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Organization and grouping as a key axis to design attention schemes for goat farmers in northern Mexico: Case study

La organización y agrupación como eje toral para el diseño de esquemas de atención a caprinocultores en el norte de México: Estudio de caso

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ABSTRACT

The present study aimed to organize and group goat farmers with similar socioeconomic and technological profiles to design targeted attention schemes according to their needs. The study consisted of two phases: As for the first phase, the socioeconomic and productive profile of the producers were stratified and characterized. In the second phase, goat producers' perceptions were considered to carry out the main problems and limitations of the production system. The data were analyzed through Multiple Correspondence Analysis. As a result, five groups of producers were identified: G1 with the highest milk production d^{-1} ($p=0.03$), the highest number of hectares susceptible to cultivation, and with the hectares sown ($p<0.0001$); G2 with the highest educational level ($p=0.0002$); G3 compounded by elder people ($p<0.0001$), with a great number of children ($p<0.0001$), and without a difference in commercialization price; G4 compounded by elder people ($p=0.0001$) with inactivity time ($p=0.0011$), and, G5 with the highest number of children ($p=0.0001$), the highest flock size ($p=0.03$) with more hours dedicated to grazing ($p=0.02$). The analysis of Principal Components indicated, that, PC 1 and PC 2, presented the highest proportion of the variation (46.55%). Additionally, producers reported the main problems that limit their productivity. The stratification and grouping of goat farmers based on their similarities allowed defining critical points of attention, in such a way that strengthening policies towards these marginalized groups will easily fulfill their mission.

Keywords: goat farmers, organization, grouping, common problems and strategic actions.

RESUMEN

El objetivo del presente estudio, fue organizar y agrupar caprinocultores con perfiles socioeconómicos y tecnológicos similares, con la finalidad de diseñar esquemas de atención dirigida y acorde a sus necesidades. El estudio constó de dos fases: En la primera se estratificó, delimitó y caracterizó el perfil socioeconómico y productivo de los caprinocultores. La segunda fase se realizó considerando la percepción de los productores hacia los principales problemas y limitantes del sistema de producción. Se realizó un análisis de correspondencia múltiple. Se identificaron 5 grupos de productores. G1 presenta la mayor producción de leche d^{-1} ($p=0.03$), el mayor número de hectáreas susceptibles a cultivo y hectáreas sembradas ($p<0.0001$). G2 posee el mayor nivel educativo ($p=0.0002$). G3 presenta mayor edad ($p<0.0001$), mayor número de hijos ($p<0.0001$) y precio de comercialización (sin diferencia). G4 tiene la mayor edad ($p=0.0001$) y tiempo en la actividad ($p=0.0011$), y G5 mayor número de hijos ($p=0.0001$), tamaño de rebaño ($p=0.03$) y horas dedicadas al pastoreo ($p=0.02$). El análisis de componentes principales indicó que los CP 1 y CP 2 presentan el 46.55% de la variación. Los

productores refirieron los principales problemas que limitan la productividad. La estratificación y agrupación de productores basados en sus similitudes permite definir claramente puntos críticos de atención, de tal manera que las políticas de fortalecimiento hacia estos grupos marginados cumplirán más fácilmente su cometido.

Palabras Clave: caprinocultores, organización, agrupación, problemáticas comunes y acciones estratégicas.

INTRODUCTION

For any country, agricultural companies play a very important role, since they are economic units that provide food for the population ([García-Pérez, 2017](#)). In this sense, the agricultural company combines knowledge, information, natural, human and capital resources to produce goods of animal or vegetable origin; or services for a target market and within a profitable and sustainable operation (Guerra, 1998). However, many of these agricultural companies are small or medium-sized and regardless of their productive profile. They are characterized by having limited natural resources and by constantly presenting a capital deficit to optimize production activities and little or no administration ([Balestri et al., 2001](#)). Therefore, [Aguilar et al. \(2016\)](#), point out that the improvement within these companies and regardless of the size of the production unit, will occur when a professional administration is started, since it is when the evolution of administrative theories to improve profitability will be considered of the companies.

On the other hand, the production of small ruminants is very important in livestock around the world, specifically dairy products of goat origin, which have an important social impact in extremely poor areas ([Dubeuf, 2005](#); [Escareño et al., 2012](#); [Salinas-González et al., 2015](#)), and in certain regions they are of great interest because they are a sustainable and very profitable resource ([Sanz et al., 2003](#)), since their production derives the production of food, they contribute to the employment and economic stability, generate additional value in the production units and facilitate the use of marginal lands ([Escareño et al., 2011](#)); but they have the limitation that they are administered directly or indirectly by the producer (Cofré, 2001) and most of the time, they lack experience in administration.

In Mexico, goat farming represents an activity that supports almost 1.5 million people and is associated with strata of the rural population with lower incomes, since it represents the livelihood for 80% of subsistence producers and takes place mainly in arid regions and semi-arid; which correspond to 60% of the national territory, where pasturelands with limited natural resources and areas with a high degree of marginalization abound ([Guerrero-Cruz, 2010](#); [SAGARPA, 2007](#)). Likewise, it is known that goat milk production represents an important source of employment for families in rural areas, since it offers job stability ([Escareño et al., 2011](#)).

In this sense, Lagunera district, in northern Mexico, is considered the main goat milk production basin. However, it has been documented that although it is the main milk-producing region, there is still low productivity; mainly due to the lack of production records, no organization of producers for the production, processing and/or commercialization of milk and lack of information and technical assistance; which results in a low technological level so that, as long as it is not visualized as a company,

it is difficult for goat activity to prosper as a business ([Maldonado-Jáquez et al., 2018](#)) and will continue to be only a subsistence activity. However, different research efforts have been made, but these have not had a sufficient impact on the innovation of production systems ([Salinas-González et al., 2016](#)), mainly due to the lack of technologies adapted to the conditions and characteristics of each producer.

Therefore, in the search for solutions to the problem presented by the producers of the Lagunera district, [Gómez \(2007\)](#), the organization is suggested as an alternative to improve the profitability of the activity, since within a cooperating group and The organized organization would not be totally dependent on intermediaries, the price of milk could be negotiated and participatory processes would be optimized in which to find areas of opportunity for innovation and efficiency in the use of producer resources ([Salinas-González et al., 2011](#)).

Therefore, the objective of this study was to characterize and group producers with similar socioeconomic and technological profiles in the northeast portion of the Lagunera district, in Coahuila state, Mexico; in order to design programs and strategic actions for research, innovation, technology transfer and/or training, according to their needs, This allows improving the production system, under the assumption that by transitioning to cooperative forms of production and commercialization, the adoption of technologies will increase and, consequently, the profitability of companies.

MATERIAL AND METHODS

The research was developed in the northeast portion of the Lagunera district, in Coahuila state, which includes the municipalities of Francisco I. Madero, San Pedro de las Colonias and Matamoros. The climate for the municipalities of Francisco I. Madero and San Pedro de las Colonias is a semi-warm dry subtype and the climate for the municipality of Matamoros is very dry and warm. The average annual temperature is between 20 and 24 °C, with average annual rainfall between 200 and 400 mm ([INAFED, 2010](#)).

Producers from the Cooperative for Productive Reconversion La Laguna, S.C. were taken as a case study by R.L. de C.V. recently formed (2016); which brings together 32 producers, after 14 common lands were visited and more than 300 goat farmers from the study area were invited.

The study consisted of two phases. In the first, the 32 producers belonging to the Productive Reconversion Cooperative were interviewed, which is dedicated to the production of goat milk in the aforementioned municipalities. This study was carried out in order to stratify and characterize the socioeconomic and productive profile of the producers. Data collection was carried out through direct interviews and visits to the production units. In this study, the methods of observation, direct interview and life histories were used to gather and document information on the production and marketing chain of goat milk ([Hernández-Sampieri et al., 2006](#)).

The questionnaire was developed based on the review of specialized literature and diagnostic surveys, proposed by SAGARPA (2015). The interview was organized in 13 blocks, where 44 ordinal and nominal variables were considered. The information obtained was captured in an Excel program matrix, and later the data were analyzed by means of a multiple correspondence analysis; which was carried out using the statistical packages InfoStat ([Balzarini et al., 2008](#)) and SPSS, adapting the methodology described by [Bernal-García et al. \(2003\)](#), [Carrasco-González \(2004\)](#) and [Castel et al. \(2003\)](#), in the multivariate statistical analysis.

For the multiple correspondence analysis, hard variables of socioeconomic, production and marketing characteristics were chosen; which were considered as quality variables, according to previous studies carried out by [Salinas-González et al. \(2016\)](#), [Escareño et al. \(2011\)](#) and [Castel et al. \(2003\)](#). Among those that were considered: age, education of the producer, economic dependents and family members, time dedicated to the activity, size of the herd, hours dedicated to grazing, milk production and price, among others; which were taken as the basis in the descriptive analysis of Clusters by Hierarchical Grouping (HGA), Principal Components (PCA) and Multiple Correspondence (MCA).

For this case, this type of analysis was considered, since it decreases the covariance range given by the over-parameterization, when the number of characteristics is very large; it reduces the dimensionality of the correlated characteristics and generates a reduced number of variables. Subsequently, to perform the grouping, we start from a distance matrix, containing all the distances between pairs of objects and are grouped considering the minimum distance ([Peña-Malavera et al., 2010](#); [Agudelo-Gómez et al., 2015](#)).

The second phase of the study included participatory workshops, where the previously interviewed producers were presented with the results of the surveys applied in the first phase. The workshops were intended for producers to formulate the main problems and limitations of the production system, as well as proposals for solutions. For this, the qualitative study technique Focus Group was used ([Santiago and Roussos, 2010](#)). This methodology is a data collection technique that uses a semi-structured group survey, directed towards a specific topic and of which the existing knowledge is inadequate or is very complex to make inferences without considering the user or interest group ([Escobar and Bonilla-Jiménez, 2009](#)).

The results obtained were classified and grouped according to the highest frequency, and starting from here, a problem tree was elaborated to help identify the main problems and their solution, through root causes and effects ([Hernández-Hernández and Garnica-González, 2015](#)); where in the strategic deployment, the main problem became the strategic objective and the root causes in the strategic actions to be implemented; this was done for the producers of each cluster found.

RESULTS AND DISCUSSION

Producer groups, even those organized as is the case of the recently formed Cooperative, are made up of individuals and production units of various characteristics. By grouping the members of the subjects of technological intervention, assertive strategies can be formulated, either for the management of innovation or the basic activities of technology transfer and training. The results found show sufficient differences between subgroups (conglomerates), for which specific strategies are presented to be implemented within the cooperative, according to the subgroup of participants. Likewise, the design and implementation of certain strategic actions within the development plan of the Cooperative are discussed.

Descriptive variables

Table 1 shows the descriptive variables, in general, of the producers for this region. In this regard, the literature that describes the characteristics of goat farmers in the Lagunera district is limited, and research has focused mainly on characterizing the productivity of goats ([Torres-Hernández et al., 2016](#)). This is where the importance of describing this component of the production system lies. It was found that the ages found for goat farmers in the region are lower than those reported by [Salinas-González et al. \(2016\)](#), in a neighboring region to that of this study (southwest of the state of Coahuila). In addition, regarding the schooling found, this is similar to that reported by [Alva-Pérez et al. \(2018\)](#) and [Chipasha et al. \(2017\)](#), for producers from the Tamaulipeco Altiplano in Mexico and the Choma district in Zambia.

Table 1. Descriptive variables of goat farmers from the northeast of the Lagunera district in northern Mexico

Variable	Mean $\pm$ S.D.
Age (years)	50.31 $\pm$ 14.98
Schooling (Years)	1.47 $\pm$ 1.05
Number of children	2.94 $\pm$ 1.81
Number of dependents	3.47 $\pm$ 1.78
Years at home	29.16 $\pm$ 19.64
Years in activity	27.38 $\pm$ 16.52
Number of goats	84.53 $\pm$ 39.44
Number of male goat	2.03 $\pm$ 1.15
Hours of grazing (h/day)	7.44 $\pm$ 2.66
Liters of milk (L/animal/day)	1.49 $\pm$ 0.61
Price per liter of milk *	0.24 $\pm$ 0.03
Total hectares	2.47 $\pm$ 3.03
Hectares sown	1.13 $\pm$ 1.87

S.D. = Standard deviation. * Price per exchange rate of \$ 1.00 US dollars for \$ 19.49 MXN as of May 8, 2019).

On the other hand, the time living in the same address is called rootedness, and it speaks of the permanence of the producers in the study locations; The years in the activity refer to the experience that the producers have, which can be considered to

describe some important characteristics in the production system; for example, the adoption of technologies and innovations by producers. In this regard, [Alva-Pérez et al., \(2018\)](#); [Chipasha et al. \(2017\)](#) and [Fonseka et al. \(2018a\)](#), indicate an average of 10, 9.2 and 10 years in the activity of the producers of Tamaulipas, Mexico, Zambia and Sri Lanka, respectively; which is less than the time in the activity of the producers of this study.

As for the productive variables, the information on herd size, milk production and hours spent grazing can be used as productivity indicators. In this regard, the production data reported by the producers in this study is higher than that reported in other studies in neighboring regions. [Maldonado-Jáquez et al. \(2018\)](#), indicate an average production in local goats from the southwest of the state of Coahuila, Mexico, within the Lagunera district, of the order of 938 g. animal⁻¹ day⁻¹. Likewise, the price per liter of milk at which producers normally sell is the main factor of incidence on the profitability of the activity. Finally, land tenure, as well as the total number of hectares they own and the number of hectares they sow, is indicative of the possibility of producing or not producing fodder or other crops that they could use, either to feed livestock or to obtain extra income and complete the family income. In this sense, [Mendoza-Jiménez](#) and [Ortega-Sánchez, \(2009\)](#), report that although 100% of the producers belong to the extensive production system, they sell their products; Mainly meat, in neighboring towns at prices imposed by the collector; very similar to the results of our study, which indicates that marketing is a problem that not only affects producers in the north of the country.

Principal component analysis

The PCA (table 2) indicated that PC 1 and 2 explain the highest proportion of the variation (28.51 and 18.04%, respectively). In this regard, PC 1 is characterized by considering socioeconomic and production aspects, and includes the following variables ordered by importance: age and education of the producer, years in goat activity (experience), liters of milk per goat⁻¹ day⁻¹, hectares of land sown and it is positively associated with age (0.8592) and years in goat activity (0.6502); but it is also negatively associated with education (-0.7613), liters of milk per goat⁻¹ day⁻¹ (-0.6432) and planted hectares (-0.5204). Therefore, PC 1 represents older producers, with more years in goat activity, with less education, with less milk production and with less cultivated area.

PC 2 includes only the variable number of goats. The rest of the components are associated to a lesser extent with the variables studied. Therefore, these two components were the only ones included in the MCA. In this regard, the composition of PC 1 and PC 2 adequately reference the characteristics of goat farmers in the extensive Mexican system, specifically for arid and semi-arid areas in the north of the country, since goat farming is the only activity that generates income and food for families in marginalized areas ([Barrera-Perales et al., 2018](#)).

Table 2. Cumulative proportion of the variation in the Principal Component Analysis for the grouping of components considered in the Multiple Correspondence Analysis

Component	Eigenvalue	Difference	Proportion variation	of Cumulative proportion
1	2.8508	1.0468	0.2851	0.3
2	1.8039	0.6132	0.1804	0.5
3	1.1907	0.1345	0.1191	0.6
4	1.0562	0.1988	0.1056	0.7
5	0.8574	0.1361	0.0857	0.8
6	0.7214	0.1721	0.0721	0.8
7	0.5493	0.0814	0.0549	0.9
8	0.4679	0.1477	0.0468	0.9
9	0.3202	0.1382	0.0320	1.0
10	0.1820		0.0182	1.0

Clusters by Hierarchical Grouping

Figure 1 shows the formation of the clusters (groups), as well as the distances between them. The analysis located the producers that contained some type of similarity in clusters, synthesizing and taking advantage of the available information, and resulting in a set of information grouped according to their hierarchical level and in which 5 groups of clusters were defined.

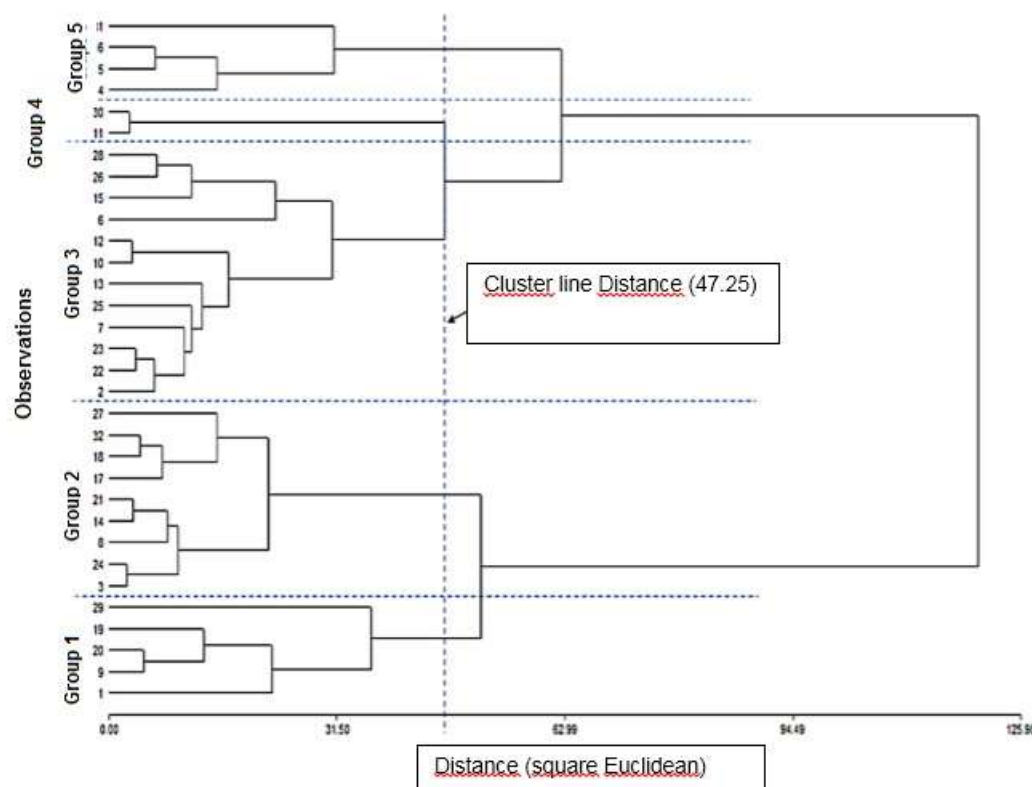


Figure 1. Dendrogram of the hierarchical cluster analysis by the Ward method

Multiple Correspondence Analysis

In figure 2, the interactions between the PCA and HGA results are shown; PC 1 and PC 2 were taken as factors, since they are the ones with the highest variance in the collection of the data set and variables (0.2851 and 0.1804 respectively; Table 2). Here it can see the results of the profile for the producers of each group and considering that a very low percentage of the producers have received some type of training, this will serve to establish the guidelines to follow for the implementation of technology transfer schemes, as well as well as innovation and research in each group.

Regarding the interactions observed in figure 2, the producers of group 1 are characterized by having the highest milk production in liters per day, total area and sown area; which shows an area of opportunity in the improvement of productive aspects, but also a considerable window of opportunity in terms of socioeconomic aspects.

On the other hand, group 2 producers have the highest educational level, which can be considered as an opportunity area for a greater incorporation of technologies in technical-productive aspects. The above coincides with the report by [Hundal et al. \(2016\)](#), where they indicate that producers with a certain degree of training improve their knowledge of the activity significantly faster than other producers. Group 3 producers present a window of opportunity in productive aspects, in addition to being one of the oldest groups and obtaining the highest price per liter of milk. Therefore, in this group it would be relatively easy to apply a technology transfer program, since they lack training in all the links of the production chain. In this regard, [Chipasha et al. \(2017\)](#), group producers, that have few production skills, little access to the market and infrastructure and a high incidence of diseases, and point out them as the group with the greatest production limitations and perfectly defined areas for improvement.

Regarding the producers of group 4, these are characterized by being of advanced age, having the largest number of dependents, more experience in goat activity and greater roots in the locality. On the other hand, the producers that comprise group 5 have a greater number of children, a greater number of goats and male goats, with more hours devoted to grazing; so they are mostly related to productive aspects, but the number of children is also included; which can be considered as an advantage to establish some technology transfer scheme, since they can have access to a greater amount of labor, compared to the rest of the groups.

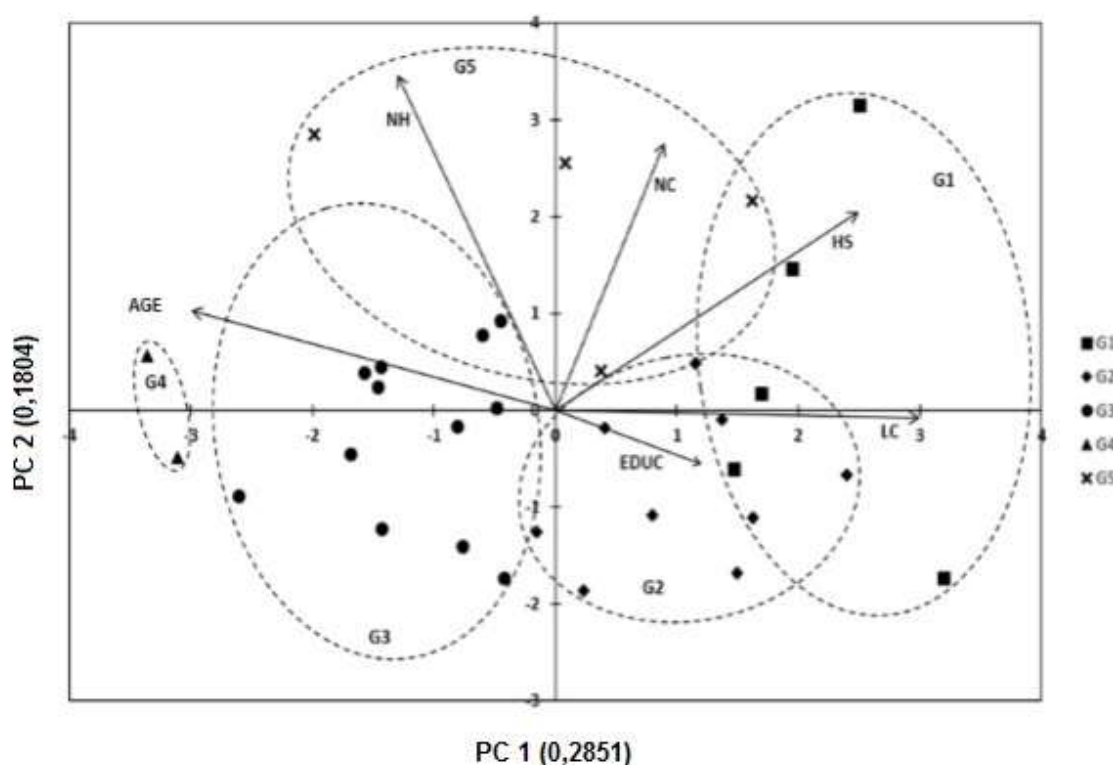


Figure 2. Set of PC 1 and PC 2 where they are integrated as factors. NH = Number of children; NC = Number of goats; HS = Hectares sown; LC = liters of goat milk⁻¹ day⁻¹; EDUC = Schooling; G1, G2, G3, G4 and G5 = Groups resulting from the HGA analysis

Descriptive Statistics Analysis by Conglomerate Group

Table 3 shows the differences between the means of the variables among the 5 clusters. Group 1 refers to having the highest milk production d-1 ($p = 0.03$), the highest number of total hectares and planted hectares ($p < 0.0001$). Group 2 has the highest educational level ($p = 0.0002$) and an outstanding characteristic of this group is that the majority (57%) of the head of the family is female; This information differs from the report by [Alva-Pérez et al. \(2018\)](#), since for the Tamaulipeco highlands in Mexico, only 4% of the production units are managed by women. In turn, group 3 is one of the oldest groups ($p < 0.0001$), the highest number of children ($p < 0.0001$) and the highest marketing price (without statistical difference between groups); group 4 presents the oldest age ($p = 0.0001$), and experience in goat activity ($p = 0.0011$). Finally, group 5 has an older age ($p < 0.0001$), a greater number of children ($p = 0.0001$), a greater number of goats and male goats ($p = 0.03$) and more hours spent grazing ($p = 0.02$). On the other hand, the common characteristics between the groups include that between 50 and 100% of the producers supplement their income, either through other jobs, pensions or support from family members (these support are remittances sent by family members living in the United States mainly). In this regard, [Kumar et al. \(2015\)](#), point out that 51% of producers in western Uttar Pradesh, India, obtain their income solely from the sale of milk, and the rest of the producers complement their income with some complementary activity. Four of the 5 groups claim to have Creole animals, and only one group has crossbred animals of the Nubian and Alpine races. In this regard, [Montaldo et al. \(2010\)](#) point out that the producers own goats that they call

criollas (creoles); however, this designation is now accepted as local goats. In this sense, studies such as those by [Maldonado-Jáquez et al. \(2018\)](#) and [Fonseka et al. \(2018b\)](#), point out that most producers own local goats in northern Mexico and Sri-Lanka, respectively. Producers do not keep production records and those who do keep records, only do so partially, since only pregnant goats and abortions are recorded. Therefore, to improve the characteristics of the innovation processes, constant motivation and information must be used to increase the adoption of registry systems among goat farmers ([Okkyla et al., 2014](#)).

Table 3. Mean $\pm$ standard deviation of the variables used in the PCA for the group of goat farmers from the northeast of the Lagunera district, in Coahuila state

Variable	Group 1 (n= 5)	Group 2 (n= 9)	Group 3 (n= 10)	Group 4 (n= 4)	Group 5 (n= 4)	p Value
Age	36.4 $\pm$ 5.0 ^b	36.1 $\pm$ 8.2 ^b	59.6 $\pm$ 6.9 ^a	76 $\pm$ 8.5 ^a	59 $\pm$ 9.8 ^a	<.0001
Scholarship	2 $\pm$ 0.7 ^{ab}	2.4 $\pm$ 0.5 ^a	0.9 $\pm$ 0.9 ^{bc}	0 ^c	1 $\pm$ 0.8 ^{bc}	0.0002
Number of children	1.6 $\pm$ 1.1 ^b	2.1 $\pm$ 1.1 ^b	3.8 $\pm$ 1.1 ^a	0 ^b	5.5 $\pm$ 1.7 ^a	<.0001
Number of dependents	3.6 $\pm$ 3.5	3.1 $\pm$ 1.1	3.6 $\pm$ 1.6	4.5 $\pm$ 0.7	3.3 $\pm$ 1.5	0.8973
Years in activity	21.4 $\pm$ 8.9 ^b	18.3 $\pm$ 9.8 ^b	29.8 $\pm$ 16.2 ^b	66.5 $\pm$ 9.2 ^a	28.3 $\pm$ 11.2 ^b	0.0011
Number of goats	107.8 $\pm$ 40.4	74.2 $\pm$ 31.4	69.9 $\pm$ 35.9	74.5 $\pm$ 13.4	127.5 $\pm$ 43.5	0.0511
Number of male goat	2.8 $\pm$ 0.8 ^{ab}	2 $\pm$ 1 ^{ab}	1.4 $\pm$ 0.7 ^b	1.5 $\pm$ 0.7 ^{ab}	3.3 $\pm$ 1.9 ^a	0.0198
Grazing hours	7.6 $\pm$ 2.2 ^b	8 $\pm$ 2.2 ^b	6.1 $\pm$ 2.5 ^b	6 ^b	10.8 $\pm$ 2.5 ^a	0.0236
Liters of goat milk ⁻¹	2.0 $\pm$ 0.5 ^a	1.6 $\pm$ 0.5 ^{ab}	1.4 $\pm$ 0.6 ^{ab}	0.5 ^b	1.5 $\pm$ 0.4 ^{ab}	0.0308
Price per liter of milk *	0.2 $\pm$ 0.1	0.2 $\pm$ 0.1	0.3 $\pm$ 0.1	0.2 $\pm$ 0.1	0.2 $\pm$ 0.1	0.3205
Total hectares	5.1 $\pm$ 3.0 ^a	0.3 $\pm$ 0.5 ^b	2 $\pm$ 3.1 ^{ab}	4.5 $\pm$ 0.7 ^{ab}	4.4 $\pm$ 3.8 ^{ab}	0.0155
Hectares sown	4.7 $\pm$ 2.2 ^a	0.2 $\pm$ 0.4 ^b	0.3 $\pm$ 0.5 ^b	0.5 $\pm$ 0.7 ^b	1.4 $\pm$ 1.1 ^b	<.0001
Years at current address	26.4 $\pm$ 14.7	19.7 $\pm$ 14.3	32.6 $\pm$ 22.3	55 $\pm$ 21.2	30.8 $\pm$ 20.2	0.1936

S.D. = Standard Deviation. ^{abc}Different literals between lines indicate differences (p <0.05). * Price per exchange rate of \$ 1.00 US dollars for \$ 19.49 MXN as of May 8, 2019)

Producers spend between 6 and 10 hours grazing per day; and milk production ranges between 500 and 2000 gr, which is sold between \$ 0.21 and \$ 0.26 Dollars / liter. Most producers do not store food for critical feeding times, they do not have technical assistance, most of them have not been trained; only a low percentage have received some type of training (8 to 11%) and have learned to make cheeses, sweets, chorizo, among others. In this regard, [Alva-Pérez et al. \(2018\)](#), point out that goat farmers from Tamaulipas, Mexico, spend around 7 hours grazing and the goats produce 680 ml of milk per day, which partially coincides with our results. [Sandhu et al. \(2018\)](#), point out that 65% of producers in Punjab, India, do not conserve forage. [Hassan et al. \(2016\)](#),

report that low-income producers have inadequate knowledge about the prevention and treatment of diseases, which is why they require technical assistance. Similarly, [Vatta et al. \(2010\)](#), point out that constant training provides the opportunity to facilitate the acquisition of skills to small goat farmers.

Main Limitations

Regarding the results obtained in the workshop carried out with the producers previously interviewed, in Table 4, an extract of the general problem tree is presented, and where the perception of the producers about the main limitations to production is focused on three problems: 1. Risk of reducing milk production due to lack of food; 2. Loss of interest in the activity by future generations; and 3. Risk in milk production due to deficiency in animal health management which, if not resolved, would put the productivity of the entire milk production system at risk, and consequently the main source of income for many families in the Lagunera district. In this regard, these results are similar to those found with the report by [Raja et al. \(2018\)](#), where goat farmers from India indicate limitations similar to those found in this study. On the other hand, [Hassan et al. \(2016\)](#) point out that one of the main concerns of goat farmers in Bangladesh focuses on the health status of farms. This information suggests that the problems faced by goat producers in arid and semi-arid areas of the world are similar. However, for the design of a strategic plan appropriate to the circumstances of the producers, it is necessary that the strategic objectives and actions are in accordance with the root causes of their problems, and the most important response variables.

Table 4. Main problems affecting the goat production system according to the perspective of producers in the northwestern portion of the Lagunera district of Coahuila Region, in northern Mexico.

Main problem	Causes	Effects
High milk production at risk due to nutritional deficit and a genetic improvement plan	Lack of production records	
	Lack of a genetic improvement strategy	Purchase of replacement animals from third parties
		Lack of crossbreeding schemes
		Effects on crops due to climate change
	Instability and dependence on food in growing areas	Deficit in forage production
		Overgrazing
		Few resources to supplement livestock
		Production reduction due to not offering a supplement after grazing

		Lack of knowledge about value-added products	There is no innovation in creating new products
		Older Producers	Price per liter of milk established by the intermediary
Loss of interest in goat activity by new generations and limited market options due to lack of attention to milk quality	Lack of vision as a family business and migration to new business models	Sale of milk as the only source of income	Low milk production
		It is required to supplement income with other sources of employment	Lack of human resources
		Lack of investment in the activity	The main source of income is compromised
		Low quality goat milk	No access to new markets
		Lack of specific areas to milk	
		Lack of proper post-milking milk handling	
Main source of income compromised by poor management of animal health	Limited financial resources for animal health care	Little or no veterinary medical assistance	High incidence of abortions
		Scarce resources for health programs	Herd reduction
	Lack of resources to improve infrastructure	Sick animals are not separated	Low milk productivity

Source: self made

Strategies for the development of producers

Goat farming is an important option for the maintenance of low-income rural producers, and it is the main livestock economic activity in the desert and semi-desert areas of Mexico (Alva-Pérez *et al.*, 2018); Therefore, Table 5 shows the strategies suggested to promote the development of producers, which are proposed based on the results obtained in the YMCA (Figure 1), the MCA (Figure 2), and the analysis of cause- effect of the problem tree (Table 4). For each group or conglomerate of producers within the Cooperative, a strategic objective and actions to be implemented are proposed to solve the main problem of each conglomerate (table 5). Likewise, each objective and strategic action was designed according to the perspective and variables to be improved according to the specificities of the group of producers in each conglomerate. Therefore, within the strategic plan, innovation, training and / or technology transfer actions were defined; which are the product of the demand of the producers themselves and are complemented by previous experiences reported in the scientific literature.

This information coincides with the existing literature for small producers in Mexico. In this regard, [Cárdenas-Bejarano et al. \(2016\)](#), point out that the rate of adoption of technologies increases as producers organize; since there is a better flow of information within the groups and they indicate that to better understand the technology adoption processes, it is necessary to consider the analysis of the structure of the group to which they belong; as well as the existing interrelationships without forgetting the socioeconomic context. On the other hand, some other authors refer some suggestions and/or recommendations to solve problems similar to those found in the groups of producers in this study; For example, there are reports ([Tanwar et al., 2011](#); [Fonseka et al., 2018b](#)), which suggest developing food conservation schemes and conservation of outstanding genetic material through selection, as well as the interaction between the different actors of the production chain to facilitate the flow of market information and the development of infrastructure that improves the marketing system for goat milk ([Chipasha et al., 2017](#)); o the training of members and organization to improve the productivity and health of the production units ([Hundal et al., 2016](#); [Kumar et al., 2015](#); [Sandhu et al., 2018](#)); as well as access to credit and extension services as triggers for the success of companies dedicated to the production of goats ([Ifeanyichukwe et al., 2018](#)). Furthermore, if one considers what [Barrera-Perales et al. \(2018\)](#), some aspects that play in favor of the Mexican semi-arid producers, is that the use of exclusively family labor, low technological level, limited infrastructure and dependence on the pasture; They are factors that contribute to the profitability and continuity of the production units, since large investments are not required to operate, and this in turn helps to alleviate the limiting effects of the current production system.

Table 5. Strategic actions for the development of producers by conglomerate for innovation management

Group	Description	Main problem	Objective	Specific Problems (Root Causes)	Strategic Actions
1	> milk production (2.4 L / day); > sup. cultivation (4.7 ha); > # of goats (107 / UP); Transition to semi-extensive system	High production of goat milk at risk due to nutritional deficit	Asegurar la alta producción de leche de cabra	a. High production of goat milk at risk due to nutritional deficit b. Lack of goat genetic improvement	Innovation and training in the conservation of crop residues. Selection of goats with the highest production
2	> Academic degree; 56% of female heads of household; Milk production (1.56 L / goat); Young people I want to study university; Sale of goat's milk contributes: livestock support, home support, education	a. Loss of interest in goat activity by new generations b. Ensure crop production.	a. Promote interest in goat farming to new generations. b. Management of resources to finance and protect crops.	a. Lack of vision of the family business model. b. Lack of added value to milk. c. Lack of safety in goat milk production	Development of new business models and implementation of good milking and milk handling practices.

3	Milk production (1.38 L / day); 75% of the goats have had an abortion; 75% of producers do not have veterinary assistance; New generations interested in goat production	Main source of income compromised by animal health and lack of good goat milking practices	Manage financial support and consulting alliances with veterinary universities	Limited financial resources for the care of animal health and improvement of confinement pens. Lack of personal hygiene during milking.	Management of resources to finance and improve the infrastructure of the pens. Strategic alliance with institutions to improve the health of herds
4	Low production (0.5 L / goat); Low price per liter of milk (\$ 0.20 Dlls / L); Without family integration; Older age of the producer (76 years).	Low production of goat milk due to lack of food and support staff	Manage alliances with other herds in the cooperative.	a. Over-exploitation of grazing lands. b. Clean water supply is not guaranteed. Food deficit	Define cooperation contracts with other producers. Integration of older producers in training in action
5	Average production 1.5 L / goat of milk per day. Greater number of goats (125) per herd. Greater number of children. Extensive system 10 hours grazing a day. They depend on mesquite to supplement the feeding of the herd.	Goat milk production at risk due to lack of food and own land	Management of resources to finance and improve the infrastructure of the pens.	They rent farmland. Only 50% of the producers have food against contingencies.	Conservation of crop residues. Preparation of nutritional blocks. Conservation of mesquite pods

CONCLUSIONS

The results found suggest that rigorously delimiting and discriminating producers according to their similarities, as well as the identification of limitations in the goat production system, from the producers' point of view, allows them to be stratified and grouped so that they can be clearly identified the critical points of attention for the establishment of research, innovation and technology transfer schemes, according to their reality. This will allow in the immediate future that the definition of strategies and public policies to strengthen goat production systems, both intensive and extensive in the arid and semi-arid zones of Mexico, have an efficient impact; and goat farming in the north of our country is consolidated as an activity that generates jobs in marginal areas.

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