



Family sheep production systems in the Mixteca region of Oaxaca, Mexico



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Abstract:

Family sheep production is common in rural Mexico. It is an important element of subsistence systems in these areas but is generally rustic. Better understanding of rustic sheep production is a first step in developing strategies and programs to support family producers. Family sheep production units in two municipalities in the Mixteca region of Oaxaca, Mexico, were characterized in terms of production system, market access and land use. A mixed methodology was applied, employing a structured questionnaire addressing socioeconomic and productive variables, and participatory observation in 29 family sheep producers. All the surveyed producers see sheep farming as their main income source. Most (86 %) use a subsistence system, and all use family labor. The main feeding strategy was grazing of communal land, and production was largely intended for sale of live animals to intermediaries or in local markets for eventual processing for meat, and/or for self-use. Most (83 %) of the production units included a pen built from regional materials, and these pens were most frequently on the family property. Implementation of management plans and animal health and safety measures were minimal. Analysis of these productive systems

identified how producers manage sheep production. Management strategies respond to the environmental services available on communal lands, and involve family-type production which fulfills economic, social, environmental and cultural functions, but provides low productivity. Unit productivity and producer livelihood could be improved by implementing measures such as pasture rotation and adopting technological innovations. Broadening producer access to government programs and creating public policy that promotes development in marginal rural areas could greatly improve productivity and consequently reduce poverty and food insecurity.

Key words: Family production, Sheep Production, Small producers, Mixteca.

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Introduction

Mexico has a sheep population of 8.9 million⁽¹⁾. Sheep farming occurs in different regions throughout the country and production systems respond to local resource availability and market conditions. Production unit scale is influenced by socioeconomic conditions, land access, and input and technology availability. Extensive, subsistence family production units (FPU) are the most common but are largely limited to valleys, hills and mountains in rural areas⁽²⁾. Improving management practices in FPU in marginal agricultural zones can provide environmental, socioeconomic and/or nutritional benefits⁽³⁾. Though considered production systems, FPU are also a way of life, a structure of social relationships and an element of identity in peasant cultures⁽⁴⁾.

Most (63.4 %) subsistence UPFs are in the states of Mexico, Oaxaca, Guerrero, Puebla, Chiapas, Veracruz, Hidalgo and Michoacán; 52.0 % of these are in highly marginalized areas and 16.4 % in extremely marginalized areas⁽⁵⁾. Of the thirty-two states in Mexico, Oaxaca is among the five poorest, with 61.7 % of its population living below the poverty line⁽⁶⁾. It is also has the sixth largest sheep population in the country, most of which are produced in subsistence FPU in the Mixteca and Central Valleys regions⁽⁷⁾. A majority (78 %) of the state's highly and extremely marginalized municipalities are in the Mixteca region, and 77.4 % of the population in this region lives in rural, small and dispersed localities; the main economic activities are seasonal agriculture and small ruminant production⁽⁸⁾. Small livestock production based on extensive grazing and communal work has been present in the

region since 1530, and is still widely used⁽⁹⁾. Small ruminants are an integral element in regional culinary tradition, and a vital contribution to the peasant economy since their production is low-cost and they provide multiple benefits^(10,11).

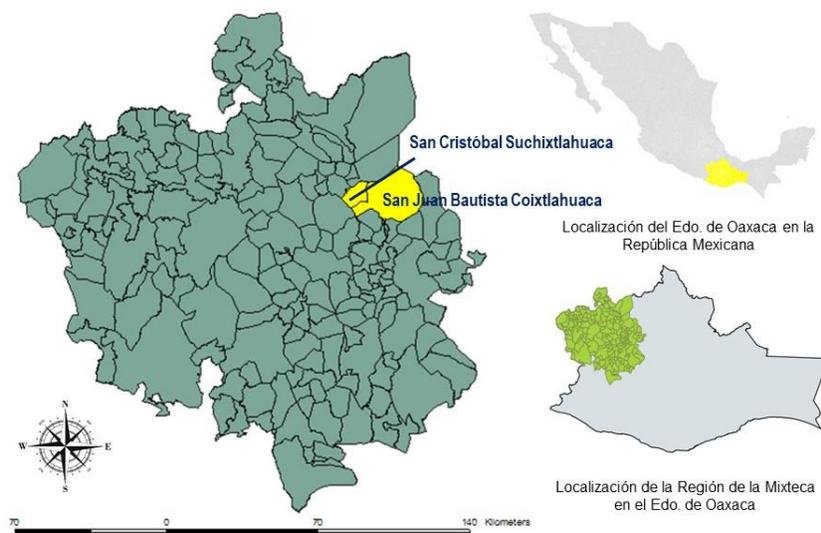
Traditional production systems of this kind help to mitigate poverty by promoting food sovereignty and security, and generating employment in agriculture, in addition to contributing to environmental, climate and cultural sustainability in rural areas⁽¹²⁾. However, FPU's face myriad challenges such as technological, social, economic, environmental and political changes (e.g., globalization). Given their precarious economic situation, small rural producers can be acutely affected and experience technological regression in production systems⁽¹³⁾. The large livestock population in Oaxaca's Mixteca region provides very low production value; for example, the current \$59.74 kg average regional price for sheep is much lower than the \$76.34 kg national average^(7,14).

Rural production systems in Mexico are extremely heterogeneous. They must adapt to varying availabilities of different natural, human and financial resources, and inconsistent and unequal access to institutions and markets. Strategies intended to promote and strengthen small family livestock production must encompass this heterogeneity to generate policies differentiated by producer type that are not overly generalized in scope⁽¹³⁾. Tailoring policy design to meet the needs of specific production systems requires identification of their particular characteristics, including their scale, management practices and territory. Strategies can then be designed and implemented based on PU type and resources, which also allow for their analysis, promote organization and social actor participation, and result in differentiated policies that help to develop marginalized rural areas. The present study objective was to analyze sheep FPU's in the municipalities of Suchixtlahuaca and Coixtlahuaca in the Mixteca region of Oaxaca, Mexico.

Material and methods

The study was carried out in the municipalities of Coixtlahuaca (17°38' and 17°49' N, 97°09' and 97°25' W; altitude 2,000 to 2,900 m asl) and Suchixtlahuaca (17°43' and 17°72' N, 97°22' and 97°36'; altitude 2,000 to 2,900 m asl) in the Mixtec region of Oaxaca (Figure 1). Both municipalities have a temperate sub-humid climate with summer rains, a 15.6 °C average annual temperature and 500 to 1,000 mm annual rainfall^(15,16).

Figure 1: Study area. San Juan Bautista Coixtlahuaca and San Cristóbal Suchixtlahuaca, Mixteca region, Oaxaca, Mexico



Scale 1:250000. Political boundaries as of 2012⁽¹⁷⁾.

Vegetation cover is limited in both municipalities, and includes oak, juniper, savin and cacti, as well as shrubs used as sheep forage such as *Leucaena leucocephala*, *Vachellia farnesiana*, *Prosopis laevigata* and *Morus* spp. This is partially due to the region's low rainfall and consequent semi-arid hydrogeography. Just north of the town of Suchixtlahuaca is the Rio Grande and to the south is the Rio de la Cruz, both of which are seasonal⁽¹⁵⁾. La Culebra river, the main drainage in Coixtlahuaca, is predominantly seasonal⁽¹⁶⁾.

The population of Coixtlahuaca largely considers itself indigenous (64.72 %) and is highly marginalized in socioeconomic terms. In Suchixtlahuaca, most (65.59 %) of the population considers itself indigenous and experiences moderate marginalization⁽¹⁷⁾.

From August 2017 to February 2018, a mixed methodology was used to study sheep producers using a FPU system in these populations. Since the number of production units and their locations were not known, a non-probabilistic (a.k.a. snowball) sampling method was applied⁽¹⁸⁾, resulting in a sample of 29 producers.

Data on population socioeconomic parameters and sheep producer systems was collected using a questionnaire structured in two sections:

1) Socioeconomic data. Items addressed the variables of gender, age, education level, years of experience in the activity, main source of herd management technical knowledge, nature of production unit, land tenure, production system type and main economic activity.

2) Production system data. Items addressed the variables of livestock inventory, breed, zotechnical purpose, production purpose, food strategy, infrastructure, health management, access to government programs and production diversification.

Questionnaire data was supported and triangulated through participatory observation from the participating sheep producers.

Family sheep production systems were classified into three categories based on market access and production system^(19,20):

a) Subsistence. Sheep diet is based on grazing grasses and legumes in rangeland. During the dry season, animals are fed stubble and straw harvested in the rainy season, in addition to sporadic supplements of salt and minerals; health and safety management is commonly poor. These systems have a holding pen. The animals represent savings for the producer, and are occasionally sold. The subsistence system also encompasses sheep production units (SPUs) in which animals remain in a holding pen all day and are fed stubble and poor quality straw.

b) Transition. Sheep are fed by grazing in extensively managed paddocks with supplements. Preventive health management is used and producers have market access, although their market articulation is hindered by intermediaries.

c) Consolidated. This intensive system involves two management strategies. One involves stabling animals and feeding with silage, hay, balanced feed and integrated rations. The feeding strategy is adjusted according to animal physiological stage. In the other, animals are intensively grazed in fenced areas on improved forages, commonly supplemented with concentrates. Both strategies employ an animal health calendar and a record system. Producers have access to sufficient feed within their production units and access to local markets. However, this system depends heavily on government support and other income sources for livestock development.

Data analysis was done by descriptive statistics and an analysis of variance (ANOVA) run with the Infostat statistical package. Participant observation data served to triangulate and contextualize the statistical analysis.

Results and discussion

The total analyzed sample of sheep producers was 29, nineteen (66 %) of which were in Coixtlahuaca and ten (34 %) in Suchixtlahuaca. Most (86 %, n= 25) production systems were subsistence and of these fifteen (60 %) were in Coixtlahuaca and ten (40 %) in Suchixtlahuaca. The remaining four systems (14 % of total) were transition systems located in Coixtlahuaca (Table 1). All the analyzed SPUs used family labor.

Table 1: Sheep production systems by municipality

| Production system | Suchixtlahuaca | | Coixtlahuaca | | Total | |
|-------------------|----------------|-----|--------------|----|-------|-----|
| | n | % | n | % | n | % |
| Subsistence | 10 | 100 | 15 | 79 | 25 | 86 |
| Transition | 0 | 0 | 4 | 21 | 4 | 14 |
| Total | 10 | 34 | 19 | 66 | 29 | 100 |

n= number of production units; %= proportion of total.

Socioeconomic data

Average producer age was 55.5 yr. Most (62 %, n= 18) were aged 20 to 59 years and the remainder (38 %, n= 11) were 60 yr or older. This coincides with the average age (52.6 yr) of heads of household reported for small SPUs⁽¹⁹⁾. Although production unit owners were older in age, their children did participate in production activities. However, family participation does not ensure intergenerational continuity. Just because producers' children have learned how to raise sheep and goats is no guarantee that they will continue in the activity once they inherit the production units. This raises the question of how to manage intergenerational turnover in production systems in a manner that maintains them as culturally relevant agroecosystems. Attaining this transition will require livestock breeds that provide economic value, are marketable in the region and beyond, meet local subsistence requirements and contribute to natural resources conservation and/or resilience.

A majority of producers (97 %, n= 28) were men, with just one woman (3 %) in the sample. There are reports of the frequent participation of women in sheep production, particularly in subsistence systems. However, cultural perceptions in the two studied municipalities consider management of land and food production as work too strenuous for women and children; nonetheless, women and children do engage in these activities when men are otherwise occupied.

Education level varied between the subsistence and transition systems evaluated in the present study. Of the producers involved in a subsistence system, 12 % (n= 3) had no formal education, 48 % (n= 12) had an elementary level education, 32 % (n= 8) had a middle school education, and 8 % (n= 2) a high school education. These data are consistent with previous reports of family-managed subsistence-level sheep production systems^(17,18). Among the producers using transition systems, 50 % (n= 2) had a middle school education and 25 % (n= 1) a high school education and professional training. Average education level among the subsistence level producers (6.8 yr) was clearly lower than among the transition system producers (11.7 yr). This supports previous reports that producers with a higher education level tend to employ greater technification in their production systems⁽²⁰⁾. It also coincides with observations that agricultural activity in rural areas in Mexico is largely managed by peasants with low education and specialization levels⁽¹⁰⁾. Indeed, the studied municipalities are highly to moderately marginalized and their populations suffer social deficiencies such as low education levels. Limited access to education prevents rural populations from specializing or acquiring training. This is coupled with their greater dependence on agricultural activities, and the fact that knowledge of productive activities is transferred between family members. No formal education is required since, through social reproduction, they acquire knowledge and understanding of their territory from social interaction and use of tangible and intangible assets.

The average number of years dedicated by producers to sheep farming was 28.1 yr, highlighting the deep-rooted tradition of sheep production in these communities. Among the producers using a subsistence system, average years of experience was 29.5 yr ($\sigma \pm 2.18$), while among those in a transition system it was 19.5 yr ($\sigma \pm 5.45$). One common aspect among all the producers was that they had entered the activity because a relative had already begun it; in other words, they continued their predecessors' efforts, essentially preserving a tradition. They continue the tradition even though production can be hampered by challenges such as health problems and low market prices, among other factors.

Agricultural activities (agriculture and livestock) were the sole economic activity for most (65.5 %, n= 19) of the producers, and sheep production was the principal income source. Slightly more than half (52 %, n= 13) the subsistence producers identified themselves as peasants living off agriculture and livestock, while 20 % (n= 5) perceived themselves as only ranchers, and 24 % (n= 6) as vendors. Among the transition producers, only one (25 %) stated agriculture and livestock to be their main economic activity, while another two (50 %) perceived themselves as vendors (Table 2). This agrees with previous studies observing that small agricultural producers tend to diversify their income strategies, mostly pursuing agriculture, sheep production and sales^(10,21).

Table 2: Main economic activities of sheep producers by production system

| Main occupation | Sheep production system | | | |
|-----------------|-------------------------|----|------------|----|
| | Subsistence | | Transition | |
| | n | % | n | % |
| Farmer/Rancher | 13 | 52 | 1 | 25 |
| Rancher | 5 | 20 | 0 | 0 |
| Construction | 1 | 14 | 0 | 0 |
| Vendor | 6 | 24 | 2 | 50 |
| Teacher | 0 | 0 | 1 | 25 |

n= number of producers; %= proportion of total.

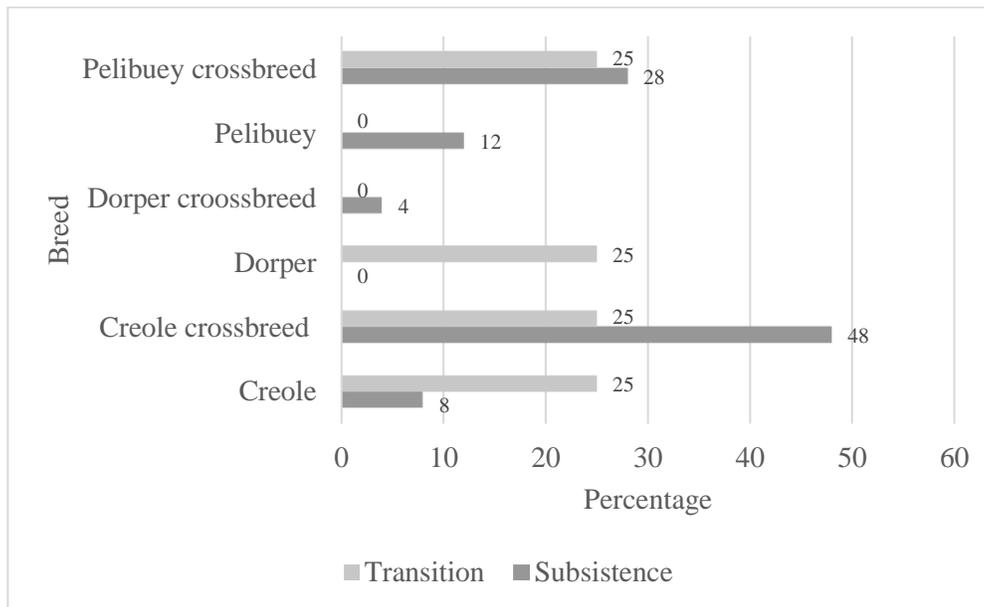
Among the subsistence producers, most (88 %, n= 22) used communal lands and 12 % (n= 3) owned small properties. All (100 %, n= 4) the transition producers used communal lands. These results contradict reports stating that use of small private properties is more widespread in transition and commercial systems⁽²⁰⁾. In the present study, this discrepancy may exist because in the historically agricultural Mixteca region communal land tenure is the primary form of tenure⁽²²⁾. This highlights the fact that the Mixteca region is a socially-constructed, rather than a merely geographic, space within which communal access is allowed on some land resources under certain rules. Therefore, sheep producers can graze their animals in the same area year round, regardless of a pasture's carrying capacity.

Production system data

Total sheep population in all the studied SPUs was 1,222, and average herd size was 42 heads (SD, $s= 43$). At the municipality level, average herd size was 23.58 heads ($\sigma \pm 11.16$) in Coixtlahuaca and 68.50 ($\sigma \pm 12.54$) in Suchixtlahuaca. In the subsistence SPUs, average animal inventory was 50.08 heads ($\sigma \pm 8.10$) and in the transition SPUs it was 15.50 heads ($\sigma \pm 19.83$). An SPU's animal inventory is linked to the production system and the feasibility of implementing technological improvements. Making technological improvements is particularly difficult for small producers since they are generally rudimentary, have only limited infrastructure, experience difficulty in accessing credit and are managed by producers with low education levels. In the present results, the subsistence SPUs had larger inventories, perhaps because they are based on grazing resources available in their natural surroundings, which keeps costs low. In contrast, transition SPUs employ more technology, consequently raising herd management costs.

The SPUs studied here produced sheep for live sale and eventual processing for meat. In the subsistence SPUs, animals were sold in bulk at a price imposed by an intermediary. Animal weight was not considered; perhaps for this reason weight is not recorded in this type of system. In the transition SPUs, average final animal weight for sale was 35 kg. Most (55.1 %, n= 16) of the SPUs used Creole breeds or Creole x commercial breed crosses as their main breed. The subsistence SPUs mostly used Creole breeds or crosses (56 %, n= 14), although many (40 %, n= 10) did use Pelibuey or Pelibuey crosses. Half (50 %, n= 2) the transition SPUs employed Creole animals or Creole crosses, although Pelibuey and Dorper animals were present at one unit each (i.e., 25 %) (Figure 2). Overall, Creole breeds continue to dominate among the studied SPUs, although commercial breeds are increasingly used. Local or Creole breeds may remain popular in the study area because they are adapted to local conditions and therefore conserved by small producers. They form an integral part of sustainable use strategies in which sheep can feed on crops and/or wild vegetation, then provide food and other resources to people⁽²³⁾.

Figure 2: Sheep genotypes in subsistence and transition production systems in Coixtlahuaca and Suchixtlahuaca, Oaxaca, Mexico



All (100 %, n= 29) the SPUs had holding pens and basic livestock infrastructure. Most (83 %, n= 24) of the infrastructure was made from regionally available materials (mesquite and oak wood), and the rest (17 %, n= 5) were made with metal; 40 % (n= 2) of those with metal structures were transition SPUs. Most (60 %) of the producers with metal infrastructure had accessed it via social programs, while the others had repurposed metal elements as a way of keeping down costs. Feeders and drinkers in pens were used in all the transition SPUs, whereas none of the subsistence SPUs had feeders and 76 % (n= 19) had drinkers inside pens.

The lack of drinkers in some of the subsistence SPUs, and feeders in all of them, may be because they are extensive grazing systems in which the animals only spend the night in a pen; producers may feel a feeder or drinker is unnecessary. These results coincide with previous reports of the use of regionally available materials in family-managed SPUs⁽²⁴⁾, which allows producers to exploit natural assets and/or ecosystem services.

Most (88 %, n= 22) of the subsistence producers used grazing as the sole feed source. This occurs from 0800 to 1600 h every day, with the producers leading animals to pasture in the morning and penning them in the afternoon (Table 3). The remaining producers (12 %, n= 3) based feeding on a combination of forage and grain. These same producers have small properties and, lacking extensive grazing land, must feed in pens. All four (100 %) transition SPUs fed in pens. Two (50 %) fed with forage, one (25 %) fed an integrated diet, and another (25 %) used a combination of grazing and an integrated diet. These producers may have more knowledge and technical training as well as economic resources to invest in their production system. The subsistence producers are taking advantage of the surrounding natural environment to lower production costs, but it is also an element of their participation in a regional socio-cultural agroforestry system. Grazing is done on communal lands, which provides substantial cost savings on the main production input, but also requires active participation in the community's social structures.

Regional tree-shrub forages such as *L. leucocephala*, *V. farnesiana*, *P. laevigata* and *Morus* spp. are quite palatable to sheep, but also provide high crude protein content⁽²⁵⁾. When managed rationally using strategies such as rotation, this renewable natural resource can be extremely productive and environmentally stable. The 19 (66 %) subsistence SPUs implemented pasture rotation. However, they did not use technical-productive strategies to manage this rotation, rather they based it on how the animals use the land and the paths the animals graze along; animal load was not considered. Year round grazing of an area or region allows for no prolonged rest period for vegetation renewal and regeneration, decreasing potential animal productivity. Grazing natural vegetation on communal lands can be sustainable and economically viable if ecosystem services are efficiently exploited by applying a grazing plan. This needs to consider the amount of forage provided by the vegetation, the most appropriate animal load to effectively exploit available forage, the most efficient grazing time, the target number of animals to be sold yearly, and herd productive and reproductive events.

Table 3: General characteristics of subsistence and transition sheep production units

| Category | Subsistence | | Transition | | |
|--------------------------------------|---------------------------|----|------------|---|-----|
| | n | % | n | % | |
| Pen | Regional materials | 22 | 88 | 2 | 50 |
| | Metal and other materials | 3 | 12 | 2 | 50 |
| Pen infrastructure | Feeder | 0 | 0 | 4 | 100 |
| | Drinker | 19 | 76 | 4 | 100 |
| Production purpose | Sale | 21 | 84 | 3 | 75 |
| | Self-use | 1 | 4 | 0 | 0 |
| | Sale/self-use | 3 | 12 | 1 | 25 |
| Market | Intermediary | 20 | 80 | 0 | 0 |
| | Local market | 4 | 16 | 4 | 100 |
| | Not sold | 1 | 4 | 0 | 0 |
| Feeding strategy | Integrated diet | 0 | 0 | 1 | 25 |
| | Forage | 0 | 0 | 2 | 50 |
| | Forage/grain | 3 | 12 | 0 | 0 |
| | Grazing | 10 | 40 | 0 | 0 |
| | Grazing/integrated diet | 0 | 0 | 1 | 25 |
| | Grazing/forage/grain | 12 | 48 | 0 | 0 |
| Pasture rotation | Yes | 19 | 76 | 0 | 0 |
| | No | 6 | 24 | 4 | 100 |
| Land tenure | Communal | 22 | 88 | 4 | 100 |
| | Small property | 3 | 12 | 0 | 0 |
| Vaccination | Yes | 0 | 0 | 3 | 75 |
| | No | 25 | 100 | 1 | 25 |
| Deparasitization | Yes | 24 | 96 | 4 | 100 |
| | No | 1 | 4 | 0 | 0 |
| Livestock production diversification | Yes | 22 | 88 | 1 | 25 |
| | No | 3 | 12 | 3 | 75 |

n= number of units, %= proportion of total.

Planned grazing provides ecosystem benefits such as manure, the growth of smaller-sized plant species, and reduction of dry plant material, a potential fuel for fires⁽²⁶⁾. If implemented based on a well-designed plan, exploitation of natural resources by sheep producers can be seen as effective usufruct of communal lands that interweaves their livelihoods. If no plan properly guides this use, it can lead to degradation of vegetation, increased soil erosion, deteriorated soil fertility and structure, and a consequent reduction in forage availability and thus animal productivity.

Among the subsistence SPUs, production was aimed at sale of live animals in most cases (84 %, n= 21), while fewer units (12 %, n= 3) used it for sale of live animals and self-use, and just one (4 %) was only for self-use. Of the four transition SPUs, three (75 %) used production for sale of live animals and one (25 %) for sale of live animals and self-use. These results support previous research indicating that in Mexico small ruminants are widely used for sale and self-use, a dynamic adapted to the rural and culinary culture which includes traditional dishes such as roasted lamb in the Mixteca region of Oaxaca⁽¹¹⁾. Family production units like those in the present study fulfill tangible and intangible functions⁽⁴⁾. Tangible functions include cash generation from sale of animals, food for self-use and in some cases manure which serves as the fertilizer that completes the productive cycle. Intangibles include the roasted sheep which is an integral element in regional food culture since it is prepared for family celebrations and religious festivities, is transmitted and enriched intergenerationally, and forms a part of regional sociocultural dynamics. The family nature of the studied SPUs also has the intangible function of perpetrating a cultural element since grazing occurs on communal land, the traditional production methods are transferred from parents to children and the herd itself represents both the family's livelihood and its continued participation in cultural traditions⁽²⁾. It is essentially a lifeway contained within a territory with its own landscape, natural environment and customs aimed at reproducing the sheep production system and with it regional culture.

Market access differed between the production systems ($P<0.05$). In the subsistence SPUs, most (80 %, n= 20) sold their animals to intermediaries, while only four (16 %) sold them in local markets. All (100 %, n= 4) the transition SPUs sold in local markets (Table 3), where the animals were acquired by intermediaries, roasters, finishers or other producers. The dependence of the subsistence SPUs on intermediaries may be linked to the generally low education level among producers, and their lack of resources, organization and information. This translates into marked inequity in market access, lower prices imposed by intermediaries and low added value. In contrast, the transition SPUs sell directly in the markets and are thus able to command better prices.

Vaccinations were only applied in three (75 %) of the transitions SPUs (Table 3), although infrequently, and the producers were unclear as to what vaccine had been used. Internal deworming was done by all the transition SPUs (100 %, n= 4) and most of the subsistence SPUs (96 %, n= 24). Very few of the producers took additional health care measures such as administering vitamins and minerals. These results coincide with a previous study indicating that family livestock production systems largely lack health and safety measures and receive minimal management. Productivity is consequently low, as is the income generated for producers⁽²⁴⁾.

Only two (6.8 %) of the studied producers (both transition SPUs) had accessed government programs. That all the subsistence SPUs had no access to these programs suggests that low

producer education level may play a role, although other factors also surely come into play, such as insufficient program information and promotion, and a lack of specific programs, differentiated policies, technical assistance, research and targeted financing focused on subsistence producers. The absence of institutional benefits in these two studied municipalities highlights their marginalization.

Diversification of agricultural production was present in most (79 %, n= 23) of the producers. Only one (25 %) of the transition SPUs diversified its production, whereas 22 (88 %) of the subsistence SPUs did so. Poultry for self-use (eggs and/or meat) was used in all (100 %) the diversified SPUs, but pigs (meat), cows (meat, milk, work animals) and horses (work animals) were also raised for self-use (Table 3 and Figure 2).

Conclusions and implications

Sheep farming in the studied municipalities is a largely subsistence activity following a peasant approach in that exploitation focuses on goods and services provided by the land, such as grazing areas and zoogenetic resources. Sheep farming is a livelihood as well as a traditional activity that fulfills socioeconomic, environmental and cultural functions in the region. Limiting factors in the studied production units include advanced age of the producers, their low educational level, their ignorance of and/or minimal participation in government programs, lack of organization and access to efficient marketing channels. In conjunction, these factors substantially lower productivity and profitability of sheep production. Only a small proportion of the production units were in transition, emphasizing the need to promote public policies for development in marginalized rural areas. The guiding axis of these policies needs to be organization and association of small family producers to work towards innovation, technology transfer, and access to financing and local markets. Improving sheep production practices in regions that depend heavily on this activity can be a very effective way of addressing the ongoing issues of poverty and food insecurity.

Conflict of interest

The authors declare no conflict of interest related to the research reported herein or its publication.

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