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Linear body measurements as a management tool for Tunisian local goat population raised in arid conditions

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Abstract. The study aims to describe the linear body measurements and their factors of variation, and to establish their possible relationship. The morphostructural parameters for 92 local kids,including the body length, the wither height, the paunch girth, the heart girth and the rump length,were collected from birth to 150 days of age. The mean body length of male was 39.80cm, while that of the female was 38.27cm. Similarly, the heart girth as well as the wither height was also higher ($p<0.05$) in male than those in female. This trend confirms sexual dimorphism in local kids. The type of birth has non-significant effect on paunch girth. A high correlation ($r=0.90$) was recorded between the paunch girth and the heart girth.This is the same for the correlation between the height at the withers and the body length. Both, the body length ($r=0.97$) and the wither height ($r=0.95$) presented the highest correlations with live body weight. It could be concluded that the weight of local kids can be predicted with accuracy from some body measurements such as the heart girth which can be exploited by goat producers for management, selection and genetic improvement programs in local goat population.

Keywords. *Morphostructural parameters, Live body weight, Selection.*

Titre : Mesures de la croissance linéaire comme un outil de gestion chez la population caprine locale élevée dans des conditions arides

Résumé.*L'étude vise à décrire les mensurations linéaires, leurs facteurs de variation et à établir leur éventuelle relation. Les paramètres morphostructuraux de 92 chevreaux locaux comprenaient la longueur du corps, la hauteur au garrot, la circonférence de la panse, la circonférence du cœur et la longueur de la croupe ont été recueillis de la naissance jusqu'à 150 jours d'âge. La longueur moyenne du corps du mâle était de 39,80cm, tandis que celle de la femelle était de 38,27cm. De même, la circonférence du cœur ainsi que la hauteur au garrot étaient également plus élevées ($p<0,05$) chez les mâles que chez les femelles. Cette tendance confirme le dimorphisme sexuel chez les chevreaux locaux. Le mode de naissance a un effet non significatif sur la taille de la panse. Une forte corrélation ($r=0,90$) a été présentée entre le tour de poitrine et le tour de cœur. Il est de même pour la corrélation entre la hauteur au garrot et la longueur du corps. La longueur du corps ($r=0,97$) et la hauteur au garrot ($r=0,95$) présentent les corrélations les plus élevées avec le poids vif. On pourrait conclure que le poids des chevreaux locaux peut être prédit avec précision à partir de certaines mesures corporelles telles que la circonférence du cœur qui peut être exploiter par les producteurs de chèvres pour la gestion, la sélection et les programmes d'amélioration génétique dans la population caprine locale.*

Mots-clés. *Paramètres morphostructuraux, Poids,Sélection.*

I – Introduction

Goat meat production is a widely extended activity in the arid areas of Tunisia. In southern Tunisia, kids' meat represents about 75% of the local meat production (Najari, 2005). Further, the demand for meat from kids is increasing because of its nutritional quality. Among others, to improve meat

production of the local goat population breeding objectives need particular attention to linear body measurement for their economic objectives.
As known for animal quantitative traits, variation in body size is one of the criteria largely used for classifying and characterizing caprine breeds (Nsoso *et al.,* 2003).
Live weight plays an important role in determining several characteristics of the farm animals especially the ones having economic importance. Birth weight, early growth, feed conversion ratio as well as feeding requirements could be predicted by knowing the live weights of several stages of the lambs (Eker and Yavuz, 1960). Estimating the live weight using body measurements is practical, faster, easier, and cheaper in the rural areas where the sources are insufficient for the breeder (Nsoso *et al.,*2003). Very few studies have been carried out on the linear body measurements of Tunisian local goat and their possible use for estimating animal growth traits. Where genetic evaluation has still limited use in developing countries, identification of some linear traits may be useful and farmers' tools for selecting kids with desirable characters.
The study aims to describe the linear body measurements and their factors of variation, and to establish their possible relationship with the live weight of local goat population.

II – Material and methods

2.1 Animals and management

All studied animals belong to the goat experimental herd "ElGORDHAB" which is located in the South-East of Tunisia with an arid continental Mediterranean climate, with irregular and sporadic rainfalls. The season of kidding begins in November and continues until March, with a concentration during November and December. Throughout the study, replacement animals were selected based on weaning weight and physical conformation. Animals grazed on natural pastures during the day. In general, pasture grasses production covered about 70% of breeding animals feed requirements. The remaining 30% was covered by a supplementation of barley provided during the mating (600 g/day), the last month of pregnancy and the beginning of lactation (750 g/day). Goats received about 1 kg per day of concentrate mixture during lactation. All animals were provided with water allowed twice a day, before and after grazing.

2.2 Data recording and studied traits

The data used in present study were collected from a total of 92 kids (40 males and 52 females), the progeny of 3 sires and 70 dams. Since the start of the kidding period and till 150 days of age, kids were weighed once every two or three weeks. In addition, five body linear parameters measured included Body length from the tip of the scapula close to the neck region to the pin bone of the tail region; Heart girth : circumference of the chest; Punch girth: circumference of the body measured immediately after the abdomen just before the hind legs; Withers height : the highest point on the dorsum of the animal to the platform at the level of the forelegs while the animal was standing; Rump length : measured with a tape measure, from the rump to the depression of the first join.

2.3 Statistical analysis

The GLM Procedure (SPSS, 20) was carried out for determining the effects of the sex, the birth type and the month of birth of local kids on the studied traits. The general model can be represented as follows:

$$Y_{ijk} = \mu + MN_i + S_j + MO_k + e_{ijk}$$

Where:
Y_{ijk}: performance to be analyzed (live weight andbody linear parameters); μ: general mean, MN_i: effect of type of birth (i = single, double), S_j: effect of sex (j = male, female),MO_k: effect of month of birth (k= November, December, January, February, March) and e_{ijk}: residual error.

After variance analysis, a means comparison test (SNK, α=0.05) was applied to identify homogenous class of studied factors for each variable. The Pearson correlation matrix was calculated to establish the qualitative relationships between the different variables.

III – Results and discussion

3.1 Body weight and linear body measurements

The descriptive statistics for average weight and linear body parameters are presented in table 1. The overall average weight was 9.20kg. Local kids were characterized by low weights. Similar results have been reported in most breeds and local populations raised under arid environments (Al-Shorepy *et al.,* 2002). Such a low weight of local kids corresponds to low energetic needs, which can be considered as a strategy of adaptation toward the difficult environmental conditions.

Kids of this local breed were characterized by low weights. Similar results have been reported in most breeds and local populations raised under arid environments Atoui et *al.,* (2020). Such a low weight of local kids corresponds to low energetic needs, which could be considered as epigenetic strategy of adaptation to the difficult environmental conditions. In this regard, low weights can be regarded are indeed specific mechanisms of adaptation to the restrictive and irregular environment as shown by Al-Shorepy *et al.,* (2002). The adaptation mechanism could be either genetic or epigenetic as these harsh and limiting environments may result in epigenetic marks oriented to limit the size of animals to endure starvation and heat-stress, as it has been observed in some African human population (Al-Shorepy *et al.,* (2002)

The local goat was characterized by small body size with an average wither height of 44.10cm and an average body length of 44.10cm. Small adult size is a characteristic of most breeds raised under arid conditions (Najari,2005).Our values were lower than that reported by Moaeen *et al,.*(2006) who reported 64.97cm body length, 70.23cm height at wither, and 61.29cm heart girth for crossbred goats raised under arid conditions. The variation in various body measurements in different studies on the same breed may be due to the difference in the environment and climate, the size of data set and the management practices adopted.

Table1. The characteristics of the data structure for body weight and linear body measurements of Tunisian local kid at 150 days of age .

Variable	Min.	Max.	Mean	SD	CV%
Live body weight(kg)	7.88	11.20	9.20	4.45	48.37
Body length(cm)	34.22	46.45	40.00	7.45	18.63
Heart girth(cm)	38.22	53.22	46.80	9.70	20.73
Punch girth(cm)	41.40	61.02	50.31	11.30	22.46
Withers height(cm)	36.89	51.12	44.10	7.20	16.33
Rump length(cm)	9.77	13.25	11.01	2.13	19.35

SD: std. deviation; CV: coefficient of variation

3.2 Estimates of environmental effect on studied traits

Table 2 shows the results of the ANOVA analyses to test the significance of the sex and type of birth effect on body weight and linear growth of local kid population. The results show that all studied linear body measurements were significantly affected ($p<0.05$) by sex of kids. The type of birth presents a highly significant ($p<0.01$) on body measurement but no significant effect on paunch girth. The body weight (LBW) was also affected ($p<0.01$) by sex and type of birth. The estimated coefficient of determination (R^2) ranges between 0.62 and 0.83.A relatively high R^2attests the importance of the fixed effects included in the model.

Table 2. Test of significance from ANOVA analyses and coefficient of determination (R^2) of a model including non-genetic factors on studied traits.

Sources of variation	DF	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
Sex of kids	1	HS	HS	HS	HS	HS	HS
Type of birth	1	HS	HS	HS	NS	S	S
R^2	----	0.80	0.71	0.83	0.72	0.77	0.62

DF: degrees of freedom; NS: non-significant; S, HS: significant ($p<0.05$; $p<0.01$, respectively).

3.3 Kid's sex effects upon body weight and linear body measurements

The sex of kids shows a significant effect in all studied traits. The average LBW over the studied period was 9.80±4.50kg for males and 8.32 ±4.02kg for females, respectively (Table 3). Such results are within the range of estimated weights in other local breeds in hot and arid conditions (Al-Shorepy *et al.,*2002).The higher values reported for the morphometric traits of males compared to females seem in accordance with earlier reports on goats (Vargas *etal.,*2007). This difference has been attributed to hormonal differences between sexes and their resultant effects on growth. Najari (2005) reports that female kids can reach the maturity state rapidly and they can begin their reproductive process since the first year of age. This can be considered as an adaptation criteria of local goat population under arid condition (Atoui *et al.,* 2020).

Table 3. Effects of sex upon body weight and linear Body measurements.

	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
Male	9.80^{a} ±4.50	39.80^{a}± 7.50	52.52^{a}±10.80	47.82^{a}± 10.12	45.02^{a}± 7.13	11.20^{a} ± 2.20
Female	8.32^{b} ± 4.02	38.27^{b}±6.60	49.01^{b}±9.80	45.45^{b}± 8.88	43.50^{b}±6.22	10.84^{b}±2.04

^{a,b}Means with different superscripts within a column are significant ($p<0.05$, $p<0.01$).

3.4 Kid's type of birth effects upon body weight and linear body measurements

The effect of type of birth is considered classic for almost livestock species (Ouni*etal.,*2007). Since fœtal life, single kids have normally better conditions to realize lower weight and larger body linear parameters than twins, and this continues during all animal life (Najari, 2005).The average LBW was10.13 ± 4.65 kg for single and 7.82 ± 3.70kgfor double respectively (Table 4). Similar results were obtained by Wenzhong *et al.,*(2005).The higher values reported for the

body length of single compared to twins seem in accordance with earlier reports on kids in the same conditions (Moaeen *et al.,* 2006).

Table 4. Effects of type of birth upon body weight and linear body measurements.

	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
Single	10.13^{a} ±4.65	40.23^{a} ± 7.43	48.41^{a}± 9.50	47.20^{a}±11.01	45.33^{a}± 7.17	11.40^{a}± 2.20
Double	7.82^{b}± 3.70	36.86^{b}±6.71	44.60^{b}±9.23	47.90^{a}± 11.50	42.42^{b}±6.80	10.50^{b} ±1.90

^{a,b}Means with different superscripts within a column are significant (p<0.05, p<0.01).

3.5 Kid's month of birth effects upon body weight and linear body measurements

The results of the comparison of means of the studied traits according to the month of birth-are presented in Table 5. The month of birth presents a highly significant effect on body weight and all body linear measurement, except the Rump length parameter. The best values were obtained with kids born during the period November to December. The effect of month of birth on studied traits is explained by the variation in pastoral resources from one season to another, especially in arid regions with irregular conditions (Najari, 2005). This variation affects the milk production of dams and forage production of the rangelands and therefore on the development of kids (Atoui*et al.,* 2020). Al-Shorepy*et al. (*2002) indicated that kids born in hot, dry season are heavier (p <0.05) than those born duringhumid season.

Table 5. Effects of month of birth upon body weight and linear body measurements.

	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
November	9.81^{a} ±4.51	39.81^{a}± 7.51	52.52^{a}±11.81	47.82^{a} ± 11.12	45.12^{a} ± 7.13	11.21^{a} ± 2.21
December	8.32^{b} ± 4.12	38.27^{b}±6.61	49.11^{b}±9.81	45.45^{b} ± 8.88	43.51^{b}±6.22	11.84^{a}±2.14
January	7.32^{b} ± 4.12	37.27^{b}±6.51	49.11^{b}±9.61	45.45^{b} ± 7.57	43.51^{b}±6.42	11.74^{a}±2.04
February	7.32^{b} ± 3.12	37.27^{b}±6.61	39.11^{b}±9.71	35.35^{b} ± 7.77	33.51^{b}±6.22	11.73^{a}±2.13
March	8.32^{b} ± 4.02	36.27^{b}±6.60	49.01^{b}±9.60	45.45^{b} ± 6.66	43.50^{b}±6.22	10.64^{a}±2.04

^{a,b}Means with different superscripts within a column are significant (p<0.05, p<0.01).

3.6 Bivariate correlations between body weight and linear body measurements

The correlation coefficient between live weight and body linear measurement of kids are shown in table 6. The correlations between the morphometric variables and the live weight are all significant (Table 6). The correlations varied from 0.60 and 0.99. A higher correlation (r=0.99) is observedbetween the LBW and the Heart girth parameter. The lowest correlation(r=0.70) is recorded between the body length and rump length .

The highest correlations are recorded between the height at the withersand the body length are in agreement with those obtained by Rashidi et *al.* (2008) in Markhoz goats and by Schoeman et *al.* (1997) in Boer goats. Due to the existence of high correlations coefficients between live

body weight and linear body measurements, these parameters, could provide a good estimate for predicting live weight in local kid population and it may be used as selection criteria in genetic improvement program.

It seems that the weight of the kid varies essentially with the measurements which represent the stature of the animal than those relating to the shape of the animal. The higher correlation coefficient of body weight with a given body dimension demonstrate that on the basis of the dimensions of various measurements, the body weight could be predicted more accurately. Nsoso et *al.*(2003) found a higher correlation coefficients between body weight and measurements for males indicated the fact that body weight could be predicted more accurately in males as compared to female goats.

The heart girth is the best parameter used for live weight estimation at farm conditions especially under smallholder farmers.

Table 6. Estimates of bivariate correlations among linear morphological traits and live weight.

	Live body weight	**Body length**	**Heart girth**	**Punch girth**	**Withers height**	**Rump length**
Live body weight	1	0.97**	0.99**	0.70*	0.95**	0.77**
Body length		1	0.80**	0.72*	0.90**	0.70*
Heart girth			1	0.90**	0.88**	0.60*
Punch girth				1	0.80*	0.61*
Withers height					1	0.63*
Rump length						1

*significant correlation.

IV - Conclusions

Kid body weight can be predicted from body measurements with high accuracy to support breed improvement and husbandry practices of local goat population. Variation in kid body weight was explained to a large extent by heart girth. It recommended to develop a simple chart that indicates heart girth and corresponding weights to be used by farmers and development agents to support genetic improvement, marketing, feeding and veterinary services.

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