Original research article

Biometrical Relationship between Body Weight and Body Measurements of Black Bengal Goat (BBG)

ABSTRACT

Aims: To develop regression equations for estimation of live weight from the external morphological measurements.

Study design: CRD with non-orthogonal hierarchy.

Place and duration of study: This study was carried out at 3 rural village communities of Bhaluka Upazila in Mymensingh district of Bangladesh from 2009 to 2013.

Methodology: All animals were ear-tagged and maintained under semi-intensive management system with scheduled vaccination and de-worming. Data were collected from a baseline survey along with 3 progressive generations produced from the community foundation stocks. Body length, chest girth, wither height, hip height and body weights were measured in a same day and recorded individually from birth up to 15 month age. Body weights were measured in kilogram by a hanging spring balance and other morphological parameters were measured in centimeter by a measuring tape. The data were analyzed by "SPSS 17.0" statistical program.

Result: A total of seven regression models were adopted and analysis of variance showed that all models were fitted significantly ($p<0.001$). The correlation coefficient was higher when multiple body measurements were included in the model. The study also revealed that when chest girth as a single body measurement was included in the model gave the highest correlation coefficient ($R=0.92$). For including multiple measurements, body length and chest girth are the best external body measures which exposed same correlation coefficient ($R^2=0.92$) when included more than these two body measures in the model. The differences between actual body weight and body weight predicted from regression equation for different ages were less than 1% ($p>0.05$) and correlation coefficient between weights was 0.92 ($p<0.01$).

Conclusion: There are strong correlations among morphometric body measurements. Thus, body weight can be estimated from a single or multiple body measurements by regression equation. Chest girth is the best single predictor for estimating live body weight more accurately.

Keywords: Black Bengal Goat, morphological measurements, biometrical relationship, regression equations.

1. INTRODUCTION

In Bangladesh there is only one native goat breed commonly known as the Black Bengal Goat (BBG). Some other pure exotic breeds such as Serohi, Beetal, Jamnapari etc. and the crossbreds between BBG and exotic breeds are also available, however BBG are found all over the country. According to Husain [1] and Amin et al. [2], more than 90% of the goats of the country are Black Bengal goat. BBG goats are dwarf goats and are known to be famous for its adaptability, higher disease resistant, fertility, fecundity, early sexual maturity, larger litter size, delicacy of meat and superior skin quality, Devendra and Burns, [3]; Husain et al. [4]. Though majorities of the BBG bear black coat color, but black and white, brown, brown and white, and white coat colors are also common in the this population.

The phenotypic variation in a population arises due to genotypic and environmental effects, and the magnitude of phenotypic variability differs under different environmental conditions. Morphometric characters are continuous characters describing aspects of body shape, Dossa et al. [5]. Morphometric variation between populations can provide a basis for understanding flock structure, and may be more applicable for studying short-term, environmentally induced variation and thus more applicable to livestock management. According to Gizaw et al*.* [6], morphological description is an essential component of breed characterization that can be used to physically identify, describe, and recognize a breed, and also to classify livestock breeds into broad categories. Dossa et al*.* [5] reported that morphological measurements such as heart girth, height at withers and body length can be used for rapid selection of large size individuals in the field to enable the establishment of elite flocks.

For animal selection purposes, it is essential to know how body shape of an animal behaves or in other word relationship among morphological measurements. It is also important to find out the relationship among different morphological traits for research purposes. However, body weight measurement at a regular interval is an important farm practice for domestic livestock. But frequently live body weight measurement is mostly a difficult task. Moreover, morphological body measurements with a measuring tape is less bothering than measuring live weight with a weighing scale. If we can estimate a regression equation considering body weight and body measurements it would be ease to estimate live body weight from a single or multiple body measurements like body length, heart girth, wither height etc. So, the present study was aimed to develop a regression model for estimating live body weight required with minimum morphometric information for BBG.

2. MATERIALS AND METHODS

2.1 STUDY SITE

The research work was carried out at rural community level goat flocks at *Gangatia*, *Borachala* and *Pachpai* villages of Hobirbari Union under Bhaluka Upazila of Mymensingh district in Bangladesh from 2009 to 2013 under a completed project entitled “UNEP-GEF-ILRI FAnGR Asia Project”.

2.2 ANIMALS AND DATA

All the animals under this study were ear tagged to maintain individual identity as well as pedigree information. The data were collected from a baseline survey of about 126 goats of different ages, sexes and colors along with 3 progressive generations produced from the foundation stock of the said community based goat breeding flocks. Separate data sheet for each animal was maintained for recording information. Goat aged from birth to market age was used for phenotypic characterization and data was recorded monthly. All the flocks were maintained under the existing semi-intensive management system. Routine vaccination and de-worming against common diseases and parasites were conducted for all animals under the project.

2.3 MORPHOLOGICAL MEASUREMENT

Morphometric measurements of body length, chest girth, wither height and hip height along with body weights were recorded individually from birth up to 15 month age. All the information were measured in a same day and sex, coat color and age of each individual were also recorded. Body weights were measured in kilogram by a hanging spring balance and other morphological parameters were measured in centimeter by a measuring tape.

2.4 DATA ANALYSIS

All data were previously recorded in spread worksheet. Prior to analysis, data were transported to analytical software, SPSS 20.0 [7] and analyses were done thereof.

3. RESULTS AND DISCUSSION

To develop regression equations for estimating live body weight from the external morphological measurements, four parameters viz. body length, chest girth, wither height and hip height were considered in this study. Thus, a total of seven regression models including single and multiple body measurements were considered. The analysis of variance showed that all the models were significant.

The biometrical relationships between actual body weights and morphological body measurements according to sex are illustrated in Table 1.

Table 1: Biometrical relationship between body measurement and body weight according to sex

Model information	Sex	*R*	R^2	Regression coefficients					Sig. level
				α	β_1	β_2	β_3	β_4	
Body length (BL)	Male	0.908	0.825	-13.008	0.598	-	-	-	***
	Female	0.900	0.811	-11.733	0.573	-	-	-	***
Chest girth (CG)	Male	0.918	0.842	-12.080	0.465	-	-	-	***
	Female	0.923	0.853	-10.737	0.445	-	-	-	***
Wither height (WH)	Male	0.884	0.782	-15.770	0.630	-	-	-	***
	Female	0.891	0.795	-14.688	0.621	-	-	-	***
Hip height (HH)	Male	0.894	0.799	-15.462	0.578	-	-	-	***
	Female	0.898	0.806	-13.990	0.558	-	-	-	***
BL+CG	Male	0.921	0.848	-12.696	0.203	0.313	-	-	***
	Female	0.925	0.856	-11.270	0.132	0.349	-	-	***
BL+CG+WH	Male	0.921	0.848	-12.601	0.193	0.306	0.022	-	***
	Female	0.926	0.857	-10.831	0.148	0.377	-0.059	-	***
BL+CG+WH+HH	Male	0.922	0.850	-13.082	0.187	0.279	-0.071	0.125	***
	Female	0.926	0.857	-10.848	0.148	0.371	-0.086	0.032	***

R* = multiple correlation coefficient; R^2 = coefficient of determination; α =constant value; β = regression coefficient; *-p<0.001;

The regression analysis as illustrated in Table 1 shows that correlations between body weights with other morphological measurements are higher for female than that of male, except body length. The coefficients of determination were higher in female than that of male in the regression models including any of the single or multiple combinations of morphological traits. Tudu et al*.* [8] reported that coefficient of determination were 0.563 in male at 3 months, 0.529 in male at 9 months and 0.404 in female at 12 months ages, respectively. The relationships between body weight and morphological measurements according to coat color are shown in Table 2. The correlations and coefficients of determination were high and very close to each other, although slightly lower values are seen in Dutch belt color. Tudu et al*.* [8] found that the coefficient of determination (R^2) for height at wither and chest girth in combination (98.4%) was higher than other body measurements in multiple traits evaluation for overall body weight of three color varieties of Bengal goats (Black, Brown and White) at 6 months of age.

The regression analyses according to different ages are given in Table 3 which shows that correlation coefficients as well as coefficients of determination increase as the age increases. The higher the ages the more accuracy of the prediction of body weight from morphological measurements. The coefficient of determination for combined tail length, body length and height at withers (86.1%) was higher than other body measurements in multiple traits evaluation for body weight in White Bengal goats at birth as reported by Tudu et al*.* [8]. They also found that the coefficient of determination (R^2) for height at withers (98.9%) and also for combined tail length, body length, height at withers and horn length (98.6%) were higher than other body measurements in multiple traits evaluation for body weight of Black Bengal goats at 9 and 12 months of age. Iqbal et al*.* [10] found that the coefficient of determination (R^2) for body length (64.8%) was higher than other body measurements in single trait evaluation in Beetal goat. They also reported that the coefficient of determination (R^2) was higher for height at withers and heart girth as compared to other body measurements.

Table 2: Biometrical relationship between body measurement and body weight according to coat color

Model information	Coat color	*R*	R^2	Regression coefficients			Sig. level
				α	β_1	β_2	
Body length (BL)	Black	0.905	0.819	-12.141	0.580	-	***
	Black Bejoar	0.913	0.833	-11.482	0.549	-	***
	Brown Bejoar	0.901	0.812	-12.736	0.599	-	***
	Dutch belt	0.866	0.750	-12.034	0.555	-	***
Chest girth (CG)	Black	0.922	0.849	-11.163	0.452	-	***
	Black Bejoar	0.912	0.832	-10.674	0.423	-	***
	Brown Bejoar	0.923	0.852	-11.959	0.467	-	***
	Dutch belt	0.865	0.749	-9.696	0.413	-	***
BL+CG	Black	0.923	0.852	-11.652	0.141	0.348	***
	Black Bejoar	0.919	0.844	-11.348	0.285	0.209	***
	Brown Bejoar	0.926	0.858	-12.599	0.165	0.348	***
	Dutch belt	0.868	0.753	-11.050	0.305	0.188	***

R* = multiple correlation coefficient; R^2 = coefficient of determination; α =constant value; β = regression coefficient; *-p<0.001;

Table 3: Biometrical relationship between body measurement and body weight according to age

Model information	Age (month)	*R*	R^2	Regression coefficients			Sig. level
				α	β_1	β_2	
Body length (BL)	0 (Birth)	0.416	0.173	0.451	0.053	-	***
	1	0.544	0.266	1.195	0.067	-	***
	2	0.454	0.206	-0.067	0.147	-	***
	3	0.376	0.142	1.304	0.146	-	***
	6	0.627	0.393	-3.109	0.342	-	***
	9	0.552	0.305	-2.218	0.376	-	***
	12	0.612	0.374	-0.189	0.382	-	***
	15	0.475	0.225	6.507	0.271	-	***
Chest girth (CG)	0 (Birth)	0.326	0.106	0.564	0.040	-	**
	1	0.520	0.270	1.421	0.049	-	***
	2	0.332	0.111	1.623	0.078	-	***
	3	0.364	0.132	1.425	0.117	-	***
	6	0.623	0.388	-3.258	0.284	-	***
	9	0.492	0.242	-0.094	0.266	-	***
	12	0.634	0.402	-1.365	0.322	-	***
	15	0.697	0.485	-6.686	0.422	-	***
BL+CG	0 (Birth)	0.420	0.176	0.367	0.047	0.009	***
	1	0.565	0.319	1.083	0.043	0.023	***
	2	0.455	0.207	-0.161	0.137	0.011	***
	3	0.399	0.159	0.537	0.092	0.061	***
	6	0.696	0.484	-6.572	0.215	0.174	***
	9	0.587	0.345	-5.098	0.273	0.135	***
	12	0.701	0.492	-5.765	0.230	0.213	***
	15	0.698	0.487	-6.874	0.030	0.402	***

*r = correlation coefficient; R^2 = regression coefficient; α =constant value; β = regression factors; ***-p<0.001; **-p<0.01); *-p<0.05)

The biometrical relationship between body weight and body measurement irrespective of sex, age coat color is illustrated in Table 4 which shows that correlation coefficients were higher when multiple body measurements were included in the model. Table 4 also shows that when chest girth as a single body measurement was included in the model gave the highest correlation coefficient. To get more accuracy, body length and chest girth are the best external body measures as coefficient of determination was high when included in the regression model. Tudu et al. [8] observed positive and significant correlation coefficients between body weight and linear body measurements with the exception of a few cases in all the three color varieties of Bengal goats. They also found that there was a high correlation between body weight and body length, height at withers and chest girth. Moela [9] found that the correlation coefficient between body weight and heart girth was high (r = 0.91), its direct effect on body weight was also the highest (path coefficient = 0.58) and significant (P<0.05) as indicated by the t-test.

Table 4: Biometrical relationship between body measurement and body weight irrespective of age, sex and coat color

Model information	R	R^2	Regression coefficients					Sig. level
			α	β_1	β_2	β_3	β_4	
Body length (BL)	0.904	0.817	-12.299	0.584	-	-	-	***
Chest girth (CG)	0.920	0.846	-11.321	0.453	-	-	-	***
Wither height (WH)	0.886	0.785	-15.041	0.621	-	-	-	***
Hip height (HH)	0.894	0.800	-14.565	0.565	-	-	-	***
BL+CG	0.922	0.851	-11.903	0.164	0.333	-	-	***
BL+CG+WH	0.922	0.851	-11.758	0.171	0.341	-0.020	-	***
BL+CG+WH+HH	0.923	0.851	-11.866	0.169	0.323	-0.090	0.089	***

*R = correlation coefficient; R^2 = coefficient of determination; α =constant value; β = regression coefficient

Table 5 shows the relationships between actual body weight and predicted body weight using regression model 05 (using body length and chest girth) for different ages. In all ages, variations of body weight between actual and predicted were less than 1% (p>0.05). The correlation coefficients for actual and predicted body weight were highly significant (p<0.01) for all ages and magnitudes were higher in later ages. The overall correlation coefficient was 0.92** irrespective of age. Adeyinka and Mohammed [11] studied on Alpine ibex Capra ibex goat and observed that the squared value of the chest girth as predictive variables in the regression equation, being the most highly correlated linear measurements with total weight.

Table 5: Comparison between actual body weight and body weight estimated from regression equations developed by external body measurements according to age using model 5

Age at	Body weight in kg (Mean±SE)		Variation between actual and predicted		Correlation (R)
	Actual	Predicted	%	Sig. level	
Birth	1.50±0.02 (090)	1.51±0.01 (090)	0.67	NS	0.42**
1 month	3.03±0.04 (107)	3.02±0.02 (107)	0.30	NS	0.57**
2 month	4.67±0.09 (113)	4.69±0.04 (113)	0.43	NS	0.46**
3 month	6.61±0.11 (120)	6.59±0.04 (120)	0.30	NS	0.40**
6 month	10.94±0.17 (122)	10.96±0.12 (122)	0.18	NS	0.70**
9 month	14.50±0.22 (089)	14.47±0.13 (089)	0.21	NS	0.59**
12 month	17.89±0.28 (070)	17.87±0.19 (070)	0.11	NS	0.70**
15 month	19.68±0.34 (053)	19.69±0.24 (053)	0.05	NS	0.70**
Overall	8.77±0.22 (764)	8.79±0.20 (764)	0.23	NS	0.922**

NS-not significant (p>0.05); **-significant at 1% (p<0.01)

The correlations between actual body weight and body weight estimated from regression equations including single and multiple combination of external body measurements are presented in Table 6. The correlation coefficients for all models were significantly (p<0.01) higher than 0.90 except model 3 and model 4. Table 6 also reveals that for a single morphological trait, chest girth is the best determinant for estimating live body weight and for multiple traits, body length along with chest girth are best determinant for estimating live body weight more accurately. Adeyinka and Mohammed [11] studied on Alpine ibex Capra ibex goat and they found the best prediction using age and different linear measurements in stepwise multiple regression.

Table 6: Correlations between actual body weight and body weight estimated from regression equations developed by external body measurements

Model	Model information	Regression model	*R*
Model 1	Body length (BL)	$Y = \alpha + \beta \times BL$	0.904**
Model 2	Chest girth (CG)	$Y = \alpha + \beta \times CG$	0.920**
Model 3	Wither height (WH)	$Y = \alpha + \beta \times WH$	0.886**
Model 4	Hip height (HH)	$Y = \alpha + \beta \times HH$	0.894**
Model 5	BL+CG	$Y = \alpha + \beta_1 \times BL + \beta_2 \times CG$	0.922**
Model 6	BL+CG+WH	$Y = \alpha + \beta_1 \times BL + \beta_2 \times CG + \beta_3 \times WH$	0.922**
Model 7	BL+CG+WH+HH	$Y = \alpha + \beta_1 \times BL + \beta_2 \times CG + \beta_3 \times WH + \beta_4 \times HH$	0.923**

**R* = correlation coefficient; α =constant value; β = regression coefficients; **-p<0.01)

Table 7 shows the relationships among regression models. The relationships among models were very strong and highly significant (p<0.01). The correlation coefficients were very close to 1 which indicates that any of the models is suitable for estimating live body weight accurately. Iqbal et al. [10] reported the best fitted regression model in adult Beetal goats (13-18 months of age) to be body length and height at withers on body weight.

Table 7: Correlations among the regression models

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Model 1	1	0.962**	0.949**	0.948**	0.980**	0.980**	0.979**
Model 2		1	0.958**	0.964**	0.997**	0.997**	0.997**
Model 3			1	0.982**	0.963**	0.960**	0.960**
Model 4				1	0.967**	0.965**	0.969**
Model 5					1	1.000**	1.000**
Model 6						1	1.000**
Model 7							1

**significant at 1% level (p<0.01)

4. CONCLUSION

The results showing that there are strong correlations among mophometric body measurements. Regression models established from the body measurements also reveal that body weight can be estimated from a single or multiple body measurements by regression equations. However, for any single body measurement, chest girth is the best predictor and for multiple body measurements, body length along with chest girth is the best predictors for estimating live body weight more accurately.

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