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***Short communication***

# Predicting goat body weight using morphometric measurements: A regression approach

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A B S T R A C T

The study was conducted local farms in Pabna district, Bangladesh, to develop an accurate regression-based model for predicting goat body weight. A total of 49 castrated male goats from four available breeds were measured to assess the relationship between live body weight and various body dimensions. The objective was to identify the most reliable body measurements for predicting live weight and to formulate both simple and multivariate regression models suitable for field use. Body weight was recorded using a digital weighing scale, and 13 morphometric traits, including Forehead Diameter, Muzzle Length, Neck Length, Neck Diameter, Heart Girth Diameter, Point of Shoulder to Knee length, Knee to Metacarpal length, Hip Bone to Hock Joint length, Hock joint to Metatarsal length, Wither Height, Rump Height, Hook to Hook length, Pinto Pin length were collected. Simple linear regression was performed for each trait, followed by multivariate regression to determine the best-fitting prediction equations. Among all measurements, wither height, rump height ($R^2$ = 0.97), and point of shoulder to knee length ($R^2$ = 0.94) showed the strongest individual relationships with body weight. A full multivariate model using all traits achieved an adjusted $R^2$ of 0.98, while a simplified model using only the three best predictors produced an adjusted $R^2$ of 0.98, making it more practical for field conditions. The study concluded that live body weight of goats can be accurately estimated using selected morphometric traits, particularly wither height, rump height, and length from point of shoulder to knee length, offering reliable alternative of weighing scales in traditional livestock markets.

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## 1.INTRODUCTION

Agriculture is the primary source of income for many Bangladeshi households, and livestock rearing, particularly goat farming, plays a significant role within this system. They have engaged themselves in cattle, goat, and sheep farming. Among the common livestock businesses run by smallholder farmers, goat farming is popular because it can be their primary source of income. Every year, goat farming grows more profitable (Rahman et al., 2022). In farming, growth is one of the key selection factors for meat animals such as cattle, goats, sheep, etc. Growth is typically measured by the growth in size or body weight at a certain age. In traditional livestock markets, farmers and traders commonly estimate a goat's body weight visually or by assessing key body measurements when determining its price. The body conformation and its measurements are important for developing selection processes for the improvement of various livestock species as well as for estimating and grading the characteristics pertaining to meat quality (Iqbal et al., 2013). Moreover, the reproductive performance of a goat is influenced by its body weight, which in turn affects the amount of milk it produces (Wangchuk et al., 2018). Furthermore, when determining the appropriate dosage of a therapeutic medication to treat an illness, body weight is the primary determinant. Moreover, livestock economic values are determined by body weight, particularly in the context of marketing, characterizations of meat and carcasses, fattening programs, breeding programs, and selection programs (Ibrahim et al., 2021). Furthermore, in a recent study, measures of muscle development and objective body dimensions have been demonstrated to supplement body weight as a productivity metric in the same species (Afolayan et al., 2006; Harrison et al., 2022). The live bodyweight is estimated using various techniques such as the balance method and the Rondotape method. The balance method is the most standard method for measuring body weight, but still, it is still not used in farms and local markets. Because the weighing balance machine cannot be moved everywhere easily. On the other hand, Rondotape is one of the most popular quick methods to determine livestock bodyweight in Bangladesh. Its foundation is the measurement of heart girth, and other parameters that have a strong correlation with goat body weights according to a previous study (Dakhlan et al., 2021; Wangchuk et al., 2018). Previous research in Bangladesh has not established a specific regression model for accurately predicting goat body weight. There is a need to develop a model for estimating body weight through physical measurements in several goats in Bangladesh.

This study was constrained by a relatively small sample size and the inclusion of multiple breeds, which limited the possibility of conducting breed-specific regression analyses. As a result, the developed models will provide reliable predictions for mixed-breed populations but may inadequately capture intra-breed variations in body measurements and weight relationships. In addition, the research was restricted to a single geographic location (Pabna, Bangladesh) and a short data collection period, which may limit the generalizability of the findings to other regions, production systems, or management practices. Future studies incorporating larger, breed-specific datasets collected across diverse geographic locations and seasons are recommended to refine the predictive models and improve their applicability under varied field conditions.

The objectives of this study were to determine the linear relationships between various body measurements and the actual live weight of goats, and to develop a predictive approach for estimating goat body weight based on these identified relationships. While body growth can follow nonlinear patterns, several body measurements tend to increase in a proportional way with live weight within similar age and breed groups. Previous studies on goats have shown that linear regression works well for this purpose (Iqbal et al., 2013; Dakhlan et al., 2021). Based on this evidence, we applied linear models in our study, though nonlinear approaches may be explored in future work.

## 2. MATERIALS AND METHODS

### Study area and period

The study was conducted on a local small farm in Pabna city, Bangladesh. There were 200 goats on this farm, representing a variety of species. The data was collected from 10th April to 2nd May 2024.

**Data Collection**

The castrated males' goats used in this research with data collected from four breeds: Black Bengal (BB), Hariana, Totapuri, and Jamnapari. A total of 49 castrated male goats were studied, consisting of 7 Harina, 13 BB, 19 Totapuri, and 10 Jamnapari goats. The parameters included body weight (BW), forehead diameter (FD), muzzle length (ML), neck length (NL), neck diameter (ND), heart girth diameter (HGD), point of shoulder to knee (PS-K) length, knee to metacarpal (K-MC) length, hip bone to hock joint (HB-HJ) length, hock joint to the metatarsal (HJ-MT) length, wither height (WH), rump height (RH), hook to hook (HO-HO) length, and pin to pin (PI-PI) length.

**Univariate Linear Regression**

To predict the live weight of goats based on several body size measurements, the data were analyzed using linear regression. The measurement of body size parameter as an independent variable (x) and the following regression model was used to predict the goat body weight:

$y = a + bx + e$

Where,
$y$=Dependent variable. e.g. body weight
$a$=Intercept or regression constant
$b$=Regression coefficient for body size parameters

Multivariate Linear Regression

In multivariate linear regression analysis, we have used our phenotypic characteristics (body size) to measure adjusted R2, level of significance, as well as regression constant and coefficient. The multivariate regression equation is given below:

$y = a + b1x1 + b2x2 + b3x3 +$ ------- $+ bnxn$
$y$= Body weight (in kg unit)
$a$= Intercept or regression constant
$b$= Regression coefficient for n numbers of body size parameters

The regression coefficient, regression constant, and adjusted $R^2$ were computed to assess the body weight prediction equations. The equation with the highest adjusted R2 value was selected as the most accurate model for predicting body weight. The analysis was performed using R statistical software version 4.4.2 to ensure robust and reliable results.

## 3. RESULTSAND DISCUSSION

The result of the linear regression model of Age, Forehead Diameter (FD), Muzzle Length (ML), Neck Length (NL), Neck Diameter (ND), Heart Girth Diameter (HGD), Point of Shoulder to Knee (PS-K) length, Knee to Metacarpal (K-MC) length, Hip Bone to Hock Joint (HB-HJ) length, Hock joint to Metatarsal (HJ-MT) length, Wither Height (WH), Rump Height (RH), Hook to Hook (HO-HO) length, Pin to Pin (PI-PI) length of goats is shown in Table 1. The result shows the coefficient of determination, interception, slope, and P value. Among these body size parameters, the highest result of adjusted $R^2$ was 0.97, 0.97, and 0.94, respectively in WH, RH, and PS-K length.

In Figure 1, the parameters showing the highest coefficient of determination ($R^2$) were identified as the strongest predictors of body weight in the sampled goat population. Moreover, they were statistically significant. The most significant parameters were also demonstrated by the regression model in Figures 1a, 1b, and 1c. The best three equations for measuring body weight were

*BW= -15.97 + 2.01PS-K, BW= -26.18 + 0.74WH, BW= -26.36 + 0.70RH.*

The equation given below reveals the multivariate regression model by using all the body size parameters.

*BW= -15.65 + 0.02FD + 0.07ML+ 0.01NL - 0.28ND + 0.07HGD + 0.26(PS-K) - 0.16(K-MC) - 0.04(HB-HJ) + 0.26 (HJ-MT) + 0.12WH + 0.23RH + 0.13(HO-HO) + 0.93(PI-PI)*

This model showed the highest adjusted $R^2$ value, which was 0.99. It was very close to 1.0, which indicates the maximum possible value of model fit. The P value was also significant, which was 2.20E-16.

Moreover, we generated a multivariate regression model by using the best 3 body size parameters that we found earlier. We used WH, RH, and PS-K to generate a new model. The equation is given below:

*BW=-24.13 +0.55PS-K– 0.01WH + 0.52RH*

This model also showed a very high adjusted R2 value (0.98), making it the closest in predictive accuracy to the full multivariate model described above.

In Table 1, we can see that WH, RH, and PS-K length showed the highest adjusted $R^2$ value. Moreover, WH was highly significant, followed by RH and PS-K length, for the measurement of body weight. Stepwise regression analysis with each independent variable expressed showed that WH, RH, and PS-K length were the best predictors of body weight, with the highest adjusted $R^2$ (0.97, 0.94). With the highest coefficient of determination, the regression equation is presented in Figure 1.

Table 1. Regression with body size parameters and live bodyweight (kg)

| x | Adjusted *R2* | a | b | P value |
|---|---|---|---|---|
| Age | 0.42 | -3.54 | 2.97 | 3.31E-07 |
| Forehead Diameter | 0.75 | -16.46 | 0.9 | <4.89E-16 |
| Muzzle Length | 0.69 | -12.04 | 3.16 | 1.04E-13 |
| Neck Length | 0.78 | -14 | 1.72 | <2.20E-16 |
| Neck Diameter | 0.31 | -13.24 | 1.06 | <2.15E-05 |
| Heart Girth Diameter | 0.76 | -37.86 | 0.93 | <2.66E-16 |
| Point of Shoulder to Knee | 0.94 | -15.97 | 2.01 | <2.20E-16* |
| Knee to Metacarpal | 0.84 | -25.56 | 3.09 | <2.20E-16 |
| Hip Bone to Hock Joint | 0.79 | -28.25 | 2.35 | <2.20E-16 |
| Hock joint to Metatarsal | 0.88 | -23.49 | 2.82 | <2.20E-16 |
| Wither Height | 0.97 | -26.18 | 0.74 | <2.20E-16** |
| Rump Height | 0.97 | -26.36 | 0.7 | <2.20E-16** |
| Hook to Hook | 0.81 | -5.96 | 2.01 | <2.20E-16 |
| Pin to Pin | 0.91 | -3.6 | 2.62 | <2.20E-16 |

## 4. DISCUSSION

In this study, multiple regression models were developed to identify the most reliable morphometric predictors of live body weight in goats. Unlike previous studies that identified HGD as the strongest predictor for measuring body weight using a regression table (Ibrahim et al., 2021; Khan & Naznin, 2013), in our dataset, HGD showed only moderate predictive power, with a comparatively lower coefficient of determination ($R^2 = 0.76$). This variation may be attributed to the inclusion of multiple goat breeds in our study, whereas many earlier studies focused on single-breed populations, where morphological uniformity often enhances the predictive value of HGD (Ibrahim et al., 2021). Previous research has shown that chest girth remains the strongest indicator for body weight in various goat populations (Dakhlan et al., 2020), and similar findings were reported by Rahman et al. (2022) and Khan & Naznin in 2013, who demonstrated strong linear relationships between HGD and live weight in both Black Bengal and Jamunapari goats. Their results, however, were derived from semi-intensive systems and genetically uniform groups, which may explain why our multi-breed sample yielded different outcomes. In contrast to earlier studies, we found that WH, RH, and PS-K length showed the highest predictive accuracy, each demonstrating strong statistical significance in our regression analysis. These findings align partially with Musa et al. (2012), who reported that height-related measurements such as height at the hip and height at the withers significantly contributed to live weight estimation in sheep, although their combined model produced a lower adjusted $R^2$ (0.61) than ours. Similarly, Mohammad et al. (2012)

predicted body weight from body measurements in indigenous sheep breeds in Pakistan using a regression tree approach, further supporting the utility of morphometric traits in small ruminant weight estimation. Furthermore, Sultana et al. (2022) emphasized the importance of using multiple morphometric predictors to improve model performance in livestock weight prediction. Their work demonstrated that increasing the number of body measurements significantly enhanced model accuracy. Consistent with this, our full regression model using all morphometric traits produced an adjusted $R^2$ of 0.99, indicating an exceptionally strong fit. Although the full regression model provided the highest accuracy, it is not practical to use in field conditions because measuring all body parameters is time-consuming. To address this, we created a simpler model that uses only the three strongest predictors (WH, RH, and PS-K length). This simplified model still produced a high adjusted $R^2$ of 0.98. Because it is both accurate and easy to implement, this model is more suitable for farmers, traders, and livestock workers who need quick weight estimates in local markets.

This study also has several limitations that should be acknowledged. First, the sample size was relatively small and consisted of goats from only one district, which may limit the generalizability of the findings to other regions. Additionally, the study included only castrated male goats, and morphometric relationships may differ in females or intact males. The inclusion of multiple breeds increased variability within the dataset, which could influence the strength of certain predictors compared to single-breed studies. Moreover, the cross-sectional design of the study prevented observing weight measurement relationships over time. Finally, although the full regression model demonstrated high accuracy, some morphometric measurements are challenging to obtain in busy or informal livestock markets, which may affect their practical application in real-world settings.

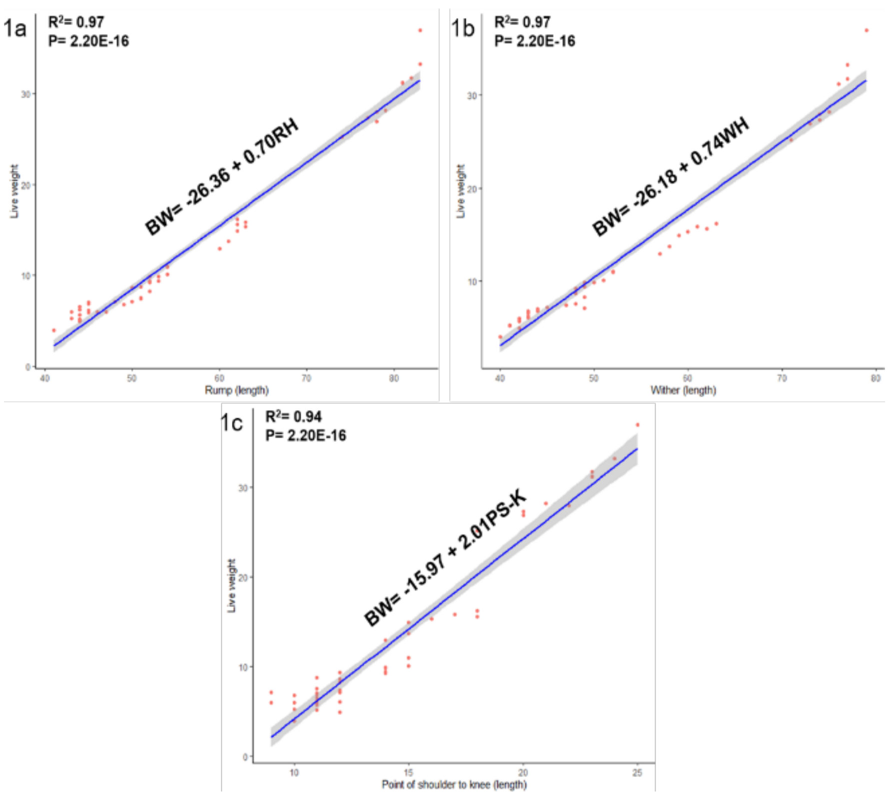


Figure 1. Linear regression model between actual body weights with the top three most significant body measurements. a) Model between actual body weight and Rump height, b) Model between actual body weight and wither height, and c) Model between actual body weight and point of shoulder to knee length.

## 5. CONCLUSION

Our findings show that live body weight in goats can be estimated reliably without depending solely on HGD, which has been emphasized in many earlier studies. By working with several breeds under field conditions, we found that WH, RH, and PS-k length were the most consistent and practical predictors. The regression model built from these three measurements performed strongly while still being simple enough to use in real-world settings such as local markets and small farms.

Like any study, ours had limitations, mainly the modest sample size, single study area, and focus on castrated males. Future work that includes more animals across different regions, ages, and sexes would help confirm and strengthen these results. It would also be useful to test nonlinear or more advanced modeling approaches, and to collect data over longer periods to see how these relationships change as animals grow. Despite these limitations, our study offers a practical and more adaptable approach to estimating goat body weight, which can help farmers, traders, and extension workers make better everyday decisions.

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