

Research Article



Assessing the Accuracy of Schaeffer's Formula for Live Weight Estimation in Black Bengal Goats

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Abstract | This study aimed to assess the accuracy of Schaeffer's formula and examine the relationships between live weight and various body measurements, including heart girth, body length, height at withers, height at back, and paunch girth in Black Bengal goats. A total of 125 Black Bengal goats were selected from Sylhet Government Goat Development Farm and Khadimnagar union of Sylhet Sadar upazila of Bangladesh. Goats were categorized into different groups based on their age and sex. Live weight was estimated by digital balance, and other body measurements were estimated by measuring tape and scale. Our findings indicated that the lowest deviation was 0.08% in the 1–2-year age female group and the highest deviation was 5.26% in the 6-month age male group with a deviation from the actual body weight. Additionally, the linear regression equations developed in this study for predicting the live body weight on heart girth, body length, and a combination of both were: $y = -22.429 + 1.6830 x_1$, $y = -19.99 + 1.7759 x_2$, and $y = -23.060 + 0.5348 + 1.2422 x_1x_2$, respectively, where y = body weight (kg), x_1 = heart girth (inch), and x_2 = body length (inch). In addition, Pearson correlation with body weight and other body measurements showed that heart girth has a significant positive correlation with body weight, with 0.97 correlated values. Finally, it can be strongly ascertained that Schaeffer's formula is one of the most reliable and cost-effective methods for predicting live body weight in Black Bengal goats.

Keywords | Black Bengal goats, body length, heart girth, live weight, Schaeffer's formula, Sylhet.

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INTRODUCTION

The Black Bengal goat is the only breed of goat originated in Bangladesh and considered as a promising goat resource of the country. More than 90% of the goat populations of the country comprised the Black Bengal breed (Amin et al., 2001). This breed is usually black in color but brown, white, gray or any combination of those colors may also find (Sultana, 2018). They are very pop-

ular in Bangladesh because of its low demand of food and high production rate. Meat and skin obtained from the Black Bengal goat are of excellent quality and fetch high prices, even in the local market. It gains popularity for its high-quality skin and high prolificacy rate (Kumar, 2007). In international market the Black Bengal goat skin is known as world "Kushtia Grade". This breed plays an important role in poverty alleviation through employment opportunity. Additionally, this breed can easily adapt to

any environment and they have a very high disease preventive ability. They require less space for living in compared to other livestock. Black Bengal goat gains sexual maturity at early age than any other goat breeds (Solaiman et al., 2020). The female goat becomes pregnant twice a year and in proper care and management they can give 2-3 kids each time (Hossain et al., 2004). An adult male goat weight about 25 to 30 kg and female 20 to 25 kg (Black Bengal Goat Farming Guide & Information, 2019). It may vary due to geographical variation, nutritional influence and overall management system of the farms.

Body weight is a critical parameter in terms of health and growth. Body weight is an indicator of good or poor health in relation to its age and physiological status, also important for understanding the dose of medication, sexual capability, feed requirement, choosing for male and female's replacement and for overall good animal management (Mahieu et al., 2011). In fact, knowing the live weight of an animal will remarkably assist in knowing the current market price of the live animal and therefore get the best value from it.

There are different methods for live weight measurement in livestock such as Weighbridge, weighing machine Schaeffer's formula, Weigh tape, Rondo tape, Agarwal's formula, calculator method, multiple linear regressions and artificial neural network for prediction of live weight (Vaidya et al., 2018; Wangchuk et al., 2017). Among these digital weighing balance provides accurate live weight of animals. But weighing scales are not available in rural settings because they are too expensive for most of the small-scale farmers or sometimes the weighing equipment's are not readily available, is often hard for estimating accurate live weight. So, the small-scale farmers mostly rely on visual or eye estimation of their goats thus accurate weighing are rarely met in that case and which may ultimately lead to economic loss to the farmers.

To predict live weight the accuracy functions used from live animal measurements is of immense financial contribution to livestock production (Afolayan et al., 2006). The economic contribution to livestock production enterprises influenced by the accuracy of measuring body functions. The ability to determine the relationship consistently provides additional options to farmers for optimum returns in all production systems in generally and particularly in the developing countries (Iqbal et al., 2013). Researchers use various parameters, such as body length, pelvis width, height at withers, and chest girth, to evaluate live animals beyond merely taking their live weight (Atta et al., 2004). The relationship between body weight and linear body measurements has been studied to predict body size and shape. Given the high correlation between body weight

and animal morphometry, assessing the extent of variation in body weight due to biometric factors is beneficial. This approach aids in formulating suitable selection criteria based on animal body conformation (Khan et al., 2003). Ultimately, enabling farmers and livestock buyers to relate body measurements to live body weight (LBW) ensures that owners receive optimal pricing and benefits for their animals. This study conducted to estimate the accuracy of Schaeffer's formula and to investigate the relationship among live weight and heart girth, body length, height at withers, height at back and punch girth of Black Bengal goat.

MATERIALS AND METHODS

ETHICAL APPROVAL

The study was successfully approved by the Institutional Ethics Committee of Sylhet Agricultural University, Sylhet-3100; Bangladesh (#AUP2022004). All the required and applicable national, international, and institutional guidelines for the animal's care were thoroughly followed during data collection.

STUDY AREA AND GOAT SELECTION

A total of 125 healthy goats were selected from two distinct locations: Government Goat Development Farm, Sylhet and several small-scale farms located in Khadimnagar union of Sylhet Sadar upazila, Bangladesh. The goats were selected based on their health status, with only healthy animals being included in the study to avoid confounding factors related to illness or injury (Muri et al., 2013). Health was assessed by trained veterinary staff based on physical examination and absence of any visible clinical signs of disease (Fortney, 2012). The goats were further categorized into groups according to age and sex to ensure a balanced representation of these factors, which could potentially affect the study outcomes. Table 1 provides a detailed breakdown of the age and sex distribution of the goats in the study.

Table 1: Selection of goat

Breed	Sex	Age	No of observation
Black Bengal Goat	Male	6 months	29
		1-2 years	8
		2-3 years	4
	Female	6 months	16
		1-2 years	18
		2-3 years	19
		>3 years	18
	Castrated	1-2 years	8
		2-3 years	5
	Total		125

STUDY PERIOD

The study was conducted for a period of two months from 7th October 2022 to 7th December 2022 in the study area.

ESTIMATION OF LIVE WEIGHT

The live weight of Black Bengal goat was estimated by digital weight balance (capacity: 200 kg, power: AC110V-220/50Hz-60Hz, division: 50gm, Manufactured by MEGA) at early in the morning before morning feeding to avoid any error due to feed. For conducting the study following equipment's were used: measuring tape/ steel tape, measuring scale and Taylor's tape.

MEASUREMENT OF BODY PARAMETERS

Following body measurement parameters were taken into consideration for conducting the study (Mahmud et al., 2014):

Heart girth: The chest circumferential measurement just behind the forelimbs and withers. It varies somewhat with extreme of posture and perhaps as the animal breaths. There is a good correlation between hearth girth and body weight.

Body length: This refers to the distance from the point of shoulder to the point of pin bone. During this measurement, make sure that the backbone is straight in both vertical and horizontal planes.

Height at withers: This is estimated as the distance from the surface of a platform on which the animal stands up to the withers. During this measurement make sure that, the legs are equally spaced and carry equal portion of its body weight.

Height at back: The distance from the surface of a platform on which the animal stands up to the back.

Punch girth: It is the abdominal circumferences just before the hind limbs.

AGE DETERMINATION BY COUNTING THE NUMBER OF TEETH

By counting the number of permanent incisor teeth age was determined (Determining the age of a goat, Onion Creek Ranch).

One year old = two permanent teeth (two-toother), two years old = four permanent teeth (four-toother), three years old = six permanent teeth (six-toother) and four years old = eight permanent teeth (eight-toother).

PREDICTION OF LIVE BODY WEIGHT BY USING SCHAEFFER'S FORMULA

The following formula used for estimating live weight was:

$$W = \frac{L \times G^2}{300}$$

where, L= Length of the animal from point of shoulder to point of pin bone in inch, and G= Chest girth of the animal in inches.

CALCULATION OF DEVIATION PERCENTAGE

Deviation from actual live weight was calculated by following formula:

$$\text{Deviation (\%)} = \frac{\text{Predicted weight} - \text{Actual weight}}{\text{Actual weight}} \times 100$$

STATISTICAL ANALYSIS

The raw data were entered in a spread sheet using Microsoft office excel 2010. Mean and Standard Errors (SE) for different body measurements were estimated with the help of SAS, 1998 and linear regression analysis was performed using Minitab statistical software by keeping the body weight as dependent variable and different body measurement as independent variables. Relationship between live weight and body measurement were conducted using simple Pearson correlation method.

RESULTS AND DISCUSSION

Mean $\pm$ SE of actual body weight, heart girth and body length along considering the age and sex are shown in Table 2. The results highlighted that the body weight, heart girth, and body length of Black Bengal goats show significant variation across different ages and sexes. At 6 months, females had a higher body weight 7.98 ± 1.02 (in kg) compared to males 6.65 ± 0.81 (in kg). In the 1-2 years age group, females also exhibited greater body measurements 12.15 ± 1.83 (in kg) body weight, 21.00 ± 0.85 (in inches) heart girth, and 18.06 ± 0.8 (in inches) body length than males and castrated goats. For the 2-3 years age group, females again had higher measurements 16.49 ± 0.71 (in kg) body weight compared to males and castrated goats. In goats older than 3 years, females showed the highest body weight 20.83 ± 0.57 (in kg), heart girth 24.83 ± 0.57 (in inches), and body length 22.23 ± 0.57 (in inches). This result clearly indicated that body weight, heart girth and body length increase as the age of the goats increased. It is a well-known fact that with the increase in age, changes in the amount of feed intake and there is a rate of change of live body weight as well as reflected on its heart girth and body length. Present study clearly points out that body weight, heart girth and body length increase as the age of the goats increased. In present study, the actual mean body weight of Black Bengal goat ranges from 6.65 to 20.83 kg. Villiers et al. (2009) reported 16.7 to 40.4 kg body weight

Table 2: Body weight, body length and heart girth of Black Bengal Goat (Mean $\pm$ SE)

Age	Sex	No. of observation	Actual Body weight measured by digital balance (kg)	Heart girth (inch)	Body length (inch)
6 months	Male	29	6.65 $\pm$ ⁱ 0.81	17.13 $\pm$ ⁱ 0.81	15.43 $\pm$ ⁱ 0.81
	Female	16	7.98 $\pm$ ^h 1.02	18.38 $\pm$ ^h 1.02	16.13 $\pm$ ^h 1.02
1-2 years	Male	8	10.06 $\pm$ ^g 1.06	19.31 $\pm$ ^g 1.06	17.25 $\pm$ ^g 1.06
	Female	18	12.15 $\pm$ ^e 1.83	21.00 $\pm$ ^e 0.85	18.06 $\pm$ ^e 0.85
	Castrated	4	11.46 $\pm$ ^f 1.23	20.23 $\pm$ ^f 1.23	18.45 $\pm$ ^f 1.23
2-3 years	Male	4	15.60 $\pm$ ^d 1.23	22.63 $\pm$ ^d 1.23	19.59 $\pm$ ^d 1.23
	Female	19	16.49 $\pm$ ^b 0.71	23.40 $\pm$ ^b 0.71	20.22 $\pm$ ^b 0.71
	Castrated	5	15.53 $\pm$ ^c 1.16	22.77 $\pm$ ^c 1.16	19.80 $\pm$ ^c 1.16
>3 years	Female	18	20.83 $\pm$ ^a 0.57	24.83 $\pm$ ^a 0.57	22.23 $\pm$ ^a 0.57

Mean with the same superscript within a column are not significantly different (P <0.001).

Table 3: Actual body weight and predicted body weight measured by Shaeffer's formula and their deviation from actual body weight

Age	Sex	No. of observation	Predicted body weight by using Shaeffer's formula (kg)	Actual body weight measured by digital balance (kg)	Deviation (%)
6 months	Male	29	7.00 $\pm$ ⁱ 0.94	6.65 $\pm$ ⁱ 0.81	5.26
	Female	16	8.34 $\pm$ ^h 1.19	7.98 $\pm$ ^h 1.02	4.51
1-2 years	Male	8	9.86 $\pm$ ^g 1.23	10.06 $\pm$ ^g 1.06	-1.99
	Female	18	12.14 $\pm$ ^c 0.99	12.15 $\pm$ ^e 1.83	-0.08
	Castrated	4	11.52 $\pm$ ^f 1.43	11.46 $\pm$ ^f 1.23	0.52
2-3 years	Male	4	15.19 $\pm$ ^d 1.43	15.60 $\pm$ ^d 1.23	-2.63
	Female	19	16.85 $\pm$ ^b 0.82	16.49 $\pm$ ^b 0.71	2.18
	Castrated	5	15.64 $\pm$ ^c 1.35	15.53 $\pm$ ^c 1.16	0.71
>3 years	Female	18	20.90 $\pm$ ^a 0.67	20.83 $\pm$ ^a 0.57	0.33

Here, mean with the same superscript within a column are not significantly different (P <0.001).

Table 4: Regression analysis for body weight on heart girth, body length of Black Bengal goat

Measurements	Regression equations	Significance level
Hearth girth	$y = -22.429 + 1.6830 x_1$	***
Body length	$y = -19.99 + 1.7759 x_2$	***
Hearth girth and body length	$y = -23.060 + 0.5348 + 1.2422 x_1 x_2$	***

Here, y = Body weight (Kg), x_1 = Heart girth (inch), x_2 = Body length (inch); P <0.001

Table 5: Pearson correlation coefficient between body weight and other body measurements in Black Bengal Goat

	Body weight	Heart girth	Body length	Punch girth	Height at withers	Height at back
Body weight	1					
Heart girth	0.97	1				
Body length	0.93	0.91	1			
Punch girth	0.91	0.92	0.85	1		
Height at withers	0.81	0.82	0.85	0.78	1	
Height at back	0.85	0.85	0.88	0.81	0.97	1

KwaZulu-Natal goats in South Africa. This variation may be due to breed differences, geographical variation, feeding, nutritional influence and overall variation in management system of the farms. Additionally, mean heart girth, body

length of Black Bengal goat ranges from 17.13 to 24.83 inch, 15.43 to 22.23 inch respectively in present findings. Afolayan et al. (2006) reported that 24-56 cm (9.45-22.04 inch) heart girth; 47.0-95.0 cm (18.50-37.40 inch) body

length which is close to present findings and support the present study. Similar type of findings also reported by Mahieu et al. (2011), Villerers et al. (2009) and Alade et al. (2008) and supports present findings.

The actual mean body weight and the predicted weight using the Schaeffer's formula with their deviation (%) from actual body weight are summarize in Table 3. Our findings reported that the deviation was lowest in 1-2 years female group with only -0.08% deviation from the actual mean body weight and the deviation percent was highest in 6 months male group with about 5.26% deviation from the actual mean body weight. Results showed that the actual mean live weight and predicted mean live weight from different body measurements by using Shaeffer's formula showed no significant variation. Wangchuk et al. (2017) conducted five different methods for comparison and reliability of these techniques for predicting the live body weight. Among these Shaeffer's formula provides estimates closer to the actual body weight and indicates the reliability of this method in estimating the body weight. Thus, the previous study strongly supports the present investigation. Regression equations were developed for heart girth, body length and combination of both (Table 4). Relationship between body weight and heart girth was demonstrated by a regression line and the equation for the line is represented graphically in Figure 1. When we draw regression line, present investigation revealed positive correlation among the body measurements (heart girth, body length) with live body weight i.e., body measurements increased as the body weight increased. This suggests that either these measurements or their combination may provide a good estimate for predicting live weight of Black Bengal goats which is supported by Ravimurugan et al. (2013). In Figure 2, relationship between body weight and body length is demonstrated graphically by a regression line. Each line indicates a significant positive correlation with body weight but the strength of correlation is slightly higher for heart girth.

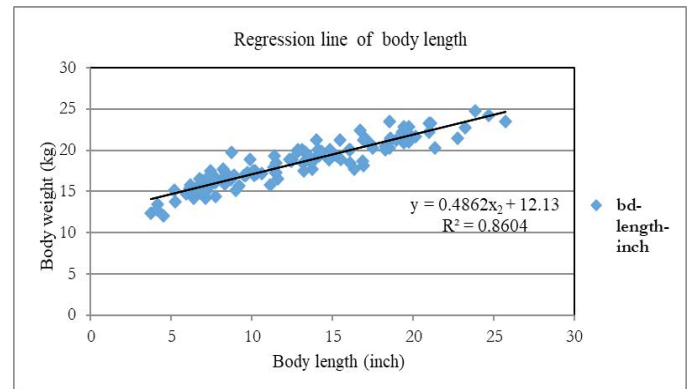


Figure 2: Regression line of heart girth on body weight

In Table 5, the Pearson correlation among the body measurements with body weight are shown. All of the measurements are positively correlated with body weight. However highest correlation was found for heart girth followed by body length, punch girth, height at back and height at withers respectively. The values from Pearson correlation indicated that, heart girth has strong correlation with body weight in compared to other body measurements. Thus, heart girth measurement may be used as a best predictor of estimating live weight of Black Bengal goat. Tella et al. (2008) suggested that correlation coefficient between heart girth and body weight may ranges from 0.67 to 0.98 and it depends on age, sex and breeds of goat. Several studies Ravimurugan et al. (2013) and Slippers et al. (2000) also reported significant correlation between heart girth and live weight which also strongly supports the present study.

LIMITATIONS OF STUDY

The study has several limitations that should be acknowledged. Firstly, the study was conducted over a short duration of two months, which may not account for seasonal variations or other long-term factors that could impact live weight estimation. Additionally, the study's sample size of 125 goats, though categorized by age and sex, may not be representative of the entire population of Black Bengal goats due to potential regional and breed-specific variations. The reliance on Schaeffer's formula for live weight estimation, while practical, was not compared in detail with more advanced methods such as 3D imaging or machine learning models, which may offer more accurate predictions. Furthermore, although the Pearson correlation coefficient between heart girth and body weight was high, the study did not explore potential confounding variables that could influence this relationship. In addition, a formal cost-benefit analysis comparing Schaeffer's formula with other methods was also not performed, which limits the assessment of its practical utility for small-scale farmers.

CONCLUSION

Live weight of Black Bengal goats can be predicted by us-

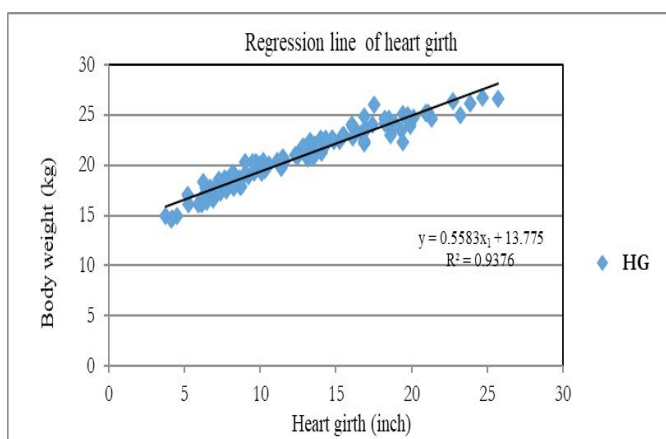


Figure 1: Regression line of heart girth on body weight

ing Schaeffer's formula and/or from different linear body measurements, which have higher correlation with body weight. This study highlighted Schaeffer's formula provides closer to the actual body weight and indicates the reliability of this method in estimating the live weight of Black Bengal goats. However, there is a little deviation found from the actual body weight. But the prediction is sufficiently accurate. For more accurate results some precautions should be followed while taking these body measurements. Because the body movement and body posture of animal can introduce errors into measurements. Pearson correlation showed that, there is a significant positive correlation between body weight and other body measurements. Among these, highest correlation was found for heart girth with 0.97 correlated value. This may suggest that, live weight can be predicted more accurately from heart girth or combination of other measurements of Black Bengal goats in Bangladesh.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

AUTHOR'S CONTRIBUTION

Jahid Hasan Tipu and Obaidul Islam conceptualized and designed the study, collected the data, carried out the whole research work and made the initial draft of the manuscript; Md. Nazim Uddin, Md Altafur Rahman and Md Ashraful Islam assisted in collecting & analyzing data and revised the manuscript. All authors discussed and approved the final version of the manuscript.

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