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Estimation of body weight and dressed weight in different sheep breeds of Karnataka

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Abstract
Animal biometry can succour in a great extent to predict the body weight in livestock when accurate scales for measuring mass is in accessible at most of the rural establishments. Under rural conditions however, where scales and records may be absent, it may be difficult to know the weight of sheep. Various body measurements are of value in judging the quantity characteristics of meat and also are helpful in developing of suitable selection criteria (Islam *et al.* 1991). Procedures for estimating weight of small ruminants in such conditions include the use of weight visual appraisal, and use of body linear measurements among others, all these measurements give estimates of the animals live weight and in turn can find out the dressed weight, which will be a difficult task but the farmer get monitory benefits. This study was designed to estimate body weight and dressed weight from various body measurements in Yalaga, Kenguri and Bannur sheep reared under rural extensive production system. Animals were brought from native tract to slaughter house. Data were recorded from 60 male sheep in each breed of 6-9 months age to investigate the relationship between body weight and dressed weight with body measurements such as body height, body length and chest girth. The statistical analysis revealed the body height and chest girth are the traits showing significant results for prediction of body weight and dressed weight in Yalaga, Kenguri and Bannur, except for body weight in Kenguri where only the body height showing significant results for body weight and dressed weight. The R^2 value ranges from 0.46 to 0.72, and highest R^2 value were found in Kenguri between body weight and body height (0.72; $p<0.01$).The analysis was done by Multiple Regression Analysis and equations were developed based on high R^2 and low AIC and Cp criterion.

Keywords: Breed, Regression, Yalaga, Kenguri, Bannur, sheep

Introduction
Sheep meat production is indispensable to meet protein needs of people throughout the world. Most scientific studies in relation to growth, one of the critical characteristics in sheep production, have been conducted to increase meat production per sheep. Information on body weight with several body measurements is necessary not only to monitor the growth of the sheep but also to estimate genetic correlations between body weight, dressed weight and body measurements. Besides, genetic and non-genetic components for the growth parameters must be estimated for improving better selection strategies relating to growth and development of sheep**.** Body weight is measured not only to evaluate carcass yield (Afolayan *et al.*, 2006) [2] and condition of the animal as a selection criterion.

Knowing the live body weight of small ruminants is important for a number of reasons, such as for breeding, correct feeding, health (Slippers *et al*., 2000) [40] and an indicator of breed standards (Pesmen and Yardimci, 2008) [33], provides great convenience for the prediction of body weight without weigh bridges (Afolayan *et al.*, 2006; Adeyinka, and Mohammed, 2006; Yakubu, 2009) [2, 1]. Body measurements have been used to predict the body weight in small ruminant's studies in particular sheep and goat (Prasad *et al.*, 1990; Aziz and Sharaby, 1993; Enevoldsen and Kristensen, 1997; Valdez *et al*., 1997; Atta and El Khidir, 2004; Riva *et al*., 2004; Afolayan *et al*., 2006; Nayak *et al*., 2008; Otoikhian *et al*., 2008; Sowande and Sobola, 2008; Edea *et al*., 2009; Getachew *et al*., 2009; Kunene *et al*., 2009; Cam *et al*., 2010a; Iqbal, 2010; Tadesse and Gebremariam, 2010; Oke and Ogbonnaya, 2011; Mohammad *et al*., 2012; Musa *et al*., 2012; Ravimurugan *et al*., 2013; Shirzeyli *et al*., 2013; Younas *et al*., 2013) [34, 4, 11, 47, 3, 37, 2, 30, 32, 41, 10, 13, 21, 6, 17, 42, 31, 26, 29, 36, 38, 51] and goat (Tandon, 1965; Mukherjee *et al*., 1981;

Mohammed and Amin, 1997; Das *et al*., 1990; Prasad *et al*., 1990; Hassan and Ciroma, 1991; Ulaganathan *et al*., 1992; Slippers *et al*., 2000; Singh and Mishra, 2004; Gül *et al*., 2005; Adeyinka and Mohammed, 2006; Khan *et al*., 2006; Moaeen-ud-Din *et al*., 2006; Rahman, 2007; Pesmen and Yardimci, 2008; Cam *et al.*, 2010b; Tsegaye, 2013) [43, 28, 27, 8, 34, 16, 46, 40, 15, 25, 35, 33, 27, 2, 7, 45]. In recent years, there have been a great number of studies on the prediction of body weight from various body measurements taken at different growth periods of sheep (Afolayan *et al.*, 2006; Kunene *et al.*, 2009; Cam *et al.*, 2010a) [15, 21, 6] and goat (Gul *et al.*, 2005; Khan *et al.*, 2006; Moaeen-ud-Din *et al.*, 2006; Rahman, 2007; Cam *et al.*, 2010b) [25, 35, 7].

Attempts have been made to arrive at a most probable body weight prediction equation for certain breeds of small ruminants (Das *et al.* 1990, Mishra *et al.* 1987) [8, 24] for the study. In these studies, Generally, Pearson correlation and regression coefficients have been used to determine the bivariate relationships between body weight, dressed weight and various body measurements. For analysing multiple relationships among all traits, use of Multiple Regression Analysis (MRA) is the simple way to predict body and dressed weight using these body measurements.

The present study involves the development of prediction equations for body weight (BW) and dressed weight (DW) based on body measurements like body height (BH), body length (BL) and chest girth (CG) in Yalaga, Kenguri and Bannur breeds of sheep. Yalaga, a tall non-descript breed of sheep found in the Bagalkote district of Karnataka. It is also known as the Belagi Kuri or Bili Kuri, having good morphometric traits with body weight (54.78±0.96kg), body height (86.29±0.49cm), body length (83.44±0.68cm) and chest girth (92.32±0.77cm) at the adult age group and had meat potentials (Dayanand, 2013) [9]. Kenguri is a proven mutton breed of Northern Karnataka found in the districts of Raichur, Koppal and Yadgir. Good morphological characters with body weight (52.6±0.86kg), body height (81.5±0.43cm), body length (74.7±0.45cm) and chest girth (89.4±0.54cm; Jain *et al*., 2013) at adult age were found with a population of 4.3 lakh in the country (Livestock census, 2012) [23]. Bannur, Southern mutton breed of Karnataka, a short and stocky breed with the morphological traits like body weight as 37.21±0.85kg, body length as 60.17±0.49cm, body height as 53.8±0.56cm and chest girth as 68.1±0.63 at adult age group which was found in the Mandya, Mysuru, Chamrajnagar and Bengaluru rural districts (Jain *et al*., 2014).

Materials and Methods

Location and Animals

The present study was conducted at Karnataka Meat and Poultry Marketing Corporation (KAMPCO), Bruhath Bengaluru Mahanagar Palike, Bengaluru and various mutton shops found at Bengaluru, where the farmers brought their animals Bannur, Kenguri and Yalaga for slaughter.

Data collection and Statistical analysis

Data for the present study was collected from 60 male animals each of Yalaga, Kenguri and Bannur, with the age group of 6-9 month. For our investigation, pre-slaughter traits such as body length (from point of shoulder to point of tuber ischii), body height (from the base of the fore-hoof to highest point of the withers), chest girth (around the thoracic cavity just behind the elbow joint) were taken by metal tape in centimetres (cm), and body weight was taken by the electronic weighing balance of 100kg capacity. Sheep age was estimated from its dentition pattern and varied from 6 to 8 milk teeth (FAO, 2012).

Dressed weight was measured after the sacrifice of animals. The jugular vein was severed with a sharp knife for sheep sacrifice; head was removed at occipito-atlantal joint after complete discharge of blood. De-skinning was done and visceral organs (heart, kidney, lungs, trachea, liver and gut) were separated from the carcass. The remaining muscle and bone portion of the carcass was dressed weight, which will be taken in kilograms (kg) by electronic weighing balance of 100kg capacity.

The linear relationship between bodyweight and dressed weight with body measurements was estimated using Pearson correlation coefficients. The dependent variable can be predicted by using regression model, based on lower Conceptual predictive criterion (Cp) and Akaike information criterion (AIC) and the high coefficient of determination (R^2) value to choose the best fit model.

To predict the dressed weight (or carcass weight) and body weight from body measurements, linear-regression analysis was done by using Multiple Linear Regression Analysis by using SAS-9.3(2013), generalized linear model (GLM) procedure.

1. The prediction equation for dressed weight (or carcass weight) from pre-slaughter traits can be estimated by using following equation.

$$DW = \beta_0 + \beta_1 (BH) + \beta_2 (BL) + \beta_3 (CG) + e$$

Where, DW= Dressed weight (Carcass weight) (Kg), β_0= Intercept, β_1, β_2 and β_3 are partial regression coefficients, BH= Body height (cm), BL= Body length (cm), CG= Chest girth (cm), e= Error (Residual).

2. The prediction equation for body weight from the morphological characters namely body height, body length and chest girth can be estimated by following equation.

$$BW = \beta_0 + \beta_1 (BH) + \beta_2 (BL) + \beta_3 (CG) + e$$

Where, BW= Body weight (Kg), β_0= Intercept, β_1, β_2 and β_3 are partial regression coefficients, BH= Body height (cm), BL= Body length (cm), CG= Chest girth (cm), e= Error (Residual).

The significance control for each regression coefficient was performed using a t-test statistic. The appropriateness of the multiple regression analysis was decided by the coefficient of determination (R^2), Conceptual predictive and Akaike information criterion.

Results and Discussion

The mean weight with standard error of Yalaga, Kenguri and Bannur sheep breeds were presented in the Table 1. The average body measurements were similar in Yalaga and Kenguri, except for chest girth and found significantly (p< 0.01) higher compared to Bannur except chest girth where it was showing non-significant difference with Yalaga sheep. The best fit models to predict the body weight were constructed using body measurements as dependent variables. Only those traits were significantly contributed to better fit were included in the model. Using these variables the predicted equations for the body weight and dressed weight in each sheep breed was given in Table 2 to 5.

Among different traits studied, BH and CG were considered as independent variables in Bannur and Yalaga, and only BH in Kenguri sheep, as other traits had non-significant effect on body weight. The best equations were BW= -29.53 + 0.45 (BH) +0.32 (CG), (R^2=56%) for Bannur, BW= -18.24 + 0.22 (BH) +0.39 (CG), (R^2=54%) for Yalaga and BW= -40.57 + 0.91 (BH), (R^2=72%) for Kenguri. Chest girth and body height is showing the best predictor of body weight in the present study due to higher R^2 value and low CP and AIC criterion in Yalaga and Bannur, but in Kenguri only body height shows the best predictor.

Similar to our study, many researchers found the better prediction equation for body weight when they considered the chest girth and body height with high R^2 value in Muzaffarnagari 85.40% (Bhadula *et al*., 1979) [15], Nellore ram 94.29% (Narasimha, 2002) [48], Ganjam sheep 68% (6 months), 74% (9 months) and 72% (12-months; Nayak *et al*., 2008) [30], Bannur sheep 90.18% (Nagraja *et al*., 1996) and in Zulu sheep 71% (Kunene *et al*., 2009) [21]. FAO have used height at withers as a prime indicator (Wilson, 1995) [49]. Atta and El Khadir (2004) [3] also reported an increased coefficient of determination based on curvilinear functions when estimating the live weight using heart girth of 2–8-month-old Nilotic sheep. Lawrence and Fowler (1997) [22] reported that the relationship between live weight (LW) and heart girth is curvilinear for animals growing over a wide weight range. Goe *et al*., (2001) [14] suggested that higher order polynomial equations are more appropriate for predicting the weight of growing animals. Although the use of wither height (WH) produced fairly good estimates (R^2 = 0.64–0.67) of LW for the sheep with milk set of teeth, these results indicate that more parameters would need to be added to WH to obtain a higher R^2. Thiruvenkandan (2005) [44] obtained higher R^2 when he used WH and HG compared to the use of WH or HG alone to compute LW equation of 1–12months old Kanni-Adu goats in India.

As that of the body weight, dressed weight can also be predicted from body measurements based on the best fit model, which shows higher R^2 value and lower CP and AIC criterion. The best prediction equation for predicting the dressed weight from body measurements is DW= -16.81 + 0.25 (BH) + 0.16 (CG), (R^2=46%) in Bannur, DW= -18.25 + 0.21 (BH) + 0.24 (CG), (R^2=50%) in Yalaga and DW= -39.47 + 0.60 (BH) +0.16 (CG), (R^2=62%) in Kenguri. Similar to our study, Ameha *et al*., 2001 used linear regression model for estimating the carcass weight in Babari kids based on the fasten body weight. They found the higher R^2 value when only fasten body weight is the variable taken 96.1%, and also found the high R^2 value when body length, neck circumference, body height, heart girth and thigh circumference was considered.

Hence it is observed that chest girth and body height are the traits showing significant results for identification of body weight and dressed weight in Yalaga, Kenguri and Bannur sheep breeds and the similar results were also found in Madras Red (Vimal Selvaraj, 2002) [48], Ganjam (Nayak *et al*., 2008) [30], Zulu (Kunene *et al*., 2009) [21], Muzaffarnagari (Bhadula *et al*., 1979) [15], Karayaka (Cam *et al*., 2010b) [7] and Bannur sheep (Nagraja *et al*., 1996).

Table 1: Mean ± S.E of different pre-slaughter measurements in Bannur, Kenguri and Yalaga breeds of sheep

Pre-slaughter trait	Bannur	Kenguri	Yalaga
Body weight (kg)	19.90±0.58^b	24.40±0.61^a	25.23±0.54^a
Body length (cm)	63.13±0.56^b	65.84±0.44^a	65.89±0.79^a
Body height (cm)	60.40±0.61^b	68.51±0.47^a	70.22±0.78^a
Chest girth (cm)	69.61±0.60^a	66.76±0.60^b	70.44±0.67^a

Means with similar superscript within a row differs non-significant. Means with dissimilar superscript within a row differ significant at p<0.01

Table 2: Multiple Regression analysis on Yalaga, Kenguri and Bannur breeds of sheep for body weight from body measurements

	Yalaga sheep			
Variable	Parameter Estimates	Standard Error	t value	P> |t|
Intercept	-18.24	5.38	-3.39	0.00
Body Height	0.22	0.08	2.39	0.01
Chest girth	0.39	0.09	4.33	<0.0
	Kenguri sheep			
Intercept	-40.57	5.30	-7.66	<0.01
Body Height	0.91	0.07	12.19	<0.01
	Bannur sheep			
Intercept	-29.53	5.96	-4.95	<0.01
Body Height	0.45	0.12	3.79	0.01
Chest girth	0.32	0.12	2.36	0.01

Table 3: Prediction equation of body weight from morphological traits in Yalaga, Kenguri and Bannur breeds of sheep.

Trait	Breed	Equation	R^2
Body weight	Bannur	BW= -29.53+ 0.45 (BH)+0.32 (CG)	0.56
	Kenguri	BW= -40.57 + 0.91 (BH)	0.72
	Yalaga	BW= -18.24 + 0.22 (BH) +0.39 (CG)	0.54

Table 4: Multiple Regression analysis on Yalaga, Kenguri and Bannur breeds of sheep for dressed weight from body measurements

	Yalaga sheep			
Variable	Parameter Estimates	Standard Error	t value	P> |t|
Intercept	-18.25	4.18	-4.37	<0.01
Body Height	0.21	0.06	3.46	0.01
Chest girth	0.24	0.07	3.34	0.01
	Kenguri sheep			
Intercept	-39.47	5.4	-7.30	<0.01
Body Height	0.60	0.10	6.13	<0.01
Chest girth	0.16	0.08	2.12	0.04
	Bannur sheep			
Intercept	-16.81	3.93	-4.28	<0.01
Body Height	0.25	0.08	3.12	0.00
Chest girth	0.16	0.08	2.05	0.04

Table 5: Prediction equation of dressed weight from morphological traits in Yalaga, Kenguri and Bannur breeds of sheep.

Trait	Breed	Equation	R^2
Dressed weight	Bannur	DW= -16.81 + 0.25 (BH) + 0.16 (CG)	0.46
	Kenguri	DW= - 39.47 + 0.60 (BH) +0.16 (CG)	0.62
	Yalaga	DW= -18.25 + 0.21 (BH) + 0.24 (CG)	0.50

Conclusion

The study concludes that, similar body measurements were found in Yalaga and Kenguri and were found significantly (p< 0.01) higher than Bannur sheep except for chest girth where it is non-significantly differ. However, only BH and CG showed significant (*p*< 0.01) results for prediction of body weight and dressed weight in both Yalaga and Bannur, but in Kenguri only BH showed significant results. At the same time, body length was non-significantly influencing the prediction of BW and DW in all three breeds of sheep *viz*. Yalaga, Kenguri and Bannur

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