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Sandeep Dhillod
Department of Livestock Production Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana, India

Vishal Sharma
Department of Livestock Production Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana, India

Madhur
Department of Livestock Production Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana, India

Man Singh
Department of Livestock Production Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana, India

Narender Singh
Department of Livestock Production Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana, India

Corresponding Author:
Sandeep Dhillod
Department of Livestock Production Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana, India

Regression modelling in predicting milk production depending on body measurements of murrah buffaloes

Sandeep Dhillod, Vishal Sharma, Madhur, Man Singh, and Narender Singh

Abstract
The aim of this study was to determine the relationship between daily milk yield and body measurements using multiple regression analyses in order to predict milk yield in Murrah buffaloes. Murrah buffalo is considered one of the promising dairy animals, yet information on their linear body measurements and their relation with performance traits such as milk yield are limited. The regression equation between milk yield and various body parts measurements was calculated from seventy lactating buffaloes. Different equations were studied and their R^2 values were compared with different equations which predict that milk yield had strong relationship with skin thickness and muzzle width.

Keywords: Regression, murrah, milk production, muzzle width, skin

Introduction
Buffaloes (*Bubalus bubalis*) are known to provide meat and milk for human consumption. The buffaloes along with providing the livelihood to human beings, also important for food security in India and popular in Asian countries also. The total buffaloes in the India is 109.85 Million (20th Livestock Census, 2019) showing an increase of about 1.0% over previous Census. India has emerged as largest milk producer country in world with 176.3 MT milk production as per DAHD annual report (2018-19) and ranks first in milk production throughout the world (DADF, GOI). Major contribution in this production comes from buffaloes followed by cattle, goat, camel, yak etc. Nearly 49% of the milk production is contributed by Indigenous Buffaloes and non-descript buffaloes followed by 36% by crossbred cows and non-descript cows. Goat milk shares a contribution of 4% in the total milk production across the country (Annual Report 2018-19, DAHD). The milk yield shows gradual increment over the last few years, the acceleration is good for future of Indian dairy industry. The livestock sector in the Haryana State play a pivotal role in the rural economy through providing income generation, draft power, socio-economic upliftment, employment avenues and better nutrition to human population through livestock products like milk, eggs & meat etc. Haryana is the home tract of world famous ‘Murrah’ buffaloes popularly known as ‘black gold’. The State has since long been the prime source of Murrah germplasm for other States and abroad for up-gradation of their low yielding, nondescript buffaloes (DAHD). Murrah buffalo is considered one of the promising dairy animals, yet information on their linear body measurements and their relation with performance traits such as milk yield are limited.
There is some association between the body measurements, the productive and reproductive traits in buffaloes (Thomas and Chakravarty 2000; Espinosa-Núnêsetal. 2011; Kern *et al.* 2014) [20, 8, 10]. The significance of this association is relatively more in cows and buffaloes because body weight, heart girth and height at withers are the common parameters reported to have some correlation with the milk production (Singh and Prasad, 1983) [18]. Vohra *et al.* (2014) [22] suggested that phenotypic selection in Buffaloes as a means to explain body confirmation of better early maturing “*Gojri*” buffaloes to be used in breeding programmes. Lin *et al.* (1987) [11] reported that milk production traits were all positively correlated with body measurements, suggesting that high producing Holstein first calver should be taller, larger and longer than low producing first calver. He also found that selection for increased milk yield results in greater heart girth, wither height, body length and rump length. Cattle body measurements are phenotypic markers to the production ability for milk yield. Body measurements have economical and vital benefits among dairy cattle, thus, it is very important to measure relationship between the appearance of the animal and its ability to production

(Dehss *et al*., 2007) [7]. Sieber *et al*. (1988) [17] concluded that cows with smaller heart girth and larger paunch girth had significantly higher yields of milk than cows with opposite circumferences.

Agasti *et al*. (1976) found that 300-day lactation yield was positively and significantly correlated with live weight as well as with most of physical traits: the regression of lactation yield was also highly significant on live weight, hip width and paunch girth in Jersey X Hariana and Holstein X Hariana crosses. Wilk *et al*. concluded that body measurements were of little value in predicting milk production, but no basis was found for the often encountered claim of a genetic antagonism between measures of body size and milk production. A body measurement therefore quantifies change in animal performance over the time. They serve as supplemental information to performance test results (Bosman, 1997) [6]. So, the study was done determine the importance of various parts measurement in selection of milch animals. The objectives at this study were to measure buffalo body measurements and milk yield to find the relationship between measurements and milk yield.

Body measurements have economical and vital benefits among dairy cattle, thus, it is very important to measure relationship between the appearance of the animal and its ability to production (Dehss *et al*., 2007) [7].

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Material and Methods

Experiment was conducted at the Buffalo farm of Department of Livestock Production Management, College of veterinary sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar. Measurements were recorded by using self-designed measuring scale, big horn caliper and measuring tape graduated in centimeters scale. Body weight of the lactating buffaloes was taken on weighing platform with the help of 1000 kg capacity "AVERY" weighing balance. Data was collected from 70 lactating Murrah buffaloes of the herd for following body measurement i.e. body weight (BW), muzzle width (MW), lower jaw width (LJW), skin thickness (STK), height at wither (HW), body length (BL), chest girth (CG), abdominal girth (AG), body depth (BD), distance between hip bones (HBD), distance between pin bones (PBD), tail length (TL), tail length up to switch (TSL) and white switch length (WSL).

Multiple regression equations were studied using all body measurements as independent variables and 305 days milk yield as dependent variable as suggested Snedecor and Cochran (1994) [19]. On the basis of multiple regression used, the highest R^2 was calculated. The best prediction equations were developed for 305 days milk yield on the basis of body parts measurement.

Results and Discussion

The results of present study are presented in table 1 and found that the average 2604.8±39.5kg MY in 305 days, 556.1±4.9 kg BW, 152.2 ±0.8cm BL, 17.3±0.1cm MW, 20.1±0.1cm LJW, 135.8±0.5cm HW, 57.73±0.5cm HCG, 226.3 ±4.8cm AG, 214.6±1.2cm CG, 97.8±1.3cm TL, 54.3±1.4cm TSL, 15.2±1.7cm WSL, 76.3±1.3cm BD, 64.2±0.5cm HBD, 39.0±0.5cm PBD and 0.8±0.0mm STK respectively, in Murrah buffaloes.

Table 1: Mean of different body parts measurements along with standard errors

Body measurements	Mean ± SE	No. of observation
Milk Yield (kg)	2604.77±39.47	70
Body Weight (kg)	556.11±4.91	70
Body Length (cm)	152.23±0.83	70
Muzzle Width (cm)	17.25±0.10	70
Lower Jaw Width (cm)	20.12±0.12	70
Height at Wither (cm)	135.78±0.46	70
Height at Chest from Ground (cm)	57.73±0.47	70
Abdominal Girth (cm)	226.27±4.78	70
Chest Girth (cm)	214.57±1.17	70
Tail Length (cm)	97.79±1.31	70
Tail Switch Length (cm)	54.31±1.36	70
White Switch Length (cm)	15.20±1.72	70
Body Depth Fore (cm)	76.23±1.27	70
Body Depth Rear (cm)	83.58±2.14	70
Hip Bone Distance (cm)	62.24±0.48	70
Pin Bone Distance (cm)	39.03±0.46	70
Skin Thickness (mm)	8.0±0.02	70

The estimated regression coefficients between body measurements and 305 days milk yield and the prediction equations are presented in table 2. The estimated regression coefficients and R^2 values for different equations to predict milk yield, indicates that skin thickness and muzzle width were the most important character followed by abdominal girth and hip bone distance. Different equations were studied and their R^2 values were compared with different equations which predict that milk yield had strong relationship with skin thickness and muzzle width. Results of the stepwise analysis compared well with those of the linear regression analyses. The R^2 for the model with linear effects of different body measurements and milk production ranged from 79% to 64% for of total variation for milk yield.

Table 2: Prediction equations for milk yield with different body parts measurements

Sr. No.	Prediction equations	R^2
1.	Y=-1555.33+0.66BW+0.59BL+203.4MW+9.7LJW+4.5HW+0.55HCG+9.01AG+0.59CG+0.63TL+0.35TSL+0.19WSL+1.95BDF+2.31BDR+9.01HBD+3.20PBD+ 928.18STK	0.79
2.	Y=-1563.38+0.65BW+0.51BL+203.14MW+9.41LJW+4.17HW+9.09AG+0.58CG +0.59TL+ 0.33TSL + 0.18WSL+1.98BDR+9.07HBD+3.13PBD+927.33STK	0.78
3	Y=-1542.05+0.65BW+0.55BL+203.06+9.21LJW+4.19HW+9.10AG+0.61CG+0.50TL+0.37TSL+2.06BDR+8.91HBD+2.97PBD+925.18STK	0.76
4	Y=-1613.12+0.67BW+202.73MW+8.95LJW+4.11HW+9.21AG+0.66CG+0.43TL+0.38TSL+2.06BDR+9.21HBD+3.01PBD+918.87STK	0.73
5	Y=-1623.01+0.69BW+202.80MW+9.75LJW+4.11HW+9.17AG+0.60CG+0.22TL+0.38TSL+2.05BDR+9.15HBD+3.11PBD+919.017STK	0.72
6	Y=-1609.75+0.69BW+203.13MW+9.10LJW+4.11HW+9.32AG+0.65CG+ 2.01BDR+9.03HBD+3.10PBD+916.13STK	0.71

7	Y=-1593.49+0.71BW+203.48MW+8.94LJW+3.58HW+9.02AG+1.96BDR+ 9.11HBD+3.0PBD-919.88STK	0.70
8	Y=-1437.03+0.66BW+203.33MW+3.66HW+8.93AG+1.97BDR+8.85HBD+ 2.90PBD-925.94STK	0.69
9	Y=-1428.73+0.66BW+205.97MW+3.53HW+8.95AG+1.75BDR+7.79HBD+9 12.44STK	0.68
10	Y=-1103.58+0.66BW+209.89MW+8.88AG+1.99BDR+6.52HBD+908.53STK	0.67
11	Y=-1075.25+0.61BW+214.25MW+8.83AG-6.53HBD+884.42STK	0.66
12	Y=-884.42+207.78MW+7.73AG+8.34HBD+903.52STK	0.64

The study revealed milk yield was significantly ($P< 0.01$) correlated with muzzle width and in agreement with the finding of Kar *et al.* (2014) [9]. However, in the present study lower jaw width was not associated with milk yield. The study also showed that abdominal girth was significantly associated with milk yield and present study was in agreement with the study of Patel *et al.* (1990). Bhatnagar *et al.* (1960) reported that milk production increases by 7.8 lb. per increase of 1inch over of 83.54 inches of abdominal girth in Murrah buffaloes. Bhakat *et al.* (2009) found that body measurements like heart girth and abdominal girth were significantly correlated with each other in crossbred cows as well as in Murrah buffaloes. Ahmed *et al.* (2013) found that heart and abdominal girths had highly positive and significant correlation with milk production, age, parity and body weight. Shanks *et al.* (1981) studied the hip height instead of wither height and found that greater than average daily milk production in early lactation was associated with taller hip height, broader hip width and deeper than average udders. It can be concluded on the basis of present study that abdominal girth should be considered for high milk production. The study is also in agreement with the work done by different scientists as mentioned above. In the present study a negative and significant ($P< 0.01$) correlation between milk yield and skin thickness was observed. Milk was higher in buffaloes having thin skin than medium and thick skin. The study was found in agreement with study done by Bhardwaj (2007) [4] who reported that milk yield was significantly higher in buffaloes having thin skin. Bhatnagar and Kumar (1980) [5] suggested that animal with thin skin could dissipate more heat and thus be more efficient for production of milk in warm regions. In contrast, Desai and Sharma (1962) reported positive and significant correlation of skin thickness with milk yield in Hariana cattle, which is not a dairy type of animal. Murlidharan (2001) [12] also found lowest skin thickness during lactation period and highest during dry period in Murrah buffaloes. In the present study, skin thickness also had negative correlation with body weight, body length, muzzle width and abdominal girth. It can be concluded that thin skinned animals should be selected for obtaining higher milk yield. Milk yield was significantly ($P< 0.01$) correlated with muzzle width and in agreement with the finding of Kar *et al.* (2014) [9]. Muzzle width was found to be strongly associated with body weight, abdominal girth but had no correlation with skin thickness. Patel *et al.* (1990) found that all the other body measurements DHB, RL, BL, HG, AG, RL, SW, and TW showed high association with 305days FLMY and per day FLMY especially in the 9 months of pregnancy.

The study revealed that hip bone distance was associated significantly with milk yield. The present study was found to agree with Patel *et al.* (1953) who reported that body length (BL), heart girth (HG), distance between hipbones (DHB), side wedge (SW) and top wedge (TW) were significantly associated with 305 days first lactation milk yield (FLMY). Ahmed *et al.* (2013) found that relationship of pin to pin bone distance and hook to hook bone distance was found positive and significant correlation with milk production in Nili Ravi buffaloes. It can be concluded that wide hip bone distance is desirable for more milk production in Murrah buffaloes. Results showed that all types of regression at milk yield on body measurements (body's length, chest area, abdomen area, front height, chest depth etc.) were also significant. Y= -884.42+207.78MW+7.73AG+8.34HBD+903STK Cattle body measurements are phenotypic markers to the production ability for milk yield. Cattle body measurements are phenotypic markers to the production ability for milk yield. The objectives at this study was to measure buffalo body and udder measurements, milk yield and the relationship between measurements was milk yield. Table (2) showed that all types of regression at milk yield on body measurements (body's length, chest area, abdomen area, front height and chest depth) were significant. Increase in body dimensions encountered by increase in absolute milk yield agreed with the results of Sieber *et al*. (1988) [17].

Conclusion

Considering the practical applicability and suitability of recording body measurements under any condition, the combination of hip bone distance and abdominal girth will be second best measurements taken in to consideration after considering the muzzle width and skin thickness as important morphometric body measurement while predicting good milch animal.

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