Research article

RELATIONSHIP BETWEEN UDDER AND TEAT CONFORMATIONS AND MORPHOMETRICS WITH MILK YIELD IN MURRAH BUFFALOES

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ABSTRACT

Udder and teat conformations and measurements play a vital role in milk productivity and mastitis resistance in dairy buffaloes. The study was conducted on apparently healthy 24 Murrah buffaloes running on different parities selected from 3 different farms in the Chitwan district of Nepal to find the relation between phenotypic characteristics of udder and milk yield. The shapes of the teat and udder were evaluated by a visual appraisal that revealed 42.7% funnel, 26% bottle, 16.7% cylindrical, 14.6% conical-shaped teats, and 37.5% round, 33.3% bowl, and 16.7% goaty, and 12.5% stepped shaped udders. The average length, width, and depth of the udder were determined as 54.50±0.92 cm, 19.33±0.46 cm, and 27.50±1.10 cm, respectively, while the respective length and diameter of the teat were 8.46±0.17 cm and 3.59±0.07 cm. Within udder quarters, teat length was significantly different ($p < 0.05$) though the diameter was non-significant. However, the teat length and teat diameter differed along the teat and udder shapes showing the highest measures at bottle-shaped teats and goaty-shaped udder. The average milk yield/day recorded was 5.90±0.36 kg per buffalo. Higher milk yield was observed in the round-shaped udder and conical-shaped teat. The correlation of udder width ($r= 0.237$, $p<0.05$) and teat length ($r= 0.222$, $p<0.05$) was observed significantly positive but that of teat to floor distance ($r= -0.232$, $p<0.05$) was negative with milk yield. Hence, the selection of Murrah buffaloes for milk production traits should consider the dimensions of the teat and udder.

Keywords: Conformations, milk yield, murrah, teat, udder

INTRODUCTION

The milk production potential was directly affected by the udder and teat morphometrics (Kaur et al., 2018) that could be used for selection in breeding programs of buffaloes. In addition, one of the host factors of mastitis is the conformational and morphometric parameters of the udder and teat. If selected of desirable shape and size, it may resist pathogenic entry to glandular tissues and increase productivity (Okano et al., 2015).

The phenotypic characteristics-based selection is a crucial tool for enhancing the production potential in dairy buffaloes (Abdullah et al., 2013) as body appearance, udder and teat measurements, and their conformations have shown a direct relationship to milk yield (Jaayid et al., 2011). The teat shapes were classified as bottle, funnel, cylindrical, and conical, whereas udder shapes were classified as round, bowl, stepped, and goaty as per the visual appraisal of the researcher (Kaur, 2017).

Tilki et al. (2005) observed that the udder and teat physiological characteristics play a vital role in dairy cows' quality and sustainable milk production. The udder and teat conformations affect milk productivity and the udder health status in dairy animals (Sinha et al., 2022). The morphometrics and conformation of udder and teat are essential while selecting and judging dairy animals for milk production. Thus, the shape and size of the udder influence milk productivity and are considered during dairy animals' selection (Bhuiyan et al., 2004). The study's objective was to explore the relationship of udder and teat morphology and measurements with the milk yield in Murrah buffaloes.

MATERIALS AND METHODS

Farm Selection

The study was conducted in the Chitwan district of Nepal. 24 Murrah buffaloes from three different farms: 10 from a well-managed private dairy farm, eight from Agriculture and Forestry University research farm, and six from subsistence level. The animals selected were healthy with no history of mastitis to ensure average milk production. The animals were ear-tagged for proper identification and record keeping.

All the animals were maintained in cemented flooring, green forages, and concentrate ration were fed year-round in sufficient amounts and watered ad-lib. Hand milking was done twice daily at 4:00 AM and 4:00 PM in 12 hours intervals, and milk yield was recorded during milking. Milking stimulation was done either by calf suckling or by manual massaging after washing the udder with water.

Udder and Teat Conformations and Morphometrics

Various morphometric parameters such as teat length, teat diameter, the distance between teats, teat tip to floor distance, udder length, udder width, and udder depth were recorded in centimeters.

Udder length (UL): A distance from the rear attachment below the vagina and moving along the udder body up to the fore attachment where the fore-udder blends smoothly to the body of the animal was measured (Abdullah et al., 2013).
Udder width (UW): A distance between the abdominal insertion of the udder on the left side to the right side, passing between the fore and rear teats at the broadest point nearby the stifle joint (Espinosa Núñez et al., 2013).
Udder depth (UD): Udder depth was estimated as the distance taken from the perineal insertion of the udder to the base of hind teats with the help of a measuring scale (Espinosa Núñez et al., 2013).
Teat length (TL): A distance from the point where the teat attaches to the udder body, i.e., the base of the teat, and moving along the teat down to the tip of the teat with the measuring scale.
Teat diameter (TD): The circumference was measured in the middle of the engorged teat using thread, and then the diameter was calculated using the formula: D = [C = Circumference, D = diameter].
Distance between Teats: Measurements were taken between right fore and left fore teats, between right hind and left hind teats, between right fore and right hind teats, and between left fore and left hind teats with a scale taking care not to touch the teat with scale.
Teat-end to floor distance (TFD): The teat end to floor distance was measured by tape in centimeters as the distance between the individual teat tip to the shed floor perpendicular.
Milk Yield (MY): Milking of each quarter was done in a separate pail, and quantities were recorded. The total was estimated by adding each quarter of milk of every individual. The average per day milk yield was calculated by recording the morning and evening milk.

Statistical Analysis

The descriptive statistics, mean comparison, and analysis of variance were done with the help of statistical software SPSS-16 and MS-Excel 2013. The data were presented in tabular form, and the means that were significantly different ($P<0.05$) were tested using the Least Significant Difference (LSD) test. Pearson's correlation of udder and teat measurements with milk yield was also determined.

RESULTS AND DISCUSSION

Distribution of Teat and Udder Shapes

Ninety-six teats were analyzed for different teat shapes, with the visual appraisal revealing 42.7% funnel-shaped, 26% bottle-shaped, 16.7% cylindrical-shaped, and 14.6% conical-shaped teats (Table 1). The distribution of the funnel and conical was highest in Left Fore (LF), while the bottle and cylindrical were found in Left Hind (LH). Similar studies revealed the cylindrical-shaped as the most occurring teat type in buffaloes (Abdullah et al., 2013; Bharadwaj et al., 2007; Danish et al., 2018).

The four different udder shapes were determined by visual appraisal as round, bowl, goaty, and stepped, with their respective frequencies as 37.5%, 33.3%, 16.7%, and 12.5% (Table 1). The result contrasts with the report showing bowl as the highest frequency by Abdullah et al. (2013). However, Danish et al. (2018) found trough-shaped udder the most, followed by round, goaty and pendulous in Murrah buffaloes.

Table 1. Distribution of teat shapes and udder shapes in Murrah buffaloes in Chitwan, 2019

Teat Shapes	Left Fore	Left Hind	Right Fore	Right Hind	Overall	Udder Shapes	N (%)
	N (%)	N (%)	N (%)	N (%)	N (%)		
Funnel	14 (58.3)	5 (20.8)	13 (54.2)	9 (37.5)	41 (42.7)	Round	9 (37.5)
Bottle	4 (16.7)	9 (37.5)	6 (25.0)	6 (25.0)	25 (26.0)	Bowl	8 (33.3)
Cylindrical	2 (8.3)	7 (29.2)	3 (12.5)	4 (16.7)	16 (16.7)	Goaty	4 (16.7)
Conical	4 (16.7)	3 (12.5)	2 (8.3)	5 (20.8)	14 (14.6)	Stepped	3 (12.5)
Total	24 (100)	24 (100)	24 (100)	24 (100)	96 (100)	Total	24 (100)

Figures in Parenthesis represent the overall percentage.

Udder Measurements

The mean UL, UW, and UD determined were 54.50±0.92 cm, 19.33±0.46 cm, and 27.50±1.10 cm, respectively (Table 2). Gu et al. (2018) reported lower average values than in the present study for UL, UW, and UD in Dehong dairy buffaloes. Prasad et al. (2010a) reported similar UL, whereas UW and UD were diverted from present findings in Murrah buffaloes. A study on Nili-Ravi buffaloes revealed the UL, UW, and UD to be 64.2±7.3 cm, 29.1±4.1cm, and 10.8±1.6 cm, respectively (Javed et al., 2013). The findings showed higher UL and UW values but lower UD values than the measures in the present study. A similar trend of udder morphometrics was shown by Kaur (2017).

The UL was the highest in stepped, followed by round, bowl, and goaty, but the UW and UD were the highest in the case of the goaty-shaped udder, but none were observed to have significant differences among each other. The result, UL, was in line with the report presented by Prasad et al. (2010b) but UW and UD were observed to diverge from the measures in the present study.

Table 2. Mean udder length, width, and depth in different udder shapes of Murrah buffaloes in Chitwan, 2019

Udder Shapes	N	Udder Length (Cm)			Udder Width (Cm)			Udder Depth (Cm)		
		Mean ± S.E	Min.	Max.	Mean ± S.E	Min.	Max.	Mean ± S.E	Min.	Max.
Round	9	$55.67^{a} \pm 1.17$	51.00	60.00	$19.55^{a} \pm 0.74$	17.00	23.00	$26.77^{a} \pm 2.01$	20.00	38.00
Bowl	8	$53.75^{a} \pm 2.11$	41.00	59.00	$18.81^{a} \pm 0.68$	17.00	22.00	$26.12^{a} \pm 1.34$	21.00	33.00
Goaty	4	$52.25^{a} \pm 2.32$	46.00	57.00	$20.50^{a} \pm 1.55$	18.00	25.00	$31.75^{a} \pm 2.86$	25.00	37.00
Stepped	3	$56.00^{a} \pm 1.52$	54.00	59.00	$18.50^{a} \pm 1.60$	15.50	21.00	$27.66^{a} \pm 3.71$	23.00	35.00
Overall Mean	24	54.50 ± 0.92	41.00	60.00	19.33 ± 0.46	15.50	25.00	27.50 ± 1.10	20.00	38.00

Means with similar superscripts don’t vary significantly ($P < 0.05$) within columns

Teat Measurements

The mean teat length and diameter determined (Table 3), 8.46±0.17 cm and 3.59±0.07 cm, respectively, were almost similar to the study in buffaloes by Kaur et al. (2018). The shorter length and thicker diameter were reported in Iraqi buffaloes (Jaayid et al., 2011).

Prasad et al. (2010a) reported slightly lower TL and TD than the average found in the present study.

Table 3. Mean teat length and diameter of different quarters in Murrah buffaloes in Chitwan, 2019

Quarters	N	Teat Length (Cm)			Teat Diameter (Cm)		
		Mean ± S.E	Minimum	Maximum	Mean ± S.E	Minimum	Maximum
Left Fore	24	$8.35^{ab} \pm 0.30$	6.00	11.00	$3.45^{a} \pm 0.10$	2.55	4.14
Left Hind	24	$9.16^{a} \pm 0.38$	6.00	13.00	$3.83^{a} \pm 0.12$	2.55	4.78
Right Fore	24	$7.58^{b} \pm 0.30$	5.00	11.00	$3.50^{a} \pm 0.18$	1.91	5.10
Right Hind	24	$8.77^{a} \pm 0.31$	7.00	13.00	$3.56^{a} \pm 0.18$	1.91	5.41
Overall Mean	96	8.46 ± 0.17	5.00	13.00	3.59 ± 0.07	1.91	5.41

Means in columns with different superscripts differ significantly by LSD ($P < 0.05$).

Quarter-Wise Teat Length and Diameter

The LH was found to have the highest teat length (9.16 ± 0.38 cm) and diameter (3.83 ± 0.12 cm) in a quarter-wise investigation where the quarter difference was significant for teat length and non-significant in teat diameter (Table 3). The result was in line with the findings of Thomas (2004) and Chandrasekar et al. (2016), which showed rear teats had comparatively higher TL and TD. Kaur et al. (2018) found a significant difference in TL and TD in teat locations where hind and left side quarters possessed longer and thicker teats. However, Bakken (1981) reported contrasting results indicating that front teats have a higher length and diameter than hind teats. Jaayid et al. (2011) had shown higher teat length in fore teats, but teat diameter was higher in hind teats.

Teat Measurements based on Udder and Teat Shapes

The study showed a significant difference in TL and TD according to different teat shapes (Table 4) and udder shapes (Table 5). The bottle-shaped teats possessed the highest TL (9.02 ± 0.38) and TD (3.82 ± 0.13), while TL (8.84 ± 0.61) was highest in bowl-shaped udder and TD (4.30 ± 0.17) in the goaty shaped udder. Bakken (1981) reported the significant positive correlation of teat measures with teat shapes and udder shapes that showed cylindrical-shaped teats being more extended than other teats.

Table 4. Mean teat length and diameter of different teat shapes in Murrah buffaloes in Chitwan, 2019

Teat Shapes	N	Teat Length (Cm)			Teat Diameter (Cm)		
		Mean ± S.E	Minimum	Maximum	Mean ± S.E	Minimum	Maximum
Funnel	41	$8.09^{b} \pm 0.22$	5.00	8.54	$3.53^{ab} \pm 0.10$	1.91	5.10
Bottle	25	$9.02^{a} \pm 0.38$	6.00	9.82	$3.82^{a} \pm 0.13$	2.23	5.41
Cylindrical	16	$8.68^{ab} \pm 0.41$	6.00	9.56	$3.27^{b} \pm 0.16$	1.91	4.14
Conical	14	$8.32^{ab} \pm 0.49$	6.00	9.39	$3.70^{ab} \pm 0.26$	1.91	5.41
Overall Mean	96	8.46 ± 0.17	5.00	8.81	3.59 ± 0.07	1.91	5.41

Means in columns with different superscripts differ significantly by LSD ($P < 0.05$).

Table 5. Mean teat length and diameter in different udder shapes in Murrah buffaloes in Chitwan, 2019

Udder Shapes	N	Teat Length (Cm) (Mean ± S.E)					Teat Diameter (Cm) (Mean ± S.E)				
		LF	LH	RF	RH	Average	LF	LH	RF	RH	Average
Round	9	7.94^{a} ± 0.49	9.55^{a} ± 0.57	7.33^{a} ± 0.46	8.66^{a} ± 0.41	8.37^{a} ± 0.38	3.43^{b} ± 0.11	3.69^{bc} ± 0.14	3.39^{a} ± 0.23	3.21^{b} ± 0.17	3.43^{b} ± 0.13
Bowl	8	8.56^{a} ± 0.55	9.37^{a} ± 0.78	8.37^{a} ± 0.58	9.06^{a} ±0.78	8.84^{a} ± 0.61	3.36^{b} ± 0.22	3.94^{ab} ± 0.24	3.54^{a} ± 0.40	3.60^{ab} ± 0.41	3.61^{ab} ± 0.28
Goaty	4	9.00^{a} ± 0.40	8.62^{a} ± 0.94	7.37^{a} ± 0.47	8.50^{a} ± 0.64	8.37^{a} ± 0.55	4.06^{a} ± 0.08	4.46^{a} ± 0.22	4.14^{a} ± 0.29	4.53^{a} ± 0.35	4.30^{a} ± 0.17
Stepped	3	8.16^{a} ± 1.42	8.16^{a} ± 1.01	6.50^{a} ± 0.76	8.66^{a} ± 0.72	7.87^{a} ± 0.56	2.97^{b} ± 0.10	3.13^{c} ± 0.22	2.86^{a} ± 0.31	3.23^{b} ± 0.13	3.05^{b} ± 0.08
Overall Mean	24	8.35 ± 0.30	9.16 ± 0.38	7.58 ± 0.30	8.77 ± 0.31	8.46 ± 0.26	3.45 ± 0.10	3.83 ± 0.12	3.50^{a} ± 0.18	3.56 ± 0.18	3.59 ± 0.12

Means in columns with different superscripts differ significantly by LSD ($P < 0.05$).

Teat to Floor Distance in Different Udder and Teat Shapes

The mean teat to floor distance was 50.02 ± 1.06 cm, and the highest distance was observed in stepped-shaped udders and cylindrical teats (Table 6).

There was no significant difference in mean teat to floor distance when comparing the different shapes of udder and teats. However, Kaur (2017) recorded lower TFD than in the present study and found a lesser distance in hind teats than in fore teats. Singh et al. (2014) reported similar dimensions as in the present results, showing 50.74 cm average TFD ranging between 21.0 to 71.0 cm.

Table 6. Mean teat to floor distance in the different udder and teat shapes in Murrah buffaloes in Chitwan, 2019

Udder Shapes	N	Teat to Floor Distance (Cm) (Mean ± S.E)			Teat Shapes	N	Teat to Floor Distance (Cm) (Mean ± S.E)		
		Mean ± S.E	Min.	Max.			Mean ± S.E	Min.	Max.
Round	9	50.08^{a} ± 2.19	35.75	59.00	Funnel	41	49.60^{a} ± 0.84	35.00	57.00
Bowl	8	51.12^{a} ± 1.55	44.50	57.50	Bottle	25	49.28^{a} ± 1.15	35.00	58.00
Goaty	4	46.43^{a} ± 2.34	40.50	51.00	Cylindrical	16	52.06^{a} ± 1.41	45.00	64.00
Stepped	3	51.66^{a} ± 1.09	49.50	53.00	Conical	14	50.21^{a} ± 1.06	43.00	59.00
Overall Mean	24	50.02 ± 1.06	35.75	59.00	Overall Mean	96	50.02 ± 0.54	35.00	64.00

Means in columns with different superscripts differ significantly by LSD ($P < 0.05$)

Distance between Teats in Different Udder Shapes

The mean distance between teats of left quarters, right quarters, forequarters, and hindquarters was found to have a non-significant difference with udder shapes (Table 7). Gu et al. (2018) reported average dimensions of a distance of fore-rear teats, fore teats, and rear teats as 7.73±2.15 cm, 11.38±3.08 cm, and 7.18±2.18 cm, respectively, in buffaloes that were similar to the measures in the present study. A slight deviation in left quarters' distance was reported by Singh et al. (2014) in cattle, but the distance between other teat pairs was similar. Jaayid et al. (2011) studied the distance between teat pairs in Iraqi buffaloes and found the overall average as 10.98±2.26 cm, which was in line with the results of this study. Furthermore, the supportive result was presented by Kaur (2017), with average values of distance between fore, rear, left and right teats were 12.72±0.34 cm, 8.64±0.25 cm, 7.26±0.21 cm, and 7.27±0.19 cm respectively.

The distance between fore teats was higher than the distance between hind teats during the study. The result was supported by Tilki et al. (2005), showing 1.6 times more prominent, and by Kaur (2017), showing 1.47 times larger. The contrasting results on the distance between teat pairs were presented in Prasad et al. (2010a), which revealed a lesser distance than recorded in the present study. Chandrasekar et al. (2016) found the increment of lateral teat distance after calving with a positive correlation to milk yield and showed LF-RF distance increment higher than LF-RH distance.

Table 7. Mean distance between teats on basis of udder shapes in Murrah buffaloes in Chitwan, 2019

Udder Shapes	N	Distance between Teats (Cm) (Mean ± S.E)			
		Left (LF_LH)	Right (RF_RH)	Fore (LF_RF)	Hind (LH_RH)
Round	9	$8.94^{a} \pm 0.45$	$9.77^{ab} \pm 0.51$	$10.22^{a} \pm 0.57$	$8.44^{a} \pm 0.64$
Bowl	8	$8.81^{a} \pm 0.81$	$8.62^{b} \pm 0.40$	$11.50^{a} \pm 1.05$	$9.50^{a} \pm 0.96$
Goaty	4	$9.25^{a} \pm 0.47$	$11.00^{a} \pm 0.40$	$12.75^{a} \pm 1.31$	$11.25^{a} \pm 1.65$
Stepped	3	$9.00^{a} \pm 0.57$	$9.33^{a} \pm 0.33$	$10.67^{a} \pm 0.33$	$8.66^{a} \pm 0.88$
Overall Mean	24	8.95 ± 0.32	9.54 ± 0.35	11.12 ± 0.47	9.29 ± 0.50

Means in columns with different superscripts differ significantly by LSD (P < 0.05)

Daily Milk Yield in Different Udder and Teat Shapes

The average milk yield recorded per day was observed to be 5.90±0.36 kg per buffaloes which was lower than the findings by Ahmad et al. (2013) and Gu et al., (2018). The daily milk yield was non-significantly associated with udder or teat shapes (Table 8), even though the higher yield was found in the round-shaped udder and conical-shaped teat. In contrast, to the present study, Prasad et al. (2010b) reported a positive correlation between milk yield and udder shapes and teat shapes, with bowl-shaped udders and cylindrical-shaped teats having the highest average yield. Tilki et al. (2005) reported that the udder and teat morphology affect the average milk yield in cattle.

Table 8. Mean daily milk yield in different udder and teat shapes in Murrah buffaloes in Chitwan, 2019

Udder Shapes	N	Daily Milk Yield (Kg)			Teat Shapes	N	Daily Milk Yield (Kg)		
		Mean ± S.E	Min.	Max.			Mean ± S.E	Min.	Max.
Round	9	$6.20^{a} \pm 0.58$	3.00	8.60	Funnel	41	$6.02^{a} \pm 0.30$	3.00	9.00
Bowl	8	$5.85^{a} \pm 0.75$	3.00	9.00	Bottle	25	$5.47^{a} \pm 0.35$	3.00	8.60
Goaty	4	$5.40^{a} \pm 0.88$	3.20	7.20	Cylindrical	16	$6.00^{a} \pm 0.35$	4.20	9.00
Stepped	3	$5.80^{a} \pm 1.13$	4.20	8.00	Conical	14	$6.18^{a} \pm 0.46$	3.00	9.00
Overall Mean	24	5.90 ± 0.36	3.00	9.00	Overall Mean	96	5.90 ± 0.18	3.00	9.00

Means in columns with similar superscripts don't differ significantly by LSD (P < 0.05).

Correlation of Udder and Teat Morphometrics with milk yield

The overall positive correlation was found between milk yield and udder or teat measurements though the significant association was revealed only with udder width and teat length. The teat to floor distance significantly correlated with milk yield, and the morphometric parameters studied. Similarly, teat length and diameter had positive correlations with the udder measures. The correlation of udder length, width and depth and teat length, teat diameter, teat to floor distance, and average daily milk yield were presented in Table 9.

Table 9. Correlation of udder and teat morphometrics with milk yield in Murrah buffaloes in Chitwan, 2019

	UL	UW	UD	TL	TD	TFD	MY
UL	1	0.021	0.169	-0.173	0.013	-0.074	-0.039
UW		1	0.597**	0.290**	0.237*	-0.460**	0.237*
UD			1	0.177	0.349**	-0.600**	0.100
TL				1	0.423**	-0.272**	0.222*
TD					1	-0.480**	0.087
TFD						1	-0.232*
MY							1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Gu et al. (2018) showed significant positive correlations with MY and udder parameters like UL and UW, but UD showed negative impacts. The UW had a highly significant positive correlation with MY, supported by Chandrasekar et al. (2016). However, a contrasting result on the correlation between UL and MY was found in the present study. A similar positive correlation between MY and UD was presented by Jaayid et al. (2011). Prasad et al. (2010a) showed significant positive correlations among udder measurements, UL, UW, and UD, similar to current findings. Javed et al. (2013) found correlations of UW with TL and TD that were significantly positive, in line with present findings. However, with TFD, the result was contrasting that showed significantly negative correlation in the present study. Furthermore, Prasad et al. (2010b) too reported significant positive correlations among udder measurements in Murrah buffaloes. Porcionato et al. (2010) observed negative correlations of TFD with TL and TD but a positive correlation between TL and TD that supported the findings in the present study.

CONCLUSION

The study is the preliminary study of the status of udder and teat shapes, their measures, and the relation with milk yield in Murrah buffaloes in Chitwan, Nepal. The udder and teat shapes showed non-significant variations in milk yield, but the higher yield was revealed in the round udder and conical teats. Furthermore, the study showed a significant correlation between udder width and teat length with milk yield. Hence, the udder and teat shapes and size need to be considered when selecting Murrah buffaloes for milk productivity.

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