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Prediction of body weight based on different linear body measurements traits in Kanni goats

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Abstract
The present study was undertaken to develop the prediction equation for body weight based on different linear body measurements traits in Kanni goats. The study was conducted at Livestock Farm Complex, Veterinary College and Research Institute, Tirunelveli, TANUVAS, Tamil Nadu. The step wise regression analysis was used to get the best prediction equations for body weight with different linear body measurements. The traits had high correlation with body weight only those traits used to get the prediction equations. During one year of age groups the high correlation was observed between body length and body weight (r=0.77). The prediction equation of body weight (Y)= -10.66+0.42×46.56 (Body length) was found to be fitted regression model in one year of age groups. It has higher R^2 values value of 60% and the adjusted R^2 Value 0.57, this indicates that 57% the variance in body weight was explained by this model. At two years of age group, the high correlation was observed between body weight and chest girth was (r= 0.76). The best prediction equation Y= -11.56 + 0.41× 61.56 (Chest girth). Correspondingly, three year of age groups the highest correlation was observed between body weight and rump height was (r=0.91). The best prediction equation Y= -33.86 + (-0.45 ×BL) + (0.70 × CG) + (0.27 × WH) + (0.23 × RH) + (0.13 × TL) + (-0.18 × 31.62) + (0.11× RL). These predictors had R^2 value of (0.87) and the highest adjusted R^2 Value 0.76, this indicates that 76% the variance in body weight was explained by this model. As an increase in the coefficient of determination (R^2) was observed as more variables were included in the prediction equation which indicates more precision in the determination of body weight. These traits can be used as a marker for estimating body weight in Kanni goats using regression analysis.

Keywords: Prediction, body weight, body length, chest girth, Kanni goat

Introduction
In recent years, goats have become an important source of income especially for landless, small and marginal farmers. Goats are commonly called poor man's cows in our country. Therefore, improving local indigenous goats productivity has become an essential strategy that could be achieved through scientific management and better genetic improvement programs. Some researchers (Martins *et al*., 2009; Yakubu, 2010) [12, 24] are reported that linear body measurements are important and will give basic information on the suitability of animals towards selection. Also, these traits can be used as management tools to increases the productivity of goats and used for many purposes like determining the body weight, prediction of genetic improvement, growth rate, body condition score, and carcass traits.
Although, live body weight is a very significant objective in the selection criteria, the potential for genetic improvement largely depends on genetic and phenotypic parameters of this trait upon which selection may be applied (Das *et al*., 1996) [6]. Moreover, non-genetic factors have to control for accurate documentation of genetic differences in the individual's goat breeds (Abd-Allah *et al*., 2019) [1]. During selection of goats for the breeding program should be given more emphasis on the age, growth rate, live body weight, body length, heart girth, and height at withers. Since many researchers have reported that body weight had the highest correlation with body length followed by height at withers. The prediction of body weight and the relationship between other morphometric traits could produce appreciable knowledge for the development of a better breeding strategy with respect to meat production per animals (Yilmaz *et al*., 2013 and Iqbal *et al*., 2013) [25, 9]. In the livestock industry, body weight is the most important trait, and prediction of body weight helps the farmers for selection of elite animals for breeding purposes, scientific management, administration of medical treatment, and determining the correct animal price (Tariq *et al*., 2012; Norris *et al*., 2015 and Eyduran *et al*., 2017) [21, 15, 7]. However, for the poor and marginal farmers in rural areas, it is very difficult to estimate the body weight due to the lack of weighing scales which are expensive to purchase (Slippers *et al*., 2000 and Berhe *et al*., 2017) [19, 3].

The chief method of weighing animals without scales is to regress body weight on a certain number of body measurements that can be measured readily. Thiruvenkadan (2005) [22] highlighted that this problem could be overcome by regressing body weight on a number of morphometric traits which can be measured easily. Such method has been used by several researchers on different species. Nesamvuni *et al*. (2000) [14] enlighten that heart girth has been used as a marker for predicting the body weight in various species of animals like Cameroon sheep, west African goats, and South Africa in cattle. Several researchers are revealed that morphometric traits can be used to predict the body weight in different breeds of Indian goats (Ulaganathan *et al*., 1992; Singh and Mishra, 2004; Seifemichal *et al*., 2014 and Hopker *et al*., 2019) [18, 8].

However, many literatures are available on body weight and other linear body measurements such as body length, chest girth, paunch girth, height at withers, rump height, tail length, neck circumference, head length, and rump length. However, scanty studies have been conducted for individual traits and combinations of many traits which may give a correct estimation of body weight, especially in small ruminants. The positive and significant correlation of body weight with other linear body measurements indicates that these measurements can be used as a marker to estimate body weight using regression equations. Therefore, the present study was undertaken to develop the best prediction regression model based on the morphometric traits. These traits could be used as selection criteria to estimate the body weight of goats in order to select elite animals for future breeding purposes, providing requirements feeding strategy, the dosage of drugs, and determining the price of animals.

Materials and Methods

Location of Study: The present study was conducted at Livestock Farm Complex, Veterinary College and Research Institute, Tirunelveli, TANUVAS, Tamil Nadu. The temperature recorded in this area ranged from 95°F and 77°F respectively.

Ethical Approval: The present study does not involve any intervention of collection of blood or the tissues from the animals under the study.

Experimental animals and Data collection

In the present study, the data comprised of forty (40) Kanni goats of different sexes on different age groups based on the permanent incisors from Veterinary College and Research Institute, Tirunelveli. TANUVAS. The experimental animals were subjected to traditional management system, which allows them to graze and feed on communal land during the day and return them to the shed. Scientific management practices like feeding, vaccination, deworming and other practices were followed.

Assessment of body linear measurements

Body weight was measured using a weighing scale calibrated in kilograms (Kg). The measurements as prescribed by (Lukuyu *et al.*, 2018) [11]. The linear body measurements such as body length, chest girth, paunch girth, height at withers, rump height, tail length, neck circumference, head length, and rump length were recorded using a measuring tape (cm). Each animal selected for measurement was restrained and calmed before measurements were taken on them to ensure that they were not unnecessarily stressed.

The measurements were taken in the morning, with the animals standing on a flat surface with head held up and held by assistants. The length and circumference measurements (cm) were affected using a tape rule. All measurements were carried out by the same person in order to avoid individual variations and suggested by Birteeb *et al*. (2012) [5]; Musa *et al*. (2012a) [13]; Ravimurugan *et al*. (2012) [16]; Alvarez *et al*. (2013) [2] and Younas *et al*. (2013) [26]. The following morphometric traits were used to predict body weight in Kanni goats.

Body length (BL) was measured as a distance from the occipital joint to the first caudal vertebra.

Height at withers (WH) was measured as the distance from the surface of a platform to the withers.

Chest girth (CG) was measured as the level of the middle of the sternum with the tape passing under the arms

Paunch girth (PG) was measured as the circumference of the body immediately after the abdomen just before the hind legs.

Rump height (RH) was measured as a distance from the surface of the platform to the rump using a measuring stick

Head length (HL) was measured as the distance from nodule of the horn to the upper lip of the animal.

Neck circumference (NC) was measured as the circumference of the neck at the midpoint.

Rump length (RL) was measured from the top of their head (crown) to the bottom of their buttocks (rump)

Prediction equation for body weight

The relationship between body weight and other linear body measurements was determined using Pearson's product-moment correlation coefficient (r). Linear regression of the linear body parameters on body weight was also performed using the following simple and multiple linear regression models:

$Y = \alpha + \beta Xs$ …… Simple regression model

$Y = \alpha + \beta 1X1 + \beta 2X2 + \ldots\ldots + \beta kXk$ Multiple regression model

Where Y = dependent variable (bodyweight)

Xs = independent variables (body length, chest girth, paunch girth, height at withers, rump height, tail length, neck circumference, head length, and rump length)

α = intercept

β = slope

Statistical analysis

The statistical data package for social science (SPSS, version 21) was used to analyse the data at 5% level of significance. The relationships between body weight with different body measurements were calculated by Pearson correlations, and regression equations were developed. Body weight was regressed on linear body measurements using stepwise multiple linear regression analysis. The coefficient of determination (R^2) was used to assess the accuracy of prediction equations between live body weights and other linear body measurements.

Results and Discussion

Prediction of body weight (Kg) based on body morphometric traits (cm

The step-wise regression analysis was used to obtain the best prediction equations for body weight with different linear

body measurements are shown in Tables 1, 2, and,3 respectively. In the present study, the correlation between body weight with other morphometric traits such as body length, chest girth, paunch girth, height at withers, rump height, tail length, neck circumference, head length, and rump length tarts were analysed. The traits had a high correlation with body weight only those traits were used to get the prediction equations. According to the high correlation, the independent variables like body length, height at withers, rump height, tail length were used and found to be more efficient in predicting body weight in Kanni goats at one year of age groups. During this period a high correlation was observed between body length and body weight (r=0.77). The different bodyweight prediction equation was obtained from different morphometric traits. The study revealed that body weight can be predicted from body length with R^2 value of (0.60) followed by the height at withers (0.44), rump height (0.36), and tail length (0.43) respectively. One-year age group (first permanent incisor teeth) the prediction equation of body weight (Y)= -10.66+0.42×46.56 (Body length) was found to be fitted, regression model. Because it has higher R^2 values value of 60% and the adjusted R^2 Value 0.57, this indicates that 57% of the variance in body weight was explained by this model. R^2 value and adjusted R2 were considered as important criteria for the selection of an appropriate linear model. The body weight was significant at (P<0.05) level. Here, the actual body weight was 9.35 ± 0.39 kg whereas the predicted body weight was 8.99 ± 0.08 kg. Since the value between actual body weight and predicted body weight was not significantly different (P<0.05).

The findings of the present study where agreement with Yilmaz *et al*., 2013 [25] reported that the highest coefficient of determination was obtained from the model was formed at body length (R^2 = 0.79) and chest girth (R^2 = 0.87) Karya sheep. A similar study was conducted by Thiruvenkadan (2005) [22] reported that the great variation in the body weight was accounted by the combination of height at withers, chest girth, and body length. Karna *et al.* (2020) have described body length as the principal predictor for the prediction of body weight for one year of age groups whereas chest girth was the most important predictor of live weight. Body length and height at withers can be used in combination with chest girth to predict body weight more accurately.

At two years of age group (two permanent incisors teeth) the high correlation was observed between body weight and chest girth was r= 0.76. The best prediction equation was Y= -11.56 + 0.41× 61.56 (Chest girth). Because it has a higher R^2 values value of 60% and the adjusted R^2 value of 0.57, this indicates that 57% of the variance in body weight was explained by this model. Here, the actual body weight was 14.15 ± 0.34 kg whereas the predicted body weight was 13.67 ± 0.09 kg. Since the value between actual body weight and predicted body weight was not significantly different (P<0.05). The study says that body weight can be predicted from chest girth with an R^2 value of (0.60) followed by the height at withers (0.48), neck circumference (0.48), rump height (0.37), and rump length (0.36) respectively.

Correspondingly, three years of age groups (three permanent incisor teeth) correlation between body weight with body length was (r=0.811), chest girth (0.920), paunch girth (0.353), height at withers (0.890), rump height (0.910), tail length (0.850), neck circumference (0.815), head length (0.562) and rump length (0.620) respectively. Among these traits, rump height (0.910) had the highest correction coefficient with body weight. For the best prediction equation was fitted for the three years of age groups (three permanent incisors teeth) number of predictors were included. The best prediction equation Y= -33.86 + (-0.45 ×BL) + (0.70 × CG) + (0.27 × WH) + (0.23 × RH) + (0.13 × TL) + (-0.18 × 31.62) + (0.11× RL). Here, the actual body weight was 21.00 ± 1.07 kg whereas the predicted body weight was 20.43 ± 2.08 kg. Since the value between actual body weight and predicted body weight was not significantly different.

Bhattacharya *et al*. (1984) studied that the relationship between body weight with heart girth, body length, heart girth, and neck circumference was the best prediction equation for body weight estimation in Black Bengal goats. Similarly, different body measurements (body length, chest girth, and height) were used to make a prediction equation for estimating the body weight in Bidri goats (Suranagi *et al*., 2005). Ravimurugan *et al*. (2012) [16] reported that chest girth was the best predictor for the estimation of body weight and its alone contributed 69.1% variation in the body weight in Kilakarsal sheep. The study reported that body weight can be predicted from the body length, chest girth, height at withers, rump height, tail length, neck circumference, and rump length with an R2 value of (0.87) and the highest adjusted R2 Value 0.76, this indicates that 76% the variance in body weight was explained by this model. An increase in the coefficient of determination was observed as more variables were included in the prediction equation which indicates more precision in the determination of body weight.

Table 1: Prediction equations in relation to body weight and linear body measurements in Kanni goats (One years of age)

Traits	Prediction equations	Multiple R	R^2 Value	Adjusted R^2 Value	Actual body weight (Kg)	Predicted body weight(kg)
Body length	Y= -10.66+0.42×46.56 (Body length)	0.77	0.60	0.57	9.35 ± 0.39	8.99 ± 0.08
Height at withers	Y= -7.22+0.29×57.06 (Height at withers)	0.66	0.44	0.40	9.35 ± 0.39	9.32 ± 0.11
Rump height	Y= -8.54+0.32×54.36 (Rump height)	0.60	0.36	0.31	9.35 ± 0.39	8.99 ± 0.12
Tail length	Y= 0.96+0.76×10.93 (Tail length)	0.65	0.43	0.39	9.35 ± 0.39	9.26 ± 0.23

(P≤0.05); R^2 = Coefficient of determination, R= Correlation Coefficient

Table 2: Prediction equations in relation to body weight and linear body measurements in Kanni goats (Two years of age)

Traits	Prediction equations	Multiple R	R2 value	Adjusted R^2 value	Actual body weight(kg)	Predicted body weight(kg)
Chest girth	Y= -11.56 + 0.41× 61.56 (Chest girth)	0.77	0.60	0.57	14.15 ± 0.34	13.67 ± 0.09
Height at withers	Y= 0.98 + 0.22 × 65.87 (Height at withers)	0.69	0.48	0.45	14.15 ± 0.34	13.59 ± 0.06
Rump height	Y= 1.91 + 0.18 × 65.75 (Rump height)	0.61	0.37	0.33	14.15 ± 0.34	13.73 ± 0.06
Neck circumference	Y = 3.44 + 0.38 × 27.50 (Neck circumference)	0.69	0.48	0.44	14.15 ± 0.34	13.89 ± 0.10
Rump length	Y= 5.23 + 0.40 × 22.06 (Rump length)	0.60	0.36	0.32	14.15 ± 0.34	14.11 ± 0.14

(P≤0.05); R^2 = Coefficient of determination, R= Correlation Coefficient

Table 3: Multiple regression equation in relation to body weight and linear body measurements in Kanni goats (Three years of age)

Traits	Prediction equations	Multiple R	R^2 value	Adjusted R^2 Value	Actual body weight (Kg)	Predicted body weight (Kg)
BL, CG, WH, RH, TL, NC, RL	Y= -33.86 + (-0.45 ×BL) + (0.70 × CG) + (0.27 × WH) + (0.23 × RH) + (0.13 × TL) + (-0.18 × 31.62) + (0.11× RL)	0.93	0.87	0.76	21.00 ± 1.07	20.43 ± 2.08

($P \leq 0.05$); R^2 = Coefficient of determination, R= Correlation Coefficient, BL- Body length, CG- Chest girth, WH= height at withers, RH- Rump height, TL - Tail length, NC- Neck circumference, RL-Rump length

Conclusion

Kanni goats are one of the goats breeds that can be used to improve the local breeds genetically as it is an attractive morphological strain of great potential for milk and meat as compared with other local breeds of goats. The study concluded that the body weight of Kanni goats could be estimated with more accuracy using different body measurements and step-wise multiple regression. So, it is recommended that the best predictive parameters of body weight were body length, chest girth and followed by the height at withers, rump height, tail length, neck circumference, and rump length. In the same way, we may conclude that in order to practice better animal husbandry, the measurement of live body weight is totally essential for breeding, nutrition, and health management. The positive and significant correlation of body weight with other linear body measurements indicated that these measurements can be used as a marker for estimating body weight using regression equations.

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