Nativa, Sinop, v. 13, n. 1, p. 156-161, 2025.
Pesquisas Agrárias e Ambientais
DOI: https://doi.org/10.31413/nat.v13i1.18865
ISSN: 2318-7670

Morphometric and phaneroptic characteristics of creole goats in the dry forest of Peru

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Submitted: 12/18/2024; Accepted: 03/27/2025; Published: 04/21/2025.

ABSTRACT: The study aimed to describe morphometric and phaneroptic parameters in goat herds from the northern region of Lambayeque, Peru. A total of 295 goats over two years old, without evidence of crossbreeding with specialized breeds, were used. For each animal, 19 morphometric and eight phaneroptic measurements were recorded, and zoometric indices were calculated using a scale, measuring tape, and zoometric stick. This was performed using R software version 4.3.1. The results showed an average live weight of 41 ± 7.5 kg and a proportionality index of 99.6, highlighting their suitability for meat or dual-purpose production (IDT: 13.4, ICO: 88.7), adapted to the local environment. Regarding phaneroptic characteristics, monochromatic coat colors predominated in 55.6% of the animals, 43.7% were hornless (72.7% of the horns observed were parallel), 20.7% had beards, and 10.5% presented wattles. Additionally, 14.7% had supernumerary teats, and 46% of males displayed testicular bifurcation. In conclusion, the Creole goat of the Dry Forest in northern Peru is medium-sized, with robust limbs and a meat-production aptitude, as reflected by the proportionality index. It is also characterized by predominantly dark coats and parallel horns when present. These features demonstrate their adaptation to this environment and their potential for meat production.
Keywords: creole goat; zoometry; phaneroptic; dry forest.

Características morfométricas e fanerópticas de cabras crioulas na floresta seca do Peru

RESUMO: O objetivo do estudo foi descrever parâmetros morfométricos e fanerópticos em rebanhos caprinos da região norte de Lambayeque, Peru. Foram utilizadas 295 cabras com mais de dois anos de idade, sem evidências de cruzamento com raças especializadas. Para cada animal, foram registradas 19 medidas morfométricas e oito fanerópticas, e os índices zoométricos foram calculados usando uma balança, fita métrica e vara zoométrica. Isso foi realizado usando o software R versão 4.3.1. Os resultados mostraram um peso vivo médio de 41 ± 7,5 kg e um índice de proporcionalidade de 99,6, destacando sua adequação para produção de carne ou dupla finalidade (IDT: 13,4, ICO: 88,7), adaptado ao ambiente local. Em relação às características fanerópticas, as cores monocromáticas da pelagem predominaram em 55,6% dos animais, 43,7% eram sem chifres (72,7% dos chifres observados eram paralelos), 20,7% tinham barbas e 10,5% apresentavam mamelas. Além disso, 14,7% tinham tetas supranumerárias e 46% dos machos apresentavam bifurcação testicular. Em conclusão, a cabra crioula da Floresta Seca no norte do Peru é de médio porte, com membros robustos e aptidão para produção de carne, conforme refletido pelo índice de proporcionalidade. Também é caracterizada por pelagens predominantemente escuras e chifres paralelos quando presentes. Essas características demonstram sua adaptação a esse ambiente e seu potencial para produção de carne.
Palavras-chave: cabra crioula; zoometria; faneróptica; floresta seca.

1. INTRODUCTION

In the Lambayeque region, goats are primarily raised for meat production. They feed on grass and agricultural residues in the dry forest. These goats possess valuable traits such as adaptation to drought periods, high fertility, low reproductive seasonality, maternal ability, disease resistance, and longevity. Therefore, it is essential to undertake initiatives to characterize and conserve these competitive advantages to maintain genetic diversity and utilize them in crossbreeding programs.

Studies on external morphology, including observing physical characteristics and precise measurements (Castellaro et al., 2019), play a crucial role in preserving the genetic diversity of native animals. This process involves measuring external features in various parts of the body, such as the

head, neck, trunk, and limbs. These regions are interconnected, and their relationship depends on the ecological environment in which they are located and the management they receive. It is necessary to evaluate different aspects, such as morphometry, to improve production (FAO, 2012). This practice is essential as it allows the measurement of the animal's conformation and the establishment of specific metrics. Through this, variations in different native animals can be identified, aiming for their effective conservation (OYOLO-CENTENO, 2020).

Identifying the body measurements of individuals helps to understand their productive capacities and approximately evaluate their functional characteristics within a zootechnical production system (HÉRNANDEZ et al., 2022). These physical traits provide insights into the animal's potential meat and/or milk production productivity. Size and shape measurements are linked to the assessment of the animal's body, including its back, hips, legs, weight, and meat yield. Therefore, it is crucial to consider this evaluation when planning improvements in meat quantity and quality (GONZÁLEZ et al., 2021). In this context, this study aimed to characterize Creole goats' phenotypic traits and morphometry (*Capra hircus*) in two districts in the northern part of Lambayeque.

2. MATERIAL AND METHODS

2.1. Study area

The study was conducted in the district of Mórrope, located in the northwest of Lambayeque province, at a latitude of 6°32'28.25" and a longitude of 80°00'46.64", with an average altitude of 16 meters above sea level. Specifically, the rural communities of Arbolsol, Cartagena, El Romero, and La Colorada were selected for the study. Additionally, the study included the district of Olmos, situated at an altitude of 118 meters above sea level, with geographic coordinates of 5°59'14.47" latitude and 79°44'44.16" longitude. In Olmos, the evaluated sectors were El Virrey, Virreicito, Las Animas, and Los Laureles.

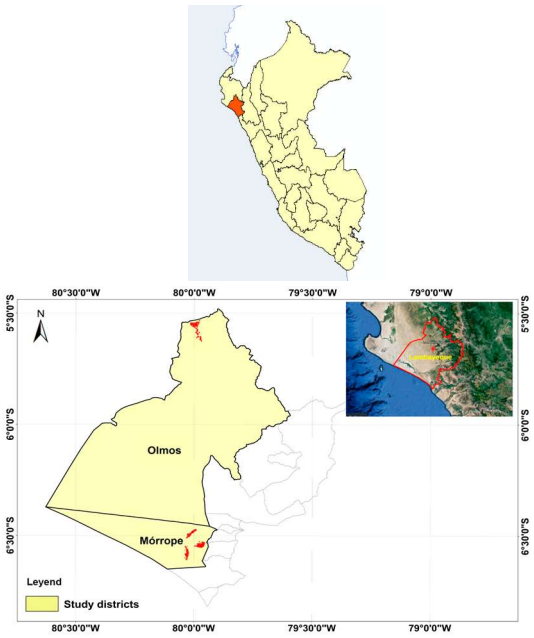

Figure 1. Map of Lambayeque, Peru, showing the study area in two districts.
Figura 1. Mapa de Lambayeque, Peru, mostrando a área de estudo em dois distritos.

2.2. Morphometric measurements

A flexible measuring tape and a zoometric stick were used to measure the animals' various morphometric variables and live weight (LW). Individual data were recorded before the measurements – Figure 2 (CASTELLARO et al., 2019).

2.3. Sampling

Empty female goats and adult males over two years old with a body condition score between 3 and 3.5 were evaluated. The sample size was estimated based on the total number of goats in the Lambayeque region, as reported by the IV National Agricultural Census (CENAGRO, 2012), which recorded 55,607 animals. The formula for finite populations of farm animals was used, with a margin of error of 5%. Based on this, 120 goats were characterized in Mórrope and 175 in Olmos.

2.4. Morphometric variables

The size and measurements of an animal can be determined using various parameters (Figure 2), such as head length (HL), head width (HW), chest width (CW), thoracic perimeter (TP), withers height (WH), rump height (RH), rump width (RW), rump length (RL), body length (BL), abdominal perimeter (AP), anterior cannon perimeter (ACP), udder depth (UD), udder length (UL), udder diameter (UDia), distance between teats (DT), teat diameter (TD), and teat length (TL). For males, scrotal circumference (SC), scrotal length (SL), and live weight (LW) were also measured (PEÑA et al., 2017; ORMACHEA et al., 2020).

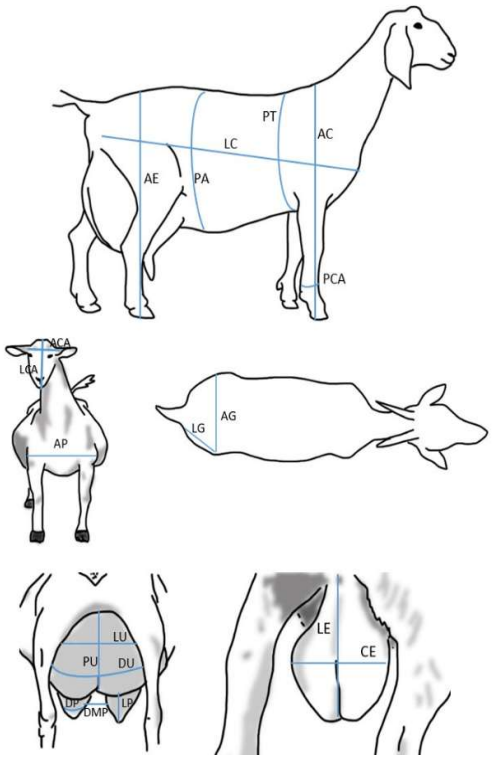

Figure 2. Morphometric Measurements of Creole Goats from Lambayeque, Peru.
Figura 2. Medidas morfométricas de cabras crioulas de Lambayeque, Peru.

The following measurements were taken: LCA: Head length, ACA: Head width, AC: Withers, height, AP: Chest width, LG: Rump length, AE: Rump height, AG: Rump width, LC: Body length, PCA: Cannon perimeter, PA: Abdominal perimeter, PT: Thoracic perimeter, CE: Scrotal circumference (males), LE: Scrotal

length (males), PU: Udder depth (females), LU: Udder length (females), DU: Udder diameter (females), DP: Distance between teats (females), DMP: Teat diameter (females), LP: Teat length (females).

2.5. Zoometric indexes

The following zoometric indices were calculated to evaluate the physical and functional characteristics of the goats:

- Cephalic Index (ICE): head width x 100/head length;
- Body Index (ICO): (Body length/Thoracic perimeter) x 100;
- Pelvic Index (IPE): (rump width/rump length) x 100;
- Proportionality Index (IPRO): (withers height/longitudinal diameter) x 100;
- Transversal Pelvic Index (IPET): (rump width/withers height) x 100
- Compactness Index (ICOMP): (live weight/withers height) x 100
- Relative Thickness of Cannon Index (IERCAÑ): (Anterior cannon perimeter/withers height) x 100
- Cannon Load Index (ICC): (Anterior cannon perimeter/live weight) x100.

These indices were derived from various body measurements, including length, diameter, weight, and height, to provide insights into the animals' morphological and functional traits. The methodology proposed by Ramírez-Roja et al. (8) for smaller ruminants was employed for the assessment.

2.6. Phenotypic variables

Eight phenotypic characteristics were recorded: Sex, Coat color, Horns, Horn direction, Beard, Wattles, Teats and Testicular Bipartition.

2.7. Statistical Analysis

Descriptive analysis was performed using R version 4.3.1, which allowed for a quantitative characterization of the goats' morphometric and phenotypic measurements. The mean, standard deviation, maximum, minimum, and coefficient of variation were calculated with a 95% confidence level. This information is essential for understanding the population's genetic diversity, evaluating its productive potential, and planning management and conservation strategies.

3. RESULTS

Table 1 presents the means and standard deviations of the zoometric variables for adult animals. The withers height (AC) of the goats was 68.3 cm, with a standard deviation (SD) of 6.9 cm, classifying them as medium-sized animals, as it surpasses the 58.8 cm threshold. The average rump height (AE) was 68.7 cm, with an SD of 6.1 cm. The rump width (AG) averaged 14.5 cm, showing low variability with an SD of 2.7 cm. Table 2 describes the zoometric indices of the goats from the Lambayeque region, where an ICE of 53.8 is observed, with dolichocephalic goats predominating.

The analysis revealed a strong positive association between the various morphometric measurements evaluated. In particular, a very high correlation of 0.73 was observed between head length (LCA) and head width (ACA). Additionally, strong positive correlations of 0.55 between LCA and AC, and 0.68 between AC and AE were detected, indicating a common trend in these measures. The results suggest that PCA decreases as LG increases, and vice versa. This inverse relationship was also observed between AG and LC, with a correlation coefficient of -0.19.

Table 1. Zoometric variables of the creole goat from Lambayeque.
Tabela 1. Variáveis zoométricas da cabra crioula de Lambayeque.

Var.	Females				Males			
	AVG	SD	min.	max.	AVG	SD	min.	max.
PV	41.0	7.5	22.0	67.0	38.3	5.0	30.2	45.6
LCA	32.2	5.4	17.0	57.0	31.5	4.8	23.0	38.0
ACA	19.0	3.9	8.0	31.0	17.0	3.6	12.0	23.0
AC	68.3	6.9	49.0	88.5	65.5	6.7	52.5	72.5
AP	17.0	5.7	11.0	99.0	15.1	2.3	12.5	19.0
LG	16.6	3.8	11.0	32.0	14.5	2.6	11.0	18.0
AE	68.7	6.1	50.0	86.0	65.2	7.4	52.0	74.5
AG	14.5	2.7	8.5	29.6	13.2	3.0	8.5	18.5
LC	70.8	6.9	50.0	87.0	66.2	7.4	54.4	7.0
PCA	11.3	2.0	7.3	18.0	9.9	1.9	6.5	12.0
PA	92.6	52.4	12.0	94.4	85.8	7.0	71.5	92.3
PT	78.6	10.4	47.0	100.0	75.1	9.5	60.9	87.4
CE	--	--	--	--	24.6	4.5	13.5	29.3
LE	--	--	--	--	10.2	3.5	6.0	15.4
PI	13.4	3.6	3.0	23.0	--	--	--	--
LU	11.9	4.2	4.0	25.0	--	--	--	--
DU	30.8	3.7	19.2	43.5	--	--	--	--
DP	9.3	2.3	2.9	17.7	--	--	--	--
DMP	6.7	1.8	2.5	13.5	--	--	--	--
LP	5.2	1.5	2.0	9.8	--	--	--	--

PV = live weight; LCA = head length; ACA = head width; AP = chest width; PT = thoracic perimeter; AC = height at the withers; AE = height at the rump; AG = rump width; LG = rump length; LC = body length; PCA = anterior shank perimeter; PA = abdominal perimeter; PU = udder depth; LU = udder length; DU = udder diameter; DP = distance between teats; DMP = teat diameter; LP = teat length; CE = scrotal circumference; LE = scrotal length.

Table 2. Zoometric indexes of the creole goat from Lambayeque.
Tabela 2. Índices zoométricos da cabra crioula de Lambayeque.

Index	AVG	SD	min.	max.
ICE	53.8	6.0	46.9	64.7
ICO	88.7	8.0	79.8	106.7
IPE	95.1	31.4	50.0	144.6
IPRO	99.6	12.0	76.6	126.1
IDT	13.3	3.0	8.5	18.5
IPRT	101.7	12.5	79.3	130.5
IPET	20.6	6.3	12.4	35.2
IPEL	24.4	6.2	15.6	51.6
ICOMP	60.0	9.5	32.2	91.8
IERCAÑ	16.6	2.9	10.3	28.0
ICC	28.3	6.5	12.9	50.0

ICE = Cephalic Index; ICO = Body Index; IPE = Pelvic Index; IPRO = Proportionality Index; IDT = Thoracic Digit Index; IPRT = Relative Depth Index of Thorax; IPET = Transversal Pelvic Index; IPEL = Longitudinal Pelvic Index; ICOMP = Compactness Index; IERCAÑ = Relative Thickness Index of the Cañal; ICC = Cañal Load Index.

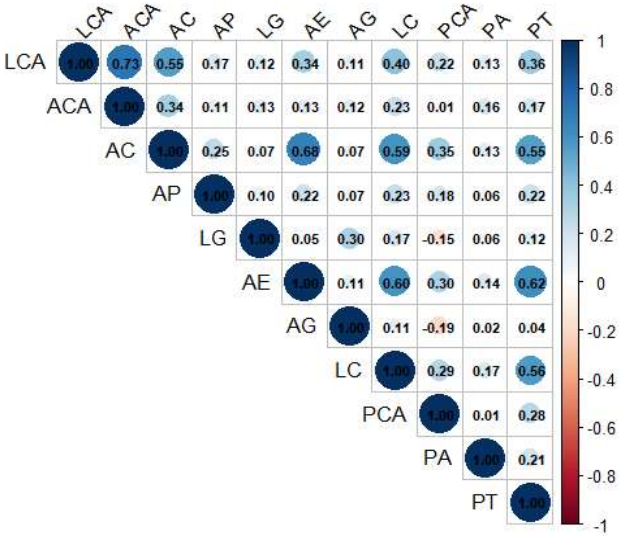

Figure 3. Correlation between the zoometric variables of the Lambayeque native goat.
Figura 3. Correlação entre as variáveis zoométricas da cabra nativa de Lambayeque.

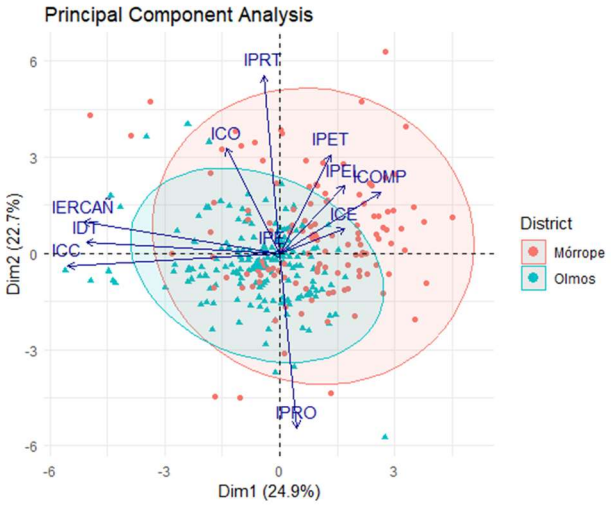

Figure 4. Zoometric indices of the Creole goat from Lambayeque.
Principal Component Analysis (PCA) of the morphometric indices of goats in the two districts studied in Lambayeque, Peru, showing the grouping and morphometric variability between Mórrope and Olmos.
Figura 4. Índices zoométricos da cabra crioula de Lambayeque.
Análise de Componentes Principais (ACP) dos índices morfométricos de cabras nos dois distritos estudados em Lambayeque, Peru, mostrando o agrupamento e a variabilidade morfométrica entre Mórrope e Olmos.

In Graph 3, it is observed that the indices ICE, ICOMP, IPEL, IPET, and IPRT point towards the upper right quadrant, indicating that they are related to the observations made in the Mórrope district, while the indices IC, IDT, and IERCAÑ point towards the left side, indicating that they are associated with characteristics different from the rest, mostly representative of the Olmos district. Dim1 (24.9%) and Dim2 (22.7%) account for a total of 47.6% of the data variability, which is a moderate percentage, indicating that these two components do not capture significant information.

Table 3. Phenotypic variables of goat livestock.
Tabela 3. Variáveis fenotípicas do rebanho caprino.

Character	Description	Frequency (%)
Sex	Female	96.6
	Male	3.4
Coat color	Solid	55.6
	Spotted	44.4
Horns	Absent	43.7
	Present	56.3
Direction of horns	Divergents	27.3
	Parallels	72.7
Beard	Absent	79.3
	Present	20.7
Wattles	Absent	89.5
	Present	10.5
Nipples	Normal	85.3
	Supernumerary	14.7
Testicular bifurcation	Absent	40
	Present	60

Table 3 presents the predominant phenotypic characteristics, with 44.4% of goats having a spotted coat and 55.6% having a solid coat. 20.7% of the goats have a beard. 56.3% of the goats have horns, and 72.7% have parallel horns.

10.5% of the individuals had mammary glands, and the average presence of supernumerary nipples was 14.7%. As for the males, 60% exhibited testicular bifurcation.

4. DISCUSSÃO

The average weight of the animals is 41 kg, ranging between 22 kg and 67 kg. It is important to note that this variable is strongly influenced by the time of year, management practices, and the type of feed the animals receive. The goats' weight was higher than reported in a study in Mexico (Hernández et al., 2022) on local goats, which was 35 kg, and also higher than what was recorded in the Tumbes region, with 37.18 kg (TEMOCHE et al., 2024).

The proportionality index is 99.6, lower than that shown in crossbred goats from Mexico, with 101.37 (15), and also lower than in goats from the central Mediterranean region of Chile, with an average of 112.39 (CASTELLARO et al., 2019). Considering a classification based on IPRO values - short-bodied (<95), medium-bodied (95-105), or long-bodied (>105) - the animals studied are classified as medium-bodied, as they had an average IPRO value between 95 and 105 (11). This is similar to what was reported in the Tumbes region, where values ranged from 99.57 to 105.73 (TEMOCHE et al., 2024).

The average height of the rump was 68.7 cm, which is lower than the 72.03 cm found in Nindirí, Masaya (4), and

also lower than the 70.54 cm reported for the black native goat in central Mexico (SILVA-JARQUIM et al., 2019). The values obtained for the height at the withers and rump were lower than those of the mestizo goats from Masaya, indicating that they are of medium size (HERNÁNDEZ et al., 2022).

Additionally, the average value for the width of the rump was 14.5 cm, with a standard deviation of 2.7%, lower than the values recorded for native goats of the Serrano biotype in northwest Argentina, which was 16.16 cm (FERNÁNDEZ et al., 2014), and for native goats in Veracruz, which was 16.77 cm (LOZADA-GARCÍA et al., 2015).

The average length of the rump (LG) was 16.6 cm with a standard deviation of 3.8, with no noticeable differences between sexes and little variation in the measurements. In the native goats, known as "Chusca lojana," higher average measurements of 21.2 cm were found (AGUIRRE et al., 2021).

The values of IPET = 20.6 and IPEL = 24.4 found in the goats indicate they have a meat aptitude, which is consistent with the values found in goats from San Luis Potosí, with IPET = 25.91 and IPEL = 24.79 (GUTIÉRREZ et al., 2017).

The average IDT was 13.3, which indicates that the animals are of a meat type, as it is higher than 11. This index suggests a well-developed skeleton suitable for adapting to a harsh environment and an extensive grazing system (FUENTES-MASCORRO et al., 2013).

The average IPE value is 95.1, higher than that reported in mestizo goats in Mexico with 72.48 (Macedo et al., 2020) and lower than that found in goats from the central Mediterranean region of Chile with 158.55 (CASTELLARO et al., 2019). It is important to select goats with a wider rump. This helps to widen the pelvic canal, facilitating delivery and providing space for the udder (ABARCA-VARGAS et al., 2020).

Regarding the phenotypic aspect, it can be observed that most of the goats have dark colors. In Venezuela, 167 native goats from Urdaneta in Lara state were studied, finding that 75.9% had a mottled coat color and 24.1% had a solid color (MUÑOZ et al., 2014).

The presence of beards in the animals analyzed was 20.7%, which coincides with a previous study conducted in four provinces of the Lima region, which determined that 29.9% of the 156 animals studied had beards (OYOLO-CENTENO, 2020).

It was found that 56.3% of the animals studied have horns, with females having horns that curve backward (MELCHOR-GARCÍA et al., 2018). These values are lower compared to goats from the Sierra Madre del Sur in Guerrero, where two types of horns were found: divergent (66.0%) and parallel (26.3%), with the former being the most common (MARTÍNEZ-ROJERO et al., 2014).

It was observed that only 10.5% of the individuals had wattle, a lower percentage than reported in a study of "Filo Mayor" white goats, where 53.7% of the goats exhibited this trait. This suggests that wattles in goats may vary independently of their breed or lineage (MARTÍNEZ-ROJERO et al., 2014).

The average percentage of supernumerary nipples was 14.7%, similar to that found in the Creole goat from central Veracruz, which was 14% (LOZADA-GARCÍA et al., 2015). Nipple defects are highly heritable, so animals with this trait should be rejected. Only 60% of the testes exhibited bipartition, a figure lower than the one found in "Filo Mayor" white goats in Guerrero, where 53.70% of the individuals had this characteristic (MARTÍNEZ-ROJERO et al., 2014).

4. CONCLUSIONS

The goats, with an average weight of 41 kg, are classified as mesoline based on their proportionality index (IPRO = 99.6). These animals are typically found in herds intended for meat or dual-purpose production. Their well-developed skeleton allows them to adapt to harsh environments and extensive grazing systems.

Regarding the phenotypic characteristics, the dominant coat colors were dark, with parallel horns. In the sample, the majority of the animals, 56.3%, had horns. 43.7% of the goats were polled, and it was observed that this population included the breeding males, so it is recommended to choose horned males to avoid reproductive problems (MELLADO et al., 2008).

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Acknowledgements: We would like to thank the producers who allowed and supported the measurement of their animals, and we recognize the National Institute of Agricultural Innovation (INIA) for its contributions under the "Improvement of Research and Technology Transfer Services for Sustainable Goat Livestock Management in Dry Forests, in the departments of Tumbes, Piura, Lambayeque, Amazonas, La Libertad, Ancash, Lima, Ica, and Ayacucho" investment project - CUI 2506684.

Authors' contributions: Conceptualization and writing: I.C.A.G. and R.A.V.; Funding acquisition: J.A.C.L., J.A.R.C.; Methodology: I.C.A.G. and R.A.V.; Research or data collection: J.E.C.F.

Data availability: Study data can be obtained by email from the corresponding author or the second author upon request. It is not available on the website as the research project is still under development.

Conflict of interest: The authors declare no conflict of interest. Supporting entities had no role in the study's design, data collection, analysis, interpretation, manuscript writing, or decision to publish the results.

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