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Milk production on cattle farms in the lower Guayas basin, Ecuador

Producción de leche en fincas con ganadería vacuna de la cuenca baja del Guayas, Ecuador

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To characterize the milk production potential on cattle farms in the lower Guayas basin, in Ecuador, a sample of 70 farms was formed and a survey that integrated structural variables was applied. A principal component analysis was performed, with the most important variables in the first two components. A cluster analysis was applied, in which three clusters were obtained, each considered a category of milk production potential. The categories were named low (I), medium (II) and high milk production (III). To validate the results and determine differences between the categories, a canonical discriminant analysis was performed. The study showed that the variables in order of priority were located in four components and were related to milk production, management, inputs, and costs. When comparing categories, there were problems with reproduction, with low coefficients of variation. The remaining variables exceeded 50 % and confirmed the heterogeneity that existed in the management and dimensions of the farms. There were statistical differences between the categories, which were determined, firstly, by the calving-calving interval, days open, milking cows, and females in the herd. The categories that characterized the milk production potential on cattle farms in the lower Guayas basin were obtained, which showed statistical differences determined by reproduction and herd management.

Key words: *categories, livestock, milk production, multivariate analysis, potential*

Para caracterizar el potencial de producción de leche en fincas con ganadería vacuna de la cuenca baja del Guayas, en Ecuador, se conformó una muestra de 70 fincas y se aplicó una encuesta que integró variables de estructura. Se efectuó un análisis de componentes principales, con las variables de mayor importancia en las dos primeras componentes. Se aplicó un análisis de conglomerados, en el que se obtuvieron tres conglomerados, cada uno considerado una categoría de potencial de producción de leche. Las categorías se denominaron de baja (I), media (II) y de alta producción de leche (III). Para validar los resultados y determinar diferencias entre las categorías, se realizó un análisis de discriminante canónico. El estudio mostró que las variables en orden de prioridad se ubicaron en cuatro componentes y se relacionaron con la producción de leche, manejo, insumos y costos. Al hacer una valoración entre las categorías, hubo problemas con la reproducción, con bajos coeficientes de variación. El resto de las variables superó 50 % y confirmó la heterogeneidad que existió en el manejo y las dimensiones de las fincas. Se presentaron diferencias estadísticas entre las categorías, las que estuvieron determinadas, en primer lugar, por el intervalo parto-parto, los días vacíos, las vacas en ordeño y las hembras en el rebaño. Se obtuvieron las categorías que caracterizaron el potencial de producción de leche en fincas con ganadería vacuna de la Cuenca baja del Guayas, las que presentaron diferencias estadísticas determinadas por la reproducción y el manejo de los rebaños.

Palabras clave: *análisis multivariado, categorías, ganadería vacuna, potencial, producción de leche*

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Introduction

The Guayas river basin in Ecuador is made up of the catchment area of the river system formed by the Daule, Vinces and Babahoyo rivers (Moreno *et al*. 2018). It is characterized by the great variety and intense agricultural, livestock and forestry activity, due to the excellent quality of its soils and the dynamics of the land, which places it as the largest production center of agricultural goods at the national level (Caicedo *et al.* 2019).

The ecological conditions in the region have encouraged the production of various crops. Livestock has been relegated to marginal areas with lower economic potential and exhibits great variability in terms of intensification levels, with a tendency towards a decrease in milk production (Medina *et al.* 2024). Filian *et al*. (2019) and Contero *et al*. (2021), when referring to the lower Guayas basin, emphasized that milk production is an option for family and local consumption, and that its marketing is a way of additional income for the farmer. Another aspect to highlight is that the trade of bovine units is a form of selling assets to obtain cash, especially in periods without income from agricultural activity. The cited authors agree on the need to evaluate livestock production systems in order to establish strategies for their sustainability in the region.

Considering the above, Torres *et al*. (2021) pointed out that multivariate analysis techniques jointly evaluate variables that provide comprehensive answers to different questions. These variables have been used by several authors to propose sustainable development alternatives to livestock, taking into account the specific conditions of each region. Vargas *et al.* (2011) typified livestock units in Los Ríos and Cotopaxi, Ecuador, and proposed alternatives for production. Segura and Torres (2014) also contrasted different classifications, based on the estimated impacts on dairy farms in Pastaza, Ecuador. In Cuba, Martínez *et al.* (2022) and Peña-Rueda *et al.* (2022) established elements for the productive reorganization of farmer dairy systems and determined the factors that limited beef production in Ciego de Ávila and Holguín provinces respectively.

Based on the mentioned experiences, the objective of this study was to characterize the milk production potential on cattle farms in the lower Guayas basin, Ecuador.

Materials and Methods

The work scenery consisted on Baba and Babahoyo cantons, located in the lower basin of Guayas river, in Los Ríos province, Ecuador. These territories have a great variety of soils, where inceptisols predominate (47.28 %), followed by entisols (37.24 %) and alfisols (8.43 %). The soil in the region is generally low, with small elevations that do not exceed 800 m o. s. l (Filian *et al*. 2020).

The climate is homogeneous. For the most part, it is classified as semi-humid megathermal tropical. It is characterized by having a very marked wet and dry season, with average rainfall per season, ranging from 500 mm to 2000 mm (Caicedo *et al.* 2019). Regarding temperatures, the annual averages have little variation, with values in the rainy season between 25.8 °C and 27.0 °C and in the dry season between 24.5 and 25.9 °C. Relative humidity varies in a range of 84 to 85 % (González *et al.* 2020).

The predominant grasses are represented by sabolla (*Megathyrsus maximun* Jacq.), star (*Cynodon nlemfuensis Vanderhyst,* Bull.), gordura (*Melinis minutiflora* P. Beauv.). Additionally, established areas can be found with para (*Urochloa mutica Forssk*. T. Q. Nguyen), signal (*Urochloa decumbens* Stapf R. D. Webster), janeiro (*Eriochloa polystachya* Kunth) and *Cenchrus purpureus Schumach*. Morrone, known for Taiwan. Regarding animal production, cattle prevail, formed by animals, generally mixed breeds, resulting from crosses between Criollo, Brahman, Brown Swiss and Holstein (Filian *et al*. 2020).

Sample selection and data collection on the farms: A stratified random sampling was performed for sample selection, according to Azeze *et al.* (2024). A total of 70 farms were selected, which fulfilled the following criteria: presence of livestock in 30 % or more of the total area and systems with stable annual production previous to the study. Those livestock owners without land and those who did not have a presence in the operation of records and/or accounting economic-productive information were excluded.

The study began with a rapid rural assessment. It was implemented through interviews and document analysis. For this purpose, a survey that integrated variables of farm structure was designed. The methodology used by Antúnez-Saiz and Ferrer-Castañedo (2021) was taken as a reference. The survey was previously validated in a small group of farmers.

The surveys were directly applied on the farms; to complete the information, existing records in the territorial offices of the Ministry of Agriculture and Livestock of the region were reviewed. The field work phase corresponded to the period November 2023-November 2024 (one year).

Variables selected for analysis: A total of 25 variables were obtained: total farm area, ha; area dedicated to livestock, ha; number of females in the cattle herd; number of cows in milking; number; birth rate, %; age at first calving, months; calving-calving interval, months; average of days open, days; global stocking rate, LAU.ha^{-1}; days with flooding on the farm, days; days with animal relocation, days; wastes used for feeding, tDM.ha^{-1}; grasses production on farms, tDM.ha^{-1}; need for animal food, tDM.ha^{-1}; introduced food for animals, tDM.ha^{-1}, percentage of food requirements met, %; number of paddocks, number; work intensity, hr.ha^{-1}d^{-1}; chemical fertilizers used, kg.ha$^{-1;}$ herbicides used, kg.ha^{-1}; fuel used, L.ha^{-1}; concentrate used, kg.ha^{-1}; costs of agricultural activity, dollars.ha^{-1}; costs for livestock activity, dollars.ha^{-1} and energy used, MJ.ha^{-1}.

Procedure for information analysis: The procedures used by Vargas *et al.* (2013) and Awoke *et al.* (2024) were followed, which included factor analysis (FA) and cluster analysis (CA). For FA, Bartlett's test of sphericity was performed, which was highly significant, and the KMO statistic, with a value of 0.73, fulfilling the criteria for the analyses. The principal component (PC) method was used, and the Varimax orthogonal rotation method was selected for its interpretation. Four components were chosen, with a cumulative explained variability higher than 70 %. In each factor or principal component, those variables that had a weight higher than 0.58 were considered significant. The components were named based on theoretical criteria, in relation to the processes involving the variables that gave rise to them (Peña-Rueda *et al.* 2022).

A CA was performed, in which the most important variables that formed the first two components of the previous analysis were used, which together explained around 50 % of the total variance and were related to milk production and herd management on cattle farms. Two stages were established: in the first, Ward's hierarchical grouping method was used to determine a preliminary number of groups to form, in the second, the final grouping of cases were obtained. The non-hierarchical k-means method was used, specifying as a starting point the number of clusters identified as optimal in the previous step.

Three clusters were defined, which were coded in relation to the mean values of the variables used from I to III. Each cluster was considered a potential category for milk production in the region. The first one (I) was designated as low production, the second one (II) as medium production, and the third one (III) as high milk production. The characterization of cases included within and between clusters was carried out through their mean values and coefficients of variation (CV).

To validate the obtained results and to evaluate if the categories formed could be discriminated through the included variables, a canonical discriminant analysis was performed. The methodology used by Acciaro *et al*. (2020) was followed. The equality of variance-covariance matrices was tested using Box's M test and a p=0.000 value was obtained. The Wilk's lambda statistic was used to corroborate if the canonical discriminant functions significantly contributed to the separation of categories. Intragroup correlations were determined, combined between the discriminant variables and the standardized canonical discriminant functions, and the highest absolute correlation between each variable and the discriminant function. The cases studied were represented in a two-dimensional graph according to the canonical functions obtained. All methods were processed using the IBM SPSS Statistics 25 program (Visauta and Martori 2023).

Results and Discussion

The principal component analysis (table 1) explained 74.95 % of the total accumulated variance, similar to that obtained by Pérez *et al*. (2024) and corroborated the suitability of the model for the classification of data. Regarding the variables, all showed correlations higher than 0.50, a value that expressed the degree of structural dependence of the data and the principal components extracted. In a similar analysis, Di Vita *et al.* (2024) used principal components to evaluate the sustainability of livestock systems with different agro-productive conditions. The authors, when studying the correlation between the variables and the extracted factors, considered 0.40 to be the lower limit, an aspect that confirmed the validity of the performed analysis.

The first component (table 1), considered by Vázquez *et al.* (2023) to be the most influential, explained about 30 % of the total variance and was higher than to that obtained by Rodríguez *et al.* (2022), who needed two components to reach a similar value. Regarding the variables, they comprised the largest number, with approximately 50 % of the total used for the analysis. All variables were related to the milk production potential of the farms and coincided with those included by Berton *et al.* (2020), Sanad *et al.* (2021) and Torres *et al.* (2022) in similar studies, although they were not always presented in the first component nor analyzed together. The result revealed the importance of milk production in the sample and coincided with what was showed by Medina *et al*. (2024), who, when referring to the lower Guayas basin, indicated that milk is the only traditional product that has given a secure and growing income in recent years to the small farmer.

The correlations in the milk production component were positive in seven variables, the highest values were in the total number of females, the number of milking cows, the total area and the area dedicated to livestock, the concentrates used and the number of paddocks. The lowest positive correlation was showed in birth rate. In this regard, Torres *et al.* (2022) related reproductive efficiency to birth rate and highlighted its importance for achieving increases in production and profitability, an aspect that could constitute an element of analysis, considering the lower relation of the variable with the component. Five variables showed an inverse relation with the extracted component: two were linked to climatic conditions, their negative influence on farm management, the need to move animals to areas with better conditions temporarily or permanently due to flooding, and three to reproductive aspects. When dealing with the topic discussed on dairy farms on the Ecuadorian coast, emphasis was placed on the need to improve bovine reproduction (Solórzano *et al.* 2022). Today, milk production on the coast has low yields, which is determined, among other things, by reproductive problems.

Table 1. Magnitude of the correlations between the inlet indicators and the extracted principal components

Total	7.46	4.69	4.16	2.42
% of variance	29.84	18.77	16.64	9.69
% accumalated	29.84	48.62	65.26	74.95
Indicators	**Milk production**	**Management**	**Inputs**	**Costs**
Milking cows, number	0.92	-0.13	0.02	0.06
Females in herds, number	0.92	-0.14	0.01	0.06
Total area, ha	0.89	-0.27	0.08	0.01
Area for livestock, ha	0.88	-0.28	-0.08	-0.00
Concentrate used, $kg.ha^{-1}$	0.81	-0.22	0.10	0.06
Number of paddocks, number	0.74	-0.38	-0.07	0.04
Claving- calving interval, months	-0.68	0.57	-0.08	-0.01
Days with animals movement, days	-0.68	0.02	-0.26	0.03
Days open, days	-0.68	0.56	-0.13	-0.03
Days with flooding, days	-0.65	-0.17	-0.12	0.04
Birthrate, %	0.59	0.00	0.30	-0.39
Age at first calving, months	-0.58	0.21	-0.25	0.03
Need of foods, $tDM.ha^{-1}$	-0.18	0.92	-0.21	0.08
Global stocking rate, LAU/ha	-0.18	0.92	-0.21	0.08
Introduced foods, $tDM.ha^{-1}$	-0.08	0.86	0.04	-0.19
Work intensity, $hr.ha^{-1}d^{-1}$	-0.37	0.81	-0.08	0.19
Fuel used, $L.ha^{-1}$	0.08	-0.52	0.01	0.10
Energy used, $MJ.ha^{-1}$	0.13	0.16	0.92	0.01
Chemical fertilizers used $kg.ha^{-1}$	0.14	-0.11	0.91	-0.14
Herbicides used, $kg.ha^{-1}$	-0.06	-0.03	0.85	0.235
Grasses production, $tDM.ha^{-1}$	-0.08	0.30	-0.74	-0.23
Wastes used, $tDM.ha^{-1}$	0.16	-0.16	0.68	0.44
Porcentage of covered foods, %	0.24	-0.19	0.52	-0.32
Costs of agricultural activity, $dollars.ha^{-1}$	-0.11	0.00	0.15	0.92
Costs of livestock activity, $dollars.ha^{-1}$	0.20	-0.06	0.13	0.92

The second component was related to livestock management in the production system. The variables with the highest correlations corresponded to animal feeding and global stocking rate. In agreement with these results, Filian *et al.* (2019) found similar variables in the second component and linked them to farm management. These authors highlighted the need to prioritize grasses, crop wastes, and establish global stocking rate capacity values according to the agro-productive capacity of the systems. In the analyzed component also included the work intensity and, with a negative value, the fuel used. Both variables, despite including agricultural activity, were related to the animals feeding of on the farms. The farmers required time for the collection and disposal of agricultural wastes for feeding the herd and grazing in communal areas, which includes the transport and care of the animals. The activities mentioned involved, in certain cases, hiring labor, especially during periods of flooding or prolonged drought. The situation is different for fuels with the lowest values. They are generally used for various crops. In Ecuadorian livestock, pastoral systems predominate and the feeding comes mainly from grasses plus wastes (Gutiérrez *et al*. 2024). The consideration showed justifies the inverse relation that the analyzed variable had with the principal component, called management.

The third component was called inputs. In this case, the variables linked to agricultural activity showed the highest correlations. Filian *et al.* (2019), when studying agricultural farms with livestock in the region, found that the variables related to inputs were in the first component, with growth in recent years. Contrary to what was stated, in the research, livestock occupied 30 % or more of the total farm area and was established primarily from local resources. In this component, grasses production also had a negative value, conditioned in certain cases by the greater production and use of agricultural wastes and the total percentage of food covered, represented in most farms by grasses plus wastes. Studies performed in other regions, but with conditions similar to those of the research, showed that livestock production systems are mainly based on natural grasslands and local resources, with low inputs and limitations, which at a certain time prevent them from being replaced by other productions (Cieza 2020), an aspect that justified the obtained result.

Costs characterized the fourth component. In livestock, costs are determined by farm management and labor, as noted by Polanco *et al.* (2021). These authors state that in Ecuador, the farmer generally does not consider his system an economic activity and therefore does not apply accounting, which does not allow for a reliable economic valuation. This aspect could justify the inclusion of the location of costs in the last component.

The component analysis (CA) was based on the first two components of the previous analysis, which together explained 48.62 % of the total variance and included variables that were determinants for milk production and cattle herd management. It is important to highlight that the farms under study had different percentages of productive diversification, in which livestock was part of the production system.

The statistical summary of the variables by categories is shown in table 2. Category I with 24 cases represented 34 %, category II 32 %, and finally category III had the same percentage value as the previous one (32 %), which showed an equitable distribution and well-defined categories in relation to their average values.

When making an assessment between the categories (table 2), the variables related to reproduction showed coefficients of variation lower than 20 %, a value considered low according to González *et al.* (2021). The rest exceeded the stated value, an aspect that confirmed the heterogeneity that existed in the structure of the herd, the dimensions of the farms and the management in the system. Musafiri *et al.* (2020) typified small farms dedicated to milk production and highlighted the social and spatial diversity they presented. Medina *et al.* (2024) also highlighted the differences between farms and their characteristics in the lower Guayas basin.

The results showed problems with reproduction. When analyzing the calving-calving interval and the average number of days open, Villoch *et al*. (2017) reported optimal intervals of 12 to 13 months for the first one and 85 to 110 days for the second one. In the sample, both variables exceeded the mentioned values. The age at first calving was higher than that reported by Solórzano *et al.* (2022), in categories I and II. It was not the case in the III category, where it was similar. However, the mentioned authors showed that maximum productive yield is achieved with an age at first calving of 22 months. In the sample, the analyzed indicator showed values that exceeded 34 months.

The birthrate was lower than that obtained by Abdourhamane (2024), who reported percentages ranging from 76.2 % to 96.2 % on dairy farms. This resulted in pregnancy losses, increased maintenance costs, and production inefficiencies. Regarding this topic, Martínez-Melo *et al.* (2011) analyzed groups of livestock units with birthrates similar to those presented in this research. These authors showed that the herds were in unsustainable conditions, a situation that compromises the efficient growth of the livestock population.

Regarding the average values of the variables in each category (table 2), category I consisted of those farms with the lowest number of females in the herd, total area, use of concentrate and number of paddocks. These farms showed the highest global stocking rate, with a greater need of foods and introduced foods, represented mainly by wastes. They required more days of moving their animals off the farm, aspects that contributed to having the highest values of work intensity.

Table 2. Average values and coefficients of variation between milk production categories

Variables	I (N=24)		II (N=23)		III (N=23)	
	Mean	CV, %	Mean	CV, %	Mean	CV, %
Milking cows, number	2.0	65	6.1	58	30.7	70
Females in herd , number	2.9	69	10.0	55	46.7	69
Total area, ha	2.8	94	10.5	42	40.8	58
Area for livestock, ha	1.9	103	7.4	58	25.9	63
Concentrate used, kg.ha^{-1}	4.8	91	12.7	49	32.5	52
Number of paddocks, number	1.7	38	3.0	34	5.1	45
Animals in movement, days	14.3	56	11.0	67	5.9	115
Days with flooding, days	23.6	52	22.5	44	15.4	53
Need of foods, tDM.ha^{-1}	9.1	33	5.1	46	5.0	26
Global stocking rate , LAU/ha	2.4	33	1.3	46	1.3	26
Introduced foods, tDM.ha^{-1}	3.7	85	0.8	209	1.0	110
Work intensity, hr.ha^{-1}d^{-1}	4.7	63	1.3	87	0.5	69
Calving-calving interval, months	22.3	5	18.8	4	16.1	5
Non- pregnant cows, days	398.8	9	298.7	8	212.6	12
Birthrate, %	49.0	20	52.2	16	59.3	9
Age at first calving, months	41.5	13	40.5	11	34.4	11

Studies conducted by Filian *et al.* (2020) in the region reported a relation between farms with smaller areas and medium to high global stocking rates, and those that had low milk production yields per hectare and income from livestock activity. These authors referred that farmer groups cultivating less than 10 hectares of land were considered small, with mixed production that included crops and where Creole cattle prevailed. They are also characterized by limited technology, floodable soils of medium to low fertility, and low yields. This characterization corresponds to category I and justified the higher values in the calving-calving interval, average number of days open, age at first calving, in addition to the lowest percentage of births, factors that negatively impacted their potential for milk production. In accordance with the above, Avilés *et al.* (2024) characterized backyard family dairy production systems, similar to the one showed in category I, when referring to reproduction they indicated that they do not implement reproductive management programs or genetic improvement, with negative results and productive deficiencies.

Regarding category II, higher values were found when compared to the previous one and coincided with those obtained by Guevara *et al.* (2020), who typified diversified dairy systems in the highlands of Ecuador, with similar results. However, the cited authors suggest that the percentage of livestock on the farms was higher. It is important to highlight that in the coastal region there is a tendency to increase agricultural production, a factor that could justify the smaller livestock area in the sample. Palacios *et al.* (2023) evaluated three groups of production systems. In the second case, they showed that they combined reproductive management between artificial insemination and the use of the bull for mating, supplemented the diet of the cows in production with feed concentrate, and carried out a more efficient management of productive resources. In the analyzed category, farmers had access to certain levels of inputs that made possible higher level of productions on the farms and better reproductive results. However, these results were lower than those previously reported.

In category III, the farms had a greater number of animals, dimensions, and use of concentrate. They showed the fewest days with animal movement and the lowest average values in the calving-calving interval, the days that the cows remain open and the highest birthrate. It is important to highlight that farmers in category III introduce herd management technologies that are in line with the largest number of paddocks, combine the use of native grasses with improved species, supplement milking animals with concentrate, and use certain reproduction techniques, including artificial insemination.

In relation to the obtained results, Torres *et al.* (2022) classified small and medium-sized farms in the studied region and revealed a correspondence between the larger area and the yields in milk production. Jurado *et al.* (2023), when evaluating the technical efficiency and potential for improvement of livestock systems, also noted that farms with high incomes had a larger area, more coverage in grasses and forests, and combined dairy activity with traditional crops. However, they pointed out that they could have more income with fewer hectares of grasses and crops. To corroborate the above, Filian *et al*. (2020) when classifying agricultural farms with livestock in the lower Guayas basin, found that those with the largest area showed negative forage balances, with milk production yields similar to those that were located in groups with smaller dimensions. According to the authors, the agricultural production potential is not linked to livestock, nor are the available resources used efficiently. Wastes and trees are highlight, aspects that could be considered when drawing up policies for the development of dairy production in the region, regardless of the area and characteristics of the farm.

Using a different procedure, Guevara *et al.* (2020) and Paredes *et al.* (2024) differentiated typologies of dairy livestock systems in the Sierra and Amazon regions of Ecuador respectively. In both cases, they compared the variables included in the groupings independently, without considering the system as a whole. Jurado *et al.* (2023) referred to systems theory and stated that characterization refers to the identification of primary attributes of variables and their interrelations in production units.

Considering the above, table 3 shows the summary of the two canonical discriminant functions, obtained by comparing the milk production potential categories. The statistical significance was tested by Wilk's Lambda (λ), with a $p=0.000$ value. The first function explained 94.9 %, a higher value than that found by Bardales *et al.* (2022), using the same procedure and considered valid for the performed analyses. The second, with a smaller percentage, represented 5.1 % of the total variation. However, it was higher than 4 %, the value allowed for the analysis according to Véliz *et al*. (2020). The results provided validity and it was possible to differentiate between the three categories of milk production potential. Other authors, with different production conditions and objectives, used the same research procedure to validate their results. Acciaro *et al*. (2020) established differences between feeding systems for meat production in two species, where cattle was included. Zambrano and Vinces (2023) also compared agricultural farmers, grouped according to clusters by means of a discriminant analysis.

The correlations between the discriminant variables and the canonical discriminant functions are shown in table 4. The first function with the highest explanation percentage of the total variance was represented by reproductive activity. The highest values were for the calving- calving interval and open days, thus significantly contributing to the differentiation between the categories.

Table 3. Summary of canonical discriminant functions

Function	Eigenvalue	% of variance	% accumulated	Canonical correlation	λ	X^2	p
1	7.961	94.9	94.9	0.943	0.078	168.101	0.000
2	0.425	5.1	100.0	0.546	0.702	23.370	0.000

λ = Wilks' - Lambda; X^2= Chi-square

Table 4. Correlations between discriminant variables and standardized canonical discriminant functions

Variables	Function	
	1	2
Calving-calving interval, months	0.987	0.121
Days open, days	0.923	0.151
Work intensity, $hr.ha^{-1}d^{-1}$	0.355	0.354
Birthrate , %	-0.207	0.152
Age at first calving, months	0.175	0.029
Milking cows, number	-0.409	0.719
Females in the herd , number	-0.406	0.714
Total area, ha	-0.401	0.684
Area for livestock , ha	-0.447	0.659
Need of foods, $tDM.ha^{-1}$	0.271	0.572
Global stocking rate, LAU/ha	0.271	0.571
Introduced foods, $tDM.ha^{-1}$	0.196	0.466
Number of paddocks, number	-0.299	0.340
Concentrate used, $kg.ha^{-1}$	-0.198	0.317
Days with animals in movement, days	0.008	-0.287
Days with flooding, days	0.023	-0.250

In function two, the variables with the highest correlations were those related to management, where the highest values were for the number of females and those that are milked, as well as the areas, the need of foods and the global stocking rate. The analysis revealed the factors that determined the differences between the evaluated categories. In accordance with what was obtained by Ruiz *et al.* (2021), it was consistent with that of clusters.

The results shown (table 4) were similar to those presented by Azeze *et al.* (2024), who typified mixed milk production systems and emphasized the need for access to technical assistance for improved management and the implementation of reproduction programs adapted to local conditions. In the study region, technical assistance and the level of education, as well as the technological infrastructure dedicated to cattle reproduction, are scarce. Only farmers with higher production, number of animals and surface area include certain techniques, including artificial insemination, an aspect that may have influenced the variability showed between the categories.

To corroborate the above, Velasco *et al.* (2015), when analyzing typologies of Ecuadorian dairy cattle units, pointed out that the activities related to management and reproduction constituted factors that determined differences, with basic deficiencies that limited the obtaining of better productions. The authors warned of the need to guarantee management and reproduction conditions in Ecuador's dairy cattle industry, as these largely determine its productivity.

The graphical representation of the canonical discriminant analysis is shown in figure 1. The evaluated categories were located on different planes, well differentiated by both functions. The studied cases were located around the centroids in each category, without overlaps. The classification by groups showed that 95.7 % of the cases were included in category III. In I and II, 100 % of the cases were included, respectively. Similar studies used Ataei *et al.* (2020) to validate differences between farmers grouped into three levels. The membership percentages shown were below those obtained in the conducted research. However, they were considered appropriate to differentiate between the studied groups, an aspect that gave importance to the obtained result. The analyses carried out corroborated the differences and made possible to determine which quantitative characteristics are useful to discriminate between the categories of milk production potential, which establishes guidelines for future analyses, particularized in the study area.

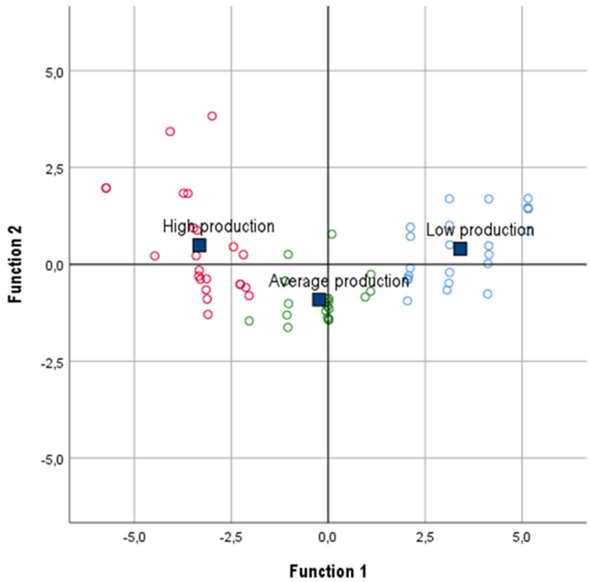

Figure 1. Discriminant scores in individual observations for each treatment in the first two canonical functions

Conclusions

The categories that characterized the milk production potential on cattle farms in the lower Guayas Basin were obtained, which showed statistical differences, determined by reproduction and herd management.

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