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REGULAR ARTICLES

Characterization of dairy goat production systems in coastal valleys of the Lima region

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Abstract

Goat farming in Peru is a husbandry activity that, although it is considered secondary in the country, has a great economic and social impact on the rural population, that is why government efforts to develop is so important. The objective of this study was to characterize dairy goat rearing systems in the coastal valleys of the Lima region to identify gaps and opportunities for improvement. This cross-sectional research was conducted in four provinces located in the Lima region, Peru. A total of 62 goat farmers participated in the trial. For data collection, a standard survey was prepared with open and closed questions distributed across two components (socioeconomic and productive). The surveys were processed for qualitative variables using a multiple correspondence analysis (MCA) followed by a hierarchical cluster analysis (HCA) to differentiate the types of farming systems prevalent based on the survey population. The hierarchical cluster analysis resulted in the formation of three separate groups of goat farmers, which can be classified as extensive systems differentiated by management practices and their production and marketing objectives. The test showed a significant difference; therefore, it can be affirmed that they are associated with the groups or clusters formed. These results will allow actors related to goat farming, such as state and regional entities, to focus efforts on addressing specific demands of the different types of goat farmers found in this study.

Keywords Characterization · Production systems · Goats · Coastal valley

Introduction

The goat population in Latin America amount to around 36 million goats, of which seven to eight million are dedicated to dairy production. Countries such as Mexico, Brazil and Argentina are the three countries where the largest number of goats are concentrated, but there is also a significant number of goats in Peru, Bolivia, Venezuela, Colombia and Cuba, most of which are Creole type, a result of the uncontrolled mating of Spanish breeds for 400 years (Sotomaior et al. 2019; FAO 2016).

A large number of goat farmers in Latin America allocate most of their milk production to the production of cheese and artisanal sweets, which are sold in local markets. Lack of access to suitable markets and processing industries, and the disorganization are the main threats affecting goat farming (Sotomaior et al. 2019). In Peru, the Integrated System of Agricultural Statistics [SIEA], 2022, reported a population of 1.774.523 goat heads, with a total of 163.437 goats in the Lima region (9.21% of the total) and a total of 3.704 agricultural units with goat.

This agricultural statistic indicates that goat farming in Peru is a husbandry activity that, although considered secondary in the country, has a great economic and social impact on the rural population due to the number of families that depend on it for their livelihood, that is why government efforts to develop it is so important (Sarria et al. 2014). In the country, goat farming is developed under an extensive grazing system. Three geographical areas of the country are described, mainly in which these extensive systems exist: north coast; west of the Andes and valleys of the central coast (Sarria et al. 2014). In the northern part of Peru, in the Piura region, there has been extensive grazing and regional trade in goat products since the introduction of goats shortly after the Spanish conquest. Goats are raised mainly for the sale of meat, they are bought by intermediaries who process the animals in slaughterhouses in the cities (Perevolotsky 1990; Sarria et al. 2014). In the western Andes, goats feed on native vegetation (grasses, herbaceous plants and

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shrubs) that grow on the slopes of hills and mountains (Sarria et al. 2014). They are family farming systems in which the use of communal lands predominates, as in the Apurímac region (Gomez 2013). While, in the valleys of the central coast, goats graze crop stubble (corn and vegetables in summer; cotton, cassava, asparagus and vegetables in winter), although in some farms, during part of the year, livestock farmers carry out transhumance, which allows them to exploit the natural grasses on the slopes or the vegetation of the hills of the coastal desert that appears during the winter (Arroyo 1998).

Extensive goat farming systems typically demonstrate minimal application of capital and a high reliance on the surrounding conditions and environment, particularly with regard to animal nutrition. This is dictated by seasonal variations in the plants utilized for grazing, leading to periods of surplus and nutrient deficiency. Consequently, practices such as transhumance often partially offset these nutritional shortfalls (Herrera & Luque 2009). There are very few cases of intensive systems that are practiced in the country, these are mainly stabled and owned by private companies, with a higher technological level, with the use of specialized breeds such as the Saanen, oriented towards milk production (Lopez 2021).

To date, few studies have attempted to characterize goat rearing systems in the different ecosystems of Peru. However, at the global level, the multivariate statistical approach is one of the most commonly used techniques for the classification of agricultural systems (pej. goat rearing systems), in which quantitative and qualitative variables were used throughout the statistical analysis to obtain groups and descriptions of farms (Cabrera et al. 2004; Usai et al. 2006; Todde et al. 2016; Kuivanen et al. 2016; Gelasakis et al. 2017; Gökdai et al. 2020; Ouchene-Khelifi et al. 2021).

A commonly used analysis for qualitative variables is the correspondence analysis, which allows to represent the association between levels of categorical variables. Specifically, the multiple correspondence analysis is used to analyze data with two response categories and multiple response categories, and to summarize a set of variables into a set of dimensions, which can then be used in hierarchical classification analysis to group the data into clusters of some homogeneity. Bi-plots play an important role in visualizing the degree of association of variables with dimensions (Khangar & Kamalja 2017).

In Peru, authors such as Temoche et al. (2019), used descriptive statistics and multiple correspondence analysis to characterize the components of the goat production system and its relationship with the producer's perception of climate change in three districts of the Piura region, as well as Sarria et al (2014) characterized farms in the central coastal valley of the district of Cañete, using multivariate analysis. Others such as Gómez (2013) characterized goat farms located in five provinces of the Apurímac region using descriptive statistics and multivariate analysis (multiple correspondence analysis, principal component analysis, average K cluster analysis and discriminant analysis) to examine the relationships between variables and characterize goat farms.

Little updated information is available on goat production systems in the Lima region. Therefore, studies to describe, characterize, and typify this livestock are necessary to diagnose the situation and address farmers' needs. Based on this context, the following study was proposed with the goal of characterize dairy goat rearing systems in the coastal valleys of the Lima region to identify gaps and opportunities for improvement.

Methodology

Study area

The study was conducted in the provinces of Barranca, Canta, Huaral and Huaura; located between the coordinates 10°40′00″S 77°43′00″W and 11°30′S 77°12′W. The surveyed producers belonged to the districts of Aucallama, Huaral, Sayan, Supe, Santa Rosa de Quives and Vegueta (Fig. 1). The study area of the districts evaluated occupies about 380.639 Hectares of surface. The population of the four provinces comprised 26.179 goat heads, as well as 828 agricultural unit breeding goats (CENAGRO 2012). The study area was located between two life zones, the first called Subtropical Desiccated Desert (dd-S) with 1800 m.a.s.l., an average annual temperature between 17.9 °C and 22.2 °C and an average total precipitation per year between 2.2 and 44.0 mm. The second is called Subtropical Superarid Desert (ds-S) with an altitude between 1000 m.a.s.l. The average annual temperature is between 19.8 °C and 20.2 °C and the average total precipitation is between 518.0 and 49.0 mm (INRENA 1995).

Field sampling

The sample size was calculated based on a finite population. A 95% confidence level and a 10% error rate were used in this study. The sample size was distributed based on the number of goat smallholders, according to CENAGRO (2012). The total sample size ($n = 62$) was stratified based on the districts with the largest number of goat farmers, which are considered the most important and representative of the systems found in the Lima region (Table 1).

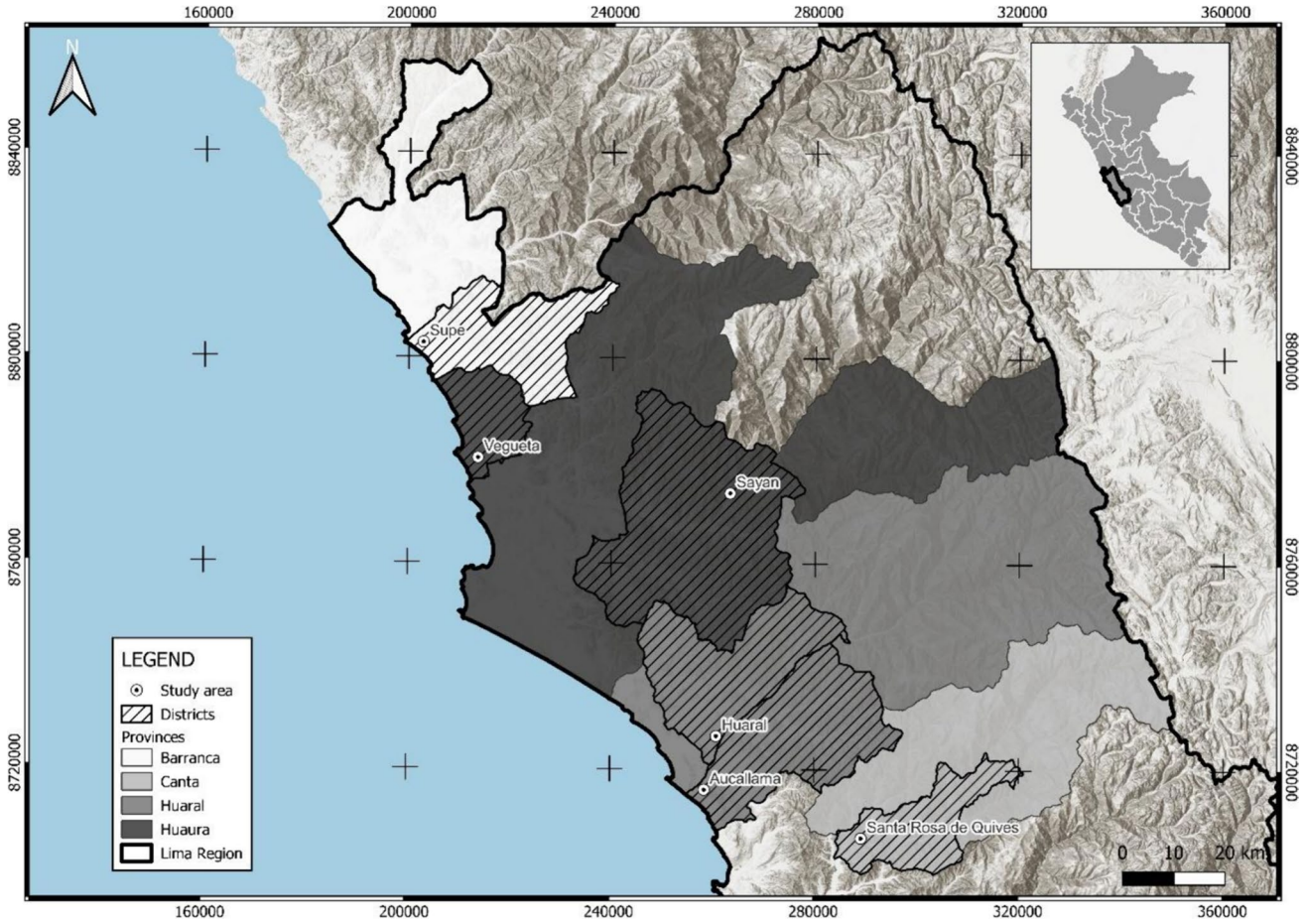

Fig.1 Location map of field sampling zones

Table 1 Stratification of the sample size by district of Lima region

PROVINCES	DISTRICTS	PRODUCERS POPULATION BY DISTRICTS		No OF FARMERS SURVEYED
		N°	%	
Barranca	Supe	48	22.86%	12
Huaral	Huaral	33	15.71%	11
	Aucallama	30	14.29%	8
Huaura	Vegueta	24	11.43%	7
	Sayan	27	12.86%	8
Canta	Santa Rosa de Quives	48	22.86%	16
Subtotal of considered districts		210	100.00%	62

Sampling tools

A standard survey was designed with 71 open and closed questions distributed in two components (socioeconomic or from producer and livestock production system). The questions used were validated with a group of five randomly selected goat farmers from two districts. The data from the validation group were not included in the statistical analysis. This was done to define the modalities of each variable. The collected data were anonymous, as no personally identifiable information was used. The survey was voluntary; therefore, ethical approval was deemed unnecessary. The selection of smallholders for the study was based on convenience and proximity. The farmers were located based on consultations with local authorities and neighbors. The survey was administered to those interested during visits to their pens or homes.

Statistical analysis

A descriptive statistical analysis of the data was carried out to determine the proportions of the modalities and the general characteristics of the goat smallholders surveyed. To establish a herd typology, 16 qualitative variables were selected from the survey that addressed important goat

farming and herd characteristics. A multiple correspondence analysis (MCA) followed by a hierarchical cluster analysis (HCA) was performed to differentiate the types of farming systems prevalent based on the survey population. The information collected through surveys was processed with R Studio 4.2.2. statistical software, using the FactoMineR library (Lê et al. 2008). The qualitative variables used for MCA and HCA are described in Table 2. Fisher's exact test was used to evaluate the dependence between clusters and categorical variables, as well as between categorical variables. For all analyses, p values were set at 1%. The graphics presented show the proximity between individuals, as well as the associations between categorical variables.

Results

Descriptive analysis

Seventy-two point six percent of the goat farmers surveyed were men, while only 27.4% were women. Fifty percent of the respondents had completed elementary education, 32.3% of the respondents had middle-high school education, while only 6.5% had higher education. On the other hand, 74.2% of the smallholders had a house made of fine materials, followed by 11.3% with wooden houses, compared to 4.8% of the total number of surveyed who had a house built with adobe; 80.6% of the surveyed had electricity in their house. In terms of income, 67.7% of the total said that they earned on average between 0 and 135 USD/month from goat farming, while only 3.2% said they earned on average more than 540 USD/month. Finally, 48.4% of the smallholders reported having received training related to goat farming (51.6%), which is lower than the number of smallholders who reported not having received training. Of the smallholders surveyed, 56.5% belonged to an association of goat smallholders. While 43.5% did not have any affiliation with an organization.

Fifty-nine point seven percent of the surveyed dedicated between 6 to 9 h of time with their goat farm in the different related activities (grazing, milking, etc.), while 3.2% of the total dedicated less than three hours of time to their care. Of the total respondents, 48.4% had wooden pens, only 3.2% had adobe pens, and 6.5% did not have a pen for their animals. A total of 46.8% had sheep in their herd. Only 14.5% of the smallholders surveyed had cattle. Sixty-two point nine percent of the surveyed smallholders stated that the average number of liters of milk per animal was between 1 and 2 L per goat. Of the total respondents, only 1 did not perform milking and 1 reported an average of more than 2 L per goat. Eighty-two-point three percent of farmers carried out a vaccination during the current year or have this practice as part of the management of their cattle. Seventeen-point-seven percent do not perform any type of vaccination. Ninety-one-point nine percent of the smallholders have carried out deworming in the last year (at least once a year). Sixty-six-point-one percent of the goat smallholders have as their main feeding system the stubble of agricultural residues, while 1.6% supplement with concentrate to their animals. The 32.3% of goat smallholders similarly use agricultural residues as stubble, however, they also supplement their animals with balanced feed or some agro-industrial by-product. 91.9% stated that the production of dairy products, specifically cheese, was one of their main sources of income. As well as 22.6% of the surveyed have goat milk production as one of their main sources of income.

Multivariate analysis: multiple correspondence analysis

From the MCA it can be observed that the first 2 dimensions retain a good part of the total variability of the data evaluated. This value amounts to 25.38% of the total. Dimensions 1 and 2 retain 16.32% and 9.06% of the total variability, respectively (Fig. 2). This analysis was performed with the 16 qualitative variables that were divided into 6 dichotomous and 10 multiple-choice variables, having a total of 46 modalities or categories for this set of variables. Only the first 2 dimensions were retained, because each additional dimension had very little contribution to the variability of the data. The correlations of the variables for dimensions 1 and 2 were then plotted (Fig. 2). It was found that for the first dimension (Dim 1) the variables showing the strongest association or closeness to the axis were: "Training", "Organization", and "Vaccination". While for the second dimension (Dim 2) the variables "Income level" and "Cheese production" are more associated. In the case of the vaccination variable, the category that does vaccinate is located opposite to the category that does not vaccinate in dimension 1. It can be observed how for Dim2 the categories: feeding with balanced food and crop stubble are opposed to the type of livestock feeding. Similarly, for the variable production per day, the category of no production is opposed to the category > 2 L in dim2.

Multivariate analysis: hierarchical cluster analysis

The HCA resulted in the formation of three separate groups (Fig. 3; Table 3) of the total variables under study: the degree of education, the hours of the day that the farmer dedicated to goat farming, cattle farming, sheep farming, and the deworming variable were not significant in Fisher's test; therefore, it can be affirmed that these variables are independent of the cluster assignment. For the variables type of housing; producer association; training; access to a power network; type of goat facility;

Table 2 Categorical variables used for the Multiple Correspondence Analysis

Variables (Codes[1])	Modalities
Instruction Level (INSTRUC)	No Studies = NO_IN
	Elementary = PRIM
	Middle-High = SEC
	University = UNIV
Type of Housing (VIVIENDA)	Adobe = ADOBE
	Wood = MADERA
	Fine Material = MN
	Other = OTRO
Average monthly household income from goat farming (INGRESO)	0 – 135 = 135
	136 – 270 = 270
	271 – 540 = 540
	> 540 = MAS 540
Belongs to a smallholders' association (ORG)	Yes = ORG_SI
	No = ORG_NO
Received training in the last 2 years (CAPACIT)	Yes = CAP_SI
	No = CAP_NO
House has access to a power network (ELECTR)	Yes = ELC_SI
	No = ELC_NO
Hours per day spent in goat farming (HORAS)	< 3 = 3 HRS
	3 – 6 = 6 HRS
	6 – 9 = 9 HRS
	> 9 = MAS 9 HRS
Type of pens used for goat farming (INST)	No Pen = NO_INS
	Mesh Pen = INS_MALL
	Wooden pen = INS_MAD
	Adobe Pen = INS_ADO
	Fine Material Pen = INS_MN
Has cattle in its goat farm (VACUNO)	Yes = VACA_SI
	No = VACA_NO
Has sheep in its goat farm (OVINO)	Yes = OV_SI
	No = OV_NO
Daily average production per animal/day (PROD_DIA)	No Milking = NO_PROD
	< 1 Lt = 1LT
	1—2 Lt = 2LT
	> 2 Lt = MAS 2LT
Periodically vaccinates livestock (VACUNA)	Yes = VAC_SI
	No = VAC_NO
Periodically deworms livestock (DESPARASITA)	Yes = DESP_SI
	No = DESP_NO
Feeding system for their Goat Livestock (ALIMENT)	Agriculture Waste = RES
	Agriculture waste and supplementation = RES_BAL
	Balanced Feed = BAL
Produces and commercializes Goat Milk (LECHE)	Yes = L_SI
	No = L_NO
Produces and commercializes Goat cheese (QUESO)	Yes = Q_SI
	No = Q_NO

[1]The code used for the variable is shown in parentheses

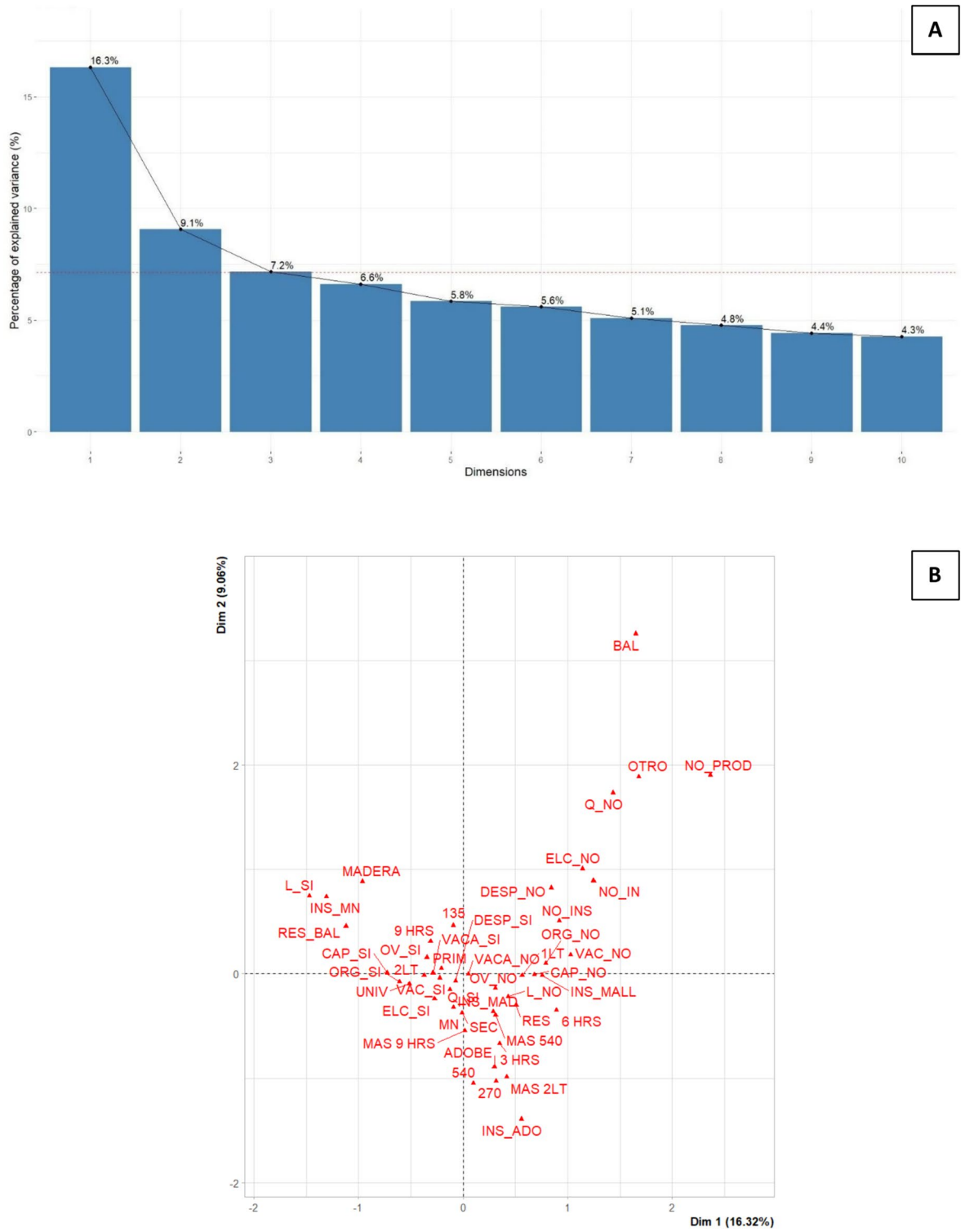

Fig.2 MCA analysis of surveyed goat farmers in the Lima region **(A)** Graphic showing the contribution percentage (%) of each dimension to the total inertia **(B)** Graphic representation of correlations between variables and dimensions of the MCA (Dim 1 y 2)

daily milk production per animal; type of feeding system; milk production and cheese production, the test showed a statistically significant difference ($p < 0.001$), so it can be affirmed that they are associated to the groups or clusters formed. At a lower significance level ($p < 0.05$), average monthly household income and herd vaccination were also associated with the groups or clusters formed.

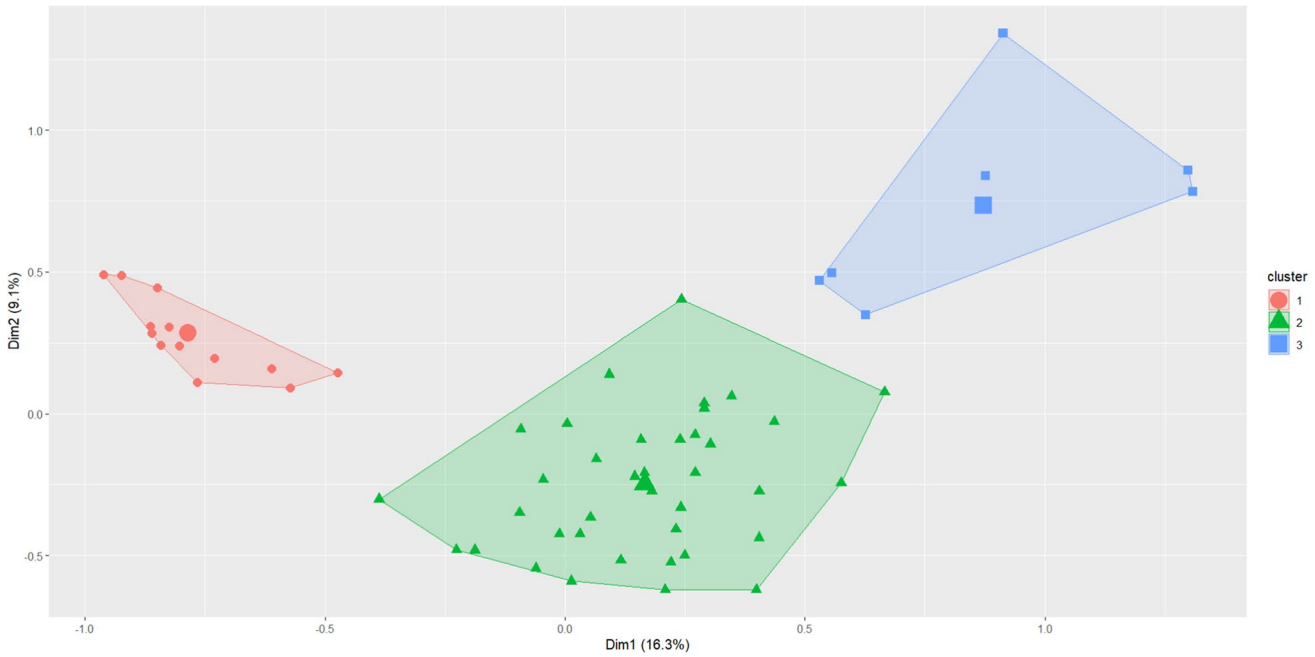

Fig. 3 Graphic representation of groups formed by types of goat farming found in the coastal valleys of the Lima region, based in Dim1 and 2

Groups description

Cluster 1 ($n=16$, 25.8% of total surveyed) can be described as a type of farmer with a primary school education (62.5%), with access to electricity in their farm, who has received training (93.75%) and belongs to an organization of goat smallholders (100%), who dedicates between six to more than nine hours to the care of the farm, who has corrals of noble material and production levels of between 1 to 2 L on average per animal/day. A large percentage of this group of farmers (68.75%) carry out mixed farming with sheep. The farmers of this cluster carry out periodic deworming and vaccination, as well as supplement their animals with agro-industrial waste or commercial rations, in addition to stubble as a food base (100%). Their production objective and source of income were goat milk (87.5%) for most individuals in this group, in addition to cheese. This group of goat farmers can be classified as an extensive system that focuses on the marketing of milk with better management practices.

Cluster 2 ($n=39$, 62.9% of total surveyed) This type of smallholder can be described with more variable characteristics; they may have a house made of noble material (87.2%), most of them have access to electricity in their homes (87.2%), and more than half of the smallholders in this group have not received training (61.5%) nor do they belong to a farmer's association (51.3%). About half of smallholders spend between 3 to 6 and 6 to 9 h a day on goat farming activities. More than 50% of smallholders of this type have wooden pens. More than 90% of the smallholders in this group produce less than 1 L of milk per animal/day to 2 L per animal/day on average. Few farmers conduct mixed farming with sheep (38.5%) and cattle (12.8%), and most of them vaccinate and deworm their animals. More than 80% of the farmers in this group have crop stubble as their main source of food for their livestock, and they do not have goat milk as a source of income. The only source of income being the production and sale of goat cheese. This group of goat farmers can be classified as an extensive system with goat livestock, focused on the marketing of cheese, and with a few management practices.

Cluster 3 ($n=7$, 11.29% of the total surveyed) can be described as a type of farmer that has almost entirely a type of housing made of very simple materials, they do not have access to electricity in their facilities, have not received training, and do not belong to a smallholders' association. Most of these have low production (less than 1 L) or no milk production. More than 50% carry out vaccinations and deworming; however, the other half do not do these practices. Their feeding systems were based on crop-waste stubbles. They do not carry out mixed farming with cattle (85.7%) and sheep (57.1%). They did not produce or sell milk, and more than 50% did not produce or sell goat cheese (57.1%). Their economic income comes from the occasional sale of offspring or discarding of animals as meat. This group of goat farmers can be classified as an extensive system, focused on self-consumption or meat production, with almost no management practices.

Table 3 Distribution of surveyed by category for the three groups identified by the hierarchical cluster analysis

Variables	Modalities	Cluster 1	Cluster 2	Cluster 3	Total	N.S
Instruction Level	No Studies	0	4	3	7	*NS*
	Elementary Level	10	19	2	31	
	Middle-High School level	4	14	2	20	
	University level	2	2	0	4	
Type of Housing	Adobe	0	3	0	3	***
	Wood	5	2	0	7	
	Fine Material	11	34	1	46	
	Other	0	0	6	6	
Average Monthly Household Income	0—135	16	19	7	42	**
	136—270	0	11	0	11	
	271—540	0	7	0	7	
	> 540	0	2	0	2	
Organization	Yes	16	19	0	35	***
	No	0	20	7	27	
Training	Yes	15	15	0	30	***
	No	1	24	7	32	
Power Network	Yes	16	34	0	50	***
	No	0	5	7	12	
Hours per day	< 3	0	2	0	2	*NS*
	3—6	0	10	2	12	
	6—9	14	19	4	37	
	> 9	2	8	1	11	
Type of Facilities	No pen	0	3	1	4	***
	Mesh Pen	0	8	2	10	
	Wooden Pen	1	26	3	30	
	Adobe Pen	0	2	0	2	
	Fine material pen	15	0	1	16	
Cattle	Yes	3	5	1	9	*NS*
	No	13	34	6	53	
Sheep	Yes	11	15	3	29	*NS*
	No	5	24	4	33	
Daily Production	Does not milk	0	0	1	1	***
	< 1 Lt	0	17	4	21	
	1—2 Lt	16	21	2	39	
	> 2 Lt	0	1	0	1	
Vaccine	Yes	16	31	4	51	**
	No	0	8	3	11	
Deworming	Yes	16	36	5	57	*NS*
	No	0	3	2	5	
Feeding	Agricultural Waste	0	35	6	41	***
	Agricultural waste and supplementation	16	4	0	20	
	Balanced feed	0	0	1	1	
Milk	Yes	14	0	0	14	***
	No	2	39	7	48	
Cheese	Yes	16	38	3	57	***
	No	0	1	4	5	

NS: No significance; *: *(p<0.05);* **:(*p*<0.01); ***: (*p*<0.001)

Discussion

Descriptive analysis

It was found that 72.6% of the surveyed were male, while 27.4% were female, in the same way Marquínez-Batista et al. (2022), had a very similar result. This result may be due to the traditional role of women in goat farming, mainly in charge of making cheese or taking care of the family while the men are in charge of milking, maintaining the livestock and relate with the other actors involved in goat farming, such as buyers, cheese stockpilers, etc. The 80.6% that had electric power was higher than the 77% found by Macedo et al. (2019), this indicates the better conditions and opportunities that goat smallholders in the region have compared to other smallholders in other countries. In terms of education level, 11.3% of the farmers surveyed had not attended school, this was lower than what was found by Gómez (2013) with 33.3% for the Apurímac region. This result is similar to what was observed in other areas of Latin America, with only 28% having completed primary school (Escareño et al. 2012). This is an important indicator that shows the context of goat smallholders in the region and how education continues to be a limiting factor for the improvement of the production system.

Of the producers surveyed, 56.5% belonged to a farmers' association, which was higher than the 42% reported by Marquínez-Batista et al. (2022) in Panama. Similarly, 48.4% of those surveyed stated that they had received training related to goat farming in recent years, showing that associated smallholders have a greater opportunity to receive government support in the form of training and technical assistance (Macedo et al. 2019; Swanson 2008).

A high number of goat farmers were found to carry out regular vaccination (82.3%) and deworming (91.9%); this was higher for vaccination and lower for deworming than those reported by Macedo et al. (2019) (55% and 95% respectively). Vaccination is carried out in this area, mainly against *Brucella melitensis*, which causes the disease brucellosis, using the rev1 vaccine provided by the state (Blasco et al. 2006; FAO/OIE/WHO 1997). This differs in other areas such as Santa Elena, Ecuador, where vaccination is carried out against triple Bacterin and Foot and Mouth disease (Villacrés et al. 2017). The stubble feeding system with balanced feed supplementation is very different from the one described by Atuesta et al. (2012) in Santander, Colombia.

Of the total number of smallholders, 48.4% had rustic wooden pens, in contrast to Villacrés et al. (2017) in Santa Elena, Ecuador with 78%. Likewise, only 3.2% had adobe pens, and 6.5% did not have a pen for their animals. Of the respondents, 46.8% practice mixed farming, having goats and sheep in the same flock. In contrast, Marquínez-Batista et al. (2022), reported the same sheep-goat farming system in 29% of the cases. Only 14.5% had cattle, and 62.9% of the surveyed stated that the average number of liters of milk per animal was between 1 to 2 per goat. Diversified production systems, such as systems that integrate agriculture and livestock or mixed farming, are strategies that ensure the environmental, economic, and social sustainability of the system over time, as well as increase the income margins that can be received by farmers as long as local agricultural practices are implemented, such as establishing an adequate stocking rate in grazing or planting cultivated pastures for livestock feeding (Martin et al. 2020; Kuchimanchi et al. 2022; Ndona et al. 2024; Al-Barakeh, et al. 2024).

Multiple correspondence analysis

Based on the results of the multiple correspondence analysis, we can observe that 11 of the 16 variables show significant differences between the values of the different groups. There are different characteristics of goat farming that were contemplated in this study through the variables and the data collected. Of the set of variables used in this study, the significant variables such as education level, mixed farming with cattle and associated producers were similar to Sarria et al. (2014) found in the central coast of the country, and only education level was similar to that found by Temoche et al. (2019) in the north coast of the country. In the same way for Sow et al. (2021), the variable education level was significant to discriminate against groups of producers. Therefore, it can be considered an adequate and efficient way to characterize goat production systems. The difference in the groups of variables found to be significant in discriminating groups of smallholders is attributed to the characteristics of the surveyed goat smallholders, geographical zones and the predominant production systems adapted to these ecosystems. The percentage of variability retained by the first two dimensions in this study was 25.38%, being lower than that found by Sarria et al. (2014) and Temoche et al. (2019) who carried out similar studies in the country, with 69.9% and 76.63% respectively, retaining in both cases the first 2 dimensions in the same way.

Hierarchical cluster analysis

Similarly, with Gómez (2013), three differentiated groups of producers were found for the Apurímac region. However, the groups formed can be differentiated mainly by herd size, a variable that was not analyzed in this study. The number of groups and their differentiation were lower in number than those reported by Sarria et al. (2014), this could be due to the number and type of variables used in the study to

differentiate groups. In comparison with similar characterization works such as that of Solís Lucas et al. (2020) that found seven groups of goat smallholders in the province of Santa Elena, Ecuador, the greater number of groups is due to the greater number of variables used, due to the objective of the study and the greater range of type of systems found, with greater participation of agricultural activity and farming of other livestock species. On the other hand, Laouadi et al. (2018) found 3 types of goat smallholders, however, this study involved different objectives and other characteristics of interest to differentiate the groups such as: herd size, mobilization, importance of goat farming in household maintenance.

Among the groups found in this study, clusters 1 and 2 showed a great difference between the educational level and milk production of the goats. Cluster 1 is largely made up of farmers with a primary level of education, they use most of their time focusing on management and marketing activities of farming, since this is their main economic activity. Therefore, they are the group that has the most interest in improving their productive performance and profitability since they do not have any other economic activity. On the other hand, in cluster 2, with a higher level of education, and with other work activities, the dedication to the herd is not as efficient. Therefore, it is possible to notice lower milk production rates in cluster 2 compared to cluster 1. It can also be seen that in Cluster 1 the farmers have a mixed farming, so this would justify the greater time invested in the attention of the livestock activity, as well as the function it has as a source of income.

The greatest differences were found between groups one and three, possibly the smallholders of group two need to be classified based on additional characteristics to obtain groups of greater homogeneity. Cluster 1 has conditions in facilities that can provide a better productive capacity, in addition to having more than one marketable product in the market. Therefore, this group has a greater probability of increasing the technification of its production system, thereby increasing competitiveness and profitability. The reference is always to a traditional system with little infrastructure and low levels of production management, where the genotypes bred are frequently local and production is lower than that established in an intensive system (Usai et al. 2006). Smallholders who have herds of younger age, larger size, and specialized breeds provide a higher income to the producer (Pathade et al. 2020). In fact, in Cluster 1, where the owners base their economic support on the income from the sale of milk and goat kids standing, the interest in acquiring specialized breeds is higher than in the other groupings.

The semi-extensive systems of goat livestock in southeast Spain had a rapid evolution to milk production, even when farming was mixed with other domestic species. In this process, it was observed that the improvement of infrastructure and facilities resulted in less natural forage resources (even reaching zero dependence), which is inevitable (Castel et al. 2003). The herds of goats in the coastal valleys of Peru directly produce milk; however, they maintain their dependence on stubble and grazing on coastal lomas and shrublands, which is similar to extensive systems in countries in the rest of South America, Europe, and Africa (Ruiz et al. 2008; Escareño et al. 2012; Sarria et al. 2014).

Goat-rearing systems located in the coastal valleys of the northern part of the Lima region can be classified as extensive systems and can be categorized into three distinct groups differentiated by management practices and their production and marketing objectives. Farmers in cluster one focused on the marketing of milk with better management practices, farmers in cluster two focused on the marketing of cheese with few management practices, and in cluster three, farmers were focused on self-consumption or meat production, with almost no management practices. These results will allow actors related to goat farming, such as state and regional entities, to focus their efforts on addressing the specific demands of the different types of goat farmers found in this study.

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Declarations

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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Consent to participate All authors agree to the publication of this paper.

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