.3%), or capacitation workshops (6.4%). These different forms of social communication and learning showed statistically significant differences in the technical management and production of apiaries ($p<0.05$, Tukey). Those who learned through employment relationships moved their apiaries to more blooms, compared to those who learned through friends, family members or workshops. However, productive diversification was linked to the interaction between learning from family and the stimulation of learning in a training workshop.

Economic characteristics

Of the beekeepers interviewed, one-third was economically dependent on beekeeping, while others supplemented their income by engaging in additional agricultural activities (ranching, growing coffee or corn) or off-farm activities (commercial trade, field worker, or private sector). In Yucatan, only 4% of producers depended exclusively on beekeeping (Magaña et al., 2007), the rest diversified their economic activities and income from the sale of honey for subsistence needs, without covering production costs (Rosales and Rubio, 2010);for them, apiculture is a secondary activity. In India, this activity is only a supplement to farming, especially for small producers who view beekeeping as a sideline and sometimes just a hobby (Karam et al., 2013). On average, each beekeeper had 3±2 family dependents and their economic expectations for meeting daily family needs averaged $20.94±$8.95 (USD).A positive relationship (r=0.43) existed between the number of dependents and the daily income needed for family support.

Beekeeping had an economic multiplier effect reflected in the generation of 2.6±1.6 family labor jobs as well as hired labor that eventually became permanent; this was in addition to labor provided by the principal beekeeper. Beekeeping is, therefore, an important source of employment generation for the rural sector (Magaña and Leyva, 2011),and is one of the primary sources of local and regional income (Magaña-Magaña et al., 2012).

Forty-eight percent of the apiaries were located on beekeeper property, unlike Yucatan where 57.8% of beekeepers placed their beehives on other properties (Magaña et al., 2007). This is explained, in part, by the predominant type of management based on migration, which is different from the Yucatan where it is fixed and provides greater security and permanence of the apiaries. Thus, the form of land tenure contributes greatly to beekeeping technology and production.

Production technology characteristics

The agro-climatic diversity in the state of Veracruz provides five periods during the year with blooms of importance to honey production (Figure 2).These, in turn, are seasonally grouped into two significant blooms per year, spring and fall (Magaña-Magaña et al., 2012). Ninety-one percent of beekeepers practice migratory beekeeping, 32.5% of these moved their hives between two blooms, 45.3% among three, 19.7% among four, and 2.3% among five blooms. This variation was mainly due to temporary overlap among blooms, as well as mobilization costs.

The average number of hives per beekeeper was 252.5±201.30, divided into 9.96±7.88 apiaries, representing an average of 25 hives per apiary. These averages are above the Yucatan which has 2.6 apiaries per beekeeper and 20.9 beehives per apiary, and are related to land possession as in Yucatan, or migration

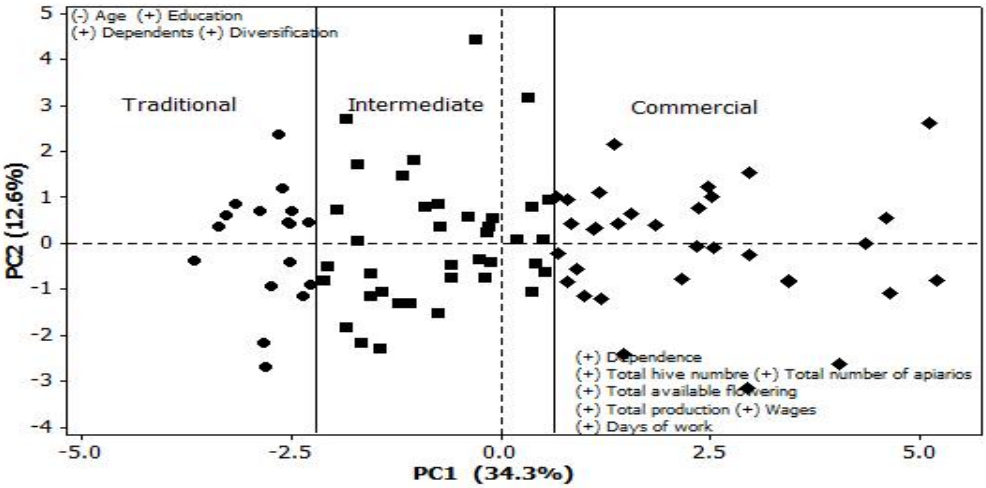

Figure 3: Identification of beekeepers categories based on Principal Components 1 y 2, and following Dalenius and Hodges.

management in Veracruz. The results agree with the average of 25 hives per apiary reported for Poland (Semkiw and Skubida, 2010).

Honey production per hive averaged 22.15±10.69 kg, superior to the 16.73 kg reported from Jalisco and 2.17 kg from Yucatan (Contreras-Escareño et al., 2013).Yet, it was below the national average (27 kg), that for the USA (26.97 kg) and that for Turkey (26.28 kg), and far below that for China (33 kg) and Argentina (40 kg), who are the principal honey-producing countries (Vural and Karaman, 2009; Popescu, 2012).

Apiaries can provide honey and various sub-products to commercial markets (Delgado, 1984). However, the zootechnical function of 100% of the beekeepers in Veracruz was honey production, and only 38% sold other hive products at a smaller scale. This was similar to the diversification practiced by some Polish beekeepers (Semkiw and Skubida, 2010); beekeeping as a primary vocation is most important, while diversification into other products is low (Magaña and Leyva, 2011).

According to the National Health Service Food Safety and Quality (SENASICA, for its acronym in Spanish) and the National Coordination of Livestock (CGG, for its acronym in Spanish), all beekeepers owned 100% of the equipment and materials recommended for good honey production and packaging and bee management practices for integration into external marketing channels. A weak transition to the use of stainless steel equipment was observed, representing one of the challenges of innovation in the beekeeping sector (Contreras-Escareño et al., 2013). As the number of hives increased, possession of these assets increased (r=0.49), indicating that more hives was positively associated with increased equipment possession (Pat et al., 2012; Contreras-Escareño et al., 2013).

Regarding transportation, 83.9% reported having a motor vehicle (pick-up modified for cargo), whereas in Yucatan and Campeche only 15% used this form of transportation, and bicycles were most frequently used (Pat et al., 2012). The former results can be attributed to the distance traveled, the number of apiaries and the type of migratory beekeeping practiced in Veracruz.

As part of the beekeeping supply-chain, 61.3% of beekeepers acquired their materials and equipment from veterinarians, or local distributors and manufacturers, 28% acquired them from foreign distributors, and the remaining 7.9% purchased them from suppliers in another state using the Internet.

Approximately 58.1% of beekeepers bought queens from local producers, which are not always certified, but reduce the risk of death because they are acclimated to the environmental conditions in the region.

Approximately 98.7% of beekeepers artificially fed their bees according to the needs of the hives. For example, 96.6% made their own food stimulus and a maintenance solution from sugar and water (2: 1) as this was more economically viable. However, fructose and processed foods should not be discarded as opportunities when they are available. Food allocation is an important beekeeping practice, and a statistical difference (p=0.01) was observed between providing food stimulation and learning about beekeeping; beekeepers being taught in a "training workshop" had more practice, compared to those who learned through a social network or "friend".

Technical assistance was low, as 56.8% of beekeepers reported not having received assistance for innovation in production processes and packaging. However, this did not eliminate the reception of financial support from the government, where 77.2% of those in a national support program (PROGRAM) were directed toward people with extensive production, having between 10 and 1500 hives in production.

Beekeeper tipology

Multivariate analysis revealed three groups of beekeepers: commercial (37.5%, n=33), intermediate (43.2%, n=39) and traditional (19.3%, n=17) (Figure 3).

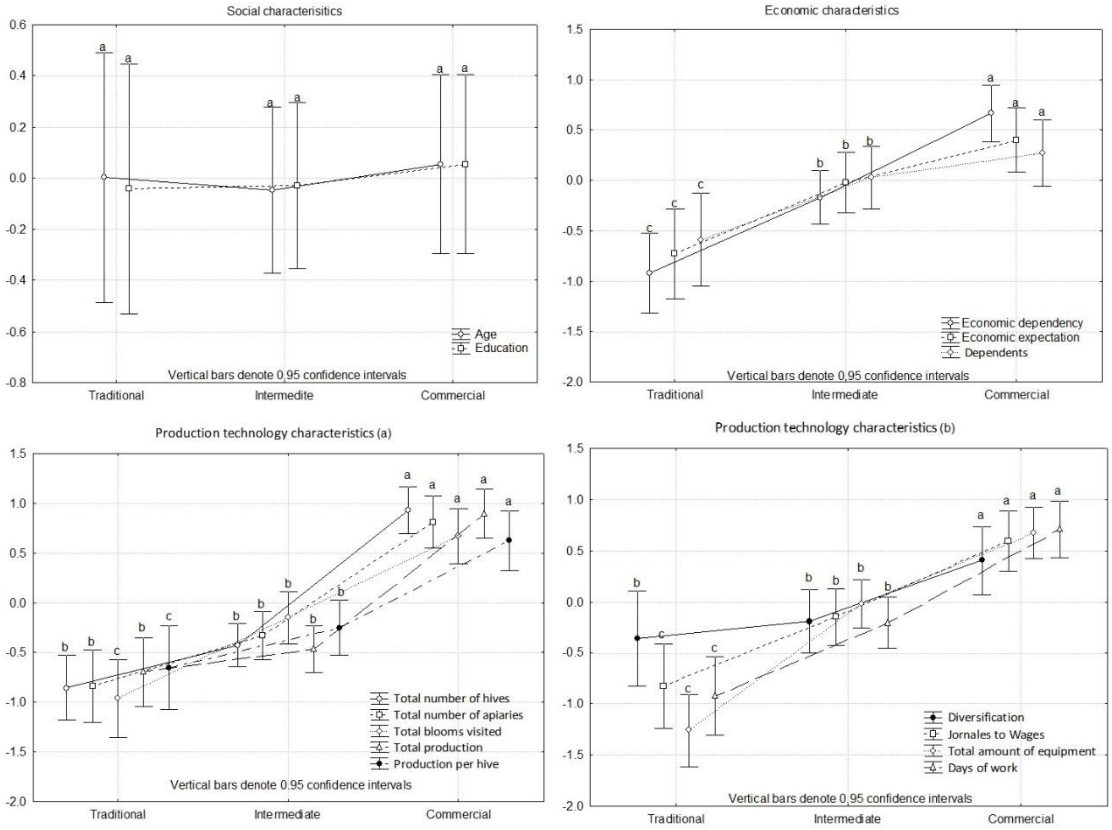

Figure 4: Distribution of standardized values for the socio-economic and production technology characteristics of beekeepers ($p<0.05$).

These groups were differentiated by 14 variables: age, education, economic dependence, economic expectation, dependents, total number of hives, total apiaries, total number of blooms visited, total honey production, honey production per hive, diversity of apiculture products, total wages produced, total equipment owned and days of work, over which a Tukey means comparison was applied (HSD) (Figure 4).

Commercial: Eighty percent of the beekeepers in this group were economically dependent on this activity and practiced migratory beekeeping. Their average age was 50.7±9.8 (n=33) years, with an average of 8.1±3.1 years of education. They possessed more equipment for the production, extraction and packaging of honey, and had a daily economic expectation of $24.31±8.35 (USD). Beekeepers in this group had the greatest number of beehives and production volume, reporting an average of 440±220 hives with a maximum of 900, and with an output of 28.9 kg of honey per hive. The hives were moved among three to five blooms, so that 57% for maintenance and 93% for stimulus. Thirty-nine percent of beekeepers began their career as the result of teaching from a family member, providing a greater diversity of apiculture products and generating an average of four jobs per year.

Given the number of hives and wages provided, beekeepers produced and repaired necessary equipment such as brood chambers, screen racks, rack frames and bees wax stamping rollers. The number of hives defines several beekeeping practices (Magaña et. al., 2009; Contreras et. al., 2013), supporting the perspective that more hives and greater economic dependence increase with the possession of more equipment and management practices.

Intermediate: Approximately 60% of these beekeepers were economically dependent on the activity and practiced migratory beekeeping. The average age was 49.6±10.21 (n=39) years, with 7.8±4.1 years of education. Beekeeping equipment was less abundant than in the previous group, beekeepers had a daily economic expectation of $20.60±8.90 (USD)and an average of 166±80.9 hives per beekeeper with a maximum of 350and an output of 19.8 kg of honey per hive. The hives were distributed among two to four blooms, providing 90% food for maintenance and 45% for stimulation using different feeders. Fifty-two percent of beekeepers learned their practice from a friend, but product diversification was very scarce and generated an average of only two jobs per year. For the acquisition and maintenance of equipment, beekeepers combined different

links in the supply network, including distributors, their own efforts and local carpenters.

Traditional: Beekeepers in this group had an economic dependence of 20%, indicating a greater number of off-farm activities and that the lower number of hives promoted more diversification of economic activities (Contreras-Escareño et al., 2013). This group did not practice migratory beekeeping due to the higher costs of moving hives. The average beekeeper age was 50±11.9 (n=17) years, with 7±3.8 years of education per beekeeper. Their daily economic expectation was $14.37±5.91 (USD). They had the least equipment for honey production, and relied on borrowed equipment for honey extraction.

Beekeepers in this group possessed 80±40 hives, with an output of 15.1 kg of honey per hive. Apiaries were not moved and took advantage of local blooms, generating an average of one employment position per year. Learning beekeeping was a combination of learning from a friend, training workshops, or work relationships and was only dedicated to honey production. Beekeepers in this group provided the least artificial feeding due to higher costs and the type of management; only 42% provided food for maintenance and 30% provided food for stimulation.

Finally, according to production technology and socio-economic characteristics, the three categories of beekeepers were primarily differentiated by the total number of hives, the total number of apiaries, the total number of blooms visited, total honey production, production per hive (technology production), as well as economic dependence, economic expectations and number of dependents. Values were higher for commercial beekeepers, followed by intermediates and least for traditional. Age and education did not show differences among groups. Therefore, differences among categories were due to production scales, beekeeper economic dependence and production efficiency of beekeeping.

DISCUSSION

Beekeepers in central Veracruz state along the Gulf of Mexico were characterized by older-aged integrated producers with over 20 years of experience and low education, a profile similar to beekeepers in Yucatán (Magaña et al., 2007) and other countries such as South Africa (Masuku, 2013) and Poland (Semkiw and Skubida, 2010). According to Sanjerman-Jarquin et al. (2014), this represents a constraint on the process of technology transfer, maintaining a lag in production practices because there are young producers who have better access to technical information that allows beekeepers achieve higher levels of competitiveness.

The low level of education contrasts with the profile of beekeepers in Saudi Arabia where 40.7% have postgraduate educations and the average age is 46.58±10.50 years, resulting in a significant positive correlation (r=0.35, p=0.0001) between the use of improved technology and the ease of beekeepers at adopting new technologies (Adgaba et al., 2014).

Korsbaek (2011) and Lozares (1999) mention that the processes by which beekeepers learned their trade are part of social capital, involving communication among beekeepers within a system, and not formal educational activities.

Possession of beekeeping equipment and other assets such as motor vehicles, were strong features of beekeeping in the region, unlike other states in Mexico such as Yucatán and Campeche where the primary means of transport were bicycles. Transportation was associated with the type of beekeeping exercised (migratory or fixed) (Magaña-Magaña et al., 2012) and level of income obtained from the sale of honey (Pat et al., 2012).

While category construction allowed for the elucidation of particular beekeeper characteristics, there are actually few studies methodologically examining beekeepers. Of the 14 socio-economic and production technology variables used in the classification, the number of hives was the primary variable differentiating each group, demonstrating that an extensive beekeeping system leads to greater production (Masuku, 2013).This contrasts with beekeepers in China and Argentina where maximizing the production per hive is the objective, placing them at the top of world production (Popescu, 2012).

Production per hive (kg hive^{-1}) increased positively with the number of hives. According to Manrique (1995), this result is associated with bee genotype, the blooms present and the form of beekeeping management; more efficient management in intermediate and commercial beekeepers was shown.

Although categorization revealed an extensive production system, migratory beekeeping is the main practice among intermediate and commercial beekeepers. Beekeepers in these categories have similar production characteristics to those in the USA (Popescu, 2012) and Turkey (Vural and Karaman, 2009) based on the number of hives and honey production per hive, which requires support directed at maximizing production. The traditional group practiced fixed beekeeping and the limited number of hives did not permit beekeepers to be competitive with the other two groups. The low number of hives and the lack of economic capital to invest in fixed activities require targeted support to help them capitalize on beekeeping. Although only 19.3% of beekeepers exist in this group, they need to receive support to help them better position themselves and increase their number of hives.

The beekeeper categories identified in this study revealed that the profiles of commercial and intermediate producers are similar to the descriptions from other honey

producing countries (USA and Turkey).The form of apiculture in the study region is extensive, with older age and poor education representing most beekeepers in each category, indicating constraints to innovation and technology transfer (Galindo et al., 2000; Adgaba et al., 2014).

CONCLUSIONS

Beekeeping in the central portion of the state of Veracruz, along the Gulf of Mexico, was mainly an extensive activity, where social networks (friends and labor relations) largely defined beekeeper technical knowledge and productive behavior.

Based on production technology and socio-economic characteristics, three types of beekeepers were identified (commercial, intermediate, and traditional).Production technology (total number of hives, total apiaries, total number of blooms visited, total honey production and honey production per hive) and economic variables (economic dependence, economic expectations and number of dependents) were greater for commercial beekeepers, followed by intermediate, and were least for traditional producers. Social characteristics (age and education) showed no difference among groups. Therefore, observed differences were due to production scale, economic dependence on beekeeping, and efficiency of this activity.

Decision-makers are encouraged to consider this classification in the planning for different support policies to improve the competitiveness of beekeeping in the region.

ACKNOWLEDGEMENTS

We thank the beekeepers who kindly participated in the survey, MVZ Florina Chapol Yepez for fieldwork guidance, Colegio de Postgraduados and the National Council of Science and Technology (CONACyT, for its acronym in Spanish) for doctoral program support.

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