Typology and characterization of the pampean beekeeping systems

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Abstract

Objective: Identify and characterize the beekeeping systems of La Pampa (Argentina) using multivariate techniques based on the main structural, productive and economic characteristics.

Methodology: The data was collected through a random survey of 80 beekeepers. The classification and description of the apicultural systems was based on a multivariate sequence comprising three stages: review and selection of variables, factor analysis and cluster analysis.

Results: Factor analysis revealed that the size of the farm and the productive and economic performance of beekeeping jointly explained 66% of the variability. Through cluster analysis, three types of beekeeping have been identified: (i) Subsistence beekeeping grouped 55% of the farms, mainly characterized by small sizes and low productive and economic yields. (ii) Industrial beekeeping concentrated 54% of production in 15% of farms, mainly characterized by large sizes and high productive and economic yields. (iii) Commercial beekeeping grouped 30% of the farms, mainly characterized by high productivity with intermediate sizes.

Limitations: The study has been carried out on a few farms due to the difficulty of obtaining answers to all the variables included in the survey.

Practical implications: Beekeeping in La Pampa is generally a highly heterogeneous complement of income or family subsistence, with low productivity and low input use. Subsistence beekeeping is a socially relevant system for its contribution to family employment and income in rural areas. Industrial beekeeping is oriented to the export market and has a more competitive scale. Commercial beekeeping is situated on an intermediate scale.

Keywords: Multivariate analysis; beekeeping; Argentina; honey; production systems.

JEL codes: O13, Q12.

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拉潘帕养蜂系统的类型学及特征

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文章摘要
研究目的：本研究目的为通过多变量分析来鉴定和描述（阿根廷）拉潘帕的养蜂系统。研究以其主要结构、生产和经济特征为基础。

分析方法：研究数据是通过对八十位随机选择的养蜂人进行问卷调查收集的。养蜂系统的分类和描述是基于包括三个阶段的多元时间序列分析进行：变量审核和选择、因子分析和聚类分析。

研究结论：因子分析结果显示，66%的变异性是受生产单位的规模以及养蜂的开采动态影响。通过聚类分析，我们发现了三种养蜂类型：（一）自给养蜂占农场的55%，其主要特点是规模小、产量低及经济效益低的养蜂场。（二）工业养蜂将生产的54%集中于15%的农场上，其主要特点是规模大、产量高及经济效益高。（三）商业养蜂占农场的30%，其主要特征是中等规模以及生产率高。

研究局限：由于研究范围只局限于好几个养蜂农场之内，因此我们难以获得调查中所有变量的答案。

实际应用：拉潘帕地区的养蜂业一向是当地人民的一种补充收入来源或家庭维持生计的经济活动，其特点为高度多样化、生产率低及生产投入物使用率低。自给养蜂系统在当地社会有着重要角色，皆因该产业能为农村地区的家庭提供就业机会和收入。工业养蜂主要针对出口市场，其规模更具竞争力。商业养蜂则为中等规模。

关键词：多变量分析、养蜂产业、阿根廷、蜂蜜、生产系统。

JEL 分类号: O13、Q12。
1. Introduction

Beekeeping in Argentina is an activity that is practiced even before the arrival of the European bee. The aboriginal settlers collected honey and wax made by autochthonous meliponas and trigonas bees (Bierzychudek, 1979). The first *Apis mellifera* hives were introduced in Mendoza and Buenos Aires in the mid-19th century. The productive advantages of this bee compared to the native ones originated a rapid expansion process (Salizzi, 2014). In 1895 beekeeping was already a consolidated activity according to Ardissone (1931), who analysed the second agricultural census of the Argentine Republic. Towards the middle of the 20th century, the sector became a main exporter of honey (Von Kotsch, 1944). Since then, the export role has intensified, which has been accompanied by a continuous process of increasing production (FAOSTAT, 2017).

Currently, Argentina is the third largest honey producer in the world and the second main exporter, allocating more than 95% of production to the foreign market (Blengino, 2015). Probably, the main challenge for Argentine beekeeping is to continue maintaining its export quota in an increasingly competitive and demanding market, especially in matters of food safety and traceability. Facts such as the complaint of dumping by the United States in 2001 or the detection of nitrofurans in 2003 in Great Britain had important consequences for Argentine exports, which, together with a poorly developed internal market, caused significant instability in the sector (Mogni et al., 2008).

The beekeeping chain was one of the first sectors with a traceability regulation in Argentina, due to the demands of the European market. However, Argentine honey is traced from the extraction room, so the market does not know what happens in the production units (Mogni et al., 2008). In the near future, traceability will most likely include the beekeeper; however, the sector may not be prepared for this change. Firstly, because in Argentine beekeeping an informal culture predominates that does not perceive traceability as an opportunity (Estrada, 2015).

On the other hand, there is little scientific information on what happens at the production level. Bragulat et al. (2018) analyzed the influence of the managerial capacity of the beekeeper on the viability in the province of La Pampa. Cozzarin and Díaz (2016) evaluated the socioeconomic situation in the province of San Luís. Estrada (2015) reviewed the types of Argentine beekeepers. Ulmer et al. (2011) evaluated beekeeping in the province of Santa Fe.

However, in other regions that compete in the same markets, different beekeeping typologies have been developed, such as in Brazil (Fachini et al., 2010) or Mexico (Contreras et al., 2013; Castellanos-Potenciano et al., 2015; Vélez-Izquierdo et al.,
These works have identified and characterized the different production systems, helping to understand the production process and the relevant factors. This information is the basis of any intervention policy or recommendations that help to improve the future of the sector.

Among the techniques used to construct livestock typologies, multivariate methods are relevant (Toro-Mújica et al., 2012; Rivas et al., 2015). The main advantage of these techniques is that the classification is based on the degree of similarities and differences of the farms with respect to a set of classification criteria, and not with respect to external criteria subject to the subjectivity of the researcher. Furthermore, it is not necessary to establish *a priori* the number of categories, but rather arises from the variability of the farms (Köbrich et al., 2003).

For these reasons, the aim of this study was to identify and characterize the beekeeping production systems in La Pampa through multivariate techniques. Taking the typology as a starting point, the main factors that affect the systems are analyzed.

**Materials and methods**

**Data acquisition**

The study was carried out in the province of La Pampa, which is located between 63° and 65° W and 35° and 39° S. The approximate surface is 32,467 km² and has a population of 1,500 farms (RENAPA, 2014). Benign winters and mild summers predominate in this area, with concentrated seasonal rains in spring. The average annual precipitation is 724 mm and the average temperature is 15° C (Directorate General of Cadastre, 2014).

The information was collected in 2013 through face-to-face interviews with producers during a visit to the farm. The same person did all the surveys. The sample consisted of 80 beekeepers and was obtained through simple random sampling, in which each beekeeper had an equal probability of being selected to represent the population. The sample represents 5% of the studied population and is made up of those beekeepers willing to supply the information.

The questionnaire was based on the Rivas et al. (2015) adapted to beekeeping; with items related to the productive and patrimonial structure of the farms, socio-economic aspects, production, performance and business management.

**Systems characterization**

The classification and description of the systems was based on the methodology used by Rivas et al. (2015) and Toro-Mújica et al. (2012), which includes three stages: Review and selection of variables, factor analysis (FA) and cluster analysis. Sixty-six variables related to the size and structure of the production unit, production and productivity, diversification, economic results and beekeeping were analyzed.
In a first stage, 30 variables were selected, those of greatest interest, with a coefficient of variation greater than 60% (Table 1). The correlation matrix was then analyzed to rule out uncorrelated variables and linearly dependent variables. The adequacy of the data to AF was verified using the Bartlett sphericity test and the KMO index (Gelasakis et al., 2012). By means of this process, the variables marked in bold in Table 1 were selected.

In a second stage, FA was used to synthesize most of the variability in a small number of orthogonal variables called factors. Previously, the variables were standardized to mean zero and standard deviation one to avoid the influence of the different scales of each variable. Factors extracted with eigenvalues greater than one were selected. Varimax orthogonal rotation was applied to more easily relate the selected variables to the extracted factors (Gelasakis et al., 2012; Köbrich et al., 2003). In a third stage, the farms were classified into groups using cluster analysis. First, hierarchical groupings were developed based on Ward’s method with Euclidean, Euclidean squared, and Manhattan distances (Köbrich et al., 2003). The optimal number of groups was determined using the Elbow method (Gelasakis et al., 2012). The optimal grouping was determined using discriminant analysis and analysis of variance (Rivas et al., 2015). The group whose discriminant functions correctly classified the highest percentage of production units and generated significant differences in the largest number of original variables was chosen.

The missing data on some variables caused the exclusion of 40 production units. The data was analysed using SPSS software version 15.0. The level of significance was assumed at $P <0.05$.

Table 1. Variables used to identify and characterize the types of beekeeping in La Pampa (Argentina)

| Variable | Description                                      | Units       |
|----------|--------------------------------------------------|-------------|
| Colm     | Number of hives at the beginning of the production cycle | number     |
| DCol     | Percentage of hives that do not finish the production cycle | %          |
| Apia     | Number of apiaries                                 | number      |
| Colm/Apia| Number of hives per apiary                         | hives/apiary|
| Inver    | Total investment including land                    | $           |
| Inver/Colm| Total investment including land per hive            | $/hive      |
| UTA      | Number of annual work units (AW)                   | AW          |
| UTAfam   | Percentage of work that is family                  | %           |
| Colm/UTA | Number of hives per worker                          | hives/AW    |
| Miel     | Honey sold                                        | kg          |
| Miel/Colm| Honey sold by hive                                 | kg/hive     |
| Miel/UTA | Honey sold by worker                               | kg/AW       |
Table 1. (Continuation)

| Variable     | Description                                                      | Units |
|--------------|------------------------------------------------------------------|-------|
| Exper        | Producer experience as a beekeeper                               | years |
| Edad         | Producer’s age                                                   | years |
| IT/Colm      | Total income per hive                                            | $/hive|
| IM/IT        | Percentage that the sale of honey supposes on the total income   | %     |
| GT/Colm      | Total expense per hive                                           | $/hive|
| Amor/Colm    | Amortization per hive                                            | $/hive|
| Sum/Colm     | Supplies spend per hive                                          | $/hive|
| Alim/Colm    | Food expense per hive                                            | $/hive|
| GSan/Colm    | Health expenditure per hive                                      | $/hive|
| SPI/Colm     | Spending on independent professional services per hive           | $/hive|
| MO/Colm      | Labor expense per hive                                           | $/hive|
| MOfija       | Percentage of labor expenditure that is fixed                    | $/hive|
| CV           | Variable cost                                                    | %     |
| CU           | Unit cost (total cost / honey sold)                              | $/kg  |
| RN           | Net result (total income - total expense)                        | $     |
| FNC/Colm     | Net cash flow (net result + amortizations) per hive              | %/hive|
| FNC/UTA      | Net cash flow per worker                                         | $/AW  |
| Rent         | Net result / total investment including land                     | $     |

Results

Main characteristics of the production system

Beekeeping was the main economic activity for 22.5% of beekeepers. For the remaining 77.5%, it was a secondary activity or an income supplement. The beekeeper has an average age of 41.1 years and has 16.5 years of experience in the sector.

The average farm size was 427.7 hives and 3.15 apiaries, of which 30.0% are leased. The average labor force was 1.7 work-year units, of which 85.2% are family members. Each worker manages an average of 224.8 hives. The average investment per hive was $ 1,052.3.

52.5% of farms practice transhumance, while the rest follow a permanent production model. 82.5% of farms use external food at some point in the production cycle. The most common nutritional practice is the provision of sugar during the winter (57.5%), which is sometimes accompanied by a protein supplement (12.5%). Feeding averaged $ 7.8 per hive and accounted for 6.6% of the total cost.
The exchange of queens was common in 85.0% of the farms, which did not prevent them from causing an average drop of 15.2% in the hives with which the production cycle begins. The average health cost per hive was $7.4 and accounted for 7.6% of the total cost. It was common to have implemented a health plan (95.0%) and apply periodic treatments against varroasis (100.0%). Although it was infrequent to resort to specific diagnoses (20.0%) and rotate the drugs used as preventive and/or routine treatments, an activity that is only carried out in 15.0% of the production units.

The fixed cost represented an average of 60.7% of the total cost and is mainly formed by the amortizations that, on average, explain 67.7% of the fixed cost. Typically, the extraction of honey and the replacement of wax used external services, since only 15.0% of the farms had sufficient structure to take on both activities.

The average production was 7,399 kg per year, representing a productivity of 13.5 kg per hive and 3,656 kg per worker. The sale of honey was the only income in 87.5% of the farms. The remaining 12.5% also sell nuclei, which represent around 44.2% of total income. The average income per hive was $75.8, while the average expense amounted to $121.9. This assumes an average net result of -$46.1 per hive. However, the average net cash flow was $3.8/hive. The average unit cost was $33.9/kg of honey, while the price of honey ranged from $6 to $7/kg in 100.0% of farms.

**Factorial analysis**

FA resulted in two factors with eigenvalues greater than one, which jointly explain 66.23% of the variance (Table 2, Figure 1). The KMO index was 0.713, while the Bartlett sphericity test was significant (p <0.05); therefore, the adequacy of the data to FA is confirmed (Köbrich et al., 2003).

Factor 1 explained 56.30% of the variability and was mainly correlated with variables related to productive and economic performance, which is why it is called “performance”. Factor 2 explained 9.93% of the variability and was positively correlated with the variables related to the size of the production unit, which is why it is called “size”.

Table 2. Results from factor analysis after applying the varimax rotation

| Variable          | $F_1$ Performance | $F_2$ Size |
|-------------------|-------------------|------------|
| Miel/Colm         | 0.758             | 0.166      |
| Miel/UTA          | 0.780             | 0.350      |
| FNC/UTA           | 0.779             | 0.372      |
| Colm/UTA          | 0.681             | 0.440      |
| CV                | 0.663             | 0.009      |
| CU                | -0.622            | -0.070     |
| IT/Colm           | 0.612             | 0.099      |
| RN                | 0.615             | 0.412      |
| Colm/Apiia        | 0.521             | 0.220      |
| Colm              | 0.431             | 0.722      |
| Apia              | 0.078             | 0.706      |
| Miel              | 0.425             | 0.565      |
| UTA               | 0.082             | 0.508      |
| Eigenvalue        | 7.320             | 1.291      |
| Variance (%)      | 56.30             | 9.93       |

Figure 1. Correlations of the original variables with the two factors extracted from factor analysis after applying the varimax rotation (• variables mainly correlated with factor 1, • variables mainly correlated with factor 2)
Farm typology

The cluster analysis with the most significant results was the solution of three groups with the Ward's method, based on the Euclidean distances (Figure 2). Table 3 and Table 4 show the main characteristics of each type of production unit.

**Group I. Subsistence Beekeeping**

Subsistence beekeeping grouped 55.0% of the farms and were characterized mainly by being very small in size and obtaining low productive and economic yields. The mean size was the smallest of all the groups with 124.1 hives, 1.3 apiaries and 1.3 jobs. The ratio of hives per worker was the lowest of all the groups (89.3 hives/AW), while the investment per hive was the highest of all the groups ($1,411.4 /hive). Although the total investment was the lowest of all the groups ($130,878).

Production (872.3 kg) and average productivity, both per hive (7.90 kg/hive) and per worker (615.2 kg/), were the lowest of all the groups. Economic performance was also the worst of all groups, both net result (-7,247.2 $) and profitability (-2.38%).

Average unit cost and cost per hive reached $53.24 /kg and $136.08 /hive and were the highest of all groups. While the income per hive was the lowest of all the groups with $54.04 /hive. The amortizations ($63.79 /hive) and the expense in supplies ($26.80 /hive) were high compared to the other groups, while the health ($6.79 /hive), the independent professional services ($1.16 /hive) and labor ($7.16 /hive) represented a lower average cost per hive than the other groups.
Figure 2. Euclidean distances between the three types of beekeeping identified in La Pampa

**Group II. Industrial beekeeping**

Industrial beekeeping grouped 15.0% of the farms and were mainly characterized by their large size and high productive and economic yields. The mean size was the largest of all the groups, with 1,466.7 hives in 8.8 apiaries and 2.7 jobs. The ratio of hives per worker was the highest (570.0 hives /AW), while investment per hive was the lowest of all the groups ($ 538.2 / hive). Although the total investment was the highest of all the groups ($ 561,638).

Production (26,650.0 kg) and production per worker (10,747.2 kg /AW) were the highest. The economic performance was also the best of all the groups, both the net result ($ 2,2018.2) and profitability (10.42%).

The average cost per hive ($ 102.84 / hive) and the average income per hive ($ 102.16 / hive) were high compared to group I; while the unit cost was intermediate to the other groups ($ 14.54 / kg). Amortizations ($ 29.24 / hive), supplies ($ 17.45 / hive) and health ($ 6.70 / hive) represented a lower average cost per hive than the other groups; while labor ($ 25.99 / hive) and independent professional services ($ 2.70 / hive) were the highest of all the groups.
Table 3. Main technical characteristics of the three types of beekeeping identified in La Pampa

| Variable           | Mean  | I         | II        | III        | SEM² | P value² |
|--------------------|-------|-----------|-----------|------------|------|----------|
| n                  | 40 (100.0%) | 22 (55.0%) | 6 (15.0%) | 12 (30.0%) |      |          |
| Colm               | 427.7 | 124.1a    | 1,466.7bc | 465.0b     | 95.3 | 0.000    |
| DCol (%)           | 15.2  | 12.0      | 21.7      | 17.73      | 4.06 | 0.666    |
| Apia               | 3.1   | 1.3a      | 8.8b      | 3.7b       | 0.68 | 0.000    |
| Colm/Apia         | 138.0 | 92.9a     | 225.7b    | 141.0b     | 13.3 | 0.001    |
| Inver ($)         | 450,068 | 130,878a  | 561,638a  | 291,792a   | 42,258 | 0.000    |
| Inver/Colm ($)    | 1,052.3 | 1,411.4b  | 538.2a    | 650.9a     | 187.6 | 0.001    |
| UTA               | 1.7   | 1.3a      | 2.7b      | 1.7a       | 0.14 | 0.003    |
| UTAfam (%)        | 85.2  | 88.6      | 68.3      | 87.5       | 3.6  | 0.144    |
| Colm/UTA          | 224.8 | 89.3a     | 570.0c    | 300.7b     | 38.2 | 0.000    |
| Honey (kg)        | 7,399.1 | 872.3a    | 26,650.0c | 9,738.3b   | 2,173.4 | 0.000    |
| Honey/Colm (kg)   | 13.5  | 7.9a      | 18.8b     | 21.0b      | 1.69 | 0.000    |
| Honey/UTA (kg)    | 3,656.2 | 615.2a    | 10,747.2b | 5,684.6b   | 1,011.1 | 0.000    |
| Exper (años)      | 16.5  | 17.0a     | 23.8b     | 15.1a      | 1.12 | 0.043    |
| Age (years)       | 41.1  | 41.1      | 43.5      | 40.0       | 1.79 | 0.833    |

¹ Mean standard error.
² Means with different letters significantly differs.

**Group III. Commercial beekeeping**

Commercial beekeeping grouped 30.0% of the farms and were mainly characterized by high productivity with intermediate farm sizes. The number of hives was 465.0, in 3.7 apiaries and 1.7 jobs. The ratio of hives per worker was intermediate (300.7 hives/AW). The investment per hive was similar to group II ($650.9 /hive), while the total investment was similar to group I ($291,792).

Production (9,738.3 kg) was intermediate to the other groups; however, the average productivity, both per hive (21.0 kg / hive) and per worker (5,684.6 kg/AW), were similar to those obtained by group II. The net result ($231.9) was also intermediate compared to the other groups, although the profitability was similar to that of group II (6.16%).

The unit cost was the lowest of all the groups, with an average of $8.14 /kg, while the average cost per hive ($105.57 /hive) and the average income per hive ($102.60 /hive) were similar to group II. Amortizations ($34.72 /hive), labor ($7.34 /hive) and supplies ($26.81 /hive) assumed an average expense per hive similar to group I; while the average health expenditure ($9.25 /hive) was the highest of all the groups.
Table 4. Main economic characteristics of the three types of beekeeping identified in La Pampa

| Variable        | Mean  | I     | II    | III   | SEM1 | P value2 |
|-----------------|-------|-------|-------|-------|------|----------|
| RN ($)          | -46.1 | -7,247.2a | 2,2018.2b | 231.9a | 3,178.31 | 0.004 |
| Rent (%)        | 2.1   | -2.4a | 10.4b | 6.2b  | 1.59 | 0.003    |
| IM/IT (%)       | 87.5  | 94.4  | 92.1  | 95.8  | 2.5  | 0.901    |
| CV (%)          | 39.3  | 32.8a | 43.8ab | 48.8b | 2.88 | 0.035    |
| CU ($/kg)       | 33.9  | 53.2b | 14.5a | 8.1a  | 8.51 | 0.037    |
| FNC/UTA ($)     | 5,466.5 | -1,071.4a | 22,401.3c | 8,985.2b | 2,212.5 | 0.000 |
| FNC/Colm ($)    | 3.8   | -18.2a | 28.6b | 31.7b | 6.03 | 0.000    |
| IT/Colm ($)     | 75.8  | 54.0a | 102.2b | 102.6b | 8.85 | 0.020    |
| GT/Colm ($)     | 121.9 | 136.1a | 102.8b | 105.6b | 9.23 | 0.023    |
| Amor/Colm ($)   | 49.9  | 63.9ab | 29.2a | 34.7a | 5.08 | 0.006    |
| Sum/Colm ($)    | 25.4  | 26.8b | 17.4a | 26.8b | 3.77 | 0.021    |
| Alim/Colm ($)   | 7.8   | 7.6   | 6.7   | 8.8   | 1.52 | 0.903    |
| GSan/Colm ($)   | 7.4   | 6.8a  | 6.0a  | 9.2b  | 0.60 | 0.011    |
| SPI/Colm ($)    | 1.8   | 1.2a  | 2.7b  | 2.5b  | 0.24 | 0.008    |
| MO/Colm ($)     | 10.0  | 7.2a  | 26.0b | 7.4a  | 3.06 | 0.008    |
| MOfija (%)      | 71.7  | 60.6  | 84.3  | 85.7  | 9.40 | 0.486    |

1 Mean standard error.
2 Means with different letters significantly differs.

Discussion

FA explained 66.23% of the variation between farms. This value is acceptable considering that it is usual to take into account solutions that represent at least 60% of the total variance (Jiménez and Aldás, 2005). Vélez-Izquierdo et al. (2016) obtained a similar value in a typology of Mexican beekeepers.

The typology has identified three systems in La Pampa: Subsistence beekeeping, commercial beekeeping and industrial beekeeping. There are few typologies and/or characterizations of systems, making it difficult to make comparisons with other regions.

Ulmer et al. (2011) studied a sample of 18 representative beekeeping farms in the province of Santa Fe (Argentina). There are no important differences with La Pampa in terms of structure (depreciation: $ 54.1 /hive), size (448 hives), family profile (83.2% family labor) and beekeeper characteristics (44% beekeeping main activity, 47 years and 17.5 years of experience). However, in La Pampa a lower mortality rate has been obtained (42% difference from hives), hives are more productive (7.1 kg of honey per hive), fewer apiaries (7 apiaries) and use of external inputs (81%
of expenses was food). At economic level, results from Santa Fe (-24% profitability) was less favourable than those obtained from La Pampa. In the province of San Luis, Cozzarin and Díaz (2016) reported a larger and more intensive beekeeping, still more productive and profitable than in La Pampa and Santa Fe.

The comparison shows a marked variability. On the one hand, the interrelationships of beekeeping with the agro-ecosystem are dynamic and complex, and also depend to a large extent on the particular conditions of each farm (orography, altitude, etc.) and on poorly controllable factors such as the climate. On the other hand, farms tend to have marked structural and technological differences (Contreras et al., 2013; Magaña-Magaña et al., 2012). In intensive systems the processes follow standards, while beekeeping is adapted to the conditions of each environment and beekeeper. All this explains that typological models constitute a good starting point in the analysis of beekeeping. Typologies are useful because they help to understand the different alternatives of the systems and, above all, because they offer a more appropriate evaluation framework, where the production units are already classified according to their main characteristics in specific systems (Vélez-Izquierdo et al., 2016).

Subsistence beekeeping is the most common type of beekeeping in La Pampa and corresponds to the so-called subsistence models, which are the most frequent in the developing world (Affognon et al., 2015; Fachini et al., 2010; Güemes - Ricalde et al., 2003; Kalanzi et al., 2015; Mujuni et al., 2012). This system is very similar to the one developed by small beekeepers with a low technological level in Morelos in Mexico (Vélez - Izquierdo et al., 2016) and the traditional system in Veracruz (Mexico) described by Castellanos - Potenciano et al., (2015). Other similar systems have been described in Serbia (Marinkovic and Nedic, 2019), Croatia (Cvitkovic et al. 2009), Ethiopia (Kumsa and Takele, 2014) or India (Agrawal, 2014).

The low barriers to entry and the low need for capital favor the expansion of this type of beekeeping (Travadelo et al., 2012). In Argentina, in addition, it has been incentivized through apicultural development plans, with the aim of absorbing surplus labor from other sectors of the economy (Crisanti et al., 2009). This process is transforming beekeeping into a micro-enterprise format, characterized by low levels of production and productivity. In La Pampa this system concentrates 55% of the farms, although they produce less than 7% of the honey. In Serbia, 98% of beekeepers produce 60% of honey (Marinkovic and Nedic, 2019). Similar results have been described in other regions of Ibero-America (eg Mexico, Contreras - Escareño et al., 2013; Chile, Leal - Méndez, 2012; Ecuador, Marín - Palma, 2017).

The main characteristic of this type of system is its low productivity. In La Pampa it was 7.9 kg of honey per hive, comparable to the 6.64 kg of Saudi Arabia (Adgaba et al., 2014), 9.5 of Ethiopia (Kumsa and Takale, 2014) or 8.5 of India Agrawal (2014). Low productivity is mainly related to a low technological and managerial level (Rege et al., 2001). This can be seen in the level of investment and spending on independent professional services, which mainly corresponds to technicians and advisers. In addition, most farms practice a fixed beekeeping. According to Freitas et al. (2004), beekeeping productivity depends mainly on management technologies, which are related to better beekeeping management and farm organization. The reduced profit
margin and the small scale make difficult to access to the financial and technological markets (Freitas et al., 2004; Güemes et al., 2003). Furthermore, under the subsistence logic, it is very difficult to carry out investments that commit the producer in the long term, such as technological ones (Rangel et al., 2017). When subsistence logic changes and technological or management improvements are introduced, small systems can achieve yields comparable to large apiculture farms. For example, small farms in Turkey or Ethiopia, when improved, obtain an average of 22 and 23 kg of honey per hive, respectively (Saner et al., 2004; Kumsa and Takale, 2014).

Productivity is also conditioned by the reduced use of external inputs, which is common in subsistence systems (Oosting et al., 2014). This can be seen in the low level of variable cost and in the reduced expenditure on food or health.

Subsistence beekeeping is socially relevant for its contribution to employment and income in rural areas (Magaña et al., 2007). In this context, the work performed by the family in the production unit does not increase the level of costs for the beekeeper (Perea et al., 2014). Consequently, the number of hives can increase or decrease until all the surplus family labor is saturated. However, there is a threshold beyond which it is necessary to increase technology to increase the number of hives per worker. In La Pampa, as in Mexico, when the technological level is low, it is estimated at around 80 - 90 hives (Vélez - Izquierdo et al., 2016). In this regard, there are important differences between producing areas. For example, in Saudi Arabia the average number of hives exceeds 351 while in Ethiopia this system operates from 10 to 140 hives (Adgaba et al., 2014; Kumsa and Takale, 2014).

The low productivity and the limited number of hives explain why the economic performance is negative. The small scale has a large negative impact, especially on fixed costs (Ramírez - Angulo et al., 2010). This can be seen, for example, in amortizations. Despite being a low investment system, the small size makes investment and amortization per hive triple and double, on average, that of the industrial and commercial systems. The low income per hive is due to its low productivity and the sale price is set by the export market, where the pampas beekeeping does not exert any type of influence. Although the economic performance is negative, under the logic of subsistence there are benefits. This is because the beekeeper does not account for depreciation or compensation for family labor as an expense (Perea et al., 2014).

According to Güemes et al. (2003), this system will continue to be relevant as long as there are no better employment alternatives in other sectors of the economy. Changes in surplus labor will cause the level of production and the number of farms to increase or decrease. However, in order for these production units to continue in the long term, they have to increase the level of production to a scale that allows them to generate economic advantages (Klaesson, 2001). The growth in the number of hives must be accompanied by technological improvements, especially in the management and advisory area (Rege et al., 2001). In other words, they must abandon the logic of subsistence and change the production system.

The system furthest from subsistence beekeeping is industrial beekeeping. This type of beekeeping is hardly mentioned in the literature, probably because there are
few production units that follow it in each region. However, they are very important because they concentrate most of the production and have a clear export vocation. In Argentina, it is the system that dominates exports and sometimes plays a relevant role as a honey gatherer from other production units (Mogni et al., 2008; Estrada, 2015).

Industrial beekeeping in La Pampa concentrates 54% of production in 15% of farms. These are large farms that have few restrictions in financial markets and in access to technology. Consequently, there are important advantages derived from scale and technological level. This is seen in different aspects of the system; for example, in the reduced expense on amortization and investment per hive compared to the high investment of the system. Another advantage derived from technology is that it increases work efficiency. Industrial beekeeping multiplies by six the number of hives that each worker manages, and by fifteen the honey that each worker produces, compared to the subsistence system. The work efficiency exceeds 500 hives that Ulmer et al. (2011) indicated as optimal in Santa Fe.

Productivity per hive increases with respect to the subsistence system and is similar to the commercial system, which derives from better management and beekeeping technology, but not from a greater use of external inputs. Productivity is comparable to that obtained by small beekeepers in Turkey (Saner et al. 2004) the large beekeepers with an intermediate technological level in Morelos (Vélez-Izquierdo et al., 2016), although lower than the commercial system in Veracruz (Castellanos - Potential et al. 2015) and, in general, the average of the large apicultural regions (Contreras et al., 2013). This is explained, in addition to the edaphoclimatic differences, by a reduced use of external inputs and food compared to other apicultural regions (García-Girou, 2002).

The reduced use of external inputs is a characteristic feature of the three beekeeping systems of La Pampa and has to do with the high price of raw materials and the availability of long, honey-quality blooms. Production units tend to use part of the flowering to maintain and reproduce the hives, as opposed to the strategy of optimizing the bee population with external food before flowering (García-Girou, 2002). The strategy followed in La Pampa reduces the productivity of the hives but increases the performance of the workforce by simplifying management. Low productivity is attempted to compensate by increasing the number of hives, which in turn is favored by a greater availability of labor. This is clearly seen in the industrial system when compared to the more competitive systems described in Mexico. The Veracruz commercial system needs 440 hives to produce 12,716 kg of honey; while the industrial system of La Pampa produces more than double but needs more than three times as many hives (Castellanos - Empowerment et al., 2015). However, the yield per worker in the La Pampa industrial system triples that of the Veracruz commercial system.

Industrial beekeeping is the system with the highest economic returns, which is mainly related to a more competitive scale. Commercial beekeeping also obtains a positive economic performance, although of lesser value due to the smaller average size of the production units. The main difference is that it operates on a smaller and
less competitive scale. This is seen above all in that the work performance is half that obtained by the industrial system and is also related to a lower technological level. This system also has similarities with the one developed by large beekeepers with an intermediate technological level in Morelos de México (Vélez-Izquierdo et al. 2016).

According to Bragulat et al. (2018), although the production system conditions the different productive and economic returns, it is not the only factor that explains them. There will be types of beekeeping that facilitate the success of the activity, and others that make it difficult or even impossible to achieve acceptable yields. In this sense, the way in which one intervenes in industrial and commercial beekeeping is the manager’s task and will strongly condition the final success of the operation. Decisions regarding which aspects should be intervened, how, at what time and with what technology, are specific to each production unit. These kinds of questions should also be subject to analysis.

Conclusions

Beekeeping in La Pampa is generally an economic complement or a subsistence activity, with low productivity, heterogeneous and low use of inputs. Three types of beekeeping have been identified, which are mainly differentiated by the yield and size of the production unit: Subsistence beekeeping groups. They are 55% of the production units and are mainly characterized by being very small in size and obtaining low productive and economic returns. It is a socially relevant system for its contribution to family employment and income in rural areas. The low productivity and the limited number of hives explain a low economic performance. This system will remain relevant as long as there are no better employment alternatives in other sectors of the economy. Industrial beekeeping concentrates 54% of production in 15% of farms, which are mainly characterized by their large size and high productive and economic yields. It is the system with the highest economic returns, which is mainly related to a more competitive scale. Commercial beekeeping groups are 30% of the production units and are mainly characterized by high productivity with intermediate farm sizes.

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