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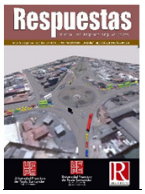

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Effect of the altitude and size of livestock farms on productive and reproductive aspects in the south-western region of Norte de Santander

Efecto de la altitud y tamaño de explotaciones ganaderas sobre aspectos productivos y reproductivos en la región sur-occidental de Norte de Santander

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Keywords:

Bovine Production,
Dual Purpose,
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ABSTRACT

To evaluate milk production (MP), daily weight gain(DWG), calving interval (CI), and use of artificial insemination in the municipalities Cacota, Chitagá, Pamplona, Pamplonita, Silos, and Mutiscua (Norte de Santander, Colombia), a sample of farms were selected (n = 113) and a direct survey was applied. Two farm sizes were characterized: up to 10 animals (47.8%) and > 10 animals (52.2%). The farms were grouped by quartiles of altitude in meters above sea level (MASL) (Q1: 1600-2300 (n = 27), Q2: 2300-2600 (n = 28), Q3: 2600-2800 (n = 28), Q4: 2800-3800 (n = 30). The Normande breed predominates (38.2%), followed by Holstein (23.0%). The presence of Normande decreases with the decrease in altitude, being different between Q4 and Q1 (P = 0.009). Zebu genotypes (Gyr, Brahman) appear in Q2 and increase in Q1 (P = 0.03). The MP was 5.5 ± 0.2 L / cow * day, with higher productions in Chitagá and Mutiscua (6.4 ± 0.6 and 6.1 ± 0.4 L / cow * day respectively), and lower (P = 0.005) in Pamplonita 4.4 ± 0.4 L / cow * day. The DWG was 367 ± 17 g / day, and tended to be lower (P = 0.09) in farms up to 10 animals (336 ± 23.3 g / day, n = 46) compared to farms with more than 10 animals (393 ± 23.7 g / day, n = 53). Larger farms (> 10 animals) had a lower average of CI with 393 ± 5.5 days (n = 59), compared with farms of up to 10 animals (419 ± 11.4 days, n = 54; P = 0.04).For the Q1 quartile, the CI was higher (438 days, P = 0.01) than Q4 (382 days). The use of semen from 9 breeds for artificial insemination was reported, 48.8% corresponded to specialized dairy breeds (Jersey 27.9%, Ayrshire 11.6%, and Holstein 9.3%), 30.2% European dual-purpose breeds (Normande 27.9%, Simmental 2.3%), and 21.0% zebu breeds or their crosses (Gyr 11.7%, Guzerá 4.7%, Girolando 2.3%, and Brahman 2.3%). The present characterization allows diagnosing the current state of the livestock industry in the studied region and projecting technical improvement guidelines.

Palabras clave:

Producción bovina,
doble propósito,
reproducción,
altitud,
inseminación artificial.

RESUMEN

Para evaluar la producción de leche (PL), la ganancia diaria de peso en las crías (GDP), el intervalo entre partos (IEP) y el uso de la inseminación artificial en los municipios Cacota, Chitagá, Pamplona, Pamplonita, Silos y Mutiscua (Norte de Santander, Colombia), se seleccionó una muestra de granjas (n = 113) y se aplicó una encuesta directa. Se caracterizaron dos tamaños de explotaciones: hasta 10 animales (47,8%) y> 10 animales (52,2%). Las fincas se agruparon por cuartiles de altitud en metros sobre el nivel del mar (MSNM) (Q1: 1600-2300 (n = 27), Q2: 2300-2600 (n = 28), Q3: 2600-2800 (n = 28), Q4: 2800-3800 (n = 30). Predomina la raza Normando (38,2%), seguida de la holstein (23,0%). La presencia de la Normando disminuye con el descenso de la altitud, siendo diferente entre el Q4 y el Q1 (P = 0,009). Los genotipos cebú (Gyr, Brahman) aparecen en el Q2 y aumentan en el Q1 (P = 0,03). La PL fue de 5,5 ± 0,2 L / vaca * día, con mayores producciones en Chitagá y Mutiscua (6,4 ± 0,6 y 6,1 ± 0,4 L / vaca * día,

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respectivamente), y menor (P = 0,005) en Pamplonita 4,4 ± 0,4 L / vaca * día. La GDP fue de 367 ± 17 g/día, y tendió a ser menor (P = 0,09) en las explotaciones de hasta 10 animales (336 ± 23,3 g/día, n = 46) en comparación con las explotaciones de más de 10 animales (393 ± 23,7 g/día, n = 53). Las explotaciones más grandes (> 10 animales) tuvieron una media más baja de IEP con 393 ± 5,5 días (n = 59), en comparación con las explotaciones de hasta 10 animales (419 ± 11,4 días, n = 54; P = 0,04). Para el cuartil Q1, el IEP fue mayor (438 días, P = 0,01) que el Q4 (382 días). Se notificó la utilización de semen de 9 razas para la inseminación artificial, de las cuales el 48,8% correspondían a razas lecheras especializadas (Jersey 27,9%, Ayrshire 11,6% y Holstein 9,3%), el 30,2% a razas europeas de doble propósito (Normando 27,9%, Simmental 2,3%) y el 21,0% a razas cebúes o sus cruces (Gyr 11,7%, Guzerá 4,7%, Girolando 2,3% y Brahman 2,3%). La presente caracterización permite diagnosticar el estado actual de la ganadería en la región estudiada y proyectar pautas de mejora técnica.

Introduction

Bovine livestock in Colombia contributes 1.4% of the national gross domestic product (GDP), 21.8% of the agricultural GDP, and 48.7% of the livestock GDP, becoming the most important economic activity in the Colombian countryside, with an inventory of 24.8 million heads [1]. In Norte de Santander there are around 456,000 cattle, distributed in regions defined by the departmental government [2].

The southwestern region of the Norte de Santander department (Colombia) includes the municipalities of Cacota, Chitagá, Pamplona, Pamplonita, Silos, and Mutiscua. The geography corresponds to the mountainous area of the eastern Andes of Colombia in an altitude range of 1600 to 4000 meters above sea level (MASL) where livestock activity stands out as a subsistence economic activity [2]. This region is part of a transition zone to the paramo ecosystem that is currently under government protection measures through territorial delimitation and control of economic activities that may affect the fragile paramo environment [3]. It is known that in the southwestern region about 38,600 cattle are vaccinated, however, there are currently no documented records on the livestock activity of this particular area, although it is known that there are small farms with few animals where mainly unspecialized systems predominate. subsistence. In oreder to generate a baseline of knowledge about the characteristics of the region and the farms, associated with productive variables that could be used for the development of livestock activity, this study was developed with the objective of describing the productive (breeds, farming systems, milk, and meat production) and reproductive (calving interval, use of artificial insemination) characteristics of the cattle farms in the area, associated with geographic factors (altitude) and development (level of education).

Materials and methods

Selection of farms and classification

The list of existing livestock farms in the region was obtained through the Norte de Santander livestock committee. The number of farms to be surveyed was determined using the equation for determining the sample size for finite populations [4]:

$$n = \frac{no}{1 + \frac{no}{N}}$$

Where

$$no = p * (1 - p) * \left(\frac{Z\left(1 - \frac{\alpha}{2}\right)}{d} \right)^2$$

N = Sample universe

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p = probability of occurrence
α = confidence level (alpha)
Z = 1- α/2

To determine the sample size, 5% was used as a margin of error and 95% as a confidence level [4], and the total number of farms was considered as the sample universe (N), according to the classification of farm size by number of animals (1-50, 51-100, 101-500, and > 500 animals) used by the Colombian Agricultural Institute (ICA) [5]. Using a random number generator (Graphpad Software, La Jolla, CA, USA) the farms to be visited were selected from the total list.

Design and application of the survey

A survey addressed to livestock producers was designed including referential aspects in terms of geography (altitude, topography), farm size (bovine inventory), zootechnical characteristics (type of productive system, predominant breeds, milk production (MP), weight gain (DWG), the calving interval (CI), nutritional and sanitary management), and aspects related to the degree of social and technological development (education of the producer, infrastructure, systematization, technical-professional assistance, and use of artificial insemination). A producer was defined as the individual owning the title of property of animals registered in the foot-and-mouth disease vaccination records (RUV) run by the ICA. Contact with cattle producers was established in collaboration with entities such as farmers associations, municipal technical assistance units, and secretaries of agriculture. In case of declining to participate in the survey, the random number generator was used to select a new property until the specified number of the sample was met.

The fieldwork consisted of physical mobilization to each of the coordinated farms to personally apply the survey to the producer. The visit included the georeferencing of the property (GPS status 8.0.170-PRO), the measurement of the altitude in meters above sea level (MASL), the visual verification of the type of topography, the established pastures, breeds present, animal inventory, productive system, infrastructure and equipment, and the living conditions and development of the residents on the farm. Each application of the survey instrument took between 1-2 hours, depending on the understanding of the points in question and the details provided by each producer.

Analysis of the information

The data obtained through the surveys were tabulated in MS-Excel (Microsoft Office 2010), the sort and filter tool was used to classify the explanatory variables altitude and farm size (number of animals). For the breed variable, a frequency histogram was made in which the percentages of breeds for each altitude group are presented. For the productive (MP, DWG) and reproductive (CI) response variables, averages and standard error (SE) were determined as a measure of dispersion. The data were grouped by altitude ranges (MASL) and by farm size (number of animals); and for the MP, DWG and CI variables, groups were compared by performing an analysis of variance using the GLIMMIX procedure of SAS (SAS version 9.3, Cary, NC, USA). The data on the use of the artificial insemination (AI) technique is presented as a percentage of use related to the total farms, were treated as a binary variable (1 = use of AI; 0 = No use),and analyzed using the GLIMMIX procedure with the binary distribution within the model. The producers' education level was assigned the following values: (0 = primary basic education, 1 = secondary education, 2 = higher education) according to the level of training reported by each of the respondents, and the averages of the municipalities were compared by analysis of variance.

Results

Livestock inventory and farm size

The southwestern area of the Norte de Santander department includes six municipalities that house a total of 38,577 head of cattle (8.5% of the departmental total of 455,871 cattle) distributed in 3,773 cattle farms. Table 1 shows the distribution according to the size of the farms (number of animals). As the first important finding, 91.2% of the farms evaluated were located within the first size classification group established by the ICA (1-50 animals), while the remaining three groups (51-100, 101-500, and > 500) comprised 8.8% of the properties. This way, in order to improve the precision of the analyzes, the majority group was sub-divided into ranges of 1-10 (47.8%), and 11-50 animals per farm (43.4%), and the remaining groups with a number greater than 51 animals per farm were grouped (8.8%, Table 1). Similar values are reported at the national level, whereby in 2016 43.6% of farms had less than 10 animals [5]. The municipalities of Mutiscua (61.1%) and Chitagá (59.3%) tend (P = 0.1) to have a greater number of small farms (1 to 10 animals) than the municipalities of Silos (31.3%) and Cacota (33.3%).

Table 1. Livestock inventory, sample selection, size of surveyed livestock farms, and altitude characteristics of the municipalities of the southwestern region of Norte de Santander.

	Cacota	Chitagá	Pamplona	Pamplonita	Silos	Mutiscua	Total / average
Total inventory (heads)	3551	9415	7344	5759	6837	5671	38577
Total number of farms	371	955	816	553	489	589	3773
Average cattle / farm	9.6	9.9	9.0	10.4	14.0	9.6	10.2
Sample of farms (n)	15	27	22	15	16	18	113
Farm size							
	33.3	59.3	40.9	53.4	31.3	61.1	47.8
1-10 animals (%)	46.7	33.3	59.1	33.3	62.5	27.8	43.4
11-50 animals (%)	20.0	7.4	0.0	13.3	6.2	11.1	8.8
> 50 animals (%)	2475±37^{B}	2651±77^{B}	2500±53^{B}	1739±29^{A}	3090±79^{D}	2874±60^{C}	2575±45
Altitude (masl ± SE)	2231-2658	1767-3453	2045-3025	1627-1998	2500-3430	2654-3800	1767-3800

masl: Meters above sea level
SE: Standard Error
Different letters between columns indicate statistical significance for the average value of altitude between municipalities (P<0.05)

Altitude and breed composition

The average altitude measured for the studied farms (n = 113) in the southwestern region of the department of Norte de Santander was 2575 ± 45 MASL. The averages and ranges of altitude are shown in table 1. The municipality with the lowest altitude is Pamplonita with an average of 1739 ± 29 while the municipality of Silos presents the highest average with 3090 ± 79 (P <0.0001). It is important to highlight that within each municipality there is a wide range of altitudes between farms, which led us to propose a classification by quartiles of altitude to compare groups of properties of similar altitudes located in different municipalities. The quartiles were obtained by organizing in descending order the 113 data records of altitude from the 6 municipalities to form four quartiles of approximately 28 observations.

The most predominant breed in the six municipalities of the southwestern region of the department of Norte de Santander is the Normande (38.2%), followed by the Holstein breed with 23.0%. Table 2 shows the participation percentages of the different breeds for each of the municipalities. There is minor participation of other European-type breeds that together reach 16.2%, emphasizing the Jersey (6.4%) and Brown Swiss (4.4%) breeds in this group. The Mixed group (14.2%) comprises animals that are the product of successive, undetermined crosses of different breeds, including European, Indicus, or Creole breeds.

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Finally, 8.3% of breed participation of the southwestern region corresponds to Zebu cattle (Brahman and Gyr) or with a greater percentage of these breed (including Girolando and Simbrah). The presence of zebu genotypes was exclusive to the municipalities of Pamplonita, Pamplona, and Cacota and absent in the three remaining municipalities (Chitagá, Silos, and Mutiscua), which is associated with the elevation ranges of the municipalities. By unifying the data of the analyzed farms and classifying them according to their altitude, it is possible to ratify patterns of influence of certain breeds in the composition of the herds at different heights above sea level. Figure 1 illustrates how the Normande race predominates in the high altitudes of the Southwestern region of the department of Norte de Santander, however, it decreases as the altitude declines, being different between the fourth and the first quartile (P = 0.009). Conversely, the participation of Zebu genotypes (Gyr, Brahman) increases in the lowest quartile (first quartile), being different from the second quartiles (P = 0.03) and quartiles 3 and 4 (P = 0.0001).

Table 2. Percentages of participation of bovine breeds in the composition of the cattle herd of the six municipalities in the southwestern region of Norte de Santander.

	Cacota	Chitagá	Pamplona	Pamplonita	Silos	Mutiscua	Average SW region
Normande (%)	31.0	53.2	28.2	17.9	53.6	39.4	38.2
Holstein (%)	13.8	23.4	28.2	10.7	28.6	30.3	23.0
Otherss[1] (%)	17.2	10.6	23.1	21.4	3.6	21.2	16.2
Mixed[2] (%)	24.1	12.8	12.8	14.3	14.3	9.1	14.2
Cebuino[3] (%)	13.8	0.0	7.7	35.7	0.0	0.0	8.3
Total	100	100	100	100	100	100	100

[1]Includes European breeds used to a lesser extent: Jersey (6.4%), Ayrshire (2.0), Brown Swiss (4.4%), Simmental (2.9%), Swedish Red (0.5%)

[2]Corresponds to undetermined crossbreeds predominantly of European breeds and adapted cattle present in the region. May contain undetermined minority percentages of Zebu and Creole genotypes.

[3]Brahman (4.9%, includes 0.9% Simbrah), Gyr (3.4%, includes girolando).

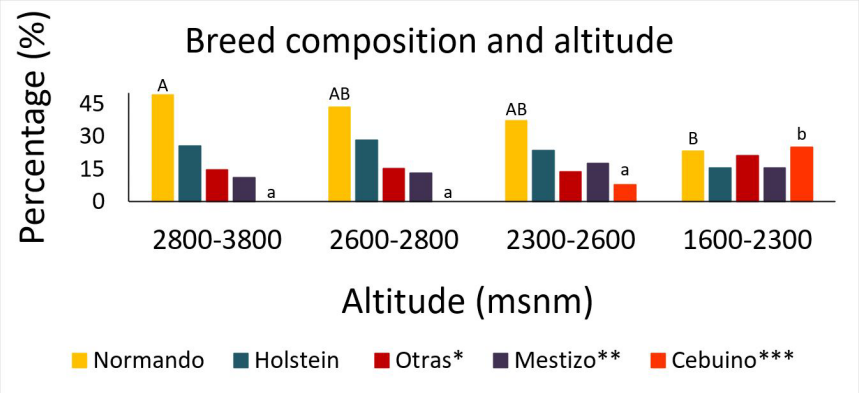

Figure 1. Percentages of participation of breeds according to quartiles of altitude in the six municipalities of the southwestern region of the Norte de Santander department.

Different letters between groups (quartiles) indicate a difference p <0.05

Different capital letters indicate statistical significance for the proportion of Normande race between quartiles of altitude
Different lowercase letters indicate statistical significance for the proportion of zebu-type breeds among altitude quartiles.

* Includes European breeds used to a lesser extent: Jersey (6.4%), Ayrshire (2.0), Brown Swiss (4.4%), Simmental (2.9%), Swedish Red (0.5%)

**Corresponds to undetermined crosses predominantly of European breeds and adapted cattle present in the region. May contain undetermined minority percentages of Zebu and Creole genotypes.

*** Brahman (4.9%, includes 0.9% Simbrah), Gyr (3.4%, includes gyrholando).

Different capital letters indicate statistical significance for the proportion of Normande race between quartiles of altitude

Different lowercase letters indicate statistical significance for the proportion of zebu breeds among altitude quartiles.

Milk Production

The average milk production per cow per day for the southwestern region was 5.5 ± 0.2 L (Table 3). The highest levels of milk production were reported in the municipalities of Chitagá and Mutiscua (6.4 ± 0.6 and 6.1 ± 0.4 L respectively), while the municipality of Pamplonita presented a lower value of 4.4 ± 0.4 L / cow * day (P = 0.005).

When organizing the data according to the size of the farm (Table 4), no differences were found (P = 0.41) between the milk production levels of systems of 10 or fewer animals (5.7 ± 0.3 L / cow * day, n = 54) compared with farms with more than 10 animals (5.3 ± 0.3 L / cow * day, n = 59). Similarly, when classifying the data by altitude quartiles (Table 5), there were no statistical differences regarding milk production (P > 0.05).

Daily weight gain

The average daily weight gains of the animals for the six municipalities analyzed was 367 ± 17 g / day. The DWG tended to be lower (P = 0.09) in small farms (1-10 animals, 336 ± 23.3 g / day, n = 46) compared to farms with more than 10 animals (393 ± 23.7 g / day, n = 53), while no differences between groups were found when comparing the quartiles of altitude.

Calving Interval

The mean value for the CI variable was 405 ± 6.3 days (Table 3). The municipalities of Mutiscua, Silos, and Chitagá presented the best values for this parameter (fewer CI days) with 385, 387, and 390 days respectively, while the municipalities of Pamplona and Pamplonita presented the longest delay (P > 0.05) for calving with 437 and 444 days on average respectively (Table 3). When analyzing the data classified according to the size of the farms (number of animals, Table 4), the larger farms (> 10 animals) had a lower average CI with 393 ± 5.5 days (n = 59), while in the small farms (1 to 10 animals), this value was higher (419 ± 11.4 days, n = 54; P = 0.04).

The analysis of the data by altitude quartiles showed a progressive decrease in CI days as the altitude increases (Table 5). There are differences (P = 0.01) between the first quartile, (altitudes between 1600 and 2300 MASL), that show a CI of 438 days, compared to quartile 4 that includes altitudes between 2800 to 3800 meters with a CI of 382 days. For the CI variable, the results of the analysis by altitude quartiles are equivalent to the analysis by municipality, since the municipality located in the lowest altitude range obtained the highest CI values. On the other hand, there were differences when the data were analyzed according to the size of the farm.

Table 3. Milk production parameters, daily weight gain and calving interval for the six municipalities in the Southwestern region of Norte de Santander

	Cacota	Chitagá	Pamplona	Pamplonita	Silos	Mutiscua	Total / Average	Value - P
n	15	27	22	15	16	18	113	
MP (liters / day ± EE)	5.3±0.5^{ABC}	6.4±0.6^{C}	4.9±0.6^{AB}	4.4±0.4^{A}	5.4±0.5^{ABC}	6.1±0.4^{BC}	5.5±0.2	0.07
DWG (grams / day ± EE)	390±54	338±35	360±42	324±42	400±45	394±31	367±17	0.78
CI (days ± SE)	391±8.1^{A}	390±8.3^{A}	437±21.4^{B}	444±23.4^{B}	387.4±11.7^{A}	385.3±7.5^{A}	405±6.3	0.01
Insemination Use (%)	66.7^{A}	14.8^{B}	13.6^{B}	6.7^{B}	50.0^{A}	55.6^{A}	31.9	0.001
Education Index	0.93±0.21^{A}	0.67±0.14^{AB}	0.27±0.13^{B}	0.33±0.19^{B}	0.75±0.21^{AB}	0.5±0.17^{AB}	0.58±0.07	0.07

SE: Standard Error
MP: Milk production
DWG: Daily weight gain
CI: Calving Interval

Different letters between columns indicate statistical significance for the average value of the variables between municipalities (P<0.05).

Table 4. Milk production parameters, daily weight gain and calving interval for smaller (1-10 animals) or larger (> 10 animals) farms in the southwestern region of Norte de Santander

	1-10 animals	>10 animals	Value - P
Farms	54	59	
MP (liters / day ± SE)	5.7±0.2	5.3±0.2	0.41
DWG (grams / day ± SE)	336±23.3	393±23.7	0.09
CI (days±SE)	419±11.4	393±5.5	0.04

SE: standard error
MP: Milk Production
DWG: Daily weight gain
CI: Calving Interval
P values less than 0.05 indicate statistical difference.
P values between 0.05 and 0.10 indicate trend.

Table 5. Milk production parameters, daily weight gain and calving interval for the different altitude quartiles in the southwestern region of Norte de Santander

	Q1	Q2	Q3	Q4	Valor-P
Farms	27	28	28	30	
Altitude MASL	1627-2325	2327-2608	2610-2795	2800-3800	
MP (liters / cow * day ± SE)	5.5±0.5	5.5±0.5	5.3±0.4	5.8±0.4	0.87
DWG (g / day ± SE)	351±31	395±48	336±87	386±31	0.48
CI (days ± SE)	438±20^{B}	398±7.2^{A}	405±8.0^{AB}	382±8.5^{A}	0.01

SE: standard error
MP: Milk production
DWG: Daily weight gain
CI: Calving Interval
Different letters between columns indicate statistical significance for the average value of the CI between municipalities ($P<0.05$)

Use of artificial insemination

Table 3 shows the percentages of use of artificial insemination in the municipalities of the region. There was a significant difference between a group of municipalities that presented a higher degree of AI use (Cacota 66.7%, Silos 50.0%, and Mutiscua 55.6%) compared to a second group with low implementation (Chitagá 14.8%, Pamplona 13.6%, and Pamplonita 6.7%). It should be noted that in the case of the municipalities of Silos and Mutiscua, local policies contributed significantly to the increase in the percentages, while in the case of the municipality of Cacota the use of AI is self-iniative of the producers.

Regarding the semen used in the AI process, the use of 9 breeds was reported, 48.8% corresponding to specialized dairy breeds (Jersey 27.9%, Ayrshire 11.6%, and Holstein 9.3%), an additional 30.2% to European breeds recognized as dual-purpose (Normande 27.9%, Simmental 2.3%) and finally 21.0% to zebu breeds or their crosses (Gyr 11.7%, Guzerá 4.7%, Girolando 2.3%, and Brahman 2.3%).

Producers' education

The educational level of the surveyed producers was rated using an arbitrary scale established as follows: 0 = The producer completed basic primary education, 1 = Secondary education completed, 2 = Higher education. For all the six municipalities, the highest percentage was in the lowest level of education (59.3%), followed by the intermediate (24.8%) and only 15.9% of the producers reported a higher level of education. The averages for the level of education are shown in table 3 and show the difference between the municipality with the highest (Cácota 0.93) compared to the two municipalities with the lowest levels of education (Pamplona and Pamplonita; 0.27 and 0.33 respectively).

Discussion

In the development of the characterization of livestock in the southwestern region of Norte de Santander, a first factor to highlight was that despite being a relatively small area within the departmental geography (2347 Km2, 10.8% of the department), there are differences in altitude among the six municipalities, and actually, within each municipality, a wide range of altitudes was found for the surveyed farms. Therefore, we decided to make an additional arrangement of the data using altitude quartiles, which allowed us to group farms with similar characteristics in the different municipalities.

An added value of this research is the modification of the farm size classification used by the ICA [5], to ranges 1-10, 11-50, and > 50 animals, which are more appropriately adjusted to the reality of the studied region and allow to visualize differential characteristics between the six municipalities, which otherwise would remain unnoticed (Table 1)

The bovine breeds present in the area are associated with the altitude ranges. The predominant breed in the entire study region was the Normande. A study carried out in the dairy micro-basin of the Antioquia highlands showed a higher proportion of the Holstein breed (83.5%) followed by Jersey (9.6%) and 6.9% corresponding to crosses of different breeds [7]. In the region of Paipa, Boyacá, Soler et al. [8] reported a higher proportion of the Normande breed, followed by the Holstein breed. It is important to highlight that in the first case the Antioquia region has

specialized milk production while Boyaca is a region of subsistence production systems, more similar to those of the present study.

In the first quartile of altitude, corresponding to the range between 1600 and 2300 MASL, the increase in the ratio of zebu (Brahman and Gyr) and crossbreed genotypes as the presence of Normande breed decreased was evident. The introduction of zebu crossbreeds adapted to high temperature, humidity, and ectoparasites conditions , is a practice established since the 1940s, to counteract the deleterious effects of the tropical environment in specialized breeds [9]. However, modern times have brought new challenges, such as the increase in the distribution of ectoparasites in higher altitude areas where previously they did not exist [10] and new alternatives, like the possibility of applying selection indexes that consider climatic characteristics in specialized breeds [11].

The document on world statistics for artificial insemination in cattle published by Thibier and Wagner [12] reports the use of 53.2% of semen from specialized milk breeds, which coincides with the 48.8% reported in this survey. However, the use of semen from beef breeds is higher than dual-purpose breeds (39.2% vs 1.9% respectively) [12], a situation that was reversed in the region studied where only 2.4% use was reported for beef breeds (Brahman) and 30.2% of dual-purpose breeds, mainly Normande. On the other hand, a high percentage of semen use from zebu breeds was found in the region (21%), which was surprising considering the altitude of the farms that reported such use (8/9 farms above 2300 MASL), and even more surprising two farms located above 3000 MASL, where the use of zebu breeds is very rare.

In any case, the consolidated data indicate that, adding up the specialized breeds, the dual-purpose and those zebus that are promoted as milk producers in the tropics, 97.6% of the semen used in the region seeks improvement in milk production, , and only 2.4% (Brahman)is used for beef production. Together with the abovementioned, the presence of the Normande breed as the basis of the herd, is a general indicator of the productive trend of the region, which is the search for milk production plus marginal weight gains in the offspring, meaning dual-purpose systems.

The milk production values found in the region were within the range of other studies conducted on dual-purpose systems similar to those in this research. Carulla and Ortega [13] determined values of 3 to 5 L / cow *day, while other authors report 3.34 L / cow *day [14], 7.7 L / cow * day [15] and 7.15 L / cow * day [16]. At similar altitudes to those of the present study, but under exclusive milk production systems, Hollman et al [17] reported productions of 12.87 and Ramírez et al. [7] of 17.3 ± 6.3 liters / cow * day.

The daily weight gains found in the region were lower than those reported by Soler et al. [8] in Boyacá (421g / day), 559 g / day in zebu and Colombian creole crossbreed steers [18], and 788 g / day in creole Costeño con cuernos calves [19].

One of the reasons for the high heterogeneity of the data regarding DWG is the breed composition and the type of production systems since the contribution of breeding systems for exclusive beef production in this particular region was low (3/113). According to this, the values found in the present work are lower than DWG in beef production systems with zebu cattle [20], where averages of 915g / animal / day can be reached with a diet based on medium-quality pastures, or in silvopastoral systems where gains between 800 and 980 g / animal / day were reported [21]. Dual-purpose systems sacrifice calf growth in exchange for marginal volumes of milk. The results obtained indicate that in smaller farms (1-10 animals), the milk extraction pressure is greater, or similarly, that larger farms can apply a selection of animals with higher milk production and leave those cows of low production for free rearing without milking, favoring the growth of their calves. In other words, dual-purpose livestock systems present a wide spectrum of management between dairy systems and beef systems, which are modulated by management conditions, market and economic capacity of the producers.

The CI found are lower than those reported by Bolívar et al [22], who found intervals equal to or greater than 460 days in Holstein, Jersey, and F1 (Holstein X Jersey) cows at an average height of 2490 MASL or as reported by Correa et at [23] 450.21 days in BON cows and 446.75 in Brahman cows. On the other hand, Botero et al [24] state that a 420-day calving interval is considered good and that this parameter is influenced by genetics (adaptation), diet, management, environment, and suckling frequency.

It is known that the variability of the postpartum period in cattle responds to multiple factors, mainly nutritional (energy balance - dam), and suckling (calf) [25]. The reproductive parameters, therefore, represent the consequence of multiple events of both the inputs of the productive systems such as environmental factors (altitude) related to nutritional factors (availability and quality of forages) as well as various management factors given by the type of operation and the degree of extraction that has already been mentioned in this type of dual-purpose systems. It is feasible to think that subsistence systems with lower supply and quality of forages with consequent nutritional imbalance, coupled with a maximum extraction of milk in detriment of the offspring, along with possible health issues, generate stressful conditions that result in the delay of reproductive function. Similarly, events associated with altitudes such as the breeds used, the quality of pastures, the incidence of diseases and parasites, can also lead to the reproductive parameters being punished in these areas.

Regarding education, it is difficult to make a direct association of this variable with the productive parameters evaluated, although it is observed that the two municipalities with the lowest education index are also those in which artificial insemination is practiced the least. A study carried out by Díaz-Rivera et al [26] did not find an association between the level of education measured in years and meat and milk production parameters in dual-purpose systems in Mexico; However, they found that operations with a higher technological level produced higher quantities of meat per year, maintaining a milk production similar to traditional type productions. It is possible to think that comprehensive education and technical training policies are an adequate complement to technology transfer programs that involve genetic improvement and zootechnical management.

Conclusions

The southwestern region of Norte de Santander has a dual-purpose livestock orientation with milk production of 5.5 liters / cow * day and calf weight gains of 367 grams / day on average. The breed with the greatest presence is the Normande, particularly in areas located at higher altitudes (> 2300 MASL), below

this altitude the percentages of other breeds such as Zebu (Brahman, Gyr) and their crosses with Holstein and other breeds increase.. Small farms (1 to 10 animals) predominate, followed by farms with no more than 50 animals and a minority of herds with more than 50 heads.

Milk production did not present differences between farms of different sizes and altitudes in the six municipalities; however, the average was higher for the municipalities of Chitagá and Mutiscua compared to Pamplonita, which in turn is the town with the lowest average altitude.

Regarding the weight gains of the offspring, these were similar for all municipalities and all altitudes, but there was a tendency for farms larger than 10 animals to obtain better daily weight gains. The intervals between calving are longer in Pamplona and Pamplonita and also in smaller farms and lower altitudes of all the municipalities studied. Future programs addressed to genetic improvement should consider the demand for females with potential for milk production and adequate weight gains in their offspring, using adequate breeds for the altitude conditions.

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References

[1] Federación Nacional de Ganaderos FEDEGAN., "Ganadería Colombiana Hoja de Ruta 2018-2022", pp. 126, 2018. ISBN: 978-958-8498-80-5.

[2] Gobernación de Norte de Santander, "Subregiones de Norte de Santander", 2012.

[3] H. Arellano and J.O. Rangel, "Patterns in the distribution of vegetation in paramo areas: heterogeneity and spacial dependence", *Caldasia*, vol. 30, no. 2, pp. 355-411, 2008.

[4] J.E. Bartlett, J.W. Kotrlik and Higgins C, "Organizational Research: Determining Appropriate Sample Size in Survey Research", *Information Technology, Learning, and Performance Journal*, vol. 19, no. 1, 2001.

[5] Instituto Colombiano Agropecuario, "Censo Pecuario nacional", 2016.

[6] FEDEGAN, "Cifras de referencia del sector ganadero colombiano", 2016.

[7] V. N. Ramírez-Arroyave, O. Henao, M. F. Cerón-Muñoz, M. G. Jaramillo, J. Cerón and Palacio L. Baena, "Factors Associated to Mastitis in Cows from the Dairy Production Basin in the Northern Highlands of Antioquia", *Revista de Medicina Veterinaria*, no. 22, pp. 31- 42, Colombia, 2011.

[8] D. Soler-Fonseca, V. Adame-Manosalva and E. Patiño Vargas, "Importancia de la cría de bovinos en la seguridad alimentaria de familias del área rural de Paipa", *Boyacá. Revista De Investigación Agraria y Ambiental (RIAA)*, vol. 2, no. 1, pp. 65-74, 2015.

[9] J. C. Bonsma, G. D. Scholtz and F. J. G. Badenhorst, "The influence of climate on cattle. Fertility and hardiness of certain breeds", *Farming 1940*, vol.15, pp.7-12, 1940.

[10] J. A. Vecino, J. A. Echeverri, J. Cárdenas and L. A. Herrera, "Distribución de garrapatas Rhipicephalus (Boophilus) microplus en bovinos y fincas del Altiplano cundiboyacense", *Colombia, Ciencia y Tecnología Agropecuaria*, vol. 11, no.1, pp. 73-84, 2010.

[11] J. R. Bryant, N. Lopez-Villalobos, J. E. Pryce, C. W. Holmes, D. L. Johnson and D. J. Garrick, "Environmental sensitivity in New Zealand dairy cattle", *Journal of Dairy Science*, vol. 90, no. 3, pp. 1538-1547, 2007.

[12] M. Thibier and H. G. Wagner, "World statistics for artificial insemination in cattle", *Livestock Production Science*, vol. 74, no. 2, pp. 203-212, 2002.

[13] J. Carulla and E. Ortega, "Sistemas de producción lechera en Colombia: retos y oportunidades",

Archivos Latinoamericanos de Producción Animal, vol. 24, no. 2, pp. 83-87, 2016.

[14] Y. Torres "Aplicación de modelos de innovación abierta en el sistema de doble propósito de Manabí (Ecuador)", Tesis de Doctorado., *Departamento de Producción Animal*, Universidad de Córdoba, Córdoba, España, pp. 172, 2015.

[15] H. Ocaña-Martínez and J. Alvarado-Cerón, "Evaluación de los parámetros productivos y reproductivos en vacas doble propósito obtenidas por inseminación artificial y monta natural en la Finca El Porvenir en Doncello", *Fagropec*, Facultad de Ciencias Agropecuarias, Caquetá vol. 9, no. 1, pp. 25-31, 2018.

[16] J. Cortés, A. Cotes and J. Cotes, "Avances en clasificación de Sistemas de Producción con Bovinos Doble Propósito en Colombia", *Archivos de Zootecnia*, vol. 63, pp. 559-562, 2014.

[17] F. L. Holmann-Rivas, J. Carulla, L.A. Giraldo, S. Guzman, M. Martínez and A. Farrow, "Evolución de los sistemas de producción de leche en el trópico latinoamericano y su interrelación con los mercados: Un análisis del caso colombiano", *Centro Internacional de Agricultura Tropical (CIAT), International Livestock Research Institute (ILRI) and Systemwide Livestock Program (SLP)*, Cali. Colombia, CIAT, 2003.

[18] R. A. Reyes and A.J. Montenegro, "Evaluación de la ganancia diaria de peso en novillos cruzados con cebú y criollo colombiano en Pinillos", *Tesis de pregrado, Escuela Agrícola Panamericana. Zamorano (Honduras)*, pp. 19, Bolívar, Colombia, 2014.

[19] G. M. Báez, H. A. Grajales and J.E. Pérez, "Caracterización del ciclo estral mediante perfiles de esteroides (progesterona, 17 β-estradiol) en la raza Costeño con cuernos (Bos taurus) en el trópico colombiano", *Livestock Research for Rural Development*, vol.19, no.132, 2007.

[20] Torres-Inga C.S., Guevara-Viera G.E., Guevara-Viera R.V., Curbelo-Rodríguez L.M., Estévez-Alfayate J.A., Ceró-Rizo Á.E., Díaz Aguirre M.J and Javier A., "Evaluación de la eficiencia en la ceba de toros en pastoreo mediante análisis envolvente de datos de panel"., *Revista de Producción Animal,* vol. 30, no. 1, pp. 22-29, 2018.

[21] Guevara R.V., Lascano P., Arcos C.N., Del Toro A., Peña E.R., Curbelo L.M., Guevara Viera G.E., Serpa García G and Soto Senra S.A., "Eficiencia anual en una operación comercial de ceba final de bovinos con la tecnología de silvopastoreo", *Archivos de Zootecnia*, vol. 65, no. 250, pp. 221-223, 2016.

[22] Bolívar D.M., Echeverry J.J., Restrepo L.F and Cerón Muñoz M.F, "Productividad de vacas Jersey, Holstein y Jersey*Holstein en una zona de bosque húmedo montano bajo (Bh-MB)", *Livestock Research for Rural Development*, vol, 21, no. 80, 2009.

[23] Correa Valencia J., Ramírez Aristizabal P., Zapata Carmona K., López Martínez J and González Herrera L., "Factores ambientales relacionados con el peso al parto, el peso al destete y el intervalo entre partos en vacas blanco orejinegro y brahman". *FAGROPEC. Facultad de Ciencias Agropecuarias*, vol. 8, no. 2, pp. 68-72, 2018.

[24] Botero M., Zambrano R and Méndez P., "Capacitación en Gestión para Empresarios GanaderosMódulo 1", G*estión de la Información en Empresas Ganaderas*, SENA. FEDEGAN, pp. 76, 2002.

[25] Báez G.M and Grajales H.A., "Anestro posparto en ganado bovino en el trópico", *MVZ Córdoba*, vol. 14, no, 3, pp. 1867-1875, 2009.

[26] P., Díaz-Rivera, Oros-Noyola, V., Vilaboa-Arroniz, J., Martínez-Dávila, J. P and Torres-Hernández, G., "Dinámica del desarrollo de la ganadería doble propósito en las Choapas", *Tropical and Subtropical Agroecosystems*, Veracruz, México., vol. 14, no. 1, 201