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Technical note

Agricultural trade networks: the case of beekeepers in central and southern Jalisco, Mexico

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Abstract:

In order to analyze the structures of commercial networks of beekeepers in central and southern Jalisco, Mexico, a survey was conducted in six municipalities of the state. Social Network Analysis (SNA) was used and the following indicators were calculated: density, centralization index, and diffusion coverage. The results showed that beekeepers are 56 yr old on average and have junior high school education; they have a diverse and well-connected network of suppliers articulated by an equipment supplier. Nevertheless, their customer network is more diffuse and limited, with few buyers, which generates a dispersed network and reduces the possibilities of integration of producers for the benefit of common objectives. The structural characteristics of these networks suggest that it would be possible to design an improvement strategy focused on the communication and articulation of key actors (with a

central position and high diffusion coverage). This strategy must also consider the experience of beekeepers and the importance of beekeeping as a source of income.

Keywords: Beekeeping, Customers, Market, Honey, Commercial network, Suppliers.

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Beekeeping is an activity that has great economic relevance in Mexico, generates employment and income in rural areas and is one of the main sources of foreign exchange within the livestock subsector[1]. Beekeeping provides a variety of products, such as honey, beeswax, royal jelly, and propolis, which are constant sources of income for beekeepers[2,3]. In 2023, Mexico's honey exports reached 16,783.8 t and a value of 67.7 million dollars[4], placing the country as the tenth largest exporter and seventh largest producer of honey in the world[5]. National honey production in 2023 amounted to 58,033.2 t, with the most outstanding states in production being the following: Yucatán (16.3 %), Chiapas (10.2 %), Jalisco (10.0 %), Veracruz (9.0 %), Oaxaca (8.3 %), and Campeche (7.9 %), which together contribute 61.7 % of national production[6].

In terms of marketing channels, Mexican beekeepers generally sell their honey through local markets, intermediaries, and merchants[7]. Nonetheless, direct sales to the final consumer are limited; the marketing of honey is mostly organized for its collection, processing and delivery to external marketers or distribution to the domestic market, with limited benefits for beekeepers[8]. The price they receive usually depends on the market in which the transaction is carried out and the market power of the agents involved in the commercial process[9,10].

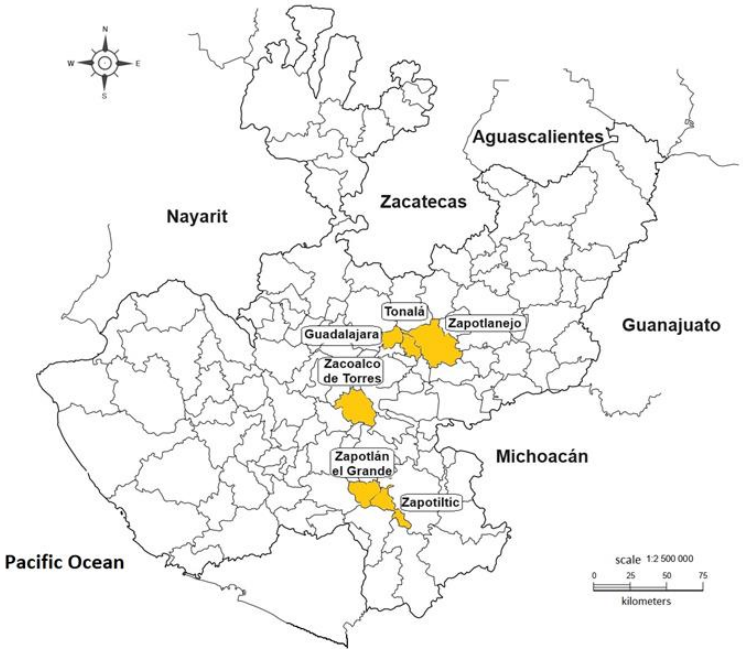
Honey sales prices and input costs are two crucial factors that affect the profitability of beekeeping[11,12]. However, beekeepers often have limited knowledge about market players and how the business dynamics in which they participate work. This is why some authors stress the importance of beekeepers understanding the relationships and actors that influence the marketing of their products[13]. In this context, Social Network Analysis (SNA) emerges as a useful tool to study the interactions of market players and visualize the relational structures between them. This methodology allow to identify the links between the different agents and analyze their roles within the commercial network[14].

The SNA, which includes a set of analytical methods and algorithms and its own theoretical system, seeks to explain social phenomena by analyzing the relationships and patterns between the actors involved. In this study, the SNA will be used to analyze the commercial

networks of beekeepers in some municipalities of central and southern Jalisco, Mexico, and to identify the players that make up their network and understand their role in the purchase of inputs and sale of products, mainly honey. It should be noted that Jalisco has been one of the major honey-producing states in Mexico, and in 2020, it reached first place in national production with 6,059.2 t, which represented 11.2 % of the total volume of honey produced in the country[6].

To achieve the objective, the study was conducted with beekeepers from six municipalities in central and southern Jalisco: Guadalajara, Tonalá, Zacoalco de Torres, Zapotlanejo, Zapotlán el Grande, and Zapotiltic (Figure 1). In 2023, Jalisco produced 5,806.07 t of honey, and except for Guadalajara, these municipalities contributed about a quarter (24.5 %) of the state's production[6]. According to the Agrifood and Fisheries Information Service[4], no information on honey production was reported in Guadalajara, and beekeepers residing in the city mentioned that they have their hives in nearby municipalities because Guadalajara is an urban area.

Figure 1: Location of the municipalities where the surveyed beekeepers reside



The information was obtained through a survey that was applied to 36 beekeepers between November 2019 and February 2020. The distribution of respondents by municipality was as follows: Guadalajara (22.2 %), Tonalá (8.3 %), Zacoalco de Torres (27.8 %), Zapotlanejo (8.3 %), Zapotlán el Grande (8.3 %), and Zapotiltic (25.0 %). Beekeepers were selected by targeted sampling using the snowball technique. This non-probabilistic method is commonly used to locate hidden or hard-to-reach populations[15]. In this case, beekeepers were selected

by reference from other producers or by their willingness to provide information on their business links, both with suppliers and customers.

The applied questionnaire contained questions about the characteristics of beekeepers, their main suppliers of equipment and inputs, as well as their customers. Some of the base questions included: How many hives do you have? How much do you produce per hive? What inputs do you use? Who are your suppliers and customers? What products do you sell and at what price? The responses provided key data on production, inputs used, and business networks of the beekeepers.

The data obtained were used to create a database in Microsoft Excel® and the business links of each beekeeper were captured in the Notepad application. Each actor (individual or organization) was assigned an identifier for representation in the network. The code catalog proposed by Rendón *et al*[16] was adapted, assigning each actor a code according to their role in the activity as follows: API (beekeeper), APIR (referred beekeeper), family and friends (FAM), end customer (CF), intermediary customer (CI), government institution (IG), input supplier (PI), bee supplier (PAB), and equipment supplier (PE).

In the UCINET program[17], version 6.288®, the following network indicators were calculated: density and centralization index. The density refers to the proportion of existing relationships to all possible relationships within a network. On the other hand, the Centralization Index (CIn) shows the presence or absence of actors concentrating the links of the network, as well as decisions or information[16]. There are two types of centralization in the network: the outbound centralization, which refers to the existence of one or more dominant beekeepers in the outbound links, that is, with a greater number of suppliers or customers. By contrast, inbound centralization means that one supplier or customer concentrates the beekeepers' business links. The index values range from 0 to 100, with 100 being the value for the most centralized network, which is characterized by one actor being connected to all the others[16].

To calculate the diffusion coverage of each actor, the harvest algorithm of the Keplayer2® program was used[18]. Diffusion coverage is defined as the percentage of actors that can be reached or influenced by a specific actor through their links directed towards this specific actor. Finally, the free software Gephi®[19] was used to design and visualize the network graphics.

The commercial networks were analyzed through the Social Network Analysis (SNA), which allow to study the relationships between players both quantitatively and qualitatively[20]. This methodology was useful to understand the links between the actors, evaluate the integration of the networks and identify those actors with greater connectivity and diffusion coverage.

The obtained results identified that beekeepers have an average age of 56 yr and an education of 9 yr, that is, they are middle-aged producers with a basic level of schooling (Table 1). These values are higher than those reported in other areas of Mexico, such as the humid tropics of the country, where schooling is 6 yr and the average age of beekeepers is 43 yr[21]. The average experience of beekeepers in the study area was 20 years, which is similar to the average of 22 yr found in beekeepers in the north-central region of Veracruz[22]. This experience is a relevant factor since productivity per hive is usually linked to seniority in the beekeeping activity[11].

Table 1: Main characteristics of the beekeepers analyzed in central and southern Jalisco

Characteristic	Minimum	Media	Maximum
Age (years)	35	56	90
Schooling (years)	0	9	18
Years as a beekeeper	1	20	60
Number of hives	8	391	2,500

The average amount of hives per beekeeper was 391, ranging from 8 to 2,500 hives, that is, both small and large honey producers are included. It is important to know this data because it provides an idea of the relevance of the activity for the producer in the southern and southeastern regions of Jalisco. Contreras-Escareño *et al*[23] observed that beekeeping was the main source of economic income for producers who had a greater number of hives; in this case, 58 % of the producers mentioned carrying out other economic activities complementary to beekeeping, such as agriculture and livestock.

Honey is the main product obtained by beekeepers, and it is intended both for sale and for self-consumption. Fifty-six (56) percent of beekeepers reported selling part of their production in local markets, open-air markets, or fairs. The average price they received for honey in 2019 was $78.50 MXN per kilogram (Table 2). Nevertheless, 32.0 % of beekeepers sold their honey at a lower price, even than the state average, which was $48.10 MXN per kilogram according to data from the Agrifood and Fisheries Information Service[6].

Table 2: Yield, price, and quantity of honey marketed by beekeepers

Variable	Minimum	Media	Maximum
Honey harvested per hive, kg	9.0	18.0	30.0
Amount of honey sold, kg	81.0	6,658.90	40,000.0
Honey price, $/kg	35.0	78.50	140.0

For 2023, the average price of honey in Jalisco was $51.38 MXN per kilogram, which meant an average annual growth of only 2 %. In the municipalities under analysis, the dynamics of

the price of honey was similar to the state one, even in Zacoalco de Torres it had a slight decrease from $56.22 MXN to $51.96 MXN. In this sense, Ramírez *et al*[24] point out that, in Mexico, the prices paid to the producer have remained constant in response to a commercial strategy to face international competition.

The above results can be explained by the geographical location of beekeepers, who, in many cases, are far from the points of sale and must transport large quantities of honey (up to 40,000 t), which forces some to resort to intermediaries to market their product. This decreases their bargaining power and affects the selling price. On the other hand, beekeepers mentioned that the supply and prices of inputs are not a priority problem, except for the high cost of sugar used in bee feeding.

In the commercial networks (producer-supplier and producer-customer) of beekeepers in Jalisco, 64 actors were identified, which were distributed in eight categories according to their function (Table 3). Suppliers accounted for 62.5 % of the players, reflecting that beekeeper have access to a considerable variety of suppliers, which can favor competition and, potentially, better prices. However, the number of customers is more limited, with only 32.8 % of players being final buyers and intermediaries. Hence, about a third of the respondents mentioned market access and the sale price of honey as problems.

Table 3: Types, number, and percentage of actors present in beekeepers' commercial networks

Type of player	Number of players	Percentage (%)
Referred beekeeper (APIR)	1	1.6
End customer (CF)	16	25.0
Intermediary customer (CI)	5	7.8
Family and friends (FAM)	1	1.6
Government Institution (IG)	1	1.6
Bee supplier (PAB)	19	29.7
Equipment supplier (PE)	5	7.8
Input supplier (PI)	16	25.0
Total	64	100.0

The network of suppliers of beekeepers in Jalisco was made up of 80 local actors (46 referred), with only 66 consolidated links between them, which was reflected in a relationship density of 1.0 %. On the contrary, the customer network showed a lower number of actors (23 referred) and links, therefore, a lower density of relationships, which was 0.7 % (Table 4). Regarding the inbound and outbound CIn, the two networks showed a number of less than 10 %, that is, the existence of a supplier or buyer that concentrated the commercial links was not identified.

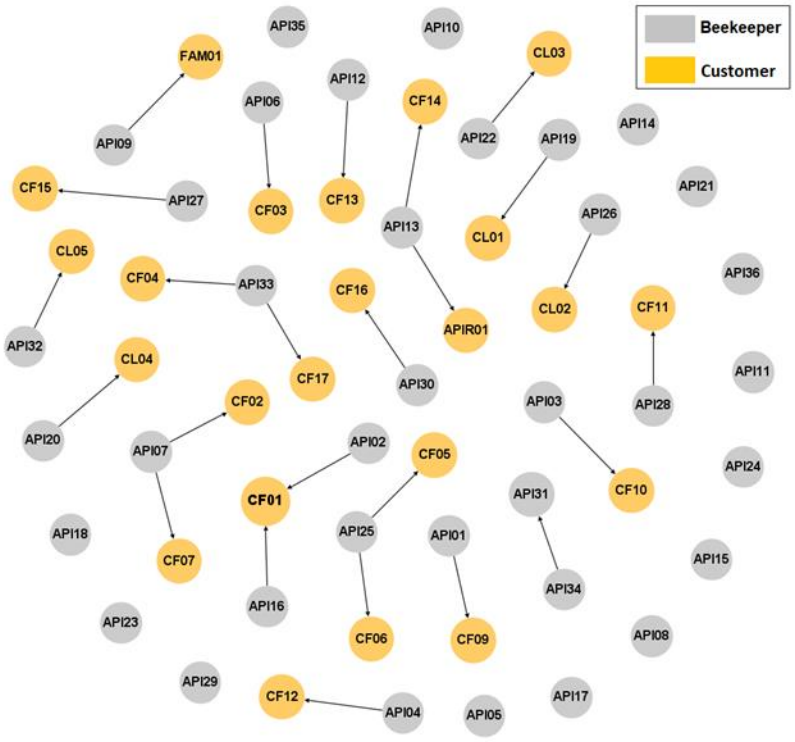
Table 4: Indicators of the commercial networks of beekeepers analyzed

Indicator	Supplier network	Customer network
Number of actors	80	59
Number of links	66	25
Inbound CIn, %	7.9	2.8
Outbound CIn, %	5.4	2.8
Density, %	1.0	0.7

Greater density and connectivity between actors imply a greater degree of interdependence between the different segments of the network and greater intergroup contact[25]. In the supplier network, it implies that, when buying inputs, beekeepers have purchasing options, can compare prices and have low dependence on specific suppliers. In contrast, a lower density in the customer network reflects a low number of relationships between participants and little communication and information transfer in the network. In this sense, it has been mentioned[26] that the connection to the commercial network is an important factor because it increases the producer's commercial capacity of and bargaining power in a free market framework.

The beekeepers' supply network presented a structure divided into nine sub-networks, joined by certain articulating actors, which function as a link between two or more actors. Figure 2 shows that there is a concentration of beekeepers around these suppliers. Likewise, seven beekeepers were found that do not have or did not mention a supplier (loose nodes).

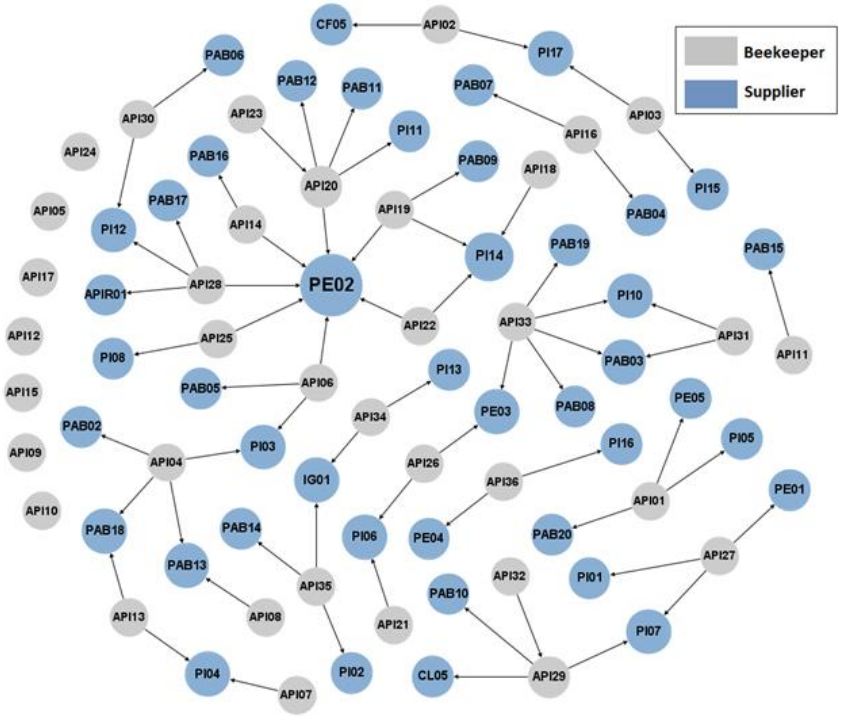
Figure 2: Network of suppliers of beekeepers in Jalisco



A relevant actor was identified in the network, an equipment supplier with the identifier "PE02" (it is highlighted with a larger size). It showed a diffusion coverage of 10.1 % of the players in the network, beekeepers turn to it to buy equipment used in honey production; likewise, due to the articulation work of this actor, the subnetwork to which it belongs presented a greater interaction. This player articulates about 25.0 % of the actors, it is the main link or mediator of the relationships between the actors, which denotes the importance of including it in the strategies to create better opportunities for the purchase of inputs for beekeepers. The results of the network show that the integration and organization of producers is vital to improve their purchasing power of inputs and equipment since producers must take advantage of the organization to purchase inputs in large quantities, such as sugar, in order to reduce production costs and improve profitability levels[27].

The beekeepers' customer network was observed with a diffuse, poorly articulated structure and with a small number of buyers. In this network, a common buyer among beekeepers was not identified, there was only one end customer (CF01) who buys honey from two beekeepers, four beekeepers with more than one customer, and 14 beekeepers who do not have or did not mention a specific customer (Figure 3).

Figure 3: Customer network of beekeepers in Jalisco



Respondents prefer to sell their products directly to end consumers (CF), so the presence of this type of actor is high, since they obtain better prices this way; however, in the network, lunch counters, grocery stores, open-air markets, and fairs were also identified as points of sale. Five intermediary customers (CL) in the area who buy honey in localities of the municipalities were also identified. Nonetheless, half of the beekeepers did not mention a specific customer for their products, some appear as loose nodes and others mentioned selling to the general public. This coincides with a study carried out in Mexico City, which mentions that one of the challenges faced by beekeeping is marketing, which is controlled by intermediaries and generates low economic profitability for producers[28]. The analysis of the network structure and types of customers identified among beekeepers show that they have limited customer options and reveals at least four relevant issues they face in marketing: 1) Uncertainty in sales: beekeepers who do not sell to a specific customer are not assured of the exit of their production, their sales are intermittent and depend on the customers' purchasing agenda. 2) Low honey prices: the small number of end customers forces beekeepers to move their product through intermediation, obtaining a price lower than the market price. 3) Dependence on customers: the low diversity of customers forces the beekeeper to depend on their purchasing conditions. 4) Sale of a single undifferentiated product: due to the sale of honey in bulk, they face unfair competition in the market because of the sale of adulterated

honey at a lower price in addition to having unfavorable conditions of negotiation with customers. The low added value and low diversification of hive products offered by beekeepers decreases their chances of obtaining better income.

Unlike other products obtained from agrifood systems, honey is a product with greater durability and can be stored and sold in times of financial difficulty[29]. To seek better alternatives for honey marketing, it is recommended to develop capacities to diversify products and especially to focus on potential customers outside the region, ensuring the sale of a natural and good quality product[7].

Beekeepers depend on processing and marketing companies that package and add value with their brand to the product to differentiate themselves from low-quality honey or honey imported from other countries. In addition to the above, the poor organization and communication that exists among beekeepers for the promotion and sale of their products complicate the possibility of obtaining better economic benefits, so organization is essential[27]. Nevertheless, there is interest from some of them to train and develop new products, as well as to carry out honey analyses to check its quality and differentiate their product; as Pat-Fernández *et al*[30] point out, an alternative to increase the competitiveness of beekeepers is the differentiation of the product through the production of organic honey or specific types of honey.

The indicators of commercial networks can be taken as a reference to set as a goal to overcome two main challenges of beekeepers: first, to diversify their portfolio of products and customers, which demands a deliberate effort to look for customers, add value, the development of new products and enter new markets; and the second is to overcome the lack of organization among beekeepers since their ability to negotiate the price of honey and inputs is limited compared to that of middlemen and their suppliers. The density of relationships in the beekeepers' networks was low, which indicates that they are disjointed and working individually on commercial aspects.

In conclusion, the indicators of the marketing network in the study areas show a weak integration and collaboration between the actors involved in the production and sale of honey, which results in a dispersed network of customers with few opportunities to establish common benefits, such as consensus on sales prices or improved negotiation conditions with buyers. The structural conditions of these commercial networks suggest the need to design improvement strategies that are based on communication and articulation between the players involved. These strategies should focus on the key actors (with greater connectivity and diffusion coverage on the network), on the experience of the beekeeper and on the economic importance of the activity for producers. Future research should explore possible mechanisms of articulation and forms of cooperation between the players of trade networks in addition to analyzing the structural factors that condition their development. It would also

be relevant to study trade relations in other agricultural activities, with different socioeconomic characteristics and territorial contexts, in order to obtain a more complete understanding of the dynamics that influence trade networks in rural areas.

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