Journal MVZ Córdoba
2022; 27(Supl):e2850
https://doi.org/10.21897/rmvz.2850

Original

Zootechnical function of a population of Blackbelly sheep in Campeche, México, based on morphometric indices

María del Carmen Ramírez-Rojas[1]; Angel Felipe Dzib-Can[2]; José Alfonso Hinojosa-Cuéllar[3]; Roberto González-Garduño[4]; Leonor Miranda-Jiménez[1]; Javier Suárez-Espinosa[5]; Glafiro Torres-Hernández[1]*.

[1]Colegio de Postgraduados-Campus Montecillo, Posgrado en Ganadería. Montecillo, Estado de México.México.
[2]Instituto Tecnológico de Chiná, Departamento de Producción Animal. Chiná, Campeche, México.
[3]Universidad Popular de la Chontalpa, Departamento de Zootecnia. Cárdenas, Tabasco. México.
[4]Universidad Autónoma Chapingo, Departamento de Zootecnia. Teapa, Tabasco, México.
5Colegio de Postgraduados-Campus Montecillo, Posgrado en Estadística. Montecillo, Estado de México. México.
*Correspondencia: glatohe@colpos.mx

Received: August 2022; Accepted: October 2022; Published: October 2022.

ABSTRACT

Objective. The objective of the study was to determine the zootechnical function of Blackbelly sheep utilizing morphometric indices (MI). **Materials and methods.** Five hundred and twenty-five females and 67 adult males were utilized to analyze live weight (LW) and eleven MI, one of ethnological type: body index, and 10 of functional type: relative shortness index, depth index, relative depth of thorax index, longitudinal index, longitudinal pelvic index, foreleg length index, dactyl-thoracic index, dactyl-costal index, body capacity index 1, and body capacity index 2. **Results.** Averages of the ethnological index in males (68.8) and females (74.2) indicated that Blackbelly sheep of this population are classified as short-sized. Results from the meat-aptitude index indicated in males a clear orientation for meat production. However, results from the milk-aptitude indices indicated in females an eumetric tendency, which means an acceptable orientation for milk production. A strong sexual dimorphism was found with higher averages ($p<0.05$) for males in most morphometric variables, with an overall mean of 1.16 in the difference between males and females. In males, 82.1% of correlations among LW and morphometric variables were positive and significant, whereas in females it was 57.1%. **Conclusions.** This population of Blackbelly sheep has a high sexual dimorphism, it is undefined in its zootechnical function, and it has a high-medium body harmony.

Keywords: Non-linear measures; live weight; meat; milk; body harmony (*Source: AGROVOC*).

RESUMEN

Objetivo. El objetivo del estudio fue determinar la función zootécnica de ovinos Blackbelly utilizando índices morfométricos (IM). **Materiales y métodos.** Se utilizaron 525 hembras y 67 machos adultos para analizar el peso vivo (PV) y once IM, uno de tipo etnológico: índice corporal, y diez de tipo funcional: índice de cortedad relativa, índice de profundidad, índice de profundidad relativa del tórax, índice longitudinal, índice pelviano longitudinal, índice de longitud de la pata delantera, índice dáctilo torácico, índice dáctilo costal, índice de capacidad corporal 1, e índice de capacidad corporal 2. **Resultados.** Los promedios del índice etnológico en machos (68.8) y hembras

How to cite (Vancouver).
Ramírez-Rojas MC, Dzib-Can AF, Hinojosa-Cuéllar JA, González-Garduño R, Miranda-Jiménez L, Suárez-Espinosa J, Torres-Hernández G. Zootechnical function of a population of Blackbelly sheep in Campeche, México, based on morphometric indices. Rev MVZ Cordoba. 2022; 27(Supl):e2850. https://doi.org/10.21897/rmvz.2850

ISSNL: 0122-0268

(74.2), indicaron que los ovinos Blackbelly de esta población se clasifican como brevilíneos. Los resultados de los índices de aptitud cárnica indicaron en los machos una clara orientación para producción de carne. Sin embargo, los resultados de los índices de aptitud lechera mostraron en las hembras una tendencia eumétrica, lo que significa una aceptable orientación para producción de leche. Se encontró un marcado dimorfismo sexual con promedios mayores (p<0.05) en los machos en PV y la mayoría de las variables morfométricas, con una media general de 1.16 en la diferencia entre machos y hembras. En los machos, el 82.1% de las correlaciones entre el PV y las variables morfométricas fueron positivas y significativas, mientras que en las hembras fue 57.1%. **Conclusiones.** Esta población de ovinos Blackbelly tiene un alto dimorfismo sexual, es indefinida en su función zootécnica y su armonía corporal es de alta a mediana.

Palabras clave: Medidas no lineales; peso vivo; carne; leche; armonía corporal (*Fuente: AGROVOC*).

INTRODUCTION

In Mexico there is no official information in the national inventory on the percentage of sheep classified by breed, but it is known that the predominant hair sheep in the tropical regions of this country are the Pelibuey (1) and Blackbelly (2) breeds. The importance of Pelibuey sheep is based on their great adaptability to various agroecological regions, which is why they are currently found almost everywhere in the country (1). As for the Blackbelly, their popularity is due to their hardiness and high prolificacy in humid and sub-humid environments, which is why they are very well adapted to the production systems of southeastern Mexico (2). However, the use of these breeds in the country has been affected by the recent introduction of exotic breed sires, such as Charollais, Dorper, Katahdin, Texel and others, which have been crossed with Pelibuey and Blackbelly females (1,3), causing, on the one hand, a slow and progressive decrease of sheep with total racial purity and, on the other hand, the appearance of females with only 50% of any of these hair genotypes. This suggests developing actions for better knowledge, genetic improvement and, above all, to maintain their biodiversity and preservation (4).

Morphometric variables in animals refer to body measurements, and although their variation has a high genetic component, they are subject to the influence of management and environmental factors (5). One type of variables related to morphometric variables are morphometric indices (MI), which are nonlinear measures constructed from linear morphometric variables that have been used to define the type and zootechnical function of sheep (6,7), goats (8,9), and cattle (10,11). However, MI data in hair sheep is still limited (12,13), especially in Blackbelly sheep. The objectives of this study were a) to determine whether there is sexual dimorphism in a population of Blackbelly sheep, b) to know the zootechnical function of this same population based on MI, and c) to define the body harmony of the population.

MATERIALS AND METHODS

Type of study. Due to its intrinsic characteristics, this study is descriptive.

Animals and management. The information for this work comes from data collected in the same year on whole males (n=67) and dry sheep (n=525) adults (average: 3.5 years old) in a Blackbelly sheep population located on a farm in central Campeche, Mexico, at 19°43’47’’ North Latitude and 90°21’03’’ West Longitude and an altitude of 20 masl. The climate of this region corresponds to the Aw classification, with an average annual rainfall of 1,000 to 1200 mm distributed from June to October, and an average annual temperature of 25.8°C (14). Sheep are managed in a semi-extensive production system, with daytime grazing and night confinement. The animals mostly consume grasses such as *Cynodon plectostachyus*, *Pennisetum sp*., and *Urochloa decumbens* (Stapf) R. D. Webster. During the rainy season, they have access to agricultural residues, such as corn, and may sporadically consume agro-industrial products, such as polished rice. Mineral salts and water are freely available in the pens. Although vaccination and internal deworming programs are at the discretion of the producers’ experience, they generally vaccinate once a year and deworm every 6 months. The care, attention and handling of animals was carried out in accordance with the recommendation of official standards (15).

Morphometric variables and index construction. In males and females, the following variables were recorded: body length (LC), girth (PT), wither height (AC), chest depth (PP), rump length (LG), shank circumference (PC), thoracic width (AT), and live weight (PV). With all these variables, the sexual dimorphism (SD) of the population was calculated, following the method of Legaz et al (16). Subsequently, with these same variables, the MI’s shown in Table 1 were constructed, following the indications of the literature (17,18).

Table 1. Morphometric indices analyzed in a population of Blackbelly sheep in Campeche, Mexico.

Index	Calculation
Body index (IC)	(LC/PT) x 100
Relative shortness index (ICR)	(AC/LC) x 100
Depth index (IP)	(PP/AC)
Relative thoracic depth index (IPRT)	(PP/AC) x 100
Length index (IL)	(LC/AC) x 100
Longitudinal pelvic index (IPL)	(LG/AC) x 100
Foreleg length Index (ILPD)	(AC – PP)
Dactyl-thoracic index (IDT)	(PC/PT) x 100
Dactyl-costal index (IDC)	(PC/AT) x 100
Body capacity index 1 (CC1)	(PV/LC) x 100
Body capacity index 2 (CC2)	(PV/PT) x 100

LC: Body length; PT: Girth; AC: Wither height; PP: Chest depth; LG: Rump length; PC: Shank circumference; AT: Thoracic width; PV: Live weight.

The MI's in Table 1 are grouped into the following categories: 1: ethnological type (IC); 2: meat suitability (ICR, IP, IPRT, IL, IPL, ILPD, CC1, CC2); and 3: dairy suitability (IDT, IDC).

Statistical analysis. A Pearson correlation analysis was performed including PV and all morphometric variables. For each morphometric variable and MI, mean, standard deviation and coefficient of variation were calculated, in addition to Student's "t" tests (19) in order to determine possible differences.

RESULTS

The descriptive statistics of the morphometric variables are shown in Table 2, in addition to the means of sexual dimorphism.

The descriptive statistics of MI's are shown in Table 3.

Meat suitability indices. The magnitude of the ICR averages (Table 3), indicates that the sheep in this population are classified as brevilineal. On the other hand, the IP and IPRT averages in this same table indicate that the zootechnical suitability of Blackbelly sheep is for meat production. Also, based on the IL and IPL averages (Table 2), Blackbelly sheep have a short body.

Table 2. Mean, standard deviation (s.d.) and coefficient of variation (C.V.) of morphometric variables in a population of male and female Blackbelly sheep in Campeche, Mexico.

Variable	Males Mean±s.d.	C.V.(%)	Females Mean±s.d.	C.V.(%)	SD (m/f)
LC (cm)	77.2±6.7a	8.6	66.7±4.6b	6.9	1.15
PT (cm)	86.5±6.5a	7.5	77.7±6.1b	7.8	1.11
AC (cm)	71.5±5.3a	7.4	66.0±4.3b	6.5	1.08
PP (cm)	33.3±4.1a	12.3	29.4±3.5b	11.9	1.13
LG (cm)	23.2±4.5a	19.4	19.8±3.7b	18.7	1.13
PC (cm)	8.8 ±0.6a	6.8	7.4±0.4a	5.4	1.19
AT (cm)	20.3±3.6a	17.7	15.7±2.8b	17.8	1.29
PV (kg)	41.0±11.9a	29.0	32.7±6.8b	20.8	1.25
		Overall mean			**1.16**

LC: body length, PT: girth, AC: wither height, PP: chest depth, LG: rump length, PC: shank circumference, AT: thoracic width, PV: live weight. s.d.: standard deviation, SD: sexual dimorphism (males/females).

Table 3. Mean, standard deviation (s.d.) and coefficient of variation (C.V.) of morphometric indices in a population of male and female Blackbelly sheep in Campeche, Mexico.

Index	Males Mean±s.d.	C.V.	Females Mean±s.d.	C.V.
IC	68.8±7.5b	10.9	74.2±7.1a	9.5
ICR	90.5±8.2a	9.0	81.2±7.1b	8.7
IP	0.46±0.04a	8.6	0.44±0.04b	9.1
IPRT	45.7±3.6a	7.9	44.0±4.0b	9.1
IL	0.81±0.07b	8.6	0.86±0.07a	8.1
IPL	21.6±3.3b	15.4	24.4±3.5a	14.4
ILPD	36.8±3.3a	8.9	35.8±3.2a	9.0
IDT	10.4±1.1a	10.2	9.9±1.1b	11.3
IDC	50.1±7.6a	15.3	46.7±6.3b	13.5
CC1	0.75±0.21a	28.0	0.59±0.12b	20.3
CC2	0.51±0.11a	21.5	0.44±0.10b	22.7

IC: Body index; ICR: Relative shortness index; IP: depth index, IPRT: Relative thoracic depth index; IL: length index; IPL: longitudinal pelvic index; ILPD: foreleg length index; IDT: Dactyl-thoracic index; IDC: Dactyl-costal index; CC1: Body capacity index 1; CC2: Body capacity index 2.

Dairy suitability indices. Table 3 shows the IDT and IDC averages, which indicate that the Blackbelly sheep of this population show an eumetric tendency, with an acceptable mil production orientation.

Sexual dimorphism. With the exception of the shank circumference, males outperformed females (p<0.05) in morphometric variables, as well as in PV (Table 2). The overall mean SD for morphometric variables was 1.16.

Ethnological index. The IC was the only ethnological index analyzed in this study. From the averages of this variable (Table 3), the Blackbelly sheep in this population are brevilineal.

Correlations between morphometric variables. Phenotypic correlations between MI's and PV of males and females are shown in Table 4.

The largest and most positive correlations in males were obtained between PV and PT (r=0.95), PV and LC (r=0.93), and PV and AC (r=0.91); in females these correlations were r=0.82, r=0.86, and r=0.89, respectively. In males, in second order of importance, the correlations between PV and PP (r=0.89), PP and LC (r=0.88), PP and AT (r=0.87), PV and AT (r=0.87) stand out; in females, in second order of importance, the correlations between PV and PC (r=0.73), and PP and AT (r=0.72) stand out. In males, 82.1% of the correlations were positive and significant, while in females this value was 57.1%.

Live weight. The superiority of males over females in this variable was 8.3 kg (Table 2).

Table 4. Phenotypic correlations between morphometric variables and live weight in a population of Blackbelly sheep in Campeche, Mexico.

				Males				
	LC	PT	AC	PP	LG	PC	AT	PV
LC		0.70**	0.55*	0.88**	0.83**	0.72**	0.61**	0.93**
PT	0.57*		0.68**	0.20^{ns}	0.68**	0.65**	0.67**	0.95**
AC	0.38^{ns}	0.53^{ns}		0.78**	0.46^{ns}	0.44^{ns}	0.68**	0.91**
PP	0.65**	-0.12^{ns}	0.52*		0.86**	0.55*	0.87**	0.89**
LG	0.65**	0.43^{ns}	-0.13^{ns}	0.25^{ns}		0.42^{ns}	0.54*	0.78**
PC	0.62**	0.52*	0.15^{ns}	0.40^{ns}	0.12^{ns}		0.83**	0.85**
AT	0.42^{ns}	0.38^{ns}	0.56*	0.72**	0.45^{ns}	0.60**		0.87**
PV	0.86**	0.82**	0.89**	0.67**	0.62**	0.73**	0.51*	
				Females				

LC: body length, PT: girth, AC: wither height, PP: chest depth, LG: rump length, PC: shank circumference, AT: thoracic width, PV: live weight. *: p<0.05; **: p<0.01; ns: not significant.

DISCUSSION

Sexual dimorphism. A marked sexual dimorphism was found (Table 1), with higher averages (p<0.05) for males in body length (15.7%), girth (11.3%), wither height (8.3%), chest depth (13.2%), rump length (17.2%), thoracic width (29.3%), and live weight (25.4%). According to Lopes D. et al (12), the superiority of males over females is generally due to the fact that they are heavier and longer, and have a greater thoracic depth, and such differences increase as the animals get older (12,28). The overall mean SD was 1.16 (table 1), an average very close to that obtained by Legaz et al (16) in Assaf sheep (1.13), but lower than that obtained in Pelibuey sheep in Mexico (20), which was 1.21.

In Pelibuey sheep (20) an SD in favor of males (p<0.05) was found in head length (10.6%), head width (22.9%), skull length (17.4%), skull width (21.3%), rump length (17.1%), rump width (14.0%), wither height (15.2%), chest girth (19.6%), chest depth (17.9%), chest width (23.7%), shank circumference (22.5%), body length (15.4%), and live weight (66.7%). In crosses of Merino sheep with hair breeds (21), an SD in favor of the males (p<0.05) was found in head length (18.5%), head width (15.9%), rump width (9.8%), wither height (7.8%), chest girth (19.8%), chest depth (14.6%), chest width (27.1%), shank circumference (18.6%), body length (9.3%), and live weight (78.4%). Due to the large differences between males and females in the study population, we could apply to the Blackbelly sheep of this population what Alvarez et al (22) attributed to the Canary sheep breed: "*the expression of a marked sexual dimorphism would explain the consideration of an environmental breed perfectly adapted to the environment in which it develops and where artificial selection has not intervened so far*".

Ethnological index. Based on the IC averages obtained in this population (68.8 in males, 74.2 in females, Table 3), Blackbelly sheep are classified as brevilineal or compact animals. This result is in agreement with studies on Santa Inês sheep in Brazil (12) and hair sheep in Colombia (13), but differs from Arredondo-Ruíz et al (20), who obtained higher CI averages for Pelibuey sheep in Mexico than those of Blackbelly in this study, so these authors classified the Pelibuey sheep of that population as a mesoline breed. This variable is ethnic in nature, so it is not influenced by environmental or management factors; but the importance of this type of index lies mainly in its use to characterize and differentiate breeds (23).

Meat suitability indices. Due to the magnitude of the ICR averages (<100, Table 3), the animals of this population are classified as brevilineal, which are averages similar to those obtained in Argentine Creole sheep (17) and Canary sheep (22), also classified as brevilineal. As this index decreases, the animal increasingly resembles a rectangle, which is the predominant shape in animals suitable for meat production.

By observing the IP and IPRT averages (Table 3), it can be deduced that the zootechnical suitability of Blackbelly sheep is for meat production. In relation to this index, Mernies et al (24) state that this condition indicates that these animals are farther from the ground, which in turn allows them to be better adapted for foraging and to withstand the heat radiation coming from the ground. Regarding IPRT, the results obtained here are in agreement with those found in Colombian Sudan Creole (13) and Uruguayan Creole (24) sheep. However, they differ from results obtained for Pelibuey sheep in Mexico (20), where the authors reported an average of 48.0, which is slightly higher than that found in this study (44.0), which means that Pelibuey sheep have a slightly higher suitability for meat production than Blackbelly.

In IL, Handiwirawan et al (25) obtained an average of 1.09 in a cross of Blackbelly sheep with Sumatra Composite. Regarding IL and IPL, the Blackbelly sheep studied here are shorter than the Creole sheep in Peru (18) and Pelibuey in Mexico (20). The longitudinal pelvic index (IPL) indicates, on the one hand, the tendency of Blackbelly sheep towards meat production and, on the other hand, a greater ease of lambing (26). Regarding ILPD, the averages obtained in this population (Table 3) are similar to those found in Sumatra Composite sheep, but different from the results obtained in sheep crossed with St. Croix (25), which had higher averages in this variable, indicating that they are tall animals. This height characteristic in animals is highly desirable, especially for foraging, as indicated by Mernies et al (24).

The CC1 and CC2 indices are related to the body capacity of an animal, which is an objective *in vivo* measurement of conformation in sheep (27). da Silva C. et al (28) mentioned that in adult animals an increase in CC1 suggests muscle and fat deposition. In relation to the three variables that are part of CC1 and CC2 (PV, LV and PT), these same authors (28) indicate that LC stabilizes when bone growth stops, while PV and PT can continue to grow, even when bone growth stabilizes, because these variables are closely related to the animal's age and nutritional conditions. The superiority of males over females for CC1 and CC2 in this study evidences a greater PV, length, and thoracic depth of males (12), a result also observed in Santa Inês sheep (28), classified as longilineal. Lower averages of CC1 and CC2 for this study were obtained by Lopes D. et al (12) for the Santa Inês sheep. In that same study (12), the authors concluded that the CC1 and CC2 indices are sufficient to assess animal conformation. In another study also for the Santa Inês sheep (27), these indices were analyzed, not as percentages, but as ratios in real units (PV in kg), (LC and PT in cm), finding values of 6.03 kg/cm in CC1 and 0.422 kg/cm in CC2. Subsequently, the same authors (27) used these indices in a multiple regression analysis to predict the PV of animals, finding that CC2 explained 74.5 to 79.0% of the PV in females, and 68.8 to 86.0% of the PV in males.

Dairy suitability indices. Based on the averages obtained in IDT (9.9) and IDC (46.7) of Table 3, the Blackbelly sheep of this population show an eumetric tendency, indicating an acceptable milk production orientation. The IDT, also known as the "metacarpal-thoracic index" (26), indicates the degree of skeletal fineness and allows for establishing the ratio between the mass of the animal and the limbs that support it, to determine whether the body volume is in accordance with bone development. A tendency towards milk production was also reported in Pelibuey (20), Canary (22), Uruguayan Creole (24), and Creole hair (26) sheep. Due to their orientation to both meat and milk production, the Blackbelly sheep of this population constitute a clearly undefined population in their zootechnical suitability, which was also how Arredondo-Ruíz et al (20) classified a population of Pelibuey sheep in Mexico.

Body harmony of the population. According to the criteria of Herrera and Luque (23), the values of the correlations shown in Table 4 indicate, on the one hand, a high-medium degree of harmony of the population and, on the other hand, an absence of a selection pattern; or, in the case of selection, the criteria were not accurate. In relation to this second criterion, there is a total absence of selection in the Campeche Blackbelly sheep population. In the study of Pelibuey sheep in Mexico (20) and using this same criterion, the females showed a high degree of harmony in their morphological model, while males showed a moderate degree of harmony.

Live weight. The superiority of males over females in this variable was 25.4%. Although the PV is highly influenced by the climatic season of the year, the feeding system and reproductive management (20), from puberty, the production of sexual hormones, specifically sexual steroids, are responsible for a large part of bodily differences between males and females (29). Aguilar-Martínez (1) report live weight values in Mexican Pelibuey sheep of 49 to 59 kg for males and 35 to 41 kg for females. However, these values are lower than those of other synthetic hair sheep breeds, such as the Katahdin breed, since males can weigh up to 120-130 kg, while females weigh up to 60-70 kg (30).

In conclusion, in this population we found a marked sexual dimorphism in favor of males in live weight and six of the seven morphometric variables analyzed. The overall mean sexual dimorphism (males/females) was 1.16, males outperformed females in live weight by 25.4%. The males in this population showed a clear orientation to meat production, while the females had an acceptable tendency towards milk production, indicating that this is an undefined Blackbelly sheep population from a zootechnical function perspective. The correlations obtained between live weight and the morphometric variables analyzed indicated a high to medium body harmony in this population.

Conflict of interest

There is no conflict of interest between the authors.

Acknowledgments

The authors thank the Instituto Tecnológico de Chiná, Campeche, and the Colegio de Postgraduados for funding the study. The first author received a scholarship from the Consejo Nacional de Ciencia y Tecnología for a Master of Science.

REFERENCES

1. Aguilar-Martínez CU, Berruecos-Villalobos JM, Espinoza-Gutiérrez B, Segura-Correa JC, Valencia-Méndez J, Roldán-Roldán A. Origen, historia y situación actual de la oveja Pelibuey en México. Trop Subtropic Agroec. 2017; 20:429-439. https://www.revista.ccba.uady.mx/ojs/index.php/TSA/article/view/2348/1085https://www.revista.ccba.uady.mx/ojs/index.php/TSA/article/view/2348/1085

2. Cadenas-Cruz PJ, Oliva-Hernández J, Hinojosa-Cuéllar JA. Productivity of Blackbelly ewes and their hybrid litter under grazing. J Anim Vet Adv. 2012; 11(1):97-102. http://dx.doi.org/10.3923/javaa.2012.97.102

3. Hinojosa-Cuéllar JA, Oliva-Hernández J, Torres-Hernández G, Segura- Correa JC, González-Garduño R. Productividad de ovejas F_1 Pelibuey x Blackbelly y sus cruces con Dorper y Katahdin en un sistema de producción del trópico húmedo de Tabasco, México. Arch Med Vet. 2015; 47:167-174. http://dx.doi.org/10.4067/S0301-732X201500020000

4. Alderson GLH. Conservation of breeds and maintenance of biodiversity: justification and methodology for the conservation of Animal Genetic Resources. Arch Zootec. 2018; 67(258):300-309. https://doi.org/10.21071/az.v67i258.3668

5. Vihotogbe Whannou HR, Ulriche Afatondji C, Ahozonlin MC, Spanoghe M, Lanterbecq D, Demblon D, Houinato MRB, Dossa LH. Morphological variability within the indigenous sheep population of Benin. PLoS ONE. 2021; 16(10):e0258761. https://doi.org/10.1371/journal. pone.0258761

6. Marković B, Dovč P, Marković M, Radonjić D, Adakalić M, Simčič M. Differentiation of some Pramenka sheep breeds based on morphometric characteristics. Arch Anim Breed. 2019; 62:393-402. https://doi.org/10.5194/aab-62-393-2019

7. Freitas NS, Ferreira J, Freitas S. RM, Sales DC, de Souza JER, Rezende PS, Evangelista FDA. Morphometric characterization and zoometric índices of White *Morada Nova* breed: The first step for conservation. Small Rum Res. 2020; 192:106178. https://doi.org/10.1016/j.smallrumres.2020.106178

8. Parés-Casanova PM, Kucherova I. Caracteres morfoestructurales de una raza caprina recientemente recuperada. Rev Inv Vet Perú. 2015; 26(2):159-165. http://dx.doi.org/10.15381/rivep.v26i2.11012

9. Gomes AJK, Vieira da S. NM, de Barros NR, Pimenta FEC, de Albuquerque BLH, Ribeiro MN. Multivariate analysis as a tool for phenotypic characterization of an endangered breed. J Appl Anim Res. 2017; 45(1):152-158. http://dx.doi.org/10.1080/09712119.2015.1125353

10. Delgado CA, García BC, Allcahuamán MD, Aguilar GC, Estrada VP, Vega AH. Caracterización fenotípica del ganado criollo en el Parque Nacional Huascarán – Ancash, Perú. Rev Inv Vet Perú. 2019; 30(3):1143-1149. http://dx.doi.org/10.15381/rivep.v30i3.16611

11. Cabezas CR, Barba CC, González MA, Cevallos FO, León JJM, Aguilar RJM, García MA. Estudio biométrico del bovino criollo de Santa Elena (Ecuador). Rev Mex Cienc Pecu. 2019; 10(4):819-836. https://doi.org/10.22319/rmcp.v10i4.4850

12. Lopez D. da CR, Quirino CR, Costa A. VA, Pacheco A, Beltrame RT, Madella-Oliveira AF, Costa AM, da Silva RMC. Morphometric indices in Santa Ines sheep. Int J Morphol. 2014; 32(4):1370-1376. http://dx.doi.org/10.4067/S0717-95022014000400039

13. Flórez MJ, Hernández PM, Bustamante YM, Vergara GO. Caracterización morfoestructural e índices zoométricos de hembras Ovino de Pelo Criollo Colombiano "OPC" Sudán. Rev MVZ Córdoba. 2020; 25(3):e1379. https://doi.org/10.21897/rmvz.1379

14. Hernández CME, Ordoñez DMJ, de Azcárate JG. Análisis comparativo de dos sistemas de clasificación bioclimática aplicados en México. Invest Geog. 2018; 95:57451. https://doi.org/10.14350/rig.57451

15. Kendall LV, Petervary N, Bergdall VK, Page RL, Baneux PJR. Institutional animal care and use committee review of clinical studies. J Am Vet Med Assoc. 2018; 253(8):980-984. http://dx.doi.org/10.2460/javma.253.8.980

16. Legaz E, Cervantes I, Pérez-Cabal MA, de la Fuente LF, Martínez R, Goyache F, Gutiérrez JP. Multivariate characterisation of morphological traits in Assaf (Assaf.E) Sheep. Small Rum Res. 2011; 100:122-130. https://doi.org/10.1016/j.smallrumres.2011.06.005

17. Peña S, López GA, Abbiati NN, Género RR, Martínez RD. Caracterización de ovinos Criollos argentinos utilizando índices zoométricos. Arch Zootec. 2017; 66(254):262-270. https://doi.org/10.21071/az.v66i254.2331

18. Ormachea EV, Alencastre RGD, Olivera LVM. Índices zoométricos del ovino criollo en el Centro Experimental de Chuquibambilla, Puno, Perú. Rev Inv Vet Perú. 2020; 31(3):e17139. https://doi.org/10.15381/rivep.v31i3.17139

19. SAS. SAS/STAT®. Version 12.1 Cary, NC: SAS Institute Inc., 2012.

20. Arredondo-Ruíz V, Macedo-Barragán R, Molina-Cárdenas J, Magaña-Álvarez J, Prado-Rebolledo O, García-Márquez LJ, Herrera-Corredor A, Lee-Rangel H. Morphological characterization of Pelibuey sheep in Colima, México. Trop Anim Health Prod. 2013; 45:895-900. https://doi.org/10.1007/s11250-012-0303-1

21. Hernández JA, Lepe M, Macedo R, Arredondo V, Cortéz CE, García LJ, Prado O. Morphological study of Socorro Island Merino sheep and its crosses with hair breeds. Trop Anim Health Prod. 2017; 49:173-178. https://doi.org/10.1007/s11250-016-1177-4

22. Álvarez S, Fresno M, Capote J, Delgado JV, Barba C. Estudio para la caracterización de la raza ovina Canaria. Arch Zootec. 2000; 49(185-186):209-215. http://hdl.handle.net/10396/2940

23. Herrera M, Luque M. Morfoestructura y Sistemas para el Futuro en la Valoración Morfológica. En: Sañudo AC (Coord). Valoración Morfológica de los Animales Domésticos. Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino; 2009. https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/LIBRO%20valoracion%20morfologica%20SEZ_tcm30-119157.pdf

24. Mernies B, Macedo F, Filonenko Y, Fernández G. Índices zoométricos en una muestra de ovejas Criollas Uruguayas. Arch Zootec. 2007; 56(Sup. 1):473-478.

25. Handiwirawan E, Noor RR, Sumantri C, Subandriyo. The differentiation of sheep breed based on the body measurements. J. Indonesian Trop Anim Agric. 2011; 36(1):1-8. http://dx.doi.org/10.14710/jitaa.36.1.1-8

26. Moreno M. J, Montes V. D, Ucros P. J, Fernández Q. A, Cardona Á. J. Variabilidad morfoestructural de la hembra ovina de pelo criollo colombiana. Livest Res Rural Develop. 2013; 25:83 http://www.lrrd.org/lrrd25/5/more25083.htm

27. da Silva SJD, do Santos DG, Emerenciano NJV, Quintão LAM, da Silva RFF, Cavalcante RPH. Biometric measurements of Santa Inês meat sheep reared on *Brachiaria brizantha* pastures in Northeast Brazil. PLoS ONE. 2019; 14(7):e0219343. https://doi.org/10.1371/journal.pone.0219343

28. da Silva CJG, Guimarães CJE, Machado RADM, Martins FR, Cavalcante RR, Batista LJ, de Oliveira ME. Morphometric characterization of Santa Inês sheep raised in the regions of Teresina and Campo Maior, Piauí. Rev Bras Zoot. 2006; 35(6):2260-2267. https://doi.org/10.1590/S1516-35982006000800009

29. Singh SK (Editor). Mammalian Endocrinology and Male Reproductive Biology. First Edition. CRC Press; 2019.

30. Lucio R, Sesento L, Bedolla JLC, Cruz AR. Parámetros genéticos para pie de cría en ovinos de la raza Katahdin. Rev Cien Nat Agrop. 2018; 5(16):1-5. https://www.ecorfan.org/bolivia/rj_cnya_xvi.php