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BODY WEIGHT ESTIMATION USING BODY MEASUREMENTS IN GOATS (*Capra hircus*) UNDER FIELD CONDITION

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ABSTRACT

Body weight information of livestock animals is significant for trade, routine animal health monitoring and dosage calculations for treatment of diseases. Under field conditions, a convenient body weight estimation formula in goats (*Capra hircus*) using body measurements was developed and evaluated. A total of 300 adult goats in Barili, Cebu were used for the development of the formula, and 66 goats from the VSU Goat Project, Baybay City, Leyte and Ubay Stock Farm, Bohol were used for its field reliability testing. Animals were selected by convenience sampling regardless of sex and breed. In the univariate level of analyses, all body measurement parameters (rump height [RH], body length [BL], heart girth [HG], and wither height [WH]) showed significant correlation (P<0.05). In the multivariate level (stepwise regression), the wither height was removed in the final equation [estimated live weight={((2xRH)+(4XBL)+(6XHG))/10}-53] which resulted into a stronger correlation with the actual live weight (R=0.899, R2=0.81, P<0.05). Body weight estimatior from other authors were compared with the current formula developed. Results revealed that the technique utilizing this formula demonstrated high reliability in goats in the study areas, implying good potential for generalized applicability.

Key words: body measurements, body weight, goats

INTRODUCTION

The body weight of an animal is essential for trade and health assessment. Its estimation must be made as close to the actual live weight as possible to maximize profits and avoid over- or under-dosing of medications. However, in the actual field in the Philippines, especially in the public market or in most rural areas, weighing scales are usually non-existent. Moreover, these weighing scales can be expensive and/ or difficult to use in the field especially if the animals are uncooperative. Hence, developing a body weight estimation technique for field use is essential. Estimation techniques are already investigated in pigs (Murillo and Valdez 2004; Walugembe *et al.*, 2014), cattle (Bagui and Valdez, 2007; PCAARD, 2002) and horses (Marante *et al.*, 2009; Macatangay and Valdez, 2002). In the Philippines, Valdez *et al.* (1981) found correlation of selected external measurements, including heart girth, wither height and midriff girth, to body weight of goats and suggested some formulas for mixed grade and combined breed groups: (-28.33) + (HG*0.82013); (-37.16492) + (HG*1.00055); (-17.72717) + (HG*0.93364) + (WH*0.23434); (-40.75258) + (HG*0.82328) + (WH*0.24673). Several studies in other countries have explored the correlation of body measurement parameters with body weight of the animal (Mohammed and Amin, 1997; Thiruvenkadan, 2005; Adeyinka & Mohammed, 2006; Slippers *et al*., 2000; Nsoso, 2003; Cam *et al*., 2010; Mahieu *et al*., 2011), but most of the

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resulting formulas still appear to be complex or difficult to remember due to the coefficients for each obtained body measurement which contain different decimal numbers. This study aimed to develop a convenient and easier to remember body weight estimation formula in goats using body weight measurements and assess its reliability under field conditions.

MATERIALS AND METHODS

Three hundred adult mixed-breed goats (105 male and 195 female) from a farm in Brgy. Nasipit, Barili, Cebu, Philippines was used for the development of an estimator formula. An addition of 66 adult mixed-bred goats (regardless of sex) goats from the Baybay City, Leyte and Ubay Stock Farm, Bohol were later utilized for the field reliability testing of the developed formula. Animals were handled humanely in accordance with the Animal Welfare Act of the Philippines and the existing animal care and use guidelines of the Philippine Association of Laboratory Animals.

A quadrant type weighing scale (with a capacity of up to 100 kilograms) was used to determine actual live weight, while a tailor measuring tape was used to obtain the needed body measurements (in cm). The weighing scale was checked and calibrated before each procedure was done. A tally sheet was used to record the data.

The weighing scale was set-up on a flat area. Each animal was placed on top of the weighing scale to get the actual live weight (ALW). In cases where the goat subject was difficult to handle, appropriate restraint techniques were applied. After determining the live weight, the animal was made to stand upright on a flat ground area. Specific body measurements (cm) obtained using the tailor measuring tape included: rump height [RH] as the distance from spina illiaca to the ground, body length [BL] as the distance between the occipital protuberance and taildrop, heart girth [HG] as the circumference of the chest just caudal to the forelimbs, and wither height as the distance between the most dorsal point of the withers and the ground (Mahieu *et al.*, 2011; Yakubu *et al.*, 2011). The average time it took for the researcher to obtain these measurements was 12 seconds per animal.

Data from the tally sheet were encoded into Microsoft Excel 2010, and analyzed using simple linear regression and multiple linear regression (stepwise) for the univariate and multivariate level of analyses, respectively, using SPSS Statistics 23 (International Business Machines Corp., Armonk, New York). After devising the new formula, estimated live weight (ELW) values were computed and compared with the ALW using independent T-test. The same procedure was performed for the measurements of research subjects from the VSU goat project and Ubay Stock Farm.

Using the obtained body measurements, ELW was also computed using formulas from other authors. Results were then compared with the values from the devised formula and ALW using analyses of variance with post-hoc analyses. To those found with no significant difference, Pearson correlation was performed with ALW to determine applicability and strength of correlation (R).

RESULTS AND DISCUSSION

In the development of the formula, the study utilized a total of 300 goats (105 male and 195 female). The male goats consistently had higher average live weights and body measurements compared to female goats similar to the findings of other studies (Pesmen and Yardimci, 2008; Abegaz and Awgichew, 2009). The over-all average body weight and body measurements were found to be 26.5 kg, and 66.14 cm (RH), 59.6 cm (BL), 70.9 cm (HG) and 61.09 cm (WH). Except for RH, all parameters were found to be significantly different between sexes (Table 1). This finding corroborated with that of

Table 1. Mean values of actual live weight and body measurements of goats (*Capra hircus*).

Parameter	Male	Female	P-value	Over-all Mean
Actual live weight* (kg)	27.42±6.36	25.43±5.40	0.005	26.13±5.82
Heart girth** (cm)	72.01±5.79	69.05±4.73	0.000	70.09±5.31
Body length** (cm)	60.96±5.59	58.87±4.40	0.001	59.60±4.94
Rump height (cm)	66.94±4.52	65.71±6.07	0.069	66.14±5.60
With height** (cm)	62.46±4.27	60.35±5.57	0.001	61.09±5.25

*Significant (P<0.05), ** Highly significant (P<0.01).

Matsebula *et al.* (2013).

Linear regression analyses between ALW and specific body measurements of research subjects showed significant relationships (P< 0.05) (Table 2). Heart girth (R=0.838, R^2=0.702) was found to have the highest correlation while the wither height (R=0.643, R^2=0.414) was the weakest. Valdez *et al.* (1981) also found HG to be the most reliable predictor if only a single body measurement parameter will be used. Several studies in other countries have found similar results (Khan *et al*. 2006; Pesmen and Yardimci, 2008; Abegaz and Awgichew, 2009; Yakubu *et al.*, 2011; Moaeen-ud-Din *et al.,* 2006; Mahieu *et al.*, 2011).

From the resulting positive coefficients, the relationship between the body measurements and ALW were shown to be directly proportional. This means that in every increase in the body measurement, there is a subsequent increase in the ALW. On the other hand, the coefficient of determination (R^2) values showed moderate to high correlation between ALW and the specific body measurements.

Stepwise regression analyses excluded WH in the different models for male, female and over-all population (Table 2). Resulting models were seen to have stronger correlations with ALW when more significant body weight measurements are included as predictors than with individual body measurements. This finding is consistent with other studies (Khan *et al*. 2006; Pesmen and Yardimci, 2008; Abegaz and Awgichew, 2009; Yakubu *et al.*, 2011; Moaeen-ud-Din *et al.,* 2006).

The resulting equation in the multiple regression analysis contained variable coefficients (with decimal numbers) which appear complex and difficult to remember. Thus, a simpler formula was devised by rounding off the decimal places and replacing them with whole numbers. Moreover, the approach of obtaining body measurements which starts from the caudal to cranial (rump height to body length to heart girth) with arranged coefficients or multipliers in ascending pattern and in whole numbers (2, 4, 6) can facilitate easy recall.

The proposed formula is:

$$ELW = \frac{(2xRH) + (4XBL) + (6XHG)}{10} - 53$$

Where:

ELW - Estimated live weight (kg)
RH - Rump height (cm)
BL - Body length (cm)
HG - Heart girth (cm)

This formula was tested using the data obtained from the different body measurements

Table 2. Results of the univariate and multivariate analyses of the different body measurement parameters with the actual live weight of goats (*Capra hircus*).

Univariate Analyses						
Parameter	R	R2	Adjusted R Square	Std. Error	P-value	Model
Heart girth (cm)	0.838	0.702	0.701	3.183	0.000	-38.242 + (HG*0.918)
Body length (cm)	0.731	0.534	0.532	3.981	0.000	-25.169 + (BL*0.861)
Rump height (cm)	0.661	0.436	0.435	4.377	0.000	-19.278 + (RH*0.686)
Wither height (cm)	0.643	0.414	0.412	4.464	0.000	-17.489 + (WH*0.714)
Multivariate Analyses						
Sex	R	R2	Adjusted R Square	Std. Error	P-value	Model
Male	0.888	0.788	0.782	2.971	0.000	-57.066+ (HG*0.55)+ (BL*0.368)+ (RH*0.335)
	0.864	0.747	0.742	3.231	0.000	-45.073 + (HG*0.647) + (BL*0.425)
	0.810	0.655	0.652	3.750	0.000	-36.577 + (HG*0.889)
Female	0.910	0.828	0.825	2.258	0.000	-51.413 + (HG*0.650) + (BL*0.355) + (RH*0.168)
	0.898	0.807	0.805	2.384	0.000	-50.804 + (HG*0.750) + (BL*0.416)
	0.856	0.732	0.731	2.804	0.000	-41.967 + (HG*0.976)
Over-all	0.899	0.808	0.806	2.562	0.000	-50.666 + (HG*0.587) + (BL*0.355) + (RH*0.219)
	0.883	0.780	0.778	2.743	0.000	-46.464 + (HG*0.684) + (BL*0.413)
	0.838	0.702	0.701	3.183	0.000	-38.242 + (HG*0.918)

to compute for live weight estimates. The same data were also used in the computation utilizing the original equation (Table 2). Comparing the 2 sets of estimates and the actual live weight, statistical analyses revealed no significant differences. This indicates that the newly devised formula is also reliable.

Moreover, the same data were used in different goat-body-weight estimating-formulas obtained by other authors (Cam *et al*., 2010; Fajemilehin and Salako, 2008; Slippers *et al*., 2000; Yakubu, 2009; Pesmen and Yardimci, 2008; Yaekob *et al*., 2015; Khan *et al*., 2004; Moaeen-ud-Din *et al*., 2006; Valdez *et al*., 1981) and compared with the ALW and current formula. Only 9 formulas (by Valdez *et al*., 1981, Khan *et al*. (2004), Pesmen and Yardimci (2008), Slippers *et al*. (2000) and Fajemilehin and Salako (2008))

Table 3. Correlation (R) of estimated live weight of goats (*Capra hircus*) with actual live weight values using different estimator formulas from different authors.

Source of Estimator Formula	Formula to estimate live weight (ELV) of goats (*Capra hircus*)	Correlation, R
Current study	=((2*RH)+(4*BL)+(6*HG)/10))-53	0.899
Khan *et al*., 2004	=(HG*HG*BL)/300	0.894
Valdez *et al*., 1981	=-40.75258+(HG*0.82328)+ (WH*0.24673)	0.861
Pesmen and Yardimci, 2008	=-53.061+(1.120*HG)	0.838
Slippers *et al*., 2000	=-43.0277+(0.992924*HG)	0.838
Valdez *et al*., 1981	=-28.33345+(0.82013*HG)	0.838
Valdez *et al*., 1981	=(HG*1.00055)-37.66	0.838
Valdez *et al*., 1981	=-17.72717 + (HG*0.93364)+(WH*0.23434)	0.832
Fajemilehin and Salako, 2008	=(0.57*WH)-7.63	0.661
Fajemilehin and Salako, 2008	=(0.49*RH)-76	0.643

were found to produce ELW values with no significant difference with ALW. Except for the formula of Khan *et al*. (2004) which used two predictors (HG and BL), the other identified reliable formulas used only a single predictor. Further analyses showed that the formula developed in this study showed the strongest correlation (Table 3), followed by that developed by Khan *et al*. (2004). While the formula of the latter appears to be simpler, input values were actually converted to be uniform with the other ELWs. The required body measurements were in inches and the resulting estimated weight was in pounds for the aforementioned formula.

Assessment of the developed formula using the 66 goats in 2 other areas revealed that there was no significance difference between ALW and ELW values (P=0.991). Analysis revealed moderate to strong correlation (R=0.754). The results provide additional evidence on the reliability of the newly devised formula and its applicability in goats in the studied areas.

CONCLUSION

A body weight estimation formula using body measurement techniques was developed with high reliability under field condition in selected areas in the Visayas, Philippines. The caudal to cranial approach of obtaining body measurements (rump height to body length to heart girth) and use of coefficients or multipliers in ascending pattern and in whole numbers (2, 4, 6) are the salient features of the formula which are easy to recall.

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