


Socioeconomic aspects, feeding, and health status of sheep flocks in the Metropolitan Area of the Toluca Valley



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Abstract:

The research aimed to characterize the sheep farming systems of the Metropolitan Area of the Toluca Valley, State of Mexico, through indicators of social and economic aspects, general farm data, feeding-supplementation, and present diseases. A survey was conducted in 2024 with 37 sheep farmers. The information obtained from the sheep production units (SPUs) was initially used to carry out a discriminant analysis and then a hierarchical cluster analysis, forming four groups that allowed the identification of descriptive statistical means of homogeneity within the groups and differentiation among them: group 1: Technified semi-confined flocks, group 2: Traditional semi-confined flocks, group 3: Transitional semi-confined flocks, and group 4: Low-stratum confined flocks. The SPUs that stand out are those with better health and nutritional conditions, as well as sheep farmers with extensive experience in sheep farming. Likewise, the participation of women stands out, who use health, productive, reproductive, and economic records. Also, there are SPUs with less experience and limited management of the confinement, which implies a greater investment with lower profitability. The generation of information and knowledge about the practices implemented in the SPUs, along with the ways to improve them, can lead to their rational, sustainable, and efficient use of resources.

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In Mexico, according to the latest report from the Agrifood and Fisheries Information Service in 2023⁽¹⁾, the sheep inventory is made up of 8'805,206 head, of which 15 % is concentrated in the State of Mexico. The primary objective of sheep farming is meat production; at the national level, its most important form of consumption (95 %) is as barbacoa⁽²⁾.

The State of Mexico is one of the most important sheep-producing states, along with Hidalgo and Veracruz⁽²⁾. Sheep farmers differ from one another across regions, entities, and even within their own localities⁽³⁾; therefore, the support and management provided to each of them must be according to their needs and characteristics.

A minority of sheep farmers adopt what it is now known as management indices regarding good practices and innovations, which likely results in low production and reproductive levels⁽⁴⁾.

This research aimed to characterize the sheep farming systems of the State of Mexico, specifically in the Metropolitan Area of the Toluca Valley. Indicators covering the following dimensions were designed: social and economic aspects, general farm data, feeding and supplementation of sheep, and diseases they present.

The research was conducted in the Metropolitan Area of the Toluca Valley, State of Mexico, which is one of the most important urban centers in the country, made up of 16 municipalities and settled in the central part of the entity with a territorial area of 2,410.5 km²; it is made up of the municipalities of Almoloya de Juárez, Calimaya, Chapultepec, Lerma, Metepec, Mexicaltzingo, Ocoyoacac, Oztolotepec, Rayón, San Antonio la Isla, San Mateo Atenco, Temoaya, Tenango del Valle, Toluca, Xonacatlán, and Zinacantepec⁽⁵⁾.

The information from the sheep production units (SPUs) was collected through interviews with 37 sheep farmers who participated in the study, and was initially obtained through the Mexican Information Access System (SAIMEX, by its Spanish acronym), which is an electronic means through which requests for public information are made and review appeals are filed; SAIMEX provided a list of 50 sheep farmers within the sampling frame, who were distributed in 8 of the 12 municipalities that comprise this area (Almoloya de Juárez, Lerma, Oztolotepec, Rayón, Temoaya, Tenango del Valle, Toluca, and Zinacantepec); this is because

there are no records of sheep farmers in all the municipalities that make up this area. An intention-based participation survey was conducted with sheep farmers, and the SPUs and municipalities were incorporated based on our knowledge of the area or recommendations from a previous unit. All elements of the population were equally likely to be part of the random sample.

The characterization of sheep farmers was carried out through a specially designed non-probabilistic survey. The survey technique is widely used as a research procedure, as it allows data to be obtained and processed quickly and efficiently⁽⁶⁾. The topics considered in the survey were as follows: socioeconomic profile, land tenure profile, data on facilities and equipment, management practices, feeding and supplementation, agronomic and health practices, livestock inventory, and animal welfare.

To achieve the study objective and based on 21 qualitative and quantitative variables that were included in the survey (after a discriminant analysis). Subsequently, a multivariate analysis was performed using Principal Components (PC) for factor extraction, along with the calculation of the Kaiser-Mayer-Olkin (KMO) index and Bartlett's test of sphericity, which allowed to measure the correlation between variables (Table 1). Those variables with a commonality ($h \leq 0.9$) were excluded from the analysis factor, and those selected with eigenvalues ≥ 1 was included. For a better understanding of the components obtained, an orthogonal rotation method (Varimax) was carried out; consequently, the scores of the factors in the analysis were estimated using the regression method. Finally, the hierarchical cluster analysis was carried out, which aims to integrate by similarities, which allows to describe the units. The distance used was the square Euclidean as a measure of similarity and agglomeration, which was carried out by Ward's method. All analyses were performed using the statistical software JMP 17.0 from SAS (SAS Institute INC., 2022).

The grouping consisted of four clusters (CL) that integrated the 37 SPUs, finding that all sheep farmers obtain less than 50 % of their total income from sheep farming. The purpose of the SPUs is to produce meat. Sex, average age of sheep farmers, level of education, municipalities to which each producer belongs, social and economic aspects, general farm data, facilities, and equipment were identified. The clusters allowed to obtain the descriptive statistical means of the homogeneity of the groups (cohesion), their management, feeding and supplementation practices, health practices, and average livestock inventory. Table 1 presents the variables that enabled the greatest differentiation between the clusters formed.

The general characteristics of the population according to its social and economic aspects showed that, of the 12 municipalities sampled, 66.7 % belonged to the Metropolitan Area of the Toluca Valley, and men manage 86.5 % of the SPUs; their experience in sheep farming ranges from 0 (zero) to 50 yr, and their range of sheep per unit goes from 20 to 72. These

SPUs practice shearing, where the producer himself predominantly carries it out or hires specialized labor. Generally, the feed is based on corn grain, corn stover, and mineral salts, with some variability in other ingredients integrated into the animals' diet.

Table 1: Characterization of sheep farmers by cluster

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Indicators
Sheep production units, n	8	6	18	5	
Municipalities	Almoloya de Juárez Rayón Villa Victoria Zinacantepec	Amanalco Almoloya de Juárez	Villa Victoria Amanalco Almoloya de Juárez Atacomulco Zinacantepec Temoaya Toluca Lerma Tenango del Valle	Atacomulco Ixtlahuaca Zinacantepec Otzolotepec	Social and economic aspects
Sex	Men 100 %	Men 67 % Women 33 %	Men 89 % Women 11 %	Men 80 % Women 20 %	
Years of experience in sheep farming	15 to 50	20 to 50	1 to 20	0 to 5	
Average number of sheep	72	20	61	25	
Productive records	Yes	Yes	No	No	
Health records	Yes	Yes	No	No	
Economic records	No	Yes	No	No	
Average number of lambs	60	12	20	20	
Antiseptics in caudectomy	They apply them	They do not apply them	They do not apply them	They do not apply them	General information about the farm
Hoof trimming	They perform it	They do not perform it	They do not perform it	They do not perform it	
Oats	No	Yes	No	No	
Wheat bran	Yes	No	No	No	

Soybean bran	Yes	No	No	No	Feeding and supplementation
Hours of grazing per day, h	4 to 7	More than 7	1 to 4	No grazing	
Grazing in communal areas	No	Yes	No	No	
Lactation supplementation	Yes	No	No	No	
Supplementation in fattening	Yes	No	No	No	
Abortions, %	30	0	55	0	Diseases
Difficult births, %	75	16	50	0	
Tympany, %	0	0	22	20	

The characteristics with the greatest differences between the four clusters are presented.

Cluster 1. It is composed of 8 SPUs, which represent 21.6 % of the total surveyed; they are located in the municipalities of Almoloya de Juárez, Rayón, Villa Victoria, and Zinacantepec. Regarding socioeconomic aspects, 100 % of these SPUs are managed by men, with an average age of 57 yr and an educational level ranging from elementary school to junior high school. The SPUs originated from the family nucleus; that is, the production unit was inherited by the father, grandfather, etc.; the producers had between 15 and 50 yr of experience in sheep farming; their flocks have an average of 72 head (made up of rams, adult ewes, and lambs).

The production system used is semi-confinement, as in clusters 2 and 3. The property regime is ejido with an area ranging from 1 to 10 ha, in which space is allocated for sheep grazing.

Regarding management, they use ear tags for identification, primarily for adult sheep. They generally perform creep feeding. For productive control, they occasionally keep records of lambed ewes, live-born lambs, dead lambs from birth to weaning, dead adults, birth weight, weaning weight, weaning days, weight at the beginning of fattening, weight at the end of fattening, as well as sanitary records as preventive control medicine for the application of bacterin, dewormers, vitamins, and selenium.

In terms of health management, these SPUs have an average of 60 lambs, and 100 % of them undergo caudectomy, which is performed when they are between 2 and 14 d old on average, using an emasculator or rubber rings, and then applying an antiseptic. Hoof trimming is carried out on approximately 25 % of the total population of their adult ewes only when they consider it necessary; the sheep farmers that make up this cluster are the only ones who carry out hoof trimming; this is relevant because foot diseases are among the most important causes of elimination in a sheep production unit⁽⁷⁾.

The feed offered to their flocks is based on corn grain, corn stover, wheat bran, soybean bran, and mineral salts. Supplementation is provided to lactating ewes and fattening lambs, which improves the health and nutritional conditions of the flock.

The diseases that occur in these SPUs, which sheep farmers mentioned in the survey, are abortions with 30 %, diarrhea 62 %, foot rot 37 %, caseous lymphadenitis 37 %, clinical and subclinical mastitis 50 %, respiratory problems or pneumonia 75 %, oestrosis 12 %, gastrointestinal parasitosis 50 %, a high percentage of difficult births 75 %, keratoconjunctivitis 25 %, and placental retention 12 %.

This cluster had the highest rate of difficult births; the most frequent causes of dystocia are an inadequate relationship between the size of the pelvic canal and the size of the fetus, and the presence of hypocalcemia; nevertheless, it may also be due to the presence of twins, fetal malformations, dead fetuses, alterations in fetal static, and primary and secondary uterine inertia, among others⁽⁸⁾.

The sheep farmers who comprise this cluster are those with the largest number of sheep and many years of experience in sheep farming; likewise, they carry out sanitary and feeding management, which was not reported in the other three clusters. Having sheep farmers with knowledge in management undoubtedly improves the productive efficiency of the flock, resulting in greater meat production, which leads to increased profitability of the establishments and consequent stability of the sheep production systems⁽⁹⁾.

Cluster 2. It is composed of 6 SPUs (16.2 %), located in the municipalities of Amanalco and Almoloya de Juárez; in terms of their socioeconomic aspects, these flocks are managed 67 % by men and 33 % by women, with an average age of 62 yr and an educational level of elementary education.

According to the census carried out between 2021 and 2022 by the National Institute of Statistics and Geography⁽¹⁰⁾, 9 out of every 100 people responsible for agricultural production units are women, and about a fifth lacked education; 30.1 % of family members who worked in agricultural production units and who did not receive a salary or wage are women, which coincides with what was found in this cluster.

The SPUs, established by the producers themselves who have 20 to 50 yr of experience in sheep farming, have flocks with an average of 20 head (including rams, adult ewes, and lambs).

For management, ear tags are used for identification, primarily for adult sheep; however, they do not have an identification method for their lambs, but they do perform creep feeding.

These SPUs indicated that they do not keep reproductive records, but they do keep productive, sanitary, and economic records, equal to the productive and sanitary records kept in cluster 1, but adding economic records, such as feeding expenses per ingredient (cost/kilogram), investment in preventive medicine (purchase of bacterin, dewormers, selenium, vitamins, antibiotics, or some other type of medication that will be needed), profits from animals sold live.

The feed offered in these SPUs, in addition to corn grain and corn stover, is forage oats, corn silage, and mineral salts. Regarding grazing management, the flock goes out to pastures in

communal areas or rented land intended for this activity 365 d a year, staying there for more than 7 h a day; this applies to both adults and lambs; they also have access to natural shade (trees) on these lands.

As preventive medicine, bacterin and selenium are applied to the lambs, and dewormers and vitamins are provided to the entire flock. Among the diseases with the highest presence in these SPUs, which were cited in the surveys, were diarrhea (50 %), caseous lymphadenitis (16 %), clinical and subclinical mastitis (33 %), respiratory problems or pneumonia (66 %), oestrosis (16 %), paratuberculosis (16 %), difficult births (16 %), and keratoconjunctivitis (16 %).

Cluster 3. It is made up of the largest number of sheep farmers (18 SPUs, 48.7 %), located in the municipalities of Victoria, Amanalco, Almoloya de Juárez, Atlacomulco, Zinacantepec, Temoaya, Toluca, Lerma, and Tenango del Valle. Eighty-nine percent of these SPUs are managed by men, and 11 % by women, which is one of their main socioeconomic aspects, with an average age of 54 yr and an educational level of elementary or junior high school. These SPUs are of family origin, with 1 to 20 yr of experience in sheep farming; their flocks have an average of 61 sheep (including rams, adult ewes, and lambs).

As for management, they use ear tags for identification, primarily for adult sheep. They carry out creep feeding until the weaning of their lambs, which can range from 3 to 5 mo. They do not keep any kind of records or control; they only count live-born lambs. As preventive medicine, they administer bacterins, dewormers, vitamins, and selenium.

The feed offered to their flocks in pens is based solely on corn grain, ears of corn, corn stover, and mineral salts.

The sheep in these SPUs go out to graze on pastures 365 d a year, for between 1 and 4 h, which applies to both adults and lambs; nevertheless, in these grazing areas, the sheep do not have access to natural shade (trees) or artificial shade (roofs).

The most commonly occurring diseases reported in the survey by sheep farmers in these SPUs were abortions with 55 %, diarrhea 61 %, foot rot 33 %, caseous lymphadenitis 33 %, clinical and subclinical mastitis 38 %, respiratory problems and/or pneumonia with a high percentage of 72 %, oestrosis 11 %, gastrointestinal parasitosis 44 %, paratuberculosis 11 %, difficult births 50 %, keratoconjunctivitis 55 %, placental retention 16 %, and tympany 22 %.

The sheep farmers that made up this cluster had a high rate of abortions compared to the other three; this is because reaching the diagnosis of an abortion episode in the sheep species

has almost the same difficulties as in cattle, where it is difficult to have a sample suitable for proper laboratory processing⁽¹¹⁾ and treat the cause of the high numbers of abortions.

Cluster 4. It is made up of five production units (13.5 %), located in the municipalities of Atlacomulco, Ixtlahuaca, Zinacantepec, and Oztolotepec; regarding their socioeconomic aspects, 80 % of these flocks are managed by men and 20 % by women, with an average age of 45 yr and with an educational level of junior high school, high school, or bachelor's degree. Their production units were established again by each producer, with zero experience in sheep farming or 5 yr at most; their flocks have an average of 25 sheep (including rams, adult ewes, and lambs).

Only family members collaborate on sheep-related activities; the system used is confinement, so their sheep do not graze, and their diet is based solely on what is offered by the sheep farmers in the pen.

The sheep farmers that make up this cluster, unlike the previous three, do not consider sheep farming as a source of income. They do not use any identification method for their sheep, both adults and lambs. The flock's feed is based on corn grain, corn stover, and mineral salts. As preventive medicine, they administer selenium and vitamins.

Among the most prevalent diseases in these SPUs reported in the surveys were diarrhea with 60 %, caseous lymphadenitis 20 %, clinical and subclinical mastitis 40 %, respiratory problems or pneumonia 60 %, parasitosis 60 %, keratoconjunctivitis 40 %, and tympany 20 %. Tympany can occur in grazing or confined animals, being an important cause of death⁽¹²⁾.

It is concluded that the identification of groups of sheep flocks used with the cluster methodology allowed to broadly characterize the range of SPUs present in the Metropolitan Area of the Toluca Valley, which were defined by their own characteristics, mainly based on the social and economic aspects, sheep feeding, and diseases with greater incidence, among other aspects. There were units with better animal welfare due to the presence of better health and nutritional conditions, associated with sheep farmers who had extensive experience in sheep farming. The participation of women in a group that utilizes health, productive, reproductive, and economic records stood out, which is a practice uncommon among sheep farmers in the State of Mexico. Likewise, it was identified that in group 4, there were limited actions regarding sheep farming and less experience, which is reflected in their management; also, it was found that a deficient confinement of the animals prevails in the SPUs, significantly decreasing their profitability. The integration of flocks in clusters, based on the aspects considered in this study, is an alternative to characterize the productive structures in the sheep sector of different regions or countries.

Acknowledgements and conflicts of interest

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