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ESTIMATION OF GOAT LIVE WEIGHT USING THE CREVAT FORMULA AND SIMPLE LINEAR REGRESSIONS

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ABSTRAC

The objective of this study is to predict the body weight of 312 goats (175 females and 135 males) from the local population of different regions in eight wilayas (Souk Ahras, El-Tarf, Jijel, Sétif, Guelma, Bordj bou Arréridj, Ouargla, and Biskra) over the age of 2 using five body measurements. The total body length (LT), scapular-ischial length (SIL), height at withers (HG), width at hips (HW), circumference of the chest (TP) and the CREVAT formula to determine the best parameters for predicting live weight and to establish specific formulas. Body measurements were taken in centimeters, and body weight (BW) was determined in kilograms using a weighing scale. The results of the correlation coefficient were more marked with the chest circumference (HG) (r = 0.994) and the scapulo-ischial length (r = 0.969) than with the height at the withers (0.959). Whereas for the linear regressions of chest circumference (HG) and height at the withers, these proved to be the most accurate predictive equations for all the animals. Based on the CREVAT formula, the goats in the study have a much higher constant "x" (***x*** = 85.30 ±38.29) than that of the other species (cattle, sheep and horses). The coefficient "***x"*** of the males is slightly higher **(**86.33 ±31.72**)** than that of the females **(**84.49 ±42.80**)**. However, the formula that is valid for the goats studied is: P = 85.30 X $(TP)^3$.

Key words: Algeria, goats, live weight, body measurements.

INTRODUCTION

In Algeria, goat farming is one of the most traditional agricultural activities, always associated with sheep farming, and mainly located in regions with difficult access. Currently, there are an estimated 5.007 million head of goats (FAO, 2024), concentrated in difficult areas and exploited as part of pastoral and/or sylvo-pastoral farming systems. The distribution of this livestock across the country depends on the nature of the region, the type of farming and the importance attached to the goat (Hafid, 2006; Moula *et al*., 2013).

Local breeds are extremely resilient and well-adapted to the difficult conditions encountered in their countries of origin (temperatures, undernourishment, parasitism). These goats are able to walk long distances and survive droughts (Boyazoglu *et al.*, 2005). They often have particularly interesting, unique characteristics (Baker and Gray, 2004), such as prolificacy, fertility,

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heat resistance and resistance to parasitism (Kosgey *et al.*, 2006; Amazougrene, 2007).

Precise knowledge of the body mass of animals is essential in many cases, including adjusting the doses of medicines administered (injections, drugging, etc.), assessing growth performance, calculating rations, choosing breeding stock and setting selling prices. The most obvious way to do this is to weigh the animal, using equipment that is adapted to its morphology and behaviour (Moutou and Pastoret, 2010; FAO, 2012). The live weight measured is the result of the 'true' body mass and the content of the digestive tract (which represents around a quarter of the total). Numerous studies have been carried out on the relationship between body measurements (length between anatomical landmarks, height at withers, thoracic perimeter, etc.) and the weight of animals of different species.

The purpose of body measurements has been shown to complement body weight as a measure of productivity and animal condition as a selection criterion, to assess carcass yield or as a selection criterion for assessing animal condition (Cam *et al*., 2010; Djaout *et al.*, 2018). Predictors of certain less visible characteristics (Djaout *et al*., 2018).

It is also used for the selection of future female and male breeding stock for the genetic improvement of herds through the use of different biotechnology methods in goats. Necessary for determining PMSG and GnRH doses for a super ovulation programme and for health monitoring of goats postpartum (Djaout *et al*., 2018; Sahi, 2020).

This study aimed to estimate body weight on the basis of a combination of body measurements using the multiple regression (stepwise) method and the CREVAT formula in the local goat population, in order to make it easier to determine body weight when farmers are faced with the unavailability of a scale.

MATERIALS AND METHODS

Study population

The present study was carried out on 312 local goats (137 males and 175 females). Aged between 2 and 6 years (3.35±0.85 years) reared in eight (8) wilayas (Souk Ahras, El-Tarf, Jijel, Sétif, Guelma, Bordj bou Arréridj, Ouargla, and Biskra). The number and shape of the teeth were used to estimate the age of the animals.

Estimation of live weight using the de CREVAT formula

Live weight is estimated using the classic Quételet and Crevât formulae based on body measurements. In our study, we used the CREVAT method calculated on the basis of thoracic perimeter (Desta, 2009). By adapting the classic Crevât formula :

$$P = x\,(c)^3$$

P*: live weight at the scale (kg).*
C*: chest circumference (m).*

We have the live weight at weighing and the weight estimated by Crevât's formula: ($P = 80\ c^3$). Our aim is to find the coefficient 'x' that links thoracic perimeter and live weight in goats from the local population.

Estimation of live weight by linear measurement

Several studies have used linear measurements to determine regression equations that can estimate live weight (Desta, 2009; Cam *et al.*, 2010; Djaout, 2018). In our study, several measures were used (Table 1): chest circumference (TP), height at withers (HG), total body length (LT), scapulo-ischial length (SIL), and width at hips (WH).

Statistical analysis

The barymmetric formulae were determined with SPSS 25 software using the linear regression method. The estimated weight was considered the dependent variable and were subjected to a three-factor analysis of

variance (region, sex of kid and number of litters).

RESULTS

Live weight

The mean (± standard deviation) of each parameter studied in the goats' weight is shown in Table 2.

Correlation analysis was used to select the measurements that had a significant direct influence on live weight. (Table 3)

Table 1: Different measurements taken.

Measurement	Definition (FAO, 2024)
Height at withers (HG)	Distance between the ground and the highest point of the withers.
Total body length (TBDL)	Distance from the head of the humerii to the distal end of the pubic bone
Scapulo-ischial length (SLI)	Distance between the point of the shoulder and the point of the ischium.
Hip width (LH)	Distance between ilions.
Chest circumference (TP)	Measurement of the circumference of the chest taken behind the front limb and passing through the passage of the straps.

Table 2*:* Descriptive statistics for body weight (kg) and body measurements (cm) of goats weighed.

Parameter	Mean ± Standard deviation			P
	PT = 312	M = 137	F = 175	
PV (*kg*)	28,93 ±5,69	31.53 ± 6.35	26.89± 4.10	***
HG (*cm*)	67,28 ±5,10	68.94 ± 4.99	65.99 ± 4.82	***
HD (*cm*)	68,79 ±4,85	70.17 ± 5.23	67.88 ± 4.37	**
HS (*cm*)	71,37 ±5,11	72.90± 5.49	70.38 ± 4.59	**
LH (*cm*)	18,55 ±4,28	19.94 ± 4.43	17.47 ± 3.83	**
LI (*cm*)	12,88 ±2,80	13.41 ± 8.31	12.54 ± 2.70	ns
TP (*cm*)	71,72 ±8,23	72.91 ± 7.77	70.79 ± 8.48	***
LSI (*cm*)	73,89 ±11,21	77.98 ± 12.26	70.68 ± 9.13	***
HP (*cm*)	32,47 ±2,99	31.90 ± 5.07	32.83 ± 6.16	ns
LB (*cm*)	20,78 ±5,77	21.30 ± 4.60	20.45 ± 4.85	ns
Lt1 (*cm*)	24,42 ±2,44	24.57 ± 2.71	24.31 ± 2.25	ns
Lt2 (*cm*)	18,94 ±2,27	18.95 ± 2.26	18.94 ± 2.28	***
LT (*cm*)	71,13 ±10,64	75,73 ±8,50	67,53 ± 10,79	***
Lq (*cm*)	16,37 ±2,74	16.32 ± 2.89	16.40 ± 2.65	ns
Lc1 (*cm*)	30,47 ±3,83	30.58 ±3,86	28.16 ± 3.12	ns
Lc2 (*cm*)	28,85 ±3,25	28,68 ±5,29	27.30 ± 3.27	ns
Pf (*cm*)	31,21 ±5,27	31.86 ± 5.96	31.41 ± 4.78	ns
oL (*cm*)	16,19 ±3,65	16.98 ± 3.54	15.67 ± 3.64	ns

***p<0.001 ; **p<0.01 ; ns=not significant. N: number, PV: live weight; HG: Height at withers, HD: Height at back, HS: Height at sacrum, LH: Width at the hips, LIsch: Width at the ischiums, TP: circumference of the chest, LSI: Scapulo-ischial length, LT: Length of the body, HP: height at withers, LB: Length of the pelvis, Lt1: Head length, Lt2: Head length, Lq: Tail length, Lc1: Neck length , Lc2: Neck length, Pf: Flank depth, oL: Ear length.

Table 3 : Correlation between live weight and various body measurements.

	HG	HD	HS	LH	LI	TP	LSI	HP	LB	Lt1	Lt2	LT	Lq	Lc1	Lc2	Pf	oL
PV	0, 959**	0, 201*	0, 206*	0, 020**	-0, 005	0, 994**	0, 014**	-0, 123*	0, 078	0, 016	0, 092	0, 969**	0, 008	0, 098	-0, 113*	0, 150	0, 094

***Significant correlation at p<0.001; *Significant correlation at p<0.05; **Significant correlation at p<0.01 PV: live weight;, HG: Height at withers, HD: Height at back, HS: Height at sacrum, LH : Width at hips, LIsch : Width at ischiums, TP : circumference of chest, LSI : Scapulo-ischial length, LT : Length of body, HP : height at withers, LB : Length of pelvis, Lt1 : Head length, Lt2: Head length, Lq: Tail length, Lc1: Neck length, Lc2: Neck length, Pf: Flank depth, oL: Ear length.

According to the CREVAT method

According to the CREVAT method, calculated on the basis of thoracic perimeter (Desta, 2009): **P = X (c) ^{3}** in large animals such as cattle and horses.

The formula obtained was as follows: **P = *x* X (c) ^{3} ====➔ *x* = P/(c) ^{3}====➔ *x* =** 85.30± 38.29.

Table 4 : Value of the "x" coefficient found according to gender.

gender	PV (kg) at scale	Value of x	(c) ^{3} (m)	P= x (c) ^{3}
M	31.53 ± 6.35	86,33 ±31,72	0.38	32,80
F	26.89± 4.10	84,49 ±42,80	0.35	29,57

M: male; F: female; PV: live weight at weighing; x: constant, C: chest circumference; P: estimated weight; m: metre.

Table 5: Prediction of the weight of the goat population studied by "x" according to region.

Region	PV (kg) at scale	(c) ^{3} (m)	P= 85.30 (c) ^{3}
Souk ahras	30.94 ± 6.50	0.37	31,56
El-tarf	30.08 ± 5.77	0.34	29,00
Sétif	31.58 ± 5.22	0.36	30,70
Guelma	28.30± 5.48	0.32	27,30
Bordj Bou Arreridj	31.12 ± 6.38	0.38	32,41
Jijel	28.63± 3.95	0.36	30,70
Ouargla	28.13± 4.12	0.37	31,56
Biskra	26.27± 3.90	0.36	30,70

M: male; F: female; PV: live weight at weighing; x: constant, C: right breast circumference, m: metre; P: estimated weight.

According to the regression equations

Correlation analysis shows that right chest circumference (TP), height at withers (HG), scapulo-ischial length (SIL), total length (TL) and width at hips (LH) have a direct significant effect on PV. Several regression equations were determined and are reported in Table (6).

Table 6: Regression equations.

Regression equation	R	R2 or R-two	Average values	Weight (kg)
P= 0 .065 TP + 24.30	0,994	0,989	TP = 71.72	28,96
P = 0.224 HG +13.89	0,959	0,920	HG= 67.28	28,96
P= 0.151 LT + 18.19	0,969	0,940	LT = 71.13	28,93
P= 0.001 LSI + 28.86	0,002	0,000	SIF = 73.89	28,93
P= 0, 056 LH + 27.89	0,042	0,002	LH = 18.55	28,92

P: Estimated weight; HG: Height at withers, LH : Width at the hips, TP: circumference of the chest, LSI: Scapulo-ischial length, LT: Length of the body.

Table 7 summarises the average live weight of females calculated according to the formulae used in the eight wilayas.

Table 7: Comparison between the different types of equations.

	Weight (kg) on the seesaw	P = x (C) ^{3}	The regression equations according to :				
			TP	*HG*	*LT*	*LSI*	*LH*
Souk ahras	30,94 ±6,50	31,56	29,95	29,05	30,24	28,93	28,85
El-tarf	30,08 ±5,77	29,00	28,82	28,44	29,01	28,93	28,92
Sétif	31,58 ±5,22	30,70	30,92	29,29	29,15	28,92	29,11
Guelma	28,30 ±5,48	27,30	28,73	29,71	27,40	28,92	28,87
Bordj B. Arreridj	31,12 ± 6,38	32,41	30,03	30,95	29,47	28,92	28,77
Jijel	28,63±3,95	30,70	29,44	28,74	28,85	28,91	29,28
Ouargla	28,13±4,12	31,56	28,97	28,89	29,24	28,93	28,87
Biskra	26,27±3,90	30,70	27,96	28,67	27,79	28,93	28,87

HG: Height at withers, LH : Width at hips, TP: chest circumference, LSI: Scapulo-ischial length, LT: Body length; x: constant, C: Right chest circumference, m: metre.

DISCUSSION

Live weight

Knowledge of weight estimation is paramount in goat production, as it is useful in the control and management of the herd throughout the rearing process. In rural communities, appropriate scales are not available, but even if they were, it would be inconvenient and a huge task to carry out every time to weigh the animals, especially when marketing. There are a number of linear dimensions which can be used to quantify the size of an animal and estimate the weight.

The most widely used linear body measurements include height at withers, thoracic girth, chest depth, body length, barrel circumference, height at rump, distance between eyes, ear length, ear width and tail length (Belete *et al.,* 2017). There are many studies for estimating live weight from body measurements (Cankaya *et al*., 2009; Desta, 2009; Cam *et al.,* 2010; Djaout, 2018). However, results from this type of study on local goats in Algeria appear to be rare, if not non-existent.

Consequently, this study was carried out to provide breeders and buyers with a simple means of estimating live weight using morphometric variables: LT (total body length), LSI (scapulo-ischial length), TP (chest circumference), HG (height at withers) and LH (width at hips).

The average weight recorded by weighing 312 goats of both sexes in the eight wilayas

was **(**28.93 ± 5.69) kg (Table 2). Weighing with a scale is the only reliable way of determining an animal's weight (Djaout, 2018). Estimation by eye can be influenced by the appearance of the animal, the location or the observation situation. Live weight (LW) is constantly changing, as the animal eats, drinks, sweats and eliminates solid and liquid excrement. This weight, therefore, depends on the time elapsed since the last meal, the state of dehydration and the diet (Sowande *et al.,* 2009).

Body weight is a very important characteristic in breeding for selection criteria and economic profit, and the size and age of goats are normally linked to their productivity. Larger animals generally produce more meat than smaller ones (Desta, 2009). Knowing the body mass of small ruminants is very useful for good animal management, including understanding drug doses, adapting feed, monitoring growth and choosing replacement males and females (Mahieu *et al.,* 2011).

According to Ouchene-Khelifi *et al*. (2018) and Djouza (2019), the recorded weight was much lower than that of the 'Arbia' goat population. These goats have almost the same weight as Pare goats (29.8 ± 0.50 kg) (Nguluma *et al.,* 2016).

Determining a specific formula for the goats studied.

According to the CREVAT method calculated according to thoracic perimeter; ***x*** = 85.30± 38.29, the average weight of males calculated by the formula P = x (c) ^{3} is 31.56 kg, more than that calculated in females (29.57) kg (Table 3), the weight predicted with the CREVAT method was very close to the observed weight, the difference between the observed weight (31.53 kg) and the predicted weight is 1.27 kg and 2.68 kg for males and females respectively. The most frequent absolute errors (differences between observed and predicted weights) generally did not exceed 3 kg of live weight.

The results showed that goats in the study have a much higher constant 'x' (***x*** = 85.30 ± 38.29) than other species (cattle, sheep and horses). Males have a slightly higher '***x***' coefficient **(**86.33 ±31.72**)** than females **(**84.49 ±42.80**)**. However, we can say that the valid formula for the goats studied is: **P = 85.30 X (TP)^{3}**

In practice, weight prediction based solely on chest circumference has the advantage of being simple, less labour-intensive and allowing the development of directly applicable chest circumference-to-weight conversion tables (Arandas *et al.,* 2017).

Djaout (2018) found that the "x" for determining the PV of *Ouled Djellal* sheep using the CREVAT method is 57.9. Mahmud et al. (2014) found that, although all linear measurements give an estimate of animals' live body weight, chest circumference is the most appropriate and confident parameter in live weight estimates for sheep and goats. Also, chest circumference has a strong correlation with body weight (Belete *et al.,* 2017).

REGRESSION EQUATIONS

In all goats (males and females), weight changed in the same direction and at approximately the same rate as thoracic perimeter, height at withers and scapulo-ischial length. The correlations between weight and the linear measurements were all significant (*P<0.001)*. Correlations between the four variables ranged from 0.923 to 0.972. The various measurements were strongly correlated with weight. The correlation was more marked with thoracic perimeter (r = 0.994) and scapulo-ischial length (r = 0.969) than with height at withers (0.959).

TP, LSI, LT, HG and LH are the measurements used in the linear regression model because they correlate with weight. Based on these measurements, the following regression equations were obtained: P= 0.224 HG +13.89; P= 0.065 TP + 24.30; P = 0.001 LSI + 28.86; P= 0.151 LT + 18.19 and

P = 0.056 LH + 27.89. All gave a weight close to that weighed at the scale, and there was no marked tendency for the predicted weight to be underestimated or overestimated **(**Table 7**)**. Linear regressions of weight on thoracic perimeter and height at withers proved to be the most accurate predictive equations for all animals.

Liveweight (a phenotypic trait) is also controlled by a large number of genes, and is largely influenced by the environment: season, diet (plant cover). Whereas biometric traits, such as height at the withers, chest circumference, etc., are quantitative traits where the environment plays a major role in their expression, such as factors acting on growth (Lahrech, 2008).

Barymetric formulae in the form of linear equations had been proposed for sheep (Djaout, 2018). Djaout (2018) concluded that live weight can be estimated by a simple linear measurement of the body: the right chest circumference (TP), consequently, the height at the withers (HG) and the scapulo-ischial length (LSI) can be used as a prediction criterion for the PV.

Numerous studies in the literature have used one or more statistical procedures to generate prediction models for estimating live body weight using linear body measurements. For example, in goats (Alade *et al.,* 2008; Pesmen and Yardimci, 2008; Mahieu *et al.,* 2011).

Data obtained by Birteeb and Ozoje (2012) showed that the results of simple linear regression by HG were the most satisfactory measure for predicting live weight of goats. Tariq *et al. (*2013) found a close correlation between the body weight of 'Nili-Ravi Nili-Ravi' buffaloes and morphometric variables, whose simple linear regression equations between HG, TP and LT with live weight could easily and with satisfactory accuracy estimate the body weight of the animals.

The measurement that provided the greatest accuracy in terms of the predictive value of live weight was the measurement of thoracic perimeter, as has been unanimously reported by various authors (Mahmud *et al*., 2014; Belete *et al*., 2017). Although morphometric variables are interesting, their execution requires perfect restraint and handling by two operators with good knowledge of animal morphology (Vanvanhossou *et al*., 2018).
In adult animals, the accuracy becomes insufficient due to the level of fattening or the physiological state in breeding females (Mahmud *et al*., 2014). Muscular and body fat conditions have a very significant impact on the nature of the connections observed. In particular, adipose deposits obey very different laws from those governing the growth of other tissues (Vanvanhossou *et al*., 2018).

CONCLUSION

In conclusion, the barymetric formulae proposed for goats are linear regressions based on (PT, HG, LSI, LT and LH). They can be used, with very satisfactory accuracy, to monitor the weight of growing animals. As part of the dissemination and monitoring of the weight performance of local goats, certain measurements (thoracic perimeter and height at withers) should be considered in the future.

CONFLICT OF INTEREST

The authors declare that no conflict of interest.

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تقدير الوزن الحي للماعز باستخدام صيغة CREVAT والانحدار الخطي البسيط

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الهدف من هذه الدراسة هو التنبؤ بوزن جسم ٣١٢ رأس ماعز (١٧٥ أنثى و١٣٥ ذكر) من الماعز المحليين في مناطق مختلفة في ثماني ولايات (سوق أهراس، الطارف، جيجل، سطيف، قالمة، برج بوعريريج، ورقلة, وبسكرة) فوق عمر السنتين باستخدام خمسة قياسات للجسم وهم الطول الكلي للجسم (TBDL)، والطول الكتفي-الإسكيتالي (SIL)، وطول الكاهل (WH)، ومحيط القلب (HG)، وعرض الفخذ (HW)، وصيغة CREVAT لتحديد أفضل المعايير للتنبؤ بالوزن الحي ووضع صيغ محددة. أُخذت قياسات الجسم بالسنتيمترات، وتم تحديد وزن الجسم (BW) بالكيلوغرامات باستخدام ميزان الوزن. كانت نتائج معامل الارتباط أكثر وضوحًا مع محيط القلب (r = ٠,٩٩٤) (HG) وطول الكتف-الكتف العضدي (r = ٠,٩٦٩) مقارنةً بالطول عند الكاهل (٠,٩٥٩). بينما بالنسبة للانحدارات الخطية للوزن على محيط القلب (HG) والطول عند الكتفين، فقد أثبتت هذه المعادلات أنها المعادلات التنبؤية الأكثر دقة لجميع الحيوانات. استنادًا إلى معادلة CREVAT، فإن الماعز في الدراسة لديها ثابت "س" أعلى بكثير (***س*** = ٨٥,٣٠ ± ٣٨,٢٩) من الأنواع الأخرى (الماشية والأغنام والخيول). المعامل "***س"*** للذكور أعلى بقليل (٨٦,٣٣ ±٣١,٧٢) من معامل "***س"*** الإناث (٨٤,٤٩ ±٤٢,٨٠). ومع ذلك، خلصت الدراسة أن المعادلة الأفضل للماعز المدروسة هي: $P = ٨٥,٣٠ X (TP)^{٣}$.