Correlation and regression analysis of the body measurements of the Doro Ncanga Buffalo (Bubalus bubalis) reared extensively in the Savanna of Mount Tambora Dompu Regency, Indonesia

by Maskur Maskur

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RESEARCH PAPER

Correlation and regression analysis of the body measurements of the Doro Ncanga Buffalo (*Bubalus bubalis*) reared extensively in the Savanna of Mount Tambora Dompu Regency, Indonesia

Husni Husni[1], Maskur Maskur[2], Chairussyuhur Arman[2*]
[1]Postgraduate Program of the Livestock Resources Management University of Mataram, [2]Faculty of Animal Science University of Mataram, West Nusa Tenggara Province, Indonesia. *Corresponding author's email: chairussyuhur.arman@yahoo.com

ABSTRACT

The objectives of the present study were to examine the correlation and regression of body measurements of the Doro Ncanga buffaloes in the savanna of Mount Tambora Dompu Regency, Indonesia. A total of 339 animals were used in this study. In female, body weight (BW) was found to be significantly ($p<0.05$) correlated with body length (BL), the degree of correlation increased from 0-6 ($r=0.319$) to 13-24 months ($r=0.394$), thereafter decreased at >36 months ($r=0.160$). The BW was not significantly correlated with height at wither (HW) for all 5 age groups. However, BW and heart girth (HG) were highly correlated ($p<0.01$) between age groups 0-6 ($r=0.967$) and >36 months ($r=0.978$). The BL was significantly ($p<0.01$) correlated with HW from 0-6 to 13-24 months of age, except for 25-36 months of age. The correlation between BL and HG was highly significant ($p<0.01$) at 0-6 ($r=0.427$) and 13-24 (0.371) months of age, then decreased with the increase of age. The HW had no strong correlation with HG at all groups. The regression model of BW changes with HG was predictable with R^2 values ranged from 0.896 to 0.957. In male, BW had a strong correlations with HG for age groups 0-6 ($r=0.979$) and 7-12 months ($r=0.972$). The BL and HW were not highly correlated with BW in all groups. However, BW was significantly ($p<0.01$) correlated with HG for age groups 0-6 ($r=0.979$) and 7-12 months ($r=0.972$). Their R^2 values were 0.958 and 0.945, respectively. A highly significant ($p<0.01$) correlations were also observed between BL and HW for age groups 0-6 months ($r=0.677$) and 7-12 months (0.462). The R^2 values were 0.458 and 0.214 for the two different age groups, respectively. The estimates of the coefficient of determinations and predictive equations show that HG alone could be used to predict BW of female and male Doro Ncanga buffalo at different age groups.

Keywords: Body weight; Body measurement; Correlation; Regression equation; Doro Ncanga buffalo

INTRODUCTION

Doro Ncanga buffalo is regarded as swamp buffalo (*Bubalus bubalis*) and farmers in Dompu keep the buffalo as sources of draught power to plow the fields during cultivation of agricultural crops, life savings that can be cashed at any time if there is an urgent need. In addition, rearing buffalo is intended to produce meat, milk, manure and additional household incomes. Although the role of buffalo is important, the attention given by the local government is still very lacking in terms of the development of their population, especially the application of technology to improve the efficiency of mating, procurement of feeds, and management of rearing and health.

In the Regency of Dompu, buffalo are mostly concentrated in the savanna of Doro Ncanga part of Mount Tambora areas. In 2016 the population of buffalo has recorded 23.943 heads (NTB, 2017). In this savanna, farmers have generally maintained their animals in extensive and traditional ways. Rearing buffalo in large herds by releasing them freely grazing to native grasses raises some problems in terms of reproduction. Mating becomes unfocused and indiscriminated among the buffalo either within the same or different herds that caused inbreeding. As a result, it is quite common to see albino calves running with their dams whose horns are bent downward. In addition, the availability of adult male buffalo is very scanty and young calves that have not been reached full sexual and body maturity probably involve in the mating activities. Mating with unproven qualified bulls or immature calves leads to decrease in the productivity of Doro Ncanga swamp buffaloes due to decreasing of the genetic materials that resulted from inbreeding.

The decrease in productivity is reflected in the shape and body size of Doro Ncanga buffalo, such as lower body weight and body measurements. Data related to body weight and body measurements of Doro Ncanga buffalo are still not available in the literature. Under field conditions in the savanna of Doro Ncanga, farmers are getting difficult in determining and predicting the precise weight of the buffalo because weighing scales are not commonly available. The accurate estimation of livestock weights is important for many purposes such as determining ration amounts, agreeing on sale prices and for ensuring the correct therapeutic dosing of animals (Lesosky *et al.*, 2013).

There are many studies that have aimed to estimate weights from various body measurements of buffaloes (Paul and Das, 2012; Buranakarl *et al.*, 2013; Dhillod *et al.*, 2017). Ozoje and Mbere (2002) reported that the use of skeletal dimensions such as heart girth and height at withers has been considered as good indicators of live weight. Additionally, the measurement of heart girth can be used in predicting body weight in goats (de Villiers *et al.*, 2009) and West African Donkey (Nininahazwe *et al.*, 2017). The usual practice of measuring the body measurements of animals is using a cloth tape measure. European-based weigh tapes developed for Holstein or other European beef breeds consistently overestimate the true weight of east African shorthorn zebu (SHZ) cattle, which have very different conformations (Mwacharo *et al.*, 2006; Machila *et al.*, 2008). However, the use of European-based weighs tapes for measuring heart girth of Doro Ncanga buffalo has not been practiced. There is the need to create a regression model that provides a highly reliable and accurate method for predicting body weights of Doro Ncanga buffalo using a single heart girth measurement which can be easily obtained with a tape measure in the field setting. Determination of body weight of an animal is necessary to calculate its feed requirements, monitor growth, determine breeding age, marketing weight and estimate its cash value (Payne, 1990; Erat, 2011).

The objectives of the present study were (1) to find out the correlation of coefficients of body weight and body measurements across different age groups in female and male Doro Ncanga swamp buffaloes, (2) to determine the degree of accuracy of a prediction equation for body weight translated from heart girth written on the measuring tape and other body measurements to be used by farmers for estimating the weight of their female and male buffaloe.

MATERIALS AND METHODS

Site and Time

The study was conducted in Doro Ncanga savanna of Mount Tambora, Dompu Regency, West Nusa Tenggara Province for eight months (July 16, 2015, to March 16, 2016). Doro Ncanga savanna is one of large native grazing communal areas for buffaloes reared by farmers who live in the surrounding areas of the location.

Animals

A total of 339 Doro Ncanga swamp buffaloes were used that consisted of 246 females and 93 males. The female animals were classified into five different age groups (0-6, 7-12, 13-25, 26-36, and >36 months) while the male animals were classified into two different age groups (0-6 and 7-12 months). Age of each animal was estimated from visual assessment of eruption and wear of teeth and farmer recall, and an age group was assigned to each animal.

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Data collection

Data were obtained from each animal of the respective age groups and sex that include body weight (BW), body length (BL), height at wither (HW) and heart girth (HG). BW was determined using the girth tape (a measuring band) marked in centimetres with the converted body weight associated with that unit in kilograms following measuring the girth of buffalo. The HG tape measured the circumference of the chest just behind the forelegs (Khan *et al.*, 2006). BL was measured from point of the shoulder to the point of tuber ischii, and HW was measured as the distance from the base of the hoof to the highest point of the withers (Ugur, 2005). All these body dimensions taken at different age groups and sex were measured by using a specially designed graduated wood stick fitted on support on base and a sliding stick on the top in centimeters. To ensure a consistent methodology, all measurements (Figure 1) were carried out by the same person.

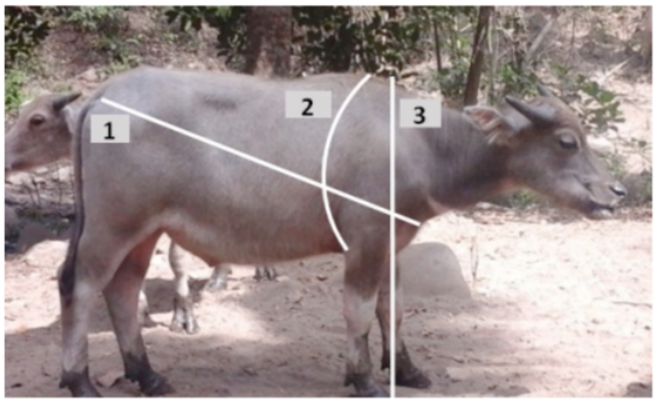

Figure 1. Body measurements were taken by tape and stick measure with 1 cm precision. (1) BL, (2) HG and (3) HW.

Data Analysis

Simple correlation coefficients were calculated to ascertain interrelationships among body weights and body measurements for each age and sex groups (Steel and Torrie, 1980). Additionally, the stepwise regression method was used to determine the best-fitted regression equation for all age groups of animals. Coefficients of determination values (R^2) were used to compare the efficiency of the best-fitted regression equations.

RESULTS

Correlation between body weight and body measurements of the female

The coefficient correlations between body weight (BW) and body length (BL) were positive and significant ($p<0.05$), their degree of correlations increased from the age group 0-6 months (r=0.319) to 7-12 months (r=0.355), and achieved a high degree of correlation ($p<0.01$) at the age of 13-24 months (r=0.394). Thereafter, the degree of correlations decreased not significantly ($p>0.05$) at an older age group. Table 1 shows the degree of coefficient correlations between body weight and linear body dimensions in different age groups of Doro Ncanga female buffaloes. However, the phenotypic correlations were not significant ($p<0.05$) for correlation between body

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weight (BW) and height at wither (HW) at all age groups studied. Likewise, highly significant and positive correlation ($p<0.01$) were found between body weight (BW) and heart girth (HG) for all age groups that ranged from 0-6 months (r=0.967) to > 36 months (r=0.978).

The correlation between body length (BL) and height at wither (HW) were highly significant ($p<0.01$) at age groups 0-6 months (r=0.803) and 13-24 months (r=0.432). However, for age groups >36 months, a highly significant and negative correlation ($p<0.01$) were found between these two body dimensions (r=-0.599). The correlation coefficient between body length (BL) and heart girth (HG) was positive and very significant ($p<0.01$) for age groups 0-6 months (r=0.427) and 13-24 months (r=0.371). However, the relationships were low and not significant ($p>0.05$) for the rest of age groups.

Table 1. Pearson correlation of coefficients between body weight and linear body dimensions from Doro Ncanga female buffaloes (N=246).

Age group (months)	n	Pearson correlation coefficient (r)					
		BW *vs* BL	BW *vs* HW	BW *vs* HG	BL *vs* HW	BL *vs* HG	HW *vs* HG
0-6	56	0.319*	0.071	0.967**	0.803**	0.427**	0.144
7-12	45	0.355*	-0.233	0.975**	-0.175	0.116	-0.091
13-24	92	0.394**	0.038	0.947**	0.432**	0.371**	0.032
25-36	41	0.108	0.097	0.957**	0.196	0.026	0.086
> 36	12	0.160	-0.110	0.978**	-0.599*	0.186	-0.162

BW=Body weight, BL=Body length, HW=Height at wither, HG=Heart girth
*Significant at $p<0.05$, **Significant at $p<0.01$

Regression of body weight on body linear measurements of the female

The best-fitted regression equation for each age group of Doro Ncanga female buffaloes was determined based on the magnitude of coefficients of determination (R^2) and these are presented in Tables 2. The present study showed that the regression analysis of body weight (BW) on heart girth (HG) was highly significant ($p<0.01$) throughout age groups followed by higher values of coefficient of determinations (R^2) for their respective age groups. The regression model of body weight (BW) changes with a linear body measurement of heart girth (HG) was predictable with R^2 values varied from 0.896 to 0.957. The R^2 values showed that 89.6 to 95.7 percent of every one-kilogram change in body weight was caused by variables of chest girth.

The regression equation of body weight (BW) (kg) = [0.242 x HG] (cm) + 73.979 at 0-6 months, [0.214 x HG] (cm) + 84.796 at 7-12 months, [0.173 x HG] (cm) + 100.538 at 13-24 months, [0.205 x HG] (cm) + 89.288 at 25-36 months, [0.176 x HG] (cm) + 95.024 at > 36 months groups could be established as a good predictor in female Doro Ncanga buffaloes. Similarly, body length (BL) is best suited for prediction of height at wither (HW) and heart girth (HG) at certain age groups with a various R^2 values (see Table 2). Coefficients of determination (R^2) of body weight on body measurements at different age groups in Doro Ncanga female buffaloes are presented in Table 2.

Table 2. Regression equation and coefficients of determination (R^2) of body weight on body measurements at different age groups in Doro Ncanga female buffaloes.

Age group (months)	Body Measurements		Regression Equation	R^2
0-6	Body Weight *vs*	Body Length	Y = 66.588 + 0.091 BL**	0.102
(56 animals)		Height at Wither	Y = 87.912 + 0.022 HW	0.005
		Heart Girth	Y = 73.979 + 0.242 HG**	0.935
	Body Length *vs*	Height at Wither	Y = 21.028 + 0.874 HW**	0.645

		Heart Girth	Y = 80.403 + 0.373 HG**	0.183
	Height at Wither	Heart Girth	Y = 99.870 + 0.116 HG	0.021
7-12 (45 animals)	Body Weight *vs*	Body Length	Y = 113.998 + 0.025 BL*	0.126
		Height at Wither	Y = 128.841 - 0.036 HW	0.054
		Heart Girth	Y = 84.796 + 0.214 HG**	0.951
	Body Length *vs*	Height at Wither	Y = 134.481 - 0.159 HW	0.031
		Heart Girth	Y = 126.272 + 0.147 HG	0.013
	Height at Wither	Heart Girth	Y = 154.037 - 0.100 HG	0.008
13-24 (92 animals)	Body Weight *vs*	Body Length	Y = 114.998 + 0.033 BL**	0.155
		Height at Wither	Y = 115.328 + 0.004 HW	0.001
		Heart Girth	Y = 100.538 + 0.173 HG**	0.896
	Body Length *vs*	Height at Wither	Y = 44.907 + 0.567 HW**	0.187
		Heart Girth	Y = 60.237 + 0.813 HG**	0.138
	Height at Wither	Heart Girth	Y = 157.309 + 0.053 HG	0.001
25-36 (41 animals)	Body Weight *vs*	Body Length	Y = 121.867+ 0.011 BL	0.012
		Height at Wither	Y = 114.263 + 0.034 HW	0.009
		Heart Girth	Y = 89.288 + 0.205 HG**	0.917
	Body Length *vs*	Height at Wither	Y = 41.878 + 0.665 HW	0.039
		Heart Girth	Y = 148.813 + 0.053 HG	0.001
	Height at Wither	Heart Girth	Y = 148.989 + 0.052 HG	0.007
>36 (12 animals)	Body Weight *vs*	Body Length	Y = 130.010 + 0.010 BL	0.025
		Height at Wither	Y = 129.327 - 0.010 HW	0.012
		Heart Girth	Y = 95.024 + 0.176 HG**	0.957
	Body Length *vs*	Height at Wither	Y = 244.724 - 0.891 HW*	0.359
		Heart Girth	Y = 90.592 + 0.550 HG	0.035
	Height at Wither *vs*	Heart Girth	Y = 204.446 - 0.320 HG	0.026

BW=Body weight, BL=Body length, HW=Height at wither, HG=Heart girth
*Significant at $p<0.05$, **Significant at $p<0.01$

Correlation between body weight and body measurements of the male

Pearson correlations between body weight (BL) and thoracic (heart) girth (HG) was 0.979 ($p<0.01$) and 0.972 ($p<0.01$) for male Doro Ncanga buffaloes 0-6 and 7-12 months of age, respectively. While, correlations between body length (BL) and height at wither (HW) was 0.677 ($p<0.01$) and 0.462 ($p<0.01$) for the same age groups 0-6 and 7-12 months, consecutively. Body weight (BW) of Doro Ncanga male buffaloes at all age groups are lower and not significantly ($p>0.05$) correlated with body length (BL) and height at wither (HW) (Table 2).

Table 3. Pearson correlation coefficients between body weight and linear body dimensions from Doro Ncanga male buffaloes (N=93).

Age group (months)	n	Coefficient correlation (r)					
		BW *vs* BL	BW *vs* HW	BW *vs* HG	BL *vs* HW	BL *vs* HG	HW *vs* HG
0-6	48	0.023	0.104	0.979**	0.677**	0.085	0.119
7-12	45	0.024	-0.145	0.972**	0.462**	0.133	-0.119

BW=Body weight, BL=Body length, HW=Height at wither, HG=Heart girth
**Significant at $p<0.01$

Regression of body weight on body linear measurements of the male

The coefficient of determination (R^2) values were 0.958 and 0.945 for the two different age groups, respectively. From the obtained field data, the regression equation of body weight (BW) (kg) = [0.328 x HG] (cm) + 65.744 at 0-6 months and [0.224 x HG] (cm) + 81.033 at 7-12

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months groups could be established as a good predictor in male Doro Ncanga buffaloes. Regression equation and coefficients of determination (R^2) of body weight on body measurements at different age groups in Doro Ncanga female buffaloes are presented in Table 4.

Table 4. Regression equation and coefficients of determination (R^2) of body weight on body measurements at different age groups in Doro Ncanga male buffaloes.

Age group (months)	Body Measurements		Regression Equation	R^2
0-6	Body Weight *vs*	Body Length	Y = 84.199 + 0.007 BL	0.001
(48 animals)		Height at Wither	Y = 85.502 + 0.036 HW	0.011
		Heart Girth	Y = 65.744 + 0.328 HG**	0.958
	Body Length *vs*	Height at Wither	Y = 27.182 + 0.730 HW**	0.458
		Heart Girth	Y = 92.111 + 0.089 HG	0.007
	Height at Wither *vs*	Heart Girth	Y = 89.361 + 0.115 HG	0.014
7-12	Body Weight *vs*	Body Length	Y = 109.746 + 0.003 BL	0.001
(45 animals)		Height at Wither	Y = 123.619 - 0.027 HW	0.021
		Heart Girth	Y = 81.033 + 0.224 HG**	0.945
	Body Length *vs*	Height at Wither	Y = 38.386 + 0.743 HW**	0.214
		Heart Girth	Y = 88.735 + 0.263 HG	0.018
	Height at Wither *vs*	Heart Girth	Y = 134.808 - 0.147 HG	0.014

BW=Body weight, BL=Body length, HW=Height at wither, HG=Heart girth
**Significant at $p<0.01$

DISCUSSION

This study is in accordance with the report of Bhagat *et al.* (2016) who observed highest correlation coefficient between body weight and body length in female Sahiwal calves of 0-6 and 24-36 months of age. This suggests that body weight and body length of Doro Ncanga female buffaloes increases significantly with age and animals ranging from age groups of 0-6 to 13-24 months have more potential to grow physically. However, the observation of present findings is in contrast with that of Bhagat *et al.* (2016) who noted highest correlation coefficient between body weight and height at wither in female Sahiwal calves between 0-6 and 24-36 months of age.

The highest relationship observed between body weight and heart girth in the present study was in agreement with previous studies in buffalo (Tariq *et al.* 2013), in sheep (Younas *et al.*, 2013), and in cattle (Yan *et al.*, 2009; Lesosky *et al.* 2012; Bhagat *et al.* 2016).

In animals of all age groups, the coefficient correlation between the height at withers (HW) and heart girth (HG) was found to be not significant ($p>0.05$). Even at age groups 7-12 and >36 months, the correlations between these two body dimensions were found to be negative. The lack of this association with change in height may reflect the relatively stable rate of increase in height generally noted during growth of Doro Ncanga female buffaloes.

In relation to the association between body weight (BW) and body measurements (BL and HG), it was seen that body length (BL) has a profound role in early stages of buffalo's life cycle i.e. the first 3 age groups, then its elongated growth was constant to the rest of groups. While the growth of heart girth (HG) increased substantially throughout the life cycle, i.e. from 0-6 to >36 months of age.

The significant correlation observed in this study between body weight (BW) and body measurements (BL and HG), and body length (BL) and body measurements (HW and HG) was also present when regression analyses were conducted with each body weight (BW) factor as the dependent variable and BL and HG as independent variables. In the case of body length (BL) and other body measurements (HW and HG), the previous one is regarded as a dependent factor and

the latter as independent variables. These all data suggest that in body weight at a given age group, increase in the rate of weight gain has the potential to increase subsequent levels of body length (BL) and heart girth (HG) of female Doro Ncanga buffaloes. Similarly, increase in length of the body will be followed by an increase in height and chest girth of the animals as well (Table 2).
In general, regression analysis of body weight on body linear measurements of the female Doro Ncanga buffaloes is in agreement to other studies reported by several researchers (Siddiqui *et al.*, 2015; Katongole *et al.,* 2013; Putra *et al.,* 2010; Paul and Das, 2012).

Table 3 shows the degree of correlation coefficients between body weight and linear body dimensions in different age groups of Doro Ncanga male buffaloes indicate the low and no significant correlation with BL. This is in contrast with that of Bhagat *et al.* (2016) who found the strong correlation between body weight (BW) and body length (BL) in male Sahiwal cattle at 0-6 and 6-12 age groups. The current study also does not support previous research of Paul and Das (2012) who noted high correlation between BW and BL (r=0.722) and BW x HW (r=0.760) in Nili-Ravi male buffalo calves 6-12 months of age (see Table 3).

A highly significant coefficient correlation between body weight (BW) and heart girth (HG) in male Doro Ncanga buffaloes age groups 0-6 and 7-12 months observed in the current studies are in line with the results reported by Parés (2012) who stated that thoracic girth was correlated with live weight from male goats in South Zambia reared under on-farm conditions. The correlations reported in the present study are also similar to other studies in male cattle that found a high correlation between body weight (BW) and heart girth (HG) of 0.976 and 0.875 at 0-6 and 6-12 age groups, respectively (Bhagat *et al.*, 2016). Findings of the study were also supported by Paul and Das (2012) who found a high correlation (r=0.908) between BW and HG in Nili-Ravi buffalo male calves aged 6-12 months. Similarly, this study is in good agreement with Paul and Das (2012) who recorded high correlation (r=0.776) between BL and HW in Nili-Ravi male buffalo calves. The relationships between heart girth (HG) and body length (BL) and height at wither (HW) was found to be low and not significant ($p>0.05$) in Doro Ncanga male buffaloes at all age groups. This is in contradiction with the earlier finding of Paul and Das (2012) who recorded high correlation (r=0.767) between HG and HW in Nili-Ravi buffalo male calves (see Table 3). These all differences can be attributed to differences in breeds and the fact that the animals are raised under different management or environmental conditions (Parés *et al.*, 2012).

CONCLUSIONS

The results obtained from the present study indicated that there were significant correlations between BW) and BL and HG, between BL and HW and HG in both female and male Doro Ncanga buffaloes at different age groups. Therefore, we conclude that the HG measurement would be translated for predicting BW with relative accuracy in Doro Ncanga buffaloes reared under extensive conditions of Mt. Tambora savannah.

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