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Possibilities of Using Morphometrics Characteristics as a Tool for Body Weight Prediction in Turkish Hair Goats (Kilkeci)

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Abstract: This study was conducted to determine body weight, body measurements, body condition score and the relationship between body weight and body measurements in adult Turkish Hair Goat (Kilkeci) reared in four different enterprises just before the mating time under rural farm conditions. Totally 195 goats, 177 does (2-4 years old, n = 91, 1D group and 4.5-6 years old age n = 86, 2D group) and 18 bulks (at 3-5 years old, B) at breeding age were used. Morphologic measurements such as body weight, wither height, heart girth, chest width, rump height and body length were determined as 47.35±0.42, 52.2±0.46 and 64.09±0.34 kg; 73.13±0.33, 74.09±0.36 and 81.89±0.40 cm; 72.47±0.36 73.80±0.39 and 81.86±0.51 cm; 73.01±0.35, 75.79±0.38 and 81.78±0.77 cm; 18.10±0.14, 18.75±0.15 and 23.22±0.32 cm; 30.76±0.15, 31.94±0.17 and 34.86±0.39 cm; 86.22±0.36, 89.67±0.38 and 98.89±0.86 cm for 1D, 2D and B, respectively. There were significant differences ($p<0.01$) between age groups in does and also between does and bulks. It was found positive and significant ($p<0.001$) correlations between body weight and body measurements. The highest correlations were found between body weight and each of heart girth (0.847), chest depth (0.775). The body weight could be estimated by using the equation of $Y = -47.8+1.12$ HG; $R^2 = 0.717$ for Kilkeci under reared rural conditions without considering age, farm and sex. It was concluded that Kilkeci has similar morphologic characteristics as peer evaluation and an important genetic source for the ecological production.

Key words: Goat, body weight, body condition score, body measurement, Kilkeci, morphologic traits

INTRODUCTION

Goat rearing is an important economic activity for farmers in rural lives where there is not any other means of subsistence. Goat can affectively survive on available shrubs and trees in adverse harsh environment in low fertility lands (Thiruvenkadan, 2005; Khan *et al*., 2006; Kebede *et al*., 2008) all over the world. The Turkish Hair Goat (Kilkeci), a native goat breed, is the most populous and dominant breed in the Black Sea region and other places of Turkey having adverse conditions, comprising approximately 95% of 6 million Turkish goat population and has a major impact on goat meat production (Cam *et al*., 2003; Simsek and Bayraktar, 2006).

Although, Kilkeci has adaptation ability to harsh environment conditions and have a power physiologic defense mechanism against disease, suffer to pressure an extensive population control to preserve forest lands in Turkey (Koyuncu *et al*., 2007). Hence, this

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breed had not been worked on genetically improved except crossbreeding studies to convert exotics goat breed such as Saanen (Cam *et al*., 1999a, b; Sengonca *et al*., 2003). On the other hand, recent years ecological products have been gained an important preferred especially with the worried of eating some by-products animals' product cross into human, these type of breed come into prominence all over the world.

Goats are known to travel long distance for food and water under cool and hot climatic environment especially in rocky and hilly places in Turkey. Their long and sturdy legs are beneficial for this survival character. Kilkeci breed is one the most important natural resource for ecological product due to its rearing characteristics. When compared the other meat type goats, Kilkeci have at least equal or higher characteristics than those of peer evaluation of the world (Devendra and McLeroy, 1988; Nsoso *et al*., 2003; Worku *et al*., 2009) with regard to morphological values. Of the morphological assessments, body measurements used for several purposes including prediction of growth rate, genetic improvement, body condition, conformation and carcass traits (Wilson *et al*., 1997; Slippers *et al*., 2000; Lambe *et al*., 2008). Although, boby weight (BW) is an important economic trait in meat type animals, it is seldom measured in rural communal areas due to lack of scales. Wilson *et al*. (1997), Sarti *et al*. (2003), Bassano *et al*. (2003) and Singh and Mishra (2004) indicated that the best method of weighing animals without a scale is to regress BW on certain body measurements that can be measured readily and also some of body measurements could be used to predict carcass and meat quality (Lambe *et al*., 2008).

Considering for the facts mentioned above the present study was carried out to determine boby weight, body measurements and body condition scores in Turkish hair goats and to estimate the correlation coefficients between all traits, to limiting the best prediction equations of b.wt., on the base of one or more body measurements, by using simple and stepwise regression, which represent a practical method of predicting the weight of goats for farmers.

MATERIALS AND METHODS

This study was conducted in Turkey in randomly chosen 4 farms in Amasya District (34° 57'-36° 31' E and 41° 04'-40° 16' N) where only Turkish hair goats reared under rural conditions during 2003. Total 195 goats, 177 does (D, between 2 to 6 years old and body weight ranging from 35.5 to 64.0 kg and body condition scores from 2-4.0, on a subjective scales 0-5) and 18 bulks (B, 3-5 years old, body weight ranging from 62.0 to 68.0 kg and body condition scores 3 to 4.5) were used in the present study. The ages of animals were determined according to the statement of herd owner and also from the state of teeth observation and does were grouped as 2-4 years old (1D, n = 91) and 4.5-6 (2D, n = 86) years old. The animals were released daily for grazing prior to the sunrise and when they stayed at shadow around noon and they were brought in the hovel with shadow after the late of the sun goes down, absolutely under the natural and rural conditions.

The following parameters were recorded in all animals prior to the beginning of breeding season: (1) body weight (BW, kg), (2) body length (BL, cm): length from anterior shoulder point to the posterior extremity of the pin bone, (3) withers height (WH, cm): the vertical distance from the top of the scapula to the ground, (4) rump height (RH, cm): the vertical distance from the top of the pelvic girdle to the ground, (5) heart girth (HG, cm): just behind the scapula, (6) chest depth (CD, cm): behind the shoulder, (7) chest width (CW, cm): between the shoulder blades and (8) body condition scores (BCS). The BCS were assessed using 5 point scale (1 = very thin to 5 = obese) by Nsoso *et al*. (2003).

Data collected were classified on the basis of farms, sex and age. There were no significant differences between farms, hence date were pooled. Means±SEM for the body weight, body condition scores and above mentioned body measurements were performed. Among the variables analyzed were live body weight, body dimensions and body condition scores. Data were evaluated by completely randomized design to investigate the effects of farm and gender on body weight, body measurements and body condition score in SPSS software. Mathematical model of this study can be given as:

$$Y_{ij} = \mu + \alpha_j + e_{ij}$$

Where:
μ : Population mean
α_i: The effect of the agexsex
e_{ij}: Error term

Correlation coefficients were estimated between body weight and the other mentioned traits as reported by Bassano *et al.* (2003), Thiruvenkadan (2005) and Khan *et al.* (2006). Differences between farms were evaluated by using Duncan multiple comparison test in SPSS software.

RESULTS

The main statistical parameters (Table 1) indicate that means for bulks and does, body weight, body measurements and body condition scores were significant differences ($p<0.01$) within farms according to Duncan multiple comparison test. When only farms evaluated, there were no significant differences in terms of body weight and the mentioned variables. As the farm has no significant effect, there is no need to this conclusion. There were significant ($p<0.01$) differences between gender and does age groups related to all mentioned variables except body condition scores.

Table 1: Mean±SE the body weights, body condition scores and body measurements of does and bulks in 4 different goat farms

Farms	N		BCS	LBW	RH	WH	BL	CW	CD	HG
1	4	B	3.38±0.08	63.40±2.40	82.25±1.56	81.00±1.68	79.63±1.78	22.75±0.69	35.13±0.79	100.00±1.90
	19	1D	2.95±0.11	49.76±0.92	74.63±0.72	72.95±0.77	75.34±0.77	17.47±0.31	30.92±0.33	87.16±0.75
	21	2D	3.26±0.11	52.43±0.88	73.52±0.68	74.62±0.73	77.19±0.73	17.90±0.29	32.10±0.32	89.14±0.71
	40	OD	3.10±0.25	51.16±0.75	74.05±0.49	73.83±0.53	76.31±0.56	17.70±0.22	31.54±0.25	88.20±0.60
	44	O	3.13±0.08a	52.28±0.79a	74.80±0.57b	74.48±0.56b	76.61±0.69a	18.16±0.32a	31.86±0.31bc	89.27±0.69c
2	4	B	3.75±0.25	64.65±2.39	81.75±1.56	83.75±1.68	83.25±1.78	24.25±0.69	34.75±0.79	97.75±1.90
	26	1D	2.96±0.10	44.73±0.79	74.81±0.61	74.54±0.66	72.98±0.66	17.52±0.26	30.85±0.29	85.23±0.64
	13	2D	3.05±0.13	49.31±1.11	75.38±0.86	74.23±0.93	75.62±0.93	18.04±0.37	31.69±0.40	87.31±0.91
	39	OD	3.00±0.08	46.26±0.76	75.00±0.50	74.44±0.54	73.86±0.57	17.69±0.22	31.13±0.25	85.92±0.61
	43	O	3.07±0.09a	47.97±1.09b	75.63±0.49b	75.30±0.61b	74.73±0.57b	18.30±0.35a	31.47±0.29ab	87.02±0.73a
3	4	B	3.63±0.25	63.60±2.39	80.75±1.56	81.50±1.68	84.00±1.78	22.75±0.69	35.25±0.79	101.50±1.90
	21	2D	2.85±0.11	46.55±0.88	71.38±0.68	71.02±0.73	72.17±0.73	18.76±0.29	30.12±0.32	85.62±0.71
	17	2D	3.00±0.12	50.00±0.97	79.21±0.76	72.35±0.82	75.32±0.81	19.23±0.32	31.12±0.35	89.35±0.79
	38	OD	2.93±0.08	48.09±0.77	72.20±0.51	71.62±0.55	73.58±0.58	18.97±0.22	30.57±0.26	87.29±0.62
	42	O	3.00±0.08a	49.57±0.87b	73.01±0.66a	72.56±0.72a	74.57±0.71b	19.33±0.24b	31.01±0.31a	88.64±0.87ab
4	6	B	3.43±0.20	64.50±1.96	82.14±1.27	81.21±1.37	79.94±1.46	22.66±0.56	34.57±0.65	96.71±1.56
	25	1D	2.36±0.10	48.34±0.80	71.70±0.62	71.36±0.67	71.56±0.67	18.64±0.27	31.16±0.29	86.88±0.65
	35	2D	2.740.08	57.19±0.68	74.23±0.53	73.99±0.57	75.03±0.56	19.80±0.23	32.86±0.25	92.89±0.55
	60	OD	2.58±0.06	53.25±0.62	73.06±0.40	72.77±0.43	73.56±0.46	19.31±0.18	32.10±0.21	90.32±0.49
	66	O	2.67±0.07b	54.50±0.83b	74.02±0.52ab	73.67±0.53ab	74.24±0.50b	19.67±0.23b	32.36±0.21c	91.00±0.60c
Gen*	18	B	3.56±0.11A	64.09±0.34A	81.89±0.40A	81.86±0.51A	81.78±0.77A	23.22±0.32A	34.86±0.39A	98.89±0.86A
	91	1D	2.90±0.05	47.35±0.42	73.13±0.33	72.47±0.36	73.01±0.35	18.10±0.14	30.76±0.15	86.22±0.36
	86	2D	2.91±0.06	52.20±0.46	74.09±0.36	73.80±0.39	75.79±0.38	18.75±0.15	31.94±0.17	89.67±0.38
	177	OD	2.87±0.04B	50.22±0.43B	73.57±0.25B	73.17±0.27B	74.26±0.28B	18.52±0.12B	31.45±0.13B	88.24±0.31B
	195	O	2.93±0.04	51.50±0.48	74.33±0.29	73.97±0.31	74.95±0.31	18.95±0.15	31.76±0.14	89.23±0.37

Different letter(s) (a, b, c; A, B, *) within column differ significantly ($p<0.01$) according to Duncan test. BW: Body weight, BCS: Body condition Score, RH: Rump height, WH: Withers height, BL: Body length, CW: Chest width, HG: Heart girth, CD: Chest depth, B: Bulks, 1D: 2-4 years old ages does, 2D: 4.5-6 years old ages does, OD: All does, O: All does and bulks

Table 2: The correlations amongst different body measurements in Turkish hair goat

Variables	BW	BCS	RH	WH	BL	CW	CD
LBW	-						
BCS	0.237*	-					
RH	0.543*	0.243*	-				
WH	0.560*	0.248*	0.823*	-			
BL	0.607*	0.423*	0.484*	0.554*	-		
CW	0.657*	0.264*	0.359*	0.360*	0.368*	-	
CD	0.775*	0.113ns	0.586*	0.620*	0.556*	0.501*	-
HG	0.847*	0.240*	0.540*	0.597*	0.595*	0.677*	0.793*

*Correlations are significant at the p<0.001 level and ns: not significant, BW: Body weight, BCS: Body condition Score, RH: Rump height, WH: Withers height, BL: Body length, CW: Chest width, HG: Heart girth, CD: Chest depth

Table 3: Prediction equations of body weight from various body measurements in Turkish hair goats

Regression equations	R^2-value
Linear (simple)	
BW = -47.77 + 1.12 HG	0.717
BW = -34.50+2.71 CD	0.601
BW = +10.52 + 2.16 CW	0.431
BW = -20.19 + 0.96 BL	0.368
BW = -14.10 + 0.89 WH	0.314
BW = -16.42 + 0.91 RH	0.295
BW = +43.22 + 2.82 BCS	0.056
Multiple (stepwise)	
BW = -47.77 + 1.12 HG	0.717
BW = -52.77 + 0.82HG + 0.98 CD	0.746
BW = -50.12 + 0.65 HG + 1.04 CD + 0.57 CW	0.762
BW = -56.00 + 0.57 HG + 0.93 CD + 0.60 CW + 0.21 BL	0.773

BW: Body weight, BCS: Body condition score, RH: Rump height, WH: Withers height, BL: Body length, CW: Chest width, HG: Heart girth, CD: Chest depth

The correlations were calculated between body weight and body measurement and amongst the body measurements. The correlations ranged from 0.243 to 0.847 between body weight and the body measurements and the correlations amongst different body measurements ranged from 0.113 to 0.823 in Turkish Hair Goat (Table 2). The highest and positive correlations ($p<0.001$) were found between body weight and heart girth ($r = 0.847$), body weight and chest width ($r = 0.775$), HG and CD ($r = 0.793$), HG and CW ($r = 0.677$), WH and RH ($r = 0.823$) whereas the lowest correlations were body condition scores and other variables.

Simple and Stepwise regression analysis were used to obtain best prediction equations for body weight from linear and circumferences body measurement traits as seen in Table 3. Different body weight prediction equations were obtained based on different body part measurement. According to R^2, the best prediction equations were based on HG, CD and CW, respectively.

According to age and sex groups different simple regression equations were demonstrated such as 1D (BW = -31.27+0.91HG, $R^2 = 0.446$; BW = -8.10+1.80 CD, $R^2 = 0.357$), 2D (BW = -32.71+0.95 HG, $R^2 = 0.539$, BW = -14.08+2.10 CD, $R^2 = 0.421$) for age groups and for B (BW=20.08+0.53 RH; $R^2 = 0.394$). Stepwise regression equations for 2-4 age groups (1D); BW = -36.08+0.66 HG +0.86 CD $R^2 = 0.494$, for 2D; BW = -43.15 +0.70 HG + 1.04 CD, $R^2 = 0.603$ and for B; BW = 11.10 + 0.42 RH + 0.23 WH, $R^2 = 0.493$.

The accurate and predicted body weights estimated from B, 1D, 2D, OD and O are summarized in Table 4, respectively. Body weight was highly correlated ($p<0.01$) with heart girth measurement for both age categories but not bulks due to the lacking number.

Table 4: Measured and predicted body weights of Turkish hair goats

		Predicted body weight kg[1]	
	Measured body weight (kg)	(BW= -47.77+1.12 HG)	(BW= -52.77+0.82HG+0.98 CD)
B	64.09±0.34	62.99±0.96, ns = 213, p>0.05	62.48±1.03, m = 0.352, p>0.05
1D	47.35±0.47	48.75±0.39, r* = 0.668, p<0.001	47.26±0.40, r* = 0.703, p>0.05
2D	52.20±0.55	52.89±0.46, r* = 0.776, p>0.05	52.51±0.47, r* = 00.734, p>0.05
OD	50.22±0.43	51.06±0.35, r* = 0.787, p<0.001	50.41±0.35, r* = 0.814, p>0.05
O	51.50±0.48	52.16±0.43, r* = 847, p<0.01	51.52±0.42, r* = 0.864, p>0.05

r*: Significant correlations (p<0.001), ns: Non significant correlations (p>0.05) [1]Predicting body weights compared with measured body weights and P refer to this significant levels, B: Bulks, 1D: 2-4 old ages does, 2D: 4.5-6 old ages does, OD: All does, O: All does and Bulks

DISCUSSION

The findings regarding body weight and linear body measurements in the present study were higher than previous findings from the similar age animals reported by Cam *et al.* (2003). Morphometric measurements and the relationships between these measurements describe roughly animal's production status and breed characteristics. For example, Turkish hair goats have the nearest values from the stand point of body length, rump height and wither height and this reflects meat type (square-shaped) characteristics. Accordingly, there was a good balance between rump height and wither height and this characteristic provides an advantage to climb up and down under the hilly conditions. Another characteristic that leg length or body height from ground measured from the difference between chest depths and withers height (is about 42 cm). Also, leg length is an advantage to long walks without their body injuries under thorns, shrubs and trees in adverse harsh environment conditions.

Also, linear body measurements and body weights reflect breed characteristics and management conditions of an animal. So that rearing under different management conditions, animals could have various growth performances. Therefore, in this study little differences between farms and animals could be attributed to farm's feeding and management conditions.

When comparing Kilkeci related to body weight, wither height, rump height its adult peer evaluation such as well known Boer (Malan, 2000; Cameron *et al.*, 2001) have lower values, but many goat breeds have equal or higher values (Devendra and McLeroy, 1988; Muhammad *et al.*, 2006; Worku *et al.*, 2009) even these extensive conditions.

Generally, body condition scoring reflects body lipids or animal fattening status more than body weight (Nsoso *et al.*, 2003; Janssens and Vandepitte, 2004). Body condition score is varied according to farm management conditions and season (Bassano *et al.*, 2003; Adeyinka and Mohammed, 2006) that forage flora is available green and through. Especially if an animal is inadequately feed from birth to adult age, it could not reach to breed standards. In this study, the estimates of body condition score in fourth farms were numerically lower than those of others. This demonstrated the differences between farm's fattening and management condition.

The relationships (correlations) between body weight and body measurements may differ due to management conditions, but the balances or ratios between body parts can not change (Thiruvenkadan, 2005; Cam *et al.*, 2009). These differences might be explained by the changes in fat deposition (Bassano *et al.*, 2003) due to feeding and management status based on especially seasonal changes. Additionally, butchers based on this fact (there are strong relationships and balance between animal body parts) say that total carcass weight equals to ten fold forearm weight and they have used to determine carcass weight for a long time.

Considering these comments, even though under rural conditions animals subject to different breeding and management systems, body measurements can vary, but these

variations can not affect relationships or proportions between body parts. If an animal subjects to bad feeding and management conditions during life span its body measurements do not reach real breed standard but body part proportion might keep constant. Consequently, it could be said that body condition score can be negligible when body weight estimation from body measurements.

Body weight is an important characteristic especially for meat type animal because of genetic improvement studies focus on it. Due to rural hard conditions and lacking of a weighbridge, many studies were planned to predict body weight from different body measurements in livestock animals (Topal *et al*., 2003; Topal and Macit, 2004 in sheep; Isaac *et al*., 2006 in goats; Adeyinka and Mohammed, 2006 in goats; Otoikhian *et al*., 2008 in goats) using simple and multiple regression equations.

When the equations obtained from data regardless of ages and sex brings to a successful conclusion for the estimation of body weight from body measurements. Hence, it is not to need different prediction equations for different age and sex and also increasing of number of prediction equations are not practical to applying for breeders.

The result of stepwise regression analysis indicated that other measurements to the heart girth would result in significantly improvement in accuracy of prediction in overall assessment even though the extra gain was small (Afolayan *et al*., 2006) as seen in R^2 change in Table 3. The estimation of body weight based on only heart girth measurement imputes, not with standing that it might be accepted as regardless of age and sex. In fact, hearth girth combined with chest depth, chest width and body length are enough to estimate body weight accurately ($R^2 = 0.77$). This finding is accordance with the reported by Afolayan *et al.* (2006) in sheep.

In this study, the respective prediction equations developed for all animals. For prediction body weights there was significant difference between actual body weight and predicted body weight based on simple regression equation obtained in the present study, but the equations that based on stepwise regression are closer to real body weight. Hence, it is plausible that multiple regression equations can be used for body weight prediction. However, prediction body weight based on simple equations comes up with close results to the actual body weight and it is acceptable for breeders and buyers due to simple.

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