PREDICTION OF BODY WEIGHT OF MALABARI GOATS FROM BODY MEASUREMENTS UNDER FIELD CONDITIONS

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Abstract

Data on body weight and body measurements were collected from the farmer's flocks of All India Co-ordinated Research Project on goats for Malabari goats, from the northern part of Kerala. The correlation between body weight and body measurements at different ages was positive and strongly correlated in most cases. Simple, multiple and curvilinear regression models were fitted with body weight as the dependent variable and body measurements as independent variables. Body measurements succeed to describe more variation in live weight. Separate prediction equations were made for females and males as well as for singles, twins, triplets and quadruplets. The coefficient of determination in different equations indicate that chest girth succeed in estimating body weight more than any other linear measurement and chest girth in combination with two or more measurement predict the body weight better.

Key words: *Body weight, Body measurements, Malabari goats, Prediction, Correlation, Regression*

Goat is a multifunctional animal serving mankind in several ways by producing milk, meat, fibre and various byproducts. They substantially contribute to the rural economy and provide livelihood to the poor sections and supplement their food with nutritious milk and meat. Assessing the body weight of goat is often a necessity that is encountered by those working on it. The chief method of weighing animals without scales is to regress body weight on a certain number of body characteristics, which can be measured easily. Body measurements have been used to predict body weight by several authors in many breeds of Indian goats (Das *et al.*, 1990; Sharma and Das, 1995; Thiruvenkadan, 2005). These procedures do not quite hold well for determining the body weight of Malabari goat. Hence the following study was made to determine the best fitted regression model for prediction of live weight of Malabari goats under field conditions.

Materials and Methods

The study was conducted based on the data collected from the farmer's flocks of All India Co-ordinated Research Project (AICRP) on goats for improvement of Malabari goat. The data was collected from three centres of AICRP on goats located in Tellichery, Tanur and Badagara, which are respectively in Kannur, Malappuram and Kozhikode districts of Kerala. These are three northern districts of Kerala, which is the home-tract of Malabari goats. Measurements used were body weight, chest girth, paunch girth, body length and height at wither at below one, three, six, nine and twelve months of age.

Within each group body weight was regressed on different body measurement using the SPSS package. Stepwise regression procedure was carried out to determine the

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combination of body measurements that can explain the maximum variation in the dependent variable, the body weight. Separate prediction equations were developed for male and females as well as for singles, twins, triplets and quadruplets.

Karl Pearson's coefficients of correlation were estimated between body weight and all body measurements. To determine the best fitted regression equation, the coefficients of multiple determination was used. In addition to the simple and multiple linear regression model, curvilinear regressions such as power and exponential functions were also tried with the independent variable which is highly correlated with body weight. The prediction bias was estimated using sample average (Di = Wi - ti (i = 1 to n) and the significance of prediction bias was tested by paired 't' test (Mayaka *et al.,* 1995).

Results and Discussion

Body measurements and body weight

Means and standard error of live weight and body measurements are presented in table 1. Each age group is classified into different groups based on sex and type of birth and comparisons were made only with in groups.

In most of these groups, among the body measurements paunch girth was highest followed by chest girth, height at wither and body length. Males had higher values than females on all age groups and there is no significant difference between males and females in case of body weight. This concurred with the results of Thiruvenkadan (2005). Higher body weight of males than that of females at all ages may be due to aggressive behavior of males during feeding and sucking and male sex hormone, which has an anabolic effect. Similarly singles have higher values followed by twins, triplets and quadruplets. Higher body weight in singles might be because the dam with one kid could provide more nutrition to their kids during prenatal and suckling period. But the difference goes on decreasing as age advances and body weights become non-significant from nine months onwards. This result was comparable with the reports of Mohammed and Amin (1996) in Sahel goats.

Correlation Coefficient

The correlation coefficient between body weight and body measurement are presented in Table 2.

Positive and highly significant correlations were observed with the exception of a few cases. Since there is high correlation coefficients between body weight and body measurements, either of these variables or combination could provide a good estimate for predicting live weight in Malabari goats. In almost all cases chest girth showed highest correlation with body weight.

Fitted Regression

Table 3 explains the regression output including the best fitted function and coefficient of determination (adjusted R^2values).

Curvilinear regression models were not found to be as useful as linear models. Besides, ease in calculation also made the linear models as the best fitted regression models. Only the best-fitted regression models in each group were included in the table. Due to inadequate data in some cases prediction equations were not developed.

Linear body measurements were found to be poor predictor for estimation of body weight for animals below one month of age. This is in agreement with the conclusion of Das *et al.* (1990) in Barbari and Jamunapari goats. At three months of age in the case of pooled sample, chest girth alone can be used to predict the body weight. But in the case of females and males the second predictor is body length and height at wither respectively. Regarding singles and twins along with chest girth height at wither is contributing much of the variation in body weight. At six months of age chest girth followed by height at wither contributes to much of the variation. This is in agreement with the findings of Badi *et al.* (2002). Adjusted R^2 for best predicted equation in this age group varied from 60.3 to 73.4%. At nine months of age chest girth continues to be the best predictor followed by body length in males and height at wither in singles. But at twelve months chest girth followed by paunch girth contributes to much of the variation. This is natural as stated by Singh *et al.* (1979) since the major body weight is due to these two portions of the body.

The coefficient of determination in different equations indicates that chest girth succeeds in estimating body weight more than any other linear measurement. Thiruvenkadan (2005) suggested the higher association of body weight with chest girth was possibly due to relatively larger contribution to body weight

Table 1. Mean (± SE) body weight and body measurements of Malabari goats

Age	Group		N	Body weight (kg)	Chest girth (cm)	Paunch girth (cm)	Body length (cm)	Height at withers (cm)
Below 1 month	Sex	F	173	2.36±0.04[a]	31.52±0.23	32.46±0.27	29.89±0.26	32.05±0.23
		M	169	2.39±0.04[a]	31.41±0.22	32.46±0.26	30.07±0.27	32.17±0.30
	Type of birth	S	191	2.36±0.04[a]	31.74±0.21	32.74±0.24	30.09±0.27	32.17±0.25
		T	117	2.38±0.05[a]	31.17±0.27	32.35±0.35	29.79±0.30	31.89±0.31
		TR	23	2.29±0.10[a]	30.26±0.44	30.65±0.70	29.7±0.81	32.22±0.99
		Q	11	2.68±0.12[a]	32.36±0.79	32.55±0.88	30.55±0.43	33.09±0.69
	Pooled	P	342	2.37±0.30	31.46±0.16	32.46±0.19	29.98±0.19	32.11±0.19
3 months	Sex	F	313	9.49±0.13[a]	47.78±0.27	51.12±0.34	44.49±0.28	46.88±0.25
		M	228	9.61±0.17[a]	48.44±0.35	51.92±0.44	45.33±0.37	47.36±0.30
	Type of birth	S	336	9.9±0.12[a]	48.61±0.25	52.36±0.29	45.56±0.25	47.6±0.23
		T	165	9.06±0.18[b]	47.47±0.39	50.91±0.52	44.02±0.40	46.47±0.33
		TR	31	8.97±0.48[cb]	46.39±0.93	48.06±1.09	42.61±1.00	45.52±0.87
		Q	9	7.06±0.55[d]	42.89±0.99	43.67±0.80	38.44±1.09	43±0.93
	Pooled	P	541	9.54±0.10	48.04±0.21	51.53±0.26	44.8±0.21	47.06±0.18
6 months	Sex	F	246	16.08±0.21[a]	56.87±0.39	61.55±0.50	52.55±0.37	55.26±0.31
		M	152	16.15±0.26[a]	56.81±0.50	60.99±0.66	53.25±0.49	56.23±0.41
	Type of birth	S	267	16.61±0.20[a]	58.14±0.34	63.07±0.42	53.82±0.34	56.24±0.29
		T	111	15.33±0.24[b]	54.42±0.49	58.46±0.73	50.77±0.50	54.61±0.43
		TR	20	14.54±0.75[cb]	53.79±1.26	56.16±2.01	52.05±1.18	54.32±0.81
	Pooled	P	398	16.14±0.16	56.84±0.29	61.38±0.38	52.84±0.28	55.66±0.24
9 months	Sex	F	91	21.16±0.31[a]	63.95±0.43	70.79±0.81	59.48±0.59	60.75±0.44
		M	44	22.23±0.52[a]	65.49±0.60	71.08±0.89	61.28±0.69	63.72±0.67
	Type of birth	S	99	21.56±0.29[a]	64.65±0.38	71.43±0.61	60.53±0.52	61.52±0.42
		T	31	21.5±0.61[a]	63.9±0.88	69.61±1.78	58.77±1.03	62.77±0.91
		TR	5	21.1±1.60[a]	64.8±1.93	69.6±3.50	59.2±2.77	60.4±2.04
	Pooled	P	135	21.53±0.26	64.48±0.35	70.95±0.62	60.07±0.46	61.76±0.38
12	Sex	F	34	25.47±0.49[a]	69.5±0.69	77.63±1.32	63.13±0.94	63.59±0.83

P=Pooled, F=Female, M= Male, S=Single, T=Twin, TR=Triplets, Q=Quadruplets,
Y= Body weight, X_1=Chest girth, X_2=paunch girth, X_3= Body length, X_4= Height at wither and N= Number of observations,
Letters with same superscript do not differ significantly ($p>0.05$)

Table 2. Phenotypic correlation between body weight and body measurements in Malabari goats

Age	Group	X_1	X_2	X_3	X_4
Below 1 Month	Pooled	0.531(**)	0.488(**)	0.490(**)	0.480(**
	Female	0.558(**)	0.531(**)	0.563(**)	0.503(**)
	Male	0.502(**)	0.440(**)	0.414(**)	0.468(**)
	Singles	0.585(**)	0.585(**)	0.552(**)	0.476(**)
	Twins	0.446(**)	0.384(**)	0.376(**)	0.492(**)
	Triplets	0.353^{ns}	0.303^{ns}	0.522(*)	0.490(*)
	Quadruplets	0.781(**)	0.502^{ns}	0.242^{ns}	0.572^{ns}
3 Months	Pooled	0.839(**)	0.758(**)	0.639(**)	0.649(**)
	Female	0.823(**)	0.719(**)	0.655(**)	0.634(**)
	Male	0.879(**)	0.819(**)	0.632(**)	0.675(**)
	Singles	0.809(**)	0.714(**)	0.549(**)	0.582(**)
	Twins	0.866(**)	0.808(**)	0.703(**)	0.712(**)
	Triplets	0.861(**)	0.758(**)	0.763(**)	0.724(**)
	Quadruplets	0.957(**)	0.543^{ns}	0.723(*)	0.627^{ns}
6 Months	Pooled	0.777(**)	0.652(**)	0.676(**)	0.673(**)
	Female	0.800(**)	0.658(**)	0.710(**)	0.683(**)
	Male	0.755(**)	0.657(**)	0.643(**)	0.692(**)
	Singles	0.765(**)	0.645(**)	0.677(**)	0.661(**)
	Twins	0.769(**)	0.616(**)	0.687(**)	0.663(**)
	Triplets	0.865(**)	0.683(**)	0.382^{ns}	0.757(**)
9 Months	Pooled	0.788(**)	0.514(**)	0.515(**)	0.615(**)
	Female	0.794(**)	0.600(**)	0.597(**)	0.539(**)
	Male	0.739(**)	0.259^{ns}	0.231^{ns}	0.701(**)
	Singles	0.781(**)	0.511(**)	0.543(**)	0.571(**)
	Twins	0.820(**)	0.498(**)	0.500(**)	0.737(**)
	Triplets	0.753^{ns}	0.894(*)	0.236^{ns}	0.571^{ns}
12 Months	Pooled	0.765(**)	0.637(**)	0.571(**)	0.505(**)
	Female	0.694(**)	0.638(**)	0.494(**)	0.379(*)
	Male	0.911(**)	0.534^{ns}	0.767(**)	0.826(**)
	Singles	0.775(**)	0.719(**)	0.575(**)	0.518(**)
	Twins	0.700^{ns}	0.188^{ns}	0.547^{ns}	0.503^{ns}

*** indicates significant at $P<0.01$*
** indicates significant at $P<0.05$*
^{ns} indicates nonsignificant

by chest girth (consisting of bones, muscles and viscera). The prediction equation obtained suggests that one single body measurement cannot predict body weight of goat accurately. Since highest variation of body weight was accounted for by combination of height at withers, chest girth, body length and paunch girth than individual values in all the age groups in both sexes and different type of birth multiple regression analysis is more effective. These

Table 3. Best fitted regression equation and coefficient of determination (adjusted R^2) at different age groups

Age	Group	Equation	Adjusted R^2
Below 1 month	Pooled	$Y= -1.183+0.062X_1+0.028X_3+0.025X_4$	0.319
Below 1 month	Female	$Y= -1.300+ 0.056\ X_3+ 0.063X_1$	0.364
Below 1 month	Male	$Y= -0.822+ 0.067X_1+ 0.035X_4$	0.277
Below 1 month	Singles	$Y= -1.367+ 0.071X_2+ 0.048X_3$	0.386
Below 1 month	Twins	$Y= -0.747+0.057X_4+0.042X_2$	0.259
Below 1 month	Triplets	$Y= 0.399+ 0.064X_3$	0.237
Below 1 month	Quadruplets	$Y= -1.224+0\ .121X_1$	0.567
3 Months	Pooled	$Y= -10.920+ 0.309X_1+ 0.075X_4+ 0.040X_2$	0.715
3 Months	Female	$Y= -9.997+ 0.328X_1+ 0.086X_3$	0.694
3 Months	Male	$Y= -11.925+0.325X_1+ 0.096X_4+ 0.074X_2+ -0.057X_3$	0.786
3 Months	Singles	$Y= -9.626+ 0.347X_1+ 0.056X_4$	0.660
3 Months	Twins	$Y=-11.808+0.262X_1+0.109X_4+0.066X_2$	0.773
3 Months	Triplets	$Y= -11.819+0.448X_1$	0.733
3 Months	Quadruplets	$Y= -15.666+ 0.530X_1$	0.904
6 Months	Pooled	$Y= -11.624+ 0.328X_1+ 0.164X_4$	0.634
6 Months	Female	$Y= -12.670+ 0.344X_1+ 0.166X_4$	0.669
6 Months	Male	$Y= -10.662+0\ .285X_1+ 0.189X_4$	0.603
6 Months	Singles	$Y= -13.031+0.349X_1+ 0.166X_4$	0.612
6 Months	Twins	$Y= -8.436+ 0.280X_1+ 0.156X_4$	0.632
6 Months	Triplets	$Y= -12.985+ 0.512X_1$	0.734
6 Months	Quadruplets	$Y= -10.500+ 0.500X_2$	1.000
9 Months	Pooled	$Y= -19.164+0.485X_1+0.153X_4$	0.648
9 Months	Female	$Y= -15.116+0.567X_1$	0.626
9 Months	Male	$Y= -25.238+ 0.429X_1+ 0.305X_4$	0.621
9 Months	Singles	$Y= -19.918+ 0.507X_1+ 0.141X_4$	0.631
9 Months	Twins	$Y= -15.114+0.573X_1$	0.661
9 Months	Triplets	$Y= -7.342+ 0.409X_2$	0.733
12 Months	Pooled	$Y= -14.751+0.311X_1+ 0.132X_2+0\ .130X_3$	0.689
12 Months	Female	$Y= -11.047+ 0.359X_1+ 0.149X_2$	0.581
12 Months	Male	$Y= -13.634+ 0.560X_1$	0.815
12 Months	Singles	$Y= -14.770+0.301X_1+ 0.160X_2+0\ .105X_3$	0.706

Y= body weight, X1=chest girth, X2= paunch girth, X3= body length and X4= height at wither, P=Pooled, F=Female, M= Male, S=Single, T=Twin, TR=Triplets, Q=Quadruplets.

results are also supported by Bassano *et al*. (2000) and Thiruvenkadan (2005).

In all the age groups the highest adjusted R^2 was obtained when more than one body measurement was included in the regression equations. This suggests that weight could be estimated more accurately by combination of two or more measurements than by girth alone.

Table 4. Predicted weight ±SE and predicted bias for different groups

Age	Group	Mean	Prediction bias
Below 1 Month	Pooled	2.37±0.02	0.461
	Female	2.36±0.03	0.013
	Male	2.39±0.02	0.012
	Singles	2.36±0.03	0.009
	Twins	2.42±0.03	1.102
	Triplets	2.29±0.05	0.001
	Quadruplets	2.69±0.09	0.639
3 Month	Pooled	9.52±0.08	0.453
	Female	9.50±0.11	0.260
	Male	9.61±0.15	0.075
	Singles	9.91±0.09	0.173
	Twins	9.05±0.16	0.163
	Triplets	8.96±0.42	0.022
	Quadruplets	7.07±0.53	0.477
6 Month	Pooled	16.15±0.13	0.045
	Female	16.07±0.17	0.077
	Male	16.16±0.21	0.035
	Singles	16.60±0.16	0.092
	Twins	15.32±0.19	0.074
	Triplets	14.55±0.65	0.035
9 Month	Pooled	21.50±0.20	0.045
	Female	21.15±0.25	0.072
	Male	22.29±0.42	0.190
	Singles	21.53±0.23	0.139
	Twins	21.50±0.50	0.007
	Triplets	21.12±1.43	0.034
12 Month	Pooled	25.30±0.33	0.124
	Female	25.47±0.38	0.003
	Male	25.65±0.64	0.006
	Singles	25.26±0.37	0.127

P=Pooled, F=Female, M= Male, S=Single, T=Twin, TR=Triplets, Q=Quadruplets, ND =not sufficient data available

Prediction Accuracy

The predicted weight and predicted bias for predicted weight in the best fitted equation in each group is presented in Table 4. In all the age groups there was no significant difference between predicted weight and actual weight.

To conclude, body weight was positively and significantly correlated with all linear body measurements in most cases. Males have higher body weight than females in all age groups but non significant. Type of birth significantly contributed to the body weight in early stages of life and they became non significant from nine months onwards. Chest girth in combination with two or more measurements predicted the body weight better.

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