Estimation of live body weight from linear body measurements for Farta Sheep

Tewodros Bimerow[1], Asresu Yitayew[1,] Mengistie Taye[2], and Shigdaf Mekuriaw[1]
[1]Andassa Livestock Research Center, P.O.Box 27, Bahir Dar, Ethiopia; [2]Bahir Dar University, Agriculture and Environmental Sciences College, P.O.Box 380, Bahir Dar, Ethiopia
tewobim@yahoo.com

Abstract

A study to develop regression models for prediction of body weight from other linear body measurements was conducted in Estie, Farta and Lai-Gaint districts, South Gondar, Amhara region. Records on body weight (BW) and other linear body measurements (Body Length (BL), Wither Height (WH), Chest Girth (CH), Pelvic Width (PW) and Ear Length (EL)) were taken from 941 sheep. Non-linear, simple linear and multiple linear regression models were developed using Statistical Package for Social Sciences (SPSS version 12.0). For the multiple linear regressions, step-wise regression procedures were used. Predicting models were developed for different age, sex and for the pool. Positive and significant ($P<0.01$) correlations were observed between body weight and linear body measurements for all sex and age groups. Among the four linear body measurements, heart girth had the highest correlation coefficient (except ear length) in all age and sex groups which is followed by body length, height at wither and pelvic width. Heart girth was the first variable to explain more variation than other variables in both sex and age groups. The models developed had a coefficient of determination of 0.26 to 0.89; the highest coefficient of determination was depicted for male while the lowest was for dentition groups having two permanent incisors. Regression models in general were poor for the dentition groups above one. Heart girth alone was able to estimate weight with a coefficient of determination of 0.77, for both sexes and the pool. The coefficient of determination of the fitted equations (in general) decreased as the age of sheep advances indicating that the fitted equations can predict weight for younger sheep with better accuracy than for older ones. Therefore, for ease of use and simplicity at field condition, it is possible to use heart girth alone as a predicting tool.

Key words: Body weight, Farta, linear body measurements, regression model.

Introduction

Farta breed of sheep is one of the sheep breeds found distributed in the south Gonder zone of the Amhara National Regional State, Ethiopia. These sheep are kept mainly for meat production (sale and slaughter) under the traditional management systems (Shigdaf *et al*., in press). There is no any specialized breed improvement program designed for this sheep. Genetic improvement of its live weight is required to increase meat yield from this breed.

Body measurements are simple and easily measured variables for estimating live weight although it is unlikely to be as accurate as direct measurement of live weight due to error in location of reference points and anatomical distortions produced when animal change position or posture or muscle tone (Sowande and Sobola, 2007). Body measurements have been used to evaluate breed performance and to characterize breed of animals. Strong linear and geometric relationships between live weight and chest girth have been reported in the literature (Benyi, 1997; Fasae *et al*., 2005; Mengistie *et al*., 2010).

Estimation of the relationship between body measurements in sheep may help provide means for predicting traits which are not normally and easily measured under field conditions. In a breeding programme where improved live weight is the overall breeding objective, other body measurements having strong correlation to live weight must be considered (Sowande and Sobola, 2007). There is paucity of information on the relationship between live weight and body measurements of Farta sheep. This study was undertaken to obtain prediction equations for estimating live weight of Farta sheep from five body measurements for the purpose of breed characterization.

Materials and methods

The study area

The study was conducted in Estie, Farta and Lai-Gaint districts of south Gondar zone where Farta sheep is distributed. Farta district is located about 100 km north-east of Bahir Dar, capital of the Amhara National Regional State. Farta lies within an altitude range of 1920 4135 m a.s.l. The district receives an average annual rainfall of 900-1099 mm and a mean-range temperature of 9-25^{0}C (Farta District OoARD, annual report). The second district, Lai-Gaint, is located 175 km from Bahir Dar and lies between an altitude ranges of 1300-3500 m.a.s.l. Lai-Gaint receives an annual average rainfall of 600-1100 mm and mean minimum and mean maximum temperatures of 9 and 19 ^{O}C, respectively. The third district, Estie , is located 157 km northwest of Bahir Dar city having an altitude range of 1500-4000 m a.s.l. The minimum and maximum mean annual rainfall of the area is 1307-1500 mm and the mean annual minimum and maximum temperature is 8.3 ^{O}C-25 ^{O}C.

Study animals and management

Study animals considered were Farta sheep. They are short fat tailed; wooly under coat; medium sized; commonly white (37.5%), brown (27.5%) and black with brown belly (15%), white/brown with brown/white patches; males are horned. Sheep were managed under traditional systems; the main feed resources were natural pasture (communal and private grazing land), crop residue, improved forage, and crop aftermath.

Data collection

Data on weight and other linear body measurements were collected from 941 sheep, with different age/dentition and sex groups. Age was estimated based on dentition groups (0PPI - sheep with milk teeth (>about 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above). For dentition group 0PPI, sheep approaching to one year of age (physical estimation) were used.

The live weight of an animal was taken using the Salter scale (50 kg capacity with 200 gram precision). Linear body measurements (heart girth, wither height, body length, pelvic width and ear length) were taken using flexible metal tape (3 meter length) to the nearest 0.5 cm after restraining and holding the animals in an unforced position. The reference points taken were: heart girth - the circumference of the chest posterior to the forelegs at right angles to the body axis; wither height - the highest point measured as the vertical distance from the top of the shoulder to the ground (bottom of forelegs); body length - horizontal length from the point of shoulder to the pin bone; pelvic width - horizontal distance between the extreme lateral points of the hook bone (*tuber coxae*) of the pelvis; and ear length - length of the external ear from its root to the tip.

Statistical analyses

Statistical analyses were carried out using SPSS Software version 12.0 (SPSS, 2003) General Linear Model (GLM) procedures, and linear and nonlinear regression procedures. Sex and dentition were considered as fixed effects. Live weight was regressed on other body measurements for sexes, dentition groups and for the pool. In the multiple regression

equation, prediction equations were developed using a stepwise elimination procedure. The following models were used for data analysis:

$Y_{ij} = \mu + S_i + T_j + (ST)_{ij} + e_{ij}$ (GLM) Model 1

$W = a + bG$ (Simple linear) Model 2

$W = a + b1G + b2G^2$ (Quadratic) Model 3

$W = a + b1G1 + b2G2 + \ldots + bnGn$ (Multiple linear) Model 4

Where; Y_{ijk} = The observation on body weight and other linear body measurements, W = The observation on live weight of the animal, μ = Overall mean, S_i = Fixed effect of sex (i = Female, Male), T_k = Fixed effect of dentition (k = 0, 1, 2, 3, 4), $(ST)_{jk}$ = the interaction effect of sex with dentition, a = Intercept, b= Regression coefficient of weight on body measurements, G = Body measurements, n = n^{th} number of body measurement, e_{ijk} = effect of random error.

Results and discussion

Body weight and linear body measurements

The mean body weight and linear body measurements of Farta sheep are presented in Table 1. The overall mean body weight, wither height, body length, chest girth, pelvic width and ear length obtained in the present study was 26.2±0.32 kg, 64.3±0.34 cm, 55.6±0.35 cm, 70.9±0.44 cm, 12.8±0.11 and 9.35+0.12 cm, respectively. There was a significant difference ($p<0.05$) in body measurements (except ear length) between sexes and dentition groups.

Correlation between weight and linear body measurements

The Pearson's correlation of linear body measurements with weight and with each other is presented in Table 2. There were significant and positive relationships between body weight and other linear body measurements and with each other. Chest girth had the highest correlation coefficient ($r = 0.43$-0.87; $p<0.01$) with body weight in both sexes and all dentition groups which is followed by wither height and body. Ear length has almost no correlation with body weight (inconsistent relationship). Good correlation coefficients

between body weight and chest girth were also reported for Menz and Washera sheep (Mengistie *et al*., 2010).

Table 1. Body weight and linear measurements of Farta sheep as affected by sex and dentition.

Variables	N	BW (kg)	WH (cm)	BL (cm)	CG (cm)	PW (cm)	EL (cm)
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	941	26.20±0.32	64.31±0.34	55.59±0.35	70.86±0.44	12.79±0.11	9.35±0.12
Sex		***	***	***	*	NS	NS
Female	800	23.82±0.19	62.16±0.20	54.30±0.20	69.76±0.26	12.83±0.06	9.67±0.07
Male	141	28.58±0.62	66.46±0.65	56.89±0.67	71.96±0.84	12.76±0.22	9.03±0.24
Dent		***	***	***	***	***	NS
0PPI	315	15.82±0.23^{a}	56.54±0.24^{a}	48.45±0.25^{a}	58.91±0.31^{a}	10.66±0.08^{a}	9.23±0.09
1PPI	64	26.02±0.70^{b}	65.12±0.74^{b}	55.36±0.76^{b}	72.25±0.95^{b}	13.00±0.25^{b}	9.40±0.27
2PPI	61	28.33±0.65^{c}	65.39±0.68^{c}	56.33±0.71^{b}	73.30±0.88^{bc}	12.78±0.23^{b}	9.44±0.25
3PPI	74	29.75±0.83^{cd}	66.83±0.87^{cd}	59.01±0.90^{c}	73.67±1.13^{bc}	13.69±0.29^{c}	8.93±0.32
4PPI	427	31.09±0.98^{d}	67.67±1.03^{d}	58.82±1.07^{c}	76.15±1.33^{c}	13.84±0.35^{c}	9.75±0.38
Sex*Dent		***	**	NS	NS	NS	NS
Female*0PPI	204	15.35±0.27	55.78±0.28	48.11±0.29	58.95±0.37	10.64±0.09	9.36±0.10
Female*1PPI	55	23.43±0.52	62.25±0.55	54.06±0.57	69.83±0.71	12.79±0.18	9.74±0.20
Female*2PPI	50	25.73±0.55	63.43±0.58	55.66±0.60	72.60±0.75	13.38±0.19	9.88±0.21
Female*3PPI	68	26.53±0.47	64.50±0.50	56.53±0.51	72.84±0.64	13.39±0.17	9.61±0.18
Female*4PPI	423	28.09±0.19	64.85±0.20	57.15±0.20	74.56±0.25	13.93±0.06	9.76±0.07
Male*0PPI	111	16.29±0.37	57.29±0.39	48.78±0.40	58.88±0.50	10.68±0.13	9.11±0.14
Male*1PPI	9	28.62±1.30	68.00±1.37	56.66±1.42	74.66±1.77	13.22±0.46	9.05±0.50
Male*2PPI	11	30.92±1.18	67.36±1.24	57.00±1.28	74.00±1.60	12.18±0.42	9.00±0.45
Male*3PPI	6	32.96±1.60	69.16±1.68	61.50±1.74	74.50±2.16	14.00±0.57	8.25±0.62
Male*4PPI	4	34.10±1.96	70.50±2.06	60.50±2.13	77.75±2.65	13.75±0.70	9.75±0.76

NS: Not significant (P>0.05), *P<0.05, **P<0.01, ***P<0.001; BW - Body Weight; CG - Chest Girth; BL - Body Length; PW - Pelvic Width; WH - Wither Height; EL - Ear length; 0PPI - sheep with milk teeth (>about 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2 PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above

Strong and positive correlations between body weight and other linear body measurements have also been reported by different scholars (Sowande and Sobola, 2007). The high correlation coefficients between body weight and linear body measurements for all age groups suggest that either of these variables or their combination could provide a good estimate for predicting live weight of Farta sheep.

Prediction of weight using body measurements

Regression models developed are presented in Figures 1, 2, 3, 4 and Table 3. Different regression models were developed for different sexes, dentition groups and for the pool with different coefficient of determinations. The regression equations developed had different coefficient of determination for different age groups. This might be because of the difference in growth and proportion of conformational traits at different ages. This tends to infer that at different ages different conformational traits may more successfully predict weight.

Chest girth was the first variable to explain more variation than other variables in both male and female Farta sheep. However, using of chest girth was less reliable in predicting the body weight at 1, 2 and 3PPI dentition groups. In these age groups, height at withers and body length accounted for the greatest amount of variation in body weight. The correlations between body weights and body measurements in pooled data were higher than those at different age groups. This might be due to more or less similar environmental influence at different age groups (Thiruvenkadan, 2005).

The coefficient of determination of the fitted equations (in general) decreased as the age of sheep advances indicating that the fitted equations can predict weight for younger sheep with better accuracy than for older ones. The highest coefficient of determination was obtained when the equations were fitted for the pool (for all age group).

Table 2. Correlation coefficients between body weight and linear body measurements of Farta sheep by age and dentition groups.

Parameter	Measurements	WH	BL	CG	PW	EL
Overall	BW	0.78**	0.78**	0.87**	0.73**	0.12**
	WH		0.75**	0.72**	0.63**	0.19**
	BL			0.66**	0.65**	0.21**
	CG				0.72**	0.11**
	PW					0.16**
Dentition						
0PPI	BW	0.75**	0.68**	0.78**	0.60**	0.17**
	WH		0.62**	0.60**	0.51**	0.16**
	BL			0.44**	0.45**	0.23**
	CG				0.58**	0.15**
	PW					0.11*
1PPI	BW	0.64**	0.41**	0.50**	0.35**	-0.02^{NS}
	WH		0.57**	0.31*	0.24^{NS}	0.18^{NS}
	BL			-0.01^{NS}	0.21^{NS}	0.25*
	CG				0.30*	-0.22^{NS}
	PW					0.11^{NS}
2PPI	BW	0.51**	0.47**	0.43**	-0.00^{NS}	-0.27*
	WH		0.44**	0.19^{NS}	-0.2^{NS}	-0.12^{NS}
	BL			0.02^{NS}	0.06^{NS}	0.03^{NS}
	CG				0.21^{NS}	-0.24^{NS}
	PW					0.21^{NS}
3PPI	BW	0.46**	0.62**	0.50**	0.49**	-0.03^{NS}
	WH		0.52**	0.14^{NS}	0.13^{NS}	-0.06^{NS}
	BL			0.10^{NS}	0.33**	0.01^{NS}
	CG				0.27*	0.06^{NS}
	PW					0.07^{NS}
4PPI	BW	0.35**	0.45**	0.64**	0.23**	0.00^{NS}
	WH		0.44**	0.25**	0.18**	0.18**
	BL			0.12**	0.22**	0.14**
	CG				0.16**	-0.03^{NS}
	PW					0.07^{NS}
Sex						
Female	BW	0.75**	0.76**	0.86**	0.71**	0.11**
	WH		0.73**	0.70**	0.62**	0.20**
	BL			0.62**	0.62**	0.20**
	CG				0.69**	0.09**
	PW					0.14**
Male	BW	0.86**	0.83**	0.87**	0.71**	-0.00^{NS}
	WH		0.79**	0.78**	0.62**	0.01^{NS}
	BL			0.67**	0.62**	0.09^{NS}
	CG				0.70**	0.00^{NS}
	PW					0.03^{NS}

***P<0.01; *P<0.05; NS Not significant; BW - Body Weight; CG - Chest Girth; BL - Body Length; PW - Pelvic Width; WH - Wither Height; EL - Ear length; 0PPI - sheep with milk teeth (>about 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2 PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above.*

BW = -34.61+0.93WH

BW = -26.576+0.9288BL

BW = -53.86+1.58WH-0.0053WH^2

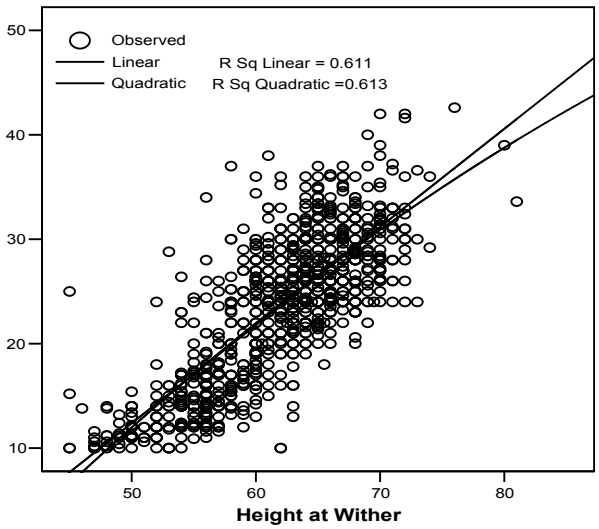


Figure 1. Estimation of weight using height at wither.

BW = -65.519+2.4207BL-0.0141BL^2

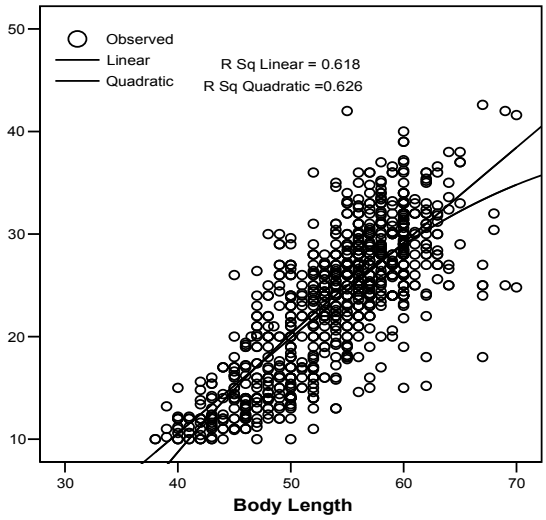
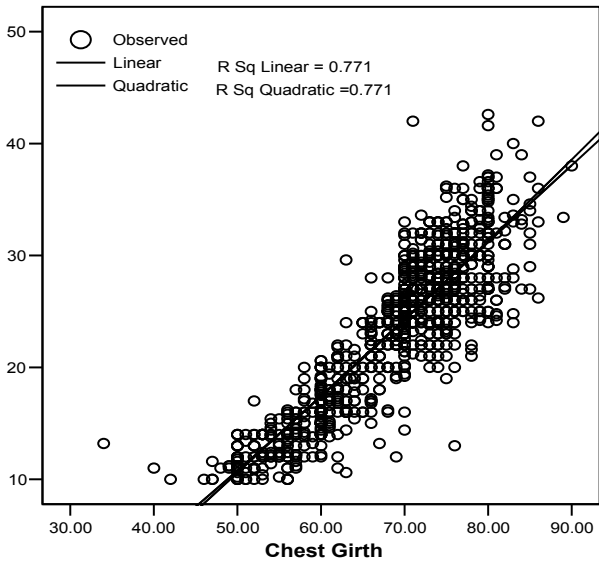


Figure 2. Estimation of weight using body length.

BW = -23.738+0.6866CG

BW = -19.173+20.5459CG+0.0011CG^2



BW = -8.3203+2.5127PW

BW = -50.880+9.4674PW-0.2767PW^2

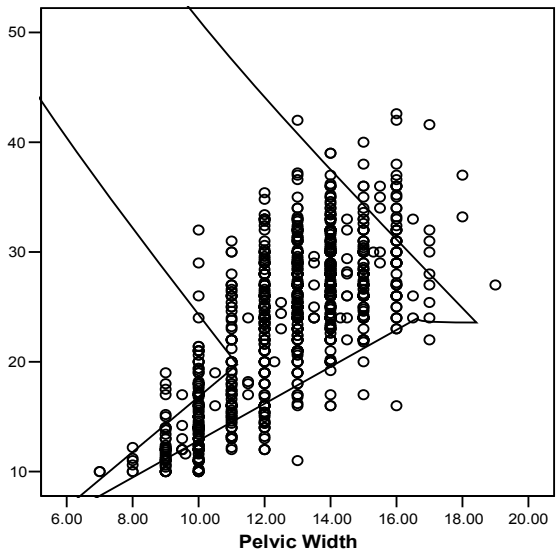


Table 3. Linear and Multiple linear regression equations for predicting body weight from linear body measurements for sex and dentition groups.

Age	Model	B0	X1	X2	X3	X4	X5	R2	R2 Change	SE
Dentition										
0PPI	CG	-11.482	0.461					0.625	0.625	2.316
	CG+BL	-20.777	0.353	0.324				0.765	0.140	1.837
	CG+BL+WH	-24.781	0.286	0.228	0.224			0.802	0.038	1.686
	CG+BL+WH+PW	-24.815	0.269	0.218	0.214	0.194		0.806	0.003	1.675
1PPI	WH	-17.747	0.665					0.416	0.416	3.740
	CG+WH	-30.006	0.269	0.558				0.516	0.100	3.432
2PPI	WH	-6.071	0.510					0.259	0.259	3.181
	CG+WH	-21.420	0.271	0.442				0.376	0.117	2.945
	CG+BL+WH	-35.729	0.287	0.414	0.286			0.469	0.093	2.741
3PPI	BL	-7.121	0.600					0.396	0.396	3.099
	CG+BL	-32.775	0.385	0.557				0.588	0.192	2.578
	CG+BL+PW	-34.245	0.341	0.495	0.610			0.624	0.036	2.481
4PPI	CG	-16.677	0.601					0.411	0.411	3.192
	CG+BL	-35.765	0.556	0.392				0.549	0.139	2.794
Sex										
Females	CG	24.306	0.694					0.755	0.755	3.273
	CG+BL	-34.503	0.516	0.416				0.830	0.076	2.722
	CG+BL+PW	-34.108	0.478	0.381	0.319			0.834	0.004	2.691
	CG+BL+PW+WH	-36.183	0.452	0.331	0.288	0.113		0.838	0.003	2.667
	CG+BL+PW+WH+EL	-35.454	0.448	0.336	0.294	0.119	-0.124	0.838	0.001	2.663
Males	CG	-23.534	0.691					0.767	0.767	3.598
	CG+BL	-35.569	0.455	0.525				0.877	0.110	2.625
	CG+BL+WH	-38.688	0.365	0.381	0.269			0.893	0.016	2.453
Pooled										
	CG	-23.686	0.686					0.771	0.771	3.32
	CG+BL	-34.038	0.497	0.433				0.846	0.076	2.72
	CG+BL+WH	-36.822	0.456	0.358	0.156			0.852	0.006	2.67
	CG+BL+WH+PW	-36.399	0.428	0.335	0.149	0.255		0.855	0.002	2.65
	CG+BL+WH+PW+EL	-35.404	0.424	0.341	0.154	0.265	0.255	0.856	0.001	2.64

[2]Dependent Variable: BW (Body weight) - Body Weight; CG - Chest Girth; BL - Body Length; PW – Pelvic Width; WH - Wither Height; EL - Ear length. [1]Dentition 0PPI - sheep with milk teeth (> 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2 PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above.

Conclusion

Body weight and other body measurements were significantly correlated with each other. From the result, it can be concluded that using linear body measurements can be a simple method for estimating body weight of Farta sheep. Body weight had higher association