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# BODY COMPOSITION AS A FUNCTION OF COAT COLOR, SEX AND AGE IN LOCAL KIDS FROM NORTHERN MEXICO

Jorge Alonso **Maldonado-Jáquez**[1,2], Pablo **Arenas-Báez**[3], Jonathan Raúl **Garay-Martínez**[4], Lorenzo Danilo **Granados-Rivera**[5*]

[1] Colegio de Postgraduados. Campus Montecillo. Montecillo, Estado de México, México. C. P. 56230.
[2] Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Campo Experimental La Laguna. Matamoros, Coahuila, Mexico. C. P. 27440.
[3] Universidad Autónoma Chapingo. Unidad Regional Universitaria de Zonas Áridas. Bermejillo, Durango, Mexico. C. P. 35230.
[4] Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Campo Experimental Las Huastecas. Estación Cuauhtémoc, Tamaulipas, Mexico. C. P. 88339
[5] Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Campo Experimental General Terán. Nuevo León, Mexico. C. P. 67400.
* Author for correspondence: granados.danilo@inifap.gob.mx

## ABSTRACT

The aim was to evaluate the effect of coat color, sex and age on body composition in local kids from northern Mexico. Eighty-three local kids between 1 and 30 days of age were selected. They were assigned to groups according to coat color (dark and light), sex (males and females) and age (1=1 to 10; 2=11 to 20 and 3=21 to 30 days). Pigmentation of skin, hooves, mucous membranes, morphostructural characteristics, live weight and 14 zoometric measurements were evaluated. A predominant phenotype was found of animals without mammels, beards, without pigment in the skin and hooves, with horns, horizontal ears and pigmented mucous membranes. The highest values ($p < 0.05$) for live weight (PV), neck length and width (LCue, ACue), chest circumference (CPe) and flank depth (PFl) were found in dark kids. The highest value ($p < 0.05$) in ear length (LO) was observed in light-colored kids. When considering sex, the highest values ($p < 0.05$) were observed in males for all traits, except for length and width of face (LCa, ACa) and width of ears (AO), height at withers (ACruz), PFl and sacrolumbar height (ASL), which were not different ($p > 0.05$). When considering age, the highest values were found in all traits for group 3. All variables were positively and significantly correlated. The variables showing the greatest magnitude of change in the first 20 days of age are PV (+40 %), LCa, LCor, CPe (+15 %) and LCue, ACruz, PFl, leg length (+10 %), while between 20 and 30 days of age the magnitude of change generally decreases. It is concluded that coat color, sex and age significantly influence the body composition of local kids from northern Mexico, which may have implications in the selection and marketing thereof.

**Keywords:** Biometric profile, phenotype, goats, arid zones.

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## INTRODUCTION

It is common in developing countries for goat production to be carried out through subsistence production systems, in rural areas with low productivity and linked to the use of local goat populations (Torres-Hernández *et al*., 2022). These populations are an important reservoir of genetic diversity; therefore, it is necessary to conserve them through development and management programs that increase productivity in a sustainable manner. However, lack of information on population characteristics can lead to underutilization and loss of this valuable genetic resource (Sevane *et al.*, 2018; Bedada *et al*., 2019).

In this regard, in recent years there has been increasing interest in studying these breeds adapted to low-income systems, especially with respect to biometric and phaneroptic characteristics (Adenaike *et al.*, 2020). Some efforts have been oriented towards the selection of animals based on coat color, since it is an easily recognizable trait, furthermore, according to the literature, it has an effect on productive behavior (Akis *et al.*, 2012). However, in criollo or local goats, the information available on this topic is still scarce, because this characteristic cannot be measured based on a scale (Tyasi *et al*., 2022; Becerril *et al*., 1996). However, evidence suggests that it is directly related to productive efficiency (Fonseca *et al.*, 2016) and, therefore, the study of this characteristic becomes necessary, especially in these subsistence systems, where the availability of herd productive information is a serious limitation (Moyao-Aríza *et al.*, 2022, Torres-Hernández *et al*., 2020). Therefore, the aim was to evaluate the effect of coat color and sex on body composition, as well as the magnitude of changes in body development when considering age in local lactating kids from northern Mexico.

## MATERIALS AND METHODS

All methods and animal handling used in the study were in accordance with the guidelines for the ethical use, care and welfare of animals used in research according to international (FASS, 2010), national (NAM, 2002) and institutional standards, through the project "Technological options to improve the productivity of the extensive goat system in Northern Mexico" financed by the National Institute of Forestry, Agricultural and Livestock Research (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias).

The study was conducted in the Laguna region, in a portion of the state of Coahuila, Mexico. This area is located between 24°22' North Latitude and 102°22' West Longitude, with an average elevation of 1139 m and a desert climate, semi-warm with a cool winter and average rainfall of 240 mm (García, 2004).

Eighty-three local lactating kids (42 males and 41 females) born between January and February 2022, aged between 1 and 30 days, were selected from a nucleus of 205 goat herds managed under an extensive grazing scheme. This management considered the separation of the kids from their mothers during grazing for a period of approximately 9 h $d^{-1}$. Once the goats returned to the resting pen, the kids were placed next to their mothers to breastfeed. During the day the kids had access to water *ad libitum*.

The kids were assigned to two groups according to coat color and sex (dark [n=33; when more than 50% of the coat was dark-black, brown, chamois]; light [n=50; when more than 50% of the coat was light-white, cream, light gray]) and to three groups according to age [1(n=32): 1 to 10; 2(n=29) 11 to 20 and 3(n=22): 21 to 30 days old].

Pigmentation of skin, hooves and mucous membranes and morphostructural characteristics such as ear orientation, presence of mammels, beard and horns, as well as live weight (PV) and 14 zoomometric measurements were considered. All measurements were recorded with a soft measuring tape (Selanusa, Mexico). The PV was taken fasting with an electronic hanging scale with a capacity of 45 kg±5 g (Metrology, Nuevo Leon, Mexico). The zoomometric measurements were (Figure 1): face length (LCa-1), face width (ACa-2), ear length (LO-3), ear width (AO-4), neck length (LCu-5), neck width (Acu-6), body length (LCor-7), height at withers (ACruz-8), chest circumference (CPe-9), barrel circumference (CBa-10), flank depth (PFl-11), sacrolumbar height (ASL-12), leg length (LPi-13), shank circumference (PCn-14) (Moyao-Ariza *et al.* , 2022).

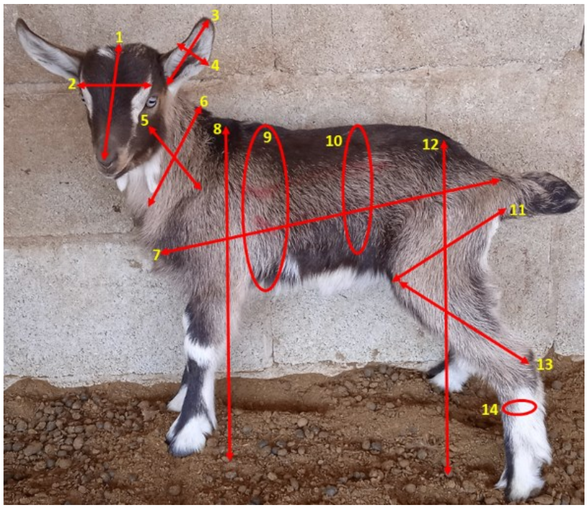


**Figure 1.** Zoomometric traits considered to evaluate morphostructural composition in local lactating kids from northern Mexico.

The magnitude of the development of the animals in the different age groups was analyzed, which means the development of each anatomical part of the animal was quantified, since they do not have the same growth speed, therefore, this analysis is proposed to identify critical growth points in developing kids. This analysis quantifies the change in the zoometric measurements of kids in each age group and is expressed as a percentage.

Statistical analysis was performed using the SAS v.9.4 statistical package (2008). Descriptive and inferential statistics were obtained for qualitative traits. For

quantitative traits, a fixed effects model was used, with a completely randomized design, with the GLM procedure and a Pearson correlation analysis was performed to determine the degree of association between variables.
The structure of the model was:

$$Y_{ijkl} = \mu + CP_i + S_j + E_k + CP_i * S_j * E_k + E_{ijkl}$$

Where: $Y_{ijkl}$: weight or zoometric measure considered; $\mu$: constant that characterize the population; $CP_i$: fixed effect of the i-th coat color ($i$ = 1,2), $S_j$: fixed effect of the j-th sex of the kids ($j$ = 1,2), $E_k$: fixed effect of the k-th age of the kid ($k$=1,2,3); $CP_i * S_j * E_k$: Effect of double or triple interactions; $E_{ijkl}$: random error, which was assumed to be normally distributed with zero mean and common variance.

## RESULTS AND DISCUSSION

Table 1 shows the absolute and relative frequencies for morphostructural and phaneroptic characteristics. A predominant phenotype was found of animals without mammels, beards, without pigment in the skin and hooves, with horns, horizontal ears and pigmented mucous membranes. The results found are similar to those reported by Sheriff *et al*. (2021), for Arab and Oromo kids regarding morphostructural characteristics. Likewise, the observed diversity is considered as “Mosaico Lagunero”, which is an undefined phenotype, characteristic in crossbred animals (Amills *et al*., 2017; Moyao-Ariza *et al*., 2022).
Regarding morphostructural composition due to coat color (Table 2), the highest values ($p$ < 0.05) were found in dark kids for PV, LCue, ACue, CPe and PFl; while for light kid differences ($p$ < 0.05) were only found in LO. The rest of the variables

**Table 1.** Absolute (FA) and relative frequencies (FR) for phaneroptic and morphostructural characteristics in lactating local kids from northern Mexico.

| Variable | FA | FR | Variable | FA | FR | Variable | FA | FR |
|---|---|---|---|---|---|---|---|---|
| Mammels | | | Beard | | | Horns | | |
| Present | 25 | 0.30 | Present | 0 | 0.00 | Present | 71 | 0.86 |
| Absent | 58 | 0.70 | Absent | 83 | 100.00 | Absent | 12 | 0.14 |
| | | | Pigmentation in: | | | | | |
| Skin | | | Hooves | | | Mucosa | | |
| Present | 30 | 0.36 | Present | 33 | 0.40 | Present | 50 | 0.60 |
| Absent | 53 | 0.64 | Absent | 50 | 0.60 | Absent | 33 | 0.40 |
| Ear orientation | | | | | | | | |
| Horizontal | 39 | 0.47 | | | | | | |
| Hanging | 19 | 0.23 | | | | | | |
| Erect | 25 | 0.30 | | | | | | |

**Table 2.** Mean ± standard error for zoometric characteristics according to coat color in local lactating kids from northern Mexico.

| Variable | Dark | Light | C.V. | *p* value |
|---|---|---|---|---|
| Live weight (kg) | 5.598±0.26 | 5.185±0.24 | 15.40 | <0.0001 |
| Face length (cm) | 10.75±0.23 | 10.71±0.28 | 12.37 | 0.5801 |
| Face width (cm) | 6.97±0.17 | 6.87±0.24 | 20.17 | 0.8189 |
| Ear length (cm) | 10.14±0.31 | 11.04±0.24 | 14.02 | 0.0005 |
| Ear width (cm) | 4.91±0.09 | 5.04±0.09 | 10.82 | 0.3382 |
| Neck length (cm) | 20.29±0.43 | 19.23±0.46 | 9.79 | 0.0159 |
| Neck width (cm) | 19.83±0.33 | 18.79±0.31 | 7.23 | 0.0417 |
| Body length (cm) | 38.58±0.78 | 38.00±0.80 | 9.66 | 0.5086 |
| Height at withers (cm) | 40.11±0.59 | 38.01±0.87 | 13.13 | 0.5569 |
| Chest circumference (cm) | 39.12±0.70 | 37.26±0.73 | 6.36 | 0.0461 |
| Barrel circumference (cm) | 38.56±0.87 | 37.53±0.82 | 10.36 | 0.9966 |
| Flank depth (cm) | 15.09±0.49 | 13.86±0.37 | 15.16 | 0.0427 |
| Sacro-Lumbar Height (cm) | 39.94±0.55 | 38.88±0.60 | 7.45 | 0.8954 |
| Leg length (cm) | 17.43±0.29 | 16.83±0.33 | 7.95 | 0.3954 |
| Cane perimeter (cm) | 6.36±0.07 | 6.28±0.10 | 7.46 | 0.7700 |

considered showed no differences due to coat color ($p > 0.05$). Our results could suggest European origin of the animals in this population (Lanari *et al*., 2019), however, this is not conclusive. On the other hand, the results obtained coincide with those found by Mia *et al*. (2018) and Choudhury *et al*. (2012), who report that dark animals are significantly larger in the Bengali black goat population. Likewise, Daramola and Adeloye (2008) and Getachew *et al*. (2020) concluded that dark animals grow faster and have higher weight gains compared to light-colored animals. This information is interesting, because, based on the conclusions and findings obtained, specific selection criteria can be developed, as has been found in species such as camelids, which govern selection based on coat color, since a higher hierarchy effect has been observed in dark-colored animals (Iglesias-Pastrana *et al*., 2021).

On the other hand, when considering the sex of the kids (Table 3), the highest values ($p < 0.05$) were found in males for PV, LCue, ACue, LCor, CPe and LPi. The rest of the variables evaluated were not different ($p > 0.05$). In this sense, the results obtained were in accordance with expectations, and this can be explained by the fact that growth hormone influences for greater development in males (Patel *et al*., 2019). In this regard, Baenyi *et al*. (2020) and Akkol (2018), reported differences between gender, and where, in general, males showed better body development compared to females.

Regarding the age of the kids, the results coincided with the expectation that the older the kids, the higher the value of morphostructural variables (Table 4). It was found that group 3 animals presented the highest values ($p < 0.05$) in all the variables considered, although without difference, with some variables in animals of group 2, while animals of group 1 presented the lowest values in all the variables considered.

**Table 3.** Mean ± standard error for zoometric characteristics, according to sex in lactating local kids from northern Mexico.

| Variable | Male | Female | C.V. | *p*-Value |
|---|---|---|---|---|
| Live weight (kg) | 5.773±0.23 | 4.916±0.25 | 15.40 | 0.0095 |
| Face length (cm) | 10.74±0.19 | 10.72±0.33 | 12.37 | 0.6751 |
| Face width (cm) | 6.89±0.13 | 6.92±0.20 | 20.17 | 0.9576 |
| Ear length (cm) | 10.67±0.24 | 10.70±0.31 | 14.02 | 0.7087 |
| Ear width (cm) | 4.91±0.07 | 5.06±0.11 | 10.82 | 0.0560 |
| Neck length (cm) | 20.21±0.45 | 18.97±0.46 | 9.79 | 0.0443 |
| Neck width (cm) | 19.96±0.31 | 18.43±0.3 | 7.23 | 0.0488 |
| Body length (cm) | 39.23±0.78 | 37.21±0.8 | 9.66 | 0.0369 |
| Height at withers (cm) | 39.25±1.03 | 38.43±0.54 | 13.13 | 0.5805 |
| Chest circumference (cm) | 38.84±0.78 | 37.14±0.70 | 6.36 | 0.0405 |
| Barrel circumference (cm) | 39.07±0.90 | 36.79±0.78 | 10.36 | 0.5831 |
| Flank depth (cm) | 14.69±0.42 | 13.99±0.43 | 15.16 | 0.5043 |
| Sacro-Lumbar Height (cm) | 39.94±0.60 | 38.88±0.57 | 7.45 | 0.3330 |
| Leg length (cm) | 17.49±0.3 | 16.64±0.33 | 7.95 | 0.0450 |
| Cane perimeter (cm) | 6.54±0.09 | 6.11±0.08 | 7.46 | 0.1014 |

**Table 4.** Mean ± standard deviation and magnitude of development (%) between age groups for zoometric characteristics, according to age group in local kids from northern Mexico.

| Variable | Age group | | | | | *p*-Value |
|---|---|---|---|---|---|---|
| | 1 | Magnitude (%) | 2 | Magnitude (%) | 3 | |
| Live weight (kg) | 2.802±0.13c | 40.8 | 4.730±0.13b | 25.5 | 6.346±0.13a | <0.001 |
| Face length (cm) | 8.55±0.23b | 18.6 | 10.51±0.24a | 8.4 | 11.48±0.21a | <0.0001 |
| Face width (cm) | 6.00±0.15b | 8.8 | 6.58±0.13ab | 9.9 | 7.30±0.23a | 0.0154 |
| Ear length (cm) | 9.31±0.46b | 6.8 | 9.99±0.28b | 11.8 | 11.33±0.23a | <0.0001 |
| Ear width (cm) | 4.57±0.16b | 7.1 | 4.92±0.10ab | 4.5 | 5.15±0.08a | 0.0018 |
| Neck length (cm) | 15.06±0.33b | 23.7 | 19.74±0.44a | 6.3 | 21.06±0.30a | <0.0001 |
| Neck width (cm) | 16.71±0.51c | 7.3 | 18.02±0.28b | 11.5 | 20.36±0.20a | <0.0001 |
| Body length (cm) | 30.98±0.69b | 18.8 | 38.13±0.70a | 5.9 | 40.53±0.58a | <0.0001 |
| Height at withers (cm) | 34.66±0.62b | 10.2 | 38.60±0.47a | 4.1 | 40.23±0.84a | 0.0056 |
| Chest circumference (cm) | 30.38±0.78c | 16.6 | 36.41±0.46b | 10.9 | 40.88±0.35a | <0.0001 |
| Barrel circumference (cm) | 31.66±0.82c | 9.7 | 35.08±0.55b | 14.0 | 40.81±0.60a | <0.0001 |
| Flank depth (cm) | 11.56±0.26b | 11.3 | 13.04±0.39b | 16.6 | 15.63±0.35a | <0.0001 |
| Sacro-Lumbar Height (cm) | 35.40±0.61b | 3.6 | 36.73±0.14b | 11.2 | 41.34±0.44a | <0.0001 |
| Leg length (cm) | 14.13±0.24c | 13.6 | 16.36±0.13b | 10.2 | 18.22±0.20a | <0.0001 |
| Cane perimeter (cm) | 5.99±0.13b | 0.2 | 6.00±0.21b | 8.3 | 6.54±0.07a | 0.0003 |

This is in agreement with the report of Akbar *et al.* (2021), who point out that all body measurements are positively correlated with respect to age, i.e., body measurements will be greater in older animals until they reach mature age and weight, which is when growth ceases. Similarly, Akpa *et al.* (2013), found that age significantly influences body weight and body conformation. Because of the above, it has been suggested that research should focus on evaluating the relationship between weight and body measurements at different ages (Assan, 2015), with the aim of identifying critical points of attention in the development of animals (Gómez-Osorio *et al*., 2017).

Likewise, the magnitude of change in body development for each of the morphostructural measures is greater (greater than 10% and up to 40%) during the first 20 days for the variables PV, LCa, LCue, LCor, ACruz, CPe, PFL and LPi. After 20 days of age, the magnitude of change in body development structure decreases and the greatest development is observed in variables such as PV, LO, ACue, CPe, CBa, PFl, ASL and LPi. Furthermore, during the first 20 days of age, the magnitude of change in body measurements on average is in the range of 11 to 13 %, while after 20 days and up to 30 days of age this change decreases from 9.5 to 10.5 %. This is most evident in body weight, which decreases from 41% to 26%. This information partially coincides with the report of Aktas *et al.* (2015), who describe that the highest growth rate in indigenous Turkos hair and Honamli goats are found between 20-40 and 60-60 days. These findings are extremely interesting, because by identifying critical growth periods, feeding management strategies that optimize productivity can be developed and implemented (Omotosho *et al.*, 2020). Likewise, as the animal grows and transforms, its proportions change, both internally and externally. These transformations that occur in an animal, considered as a whole, result from the simultaneous development of all its parts, but in proportions that vary individually. In this regard, Hammond (1960) established that the different organs, tissues and anatomical parts of the animal do not have the same growth rate at a given time, therefore, each individual presents a characteristic growth rate according to age and in a defined order. That is, the nutrients absorbed during digestion are not distributed evenly, but are distributed following a regime of strict priorities and where the different tissues reach their maximum growth rate according to the following order: nervous, bone, muscle and fat (Ayala-Vargas, 2018).

Finally, Table 5 shows the matrix of phenotypic correlations for body traits in local lactating kids. In this regard, it was found that all variables correlated positively and significantly, except for the variables ACruz, which correlated non-significantly with LO and AO, PFl with AO and PCn with ACa. These results show that in their first days of development these animals have a positive growth of more than 12% in all morphostructural components and without considering live weight. These results are consistent with the reports of Okpeku *et al*. (2011) and Akkol (2018), who indicated that correlation coefficients are positive between live weight and all body measurements, in particular, when relating PV to variables such as ACruz, LCor, LCue, CPe in Red Sokoto, West African Dwarf and hair goats.

**Table 5.** Matrix of phenotypic correlations for morphostructural variables in local lactating kids from northern Mexico.

| | Weight | LCa | ACa | LO | AO | LCu | ACu | LCor | ACruz | CPe | CBa | PFl | ASL | LPi | PCn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight | 1.000 | | | | | | | | | | | | | | |
| LCa | 0.6333 *** | 1.000 | | | | | | | | | | | | | |
| ACa | 0.4178 *** | 0.6203 *** | 1.000 | | | | | | | | | | | | |
| LO | 0.4786 *** | 0.4416 *** | 0.2941 ** | 1.000 | | | | | | | | | | | |
| AO | 0.4517 *** | 0.4796 *** | 0.2840 ** | 0.6579 *** | 1.000 | | | | | | | | | | |
| LCu | 0.7376 *** | 0.5345 *** | 0.2993 ** | 0.3678 ** | 0.3453 *** | 1.000 | | | | | | | | | |
| Acu | 0.7581 *** | 0.6150 *** | 0.2809 * | 0.3813 ** | 0.2924 ** | 0.5156 *** | 1.000 | | | | | | | | |
| LCor | 0.8013 *** | 0.5800 *** | 0.2501 * | 0.4089 *** | 0.5549 *** | 0.5045 *** | 0.6351 *** | 1.000 | | | | | | | |
| ACruz | 0.5068 *** | 0.3154 ** | 0.2203 * | 0.1242 NS | 0.1880 NS | 0.4325 *** | 0.3557 ** | 0.3407 *** | 1.000 | | | | | | |
| CPe | 0.9248 *** | 0.6783 *** | 0.4431 *** | 0.3886 *** | 0.4065 *** | 0.6699 *** | 0.7679 *** | 0.7525 *** | 0.4944 *** | 1.000 | | | | | |
| CBa | 0.8144 *** | 0.6445 *** | 0.4297 *** | 0.4051 *** | 0.3794 *** | 0.4296 *** | 0.7594 *** | 0.6872 *** | 0.4317 *** | 0.8508 *** | 1.000 | | | | |
| PFl | 0.6887 *** | 0.4839 *** | 0.3420 ** | 0.3203 ** | 0.1815 NS | 0.4497 *** | 0.6686 *** | 0.4954 *** | 0.4740 *** | 0.7022 *** | 0.7109 *** | 1.000 | | | |
| ASL | 0.7450 *** | 0.5009 *** | 0.3420 ** | 0.3057 *** | 0.3685 *** | 0.5556 *** | 0.5915 *** | 0.5794 *** | 0.5733 *** | 0.7017 *** | 0.6981 *** | 0.6558 *** | 1.000 | | |
| LPi | 0.7840 *** | 0.5169 *** | 0.3259 ** | 0.3890 *** | 0.2683 * | 0.6793 *** | 0.6004 *** | 0.5981 *** | 0.4130 *** | 0.7637 *** | 0.5842 *** | 0.6119 *** | 0.6504 *** | 1.000 | |
| PCn | 0.5724 *** | 0.2875 ** | 0.1374 NS | 0.3753 *** | 0.3199 *** | 0.2897 ** | 0.6161 *** | 0.4574 *** | 0.2251 * | 0.5095 *** | 0.6117 *** | 0.4721 *** | 0.4774 *** | 0.4519 *** | 1.000 |

NS= Not significant; *p < 0.05; **p<0.001; ***p < 0.0001; LCa= face length; Aca= face width; LO= ear length; AO= ear width; LCu= neck length; Acu= neck width; LCor= body length; ACruz= withers height; CPe= chest circumference; CBa= barrel circumference; PFl= flank depth; ASL= sacro-lumbar height; LPi= leg length; PCn= cane perimeter.

## CONCLUSIONS

A significant effect of coat color, sex and age on body composition was found, which is directly related to better body development. Therefore, this information could be used as a basis for the implementation of replacement selection schemes, to establish feeding management schemes to optimize kid production, or to investigate genetic improvement strategies at early ages.

These results are relevant because they may have practical implications in the development of selection criteria for replacement animals and specific criteria for the marketing of kids for slaughter, thus being able to negotiate a better price for the producer. However, more detailed studies must be conducted to find out whether this better development is indeed attributable to these variables or to genetic or environmental factors.

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