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A Study on Relationship between Udder Conformation and Milk Yield, Fat and Solids-Not-Fat Percent in Murrah Graded Buffaloes under Field Conditions

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A B S T R A C T

The present experiment was conducted to study the relationship of Udder Conformation with milk yield, fat and solids-not-fat percent in murrah graded buffaloes under field conditions. In this 150 murrah graded buffaloes of different parities (1st to 6th parities) from different commercial farms of Guntur and Krishna districts were selected. Various parameters like Udder Length, Udder Width, Udder Depth, teat length, teat diameter related to average milk yield, fat per cent, SNF per cent was taken into consideration for the present study and a correlated study of udder morphology and the milk yield was studied. The mean±S.E of udder length, udder width and udder depth of different udder shapes ranged from 47.44±0.37 to 51.55±0.90 cm, 41.81±1.18 to 46.15±0.94 cm and 11.67±0.05 to 12.3±0.16 cm, respectively. The overall average udder length, udder width and udder depth were 48.1±0.33, 42.80±0.32 and 11.80±0.05 cm, respectively. Maximum udder length, udder width and udder depth were found in pendulous shaped udder. The overall mean(±S.E) of teat lengths of right fore, left fore, right rear, left fore were 5.42±0.02, 5.60±0.02, 5.74±0.03 and 5.96±0.02 cm, respectively. Similarly the overall mean (±S.E) of diameter of the teat in right fore, left fore, right rear, left rear were 2.48±0.01, 2.60±0.01, 2.72±0.01 and 2.87±0.02 cm, respectively. The pendulous shaped udder and funnel shaped teats yielded maximum average daily milk yield. The average daily milk yield, milk fat and SNF per cent showed positive correlation with all the udder and teat measurements. Milk yield showed high positive correlation with left rear teat diameter (0.60), udder length (0.62) and udder width (0.59). Milk fat per cent showed highest correlation with udder depth (0.48), udder width (0.44) and udder length (0.42). SNF per cent showed highest correlation with udder width (0.53), udder length (0.49) and udder depth (0.46).

Introduction

The world buffalo population is found to be 199.784 million (FAO 2015) and 56.6% Buffaloes are in India. During the last 10 years, an annual growth of buffalo population was 1.49% and 1.53% in the world and India respectively. There are 108.70 million

buffaloes in India which contribute 21.23% of the total livestock population in India. The female buffalo population has increased by 7.99% over the previous census and the total number of female buffalo is 92.5 million in 2012 (19th livestock census). India ranks first among the world's milk producing nations with production of 146.3 million tons during 2014-15 and contributing 17.4% of world milk production. The buffalo milk alone contributes 51% of the total milk production in the India. Andhra Pradesh endowed with buffalo population of 10.6 million with a milk production of 7.4 metric tonnes (GOI 2017). About 72% of the milk produced in Andhra Pradesh comes from the buffaloes. It is one of the major buffalo milk producing states of the country.

Buffaloes are preferred over cattle in India because of their distinctive qualities such as better feed conversion efficiency, more resistance to diseases and higher milk fat percentage than in cows. Moreover, buffalo can efficiently convert low quality feed stuffs like straws and agro industrial waste into human food and improve soil structure through bio fertilizer. When the buffalo rearing has shifted from the backyard to commercial farms, popularity of buffalo milk has ensured buffalo production as a main stay in the path of the dairy industry in India. However, for this species to perform optimally under the pressure of intensive production systems, the animals have to be improved with clear focus on the desired output.

The morphology of udder is one of the genetic characteristics and fundamental criteria for selecting animals of dairy type. The size and shape of udder are very important conformation traits which could play a vital role for the suitability of economical milk production and should be considered for selecting dairy animals (Bhuiyan *et al.,* 2004). It was also concluded that the udder length, width, depth and circumference had a good relationship with milk yield of swamp buffalo (Akhtar *et al.,* 1998). It is presumed that the size and morphology of udder varies greatly from individual to individual animal and between different lactation orders.

In the state of Andhra Pradesh, as a result of upgradation of genetic potential of Non-descript buffaloes with Murrah buffaloes through Artificial Insemination programme, buffaloes are upgraded as Murrah Graded Buffaloes, Guntur, Krishna districts of Andhra Pradesh occupy first and third in buffalo population with 10.07 lakhs and 6.96 lakhs respectively. In these districts, most of the buffalo farms are with 10-30 animals. Keeping in view the role of Udder Conformation in expression of milk production potential of buffaloes, a study was taken up in both the districts i.e. Guntur and Krishna with the following objective. To study the association between Udder Conformation and milk yield, fat and Solids-not-fat percent in Murrah Graded Buffaloes under field conditions.

Materials and Methods

A total of one hundred and fifty lactating Murrah graded buffaloes with different parities of various buffalo farms located at various villages like Balusulapalem, Bhattiprolu, Nagaram, Borravaripalem, Dosapalem, Pudivada and Uppuluru were utilized for this study and presented in the Table 1. To study the relationship between Udder conformation (UC) with milk yield, fat and solids-not-fat (SNF) per cent in Murrah graded buffaloes, the animals were visually assessed according to Udder and teat morphologies, variations in Udder and teat shapes and measurements of various traits on farm. The buffaloes of various Udder and teat measurements were recorded according to the parity of each animal and the values were

used to study the correlation between them to know the effect of parity on the milk yield, fat and SNF per cent. Test day milk yield was recorded, fat percentage and solids-not-fat percentage were tested and other observations were also recorded on the same.

Udder conformation

Udder morphology

For studying the Udder morphology, Udder characteristics like Udder length, Udder width, Udder depth, teat length, teat diameter were measured while the shape of the Udder was visually assessed and measured as per the procedures followed by Prasad et al. (2010) and udder depth according to Patel et al. (2016). All these characteristics were measured thirty minutes prior to milking. Milk yield, fat per cent and SNF were recorded on the same day.

Udder shape

The Udder being the milk secreting gland, the shape and size of the Udder is important, as it plays an important role in the milk secretion. Therefore, efforts are being made to evaluate the Udder by visual assessment. The shapes of the Udders based on the visual assessment were classified into Bowl, Globular, Goaty and Pendulous shapes.

Udder Length (UL)

The Udder length was measured by using the measuring tape from the rear attachment of the Udder, near the escutcheon, to the front of the Udder, where it blends smoothly with the body (Fig. 1).

Udder Width (UW)

The Udder width was measured as a distance between two lateral lines of attachment of the Udder to abdominal wall, beneath the flank. Measuring tape was kept in position on one side of the animal, under flank, near the stifle joint and it was passed over in between Fore and Rear teats to the other side (Fig. 2).

Udder Depth (UD)

Udder depth (UD) was measured by taking the differences of two mentioned measurements (Fig.3).

Distance from ground floor to the base of the udder.
Distance from ground floor to the lowest point of the udder at the place of attachment of teats.

Teat morphology

The morphological characteristics of the teat like length and diameter were measured by using a measuring tape and thread, while the shape of the teat was visually observed as per Prasad et al. (2010).

Teat shape

The teat shape plays an important role in milk secretion which effects the milk production. Teat shapes were classified into Conical, Bottle, Pear, Cylindrical and Funnel shapes based on the visual assessment.

Teat length

The length of the teat was measured from the upper part of the teat where it hangs perpendicularly from the Udder to the tip of the teat by using measuring tape (Fig. 4).

Teat diameter

Teat diameter was measured at the middle of the teat by using measuring tape to prevent damage to the teats by mishandling (Fig. 5).

Test day milk yield, fat and SNF percent

The test day milk yield of the particular buffalo was measured and recorded on the same day. The milk samples were collected for estimation of fat per cent and this was done by using the automatic milk fat analyzer on the same day at the local collection centres.

The SNF content of the milk was estimated by using the following Richmond's formula.

$$SNF\ \% = \frac{CLR}{4} + 0.21\ F + 0.14$$

CLR: Corrected Lactometer Reading
F: Fat per cent

Statistical analysis

Statistical analysis of the data was carried out according to the procedures suggested by Snedecor and Cochran (1989) and the data obtained on various Udder and teat parameters were analyzed using an SPSS statistical package (version 17.0) to obtain the mean and standard error (S.E) values in different lactations. The Pearson's correlation coefficient was estimated to study the relationship of Udder and teat measurements and the average daily milk yield, fat and SNF per cent to find any relationship of these parameters and also to study the overall relationship of Udder conformation with milk yield, fat and SNF per cent.

Results and Discussion

Udder and teat morphology of murrah graded buffaloes

The results pertaining to the Udder and Teat morphology of Murrah Graded Buffaloes have been observed in the present study are presented in following subsections.

Udder shape

In the present study various Udder shapes like Bowl, Pendulous, Globular and Goaty were observed. Occurrence of various Udder shapes in percentage in Murrah Graded Buffaloes was presented in the Table 2. Among the different shapes of Udder in Murrah Graded Buffaloes the occurrence of the Bowl shape was the most common type followed by Pendulous, Globular and Goaty Udders.

The occurrence of udder shape in murrah Graded Buffaloes was found to be bowl (73%), pendulous (13%), globular (8%) and goaty (6%).

Udder measurements of murrah graded buffaloes

Different Udder measurements in the Murrah Graded Buffaloes of different Udder shapes were presented in the Table 3. The Mean (±S.E) of udder length, udder width and udder depth of different udder shapes ranged from 47.44±0.37 to 51.55±0.90, 41.81±1.18 to 46.15±0.94 and 11.67±0.05 to 12.3±0.16 cm, respectively. The overall average udder length, udder width and udder depth were 48.10±0.33, 42.80±0.32 and 11.80±0.05 cm, respectively.

The Mean (±S.E) of udder length, udder width and udder depth for bowl udder were 47.44±0.3, 42.08±0.34 and 11.67±0.05, for pendulous udder were 51.55±0.90, 46.15±0.94 and 12.3±0.16, for globular udder were 47.54±1.03, 41.81±1.182and 11.90±0.14 and for goatyudder were 49.11±0.97, 45.44±0.94 and 12.16±0.20 cm, respectively.

Minimum and maximum udder length was observed in bowl udder and pendulous udder with the values as 47.44±0.37 and 51.55±0.90 cm respectively, likewise udder width was

minimum and maximum in globular and pendulous udders with values as 41.81±1.18 and 46.15±0.94 cm respectively. The maximum and minimum udder depth was observed in pendulous and bowl-shaped udders. It is concluded that maximum udder length, udder width and udder depth were observed in pendulous udder.

Teat shape of murrah graded buffaloes

In the present study different shapes of Teats were observed in Murrah Graded Buffaloes like conical, Bottle, Cylindrical, Pear and funnel. Occurrence of various shapes of teats is presented in Table 4. Among all the shapes, cylindrical shaped teats were commonly observed. Out of 150 animals, 90 animals were having cylindrical shape teats followed by conical, pear, bottle and funnel shaped teats in that order. Percentage of occurrence of cylindrical, conical, pear, bottle and funnel shaped teats were 60, 16, 10, 8 and 6, respectively. It is concluded that cylindrical teats were commonly observed and about 60% of Murrah Graded Buffaloes possess cylindrical teats.

Teat measurements of murrah graded buffaloes

Various Teat measurements according to Udder shapes were shown in the Table 5. In the present study overall teat lengths of right fore, left fore, right rear, left fore were 5.42±0.02, 5.60±0.02, 5.74±0.03 and 5.96±0.02 cm, respectively. While highest value was observed in left rear teat, while the lowest value was observed in right fore teat with the values of 5.42±0.02 and 5.96±0.02 cm, respectively. Similarly, the diameter of teats is presented in the Table 6. The overall diameter of the teat in right fore, left fore, right rear, left rear were 2.48±0.01, 2.60±0.01, 2.72±0.01 and 2.87±0.02 cm, respectively. Highest diameter was observed in left rear teat and the lowest was observed in right fore teat with the value was 2.48±0.01 and 2.87±0.02 cm, respectively.

Correlation of various udder and teat morphology with milk yield, fat and SNF per cent in graded murrah buffaloes

Average milk yield in different udder and teat shape in murrah graded buffaloes

The Milk yield according to different Udder shape are given in the Table 7. In the present study it was observed that pendulous udder yielded maximum milk when compared to other types of udder. The yields were 8.27±0.14, 10.36±0.35, 8.66±0.46 and 9.01±0.47 kg in bowl, pendulous, globular and goaty type of udders respectively. Similarly, minimum milk yield was observed in Bowl shaped udder.

Milk yield according to various Teat shapes is presented in the Table 8. The result revealed that highest milk yield was observed in funnel shaped teats when compared to other types of teat. The Milk yield according to various teat shapes were 9.97±0.36 kg in funnel shape teats, 8.68±0.42 kg in conical shape teats, 8.59±0.15 kg in cylindrical shape teats, 8.31±0.50 kg in pear shape teats and 8.12±0.40 kg in bottle shaped teats.

Average of milk fat and SNF per cent according to udder and teat shapes:

The observed fat and SNF percent on various udder shapes are presented in the Table 9. Maximum and minimum fat percent was observed in pendulous and globular udders with Mean value of 7.71±0.08 and 7.37±0.12 respectively. Similarly, maximum and minimum SNF per cent were observed in goaty and globular udders with values of 9.52±0.03 and 9.37±0.38, respectively. Similarly, fat per cent and SNF per cent according to various teat shapes are presented in the Table 10. Maximum and minimum fat

per cent was observed in funnel shaped and bottle shaped teats with values of 7.82±0.22 and 7.30±0.12 respectively. Similarly, maximum and minimum SNF per cent were observed in funnel and pear-shaped teats with a mean value of 9.57±0.05 and 9.40±0.05 respectively.

Table.1 Table showing the number of animals assessed in the villages of Guntur and Krishna districts

S. NO	Village	District	No. of animals assessed
1	Balusulapalem	Guntur	10
2	Bhattiprolu	Guntur	40
3	Nagaram	Guntur	20
4	Borravaripalem	Guntur	20
5	Dosapalem	Guntur	20
6	Pudivada	Guntur	20
7	Uppuluru	Guntur	20

Table.2 Occurrence of various Udder shapes in Graded Murrah Buffaloes

Shape	No. of observations	Percentage
Bowl	110	73
Pendulous	20	13
Globular	11	8
Goaty	9	6

Table.3 Udder measurements (cm) of different Udder shapes in Murrah Graded Buffaloes (Mean±S.E)

Udder shape	No. Of animals	Udder length	Udder width	Udder depth
Bowl	110	47.44±0.37	42.08±0.34	11.67±0.05
Pendulous	20	51.55±0.90	46.15±0.94	12.30±0.16
Globular	11	47.54±1.03	41.81±1.18	11.90±0.14
Goaty	9	49.11±0.97	45.44±0.94	12.16±0.20

Table.5 Teat Length (cm) of different Udder shapes in Murrah Graded Buffaloes (Mean±S.E)

Teat shape	No. of animals	Percentage
Bottle	12	8
Conical	24	16
Cylindrical	90	60
Funnel	9	6
Pear	15	10

Table.6 Teat diameter (cm) of different Udder shapes in Murrah Graded Buffaloes (Mean±S.E)

Udder shape	Teat length (cm)			
	Right Fore	Left Fore	Right Rear	Left Rear
Bowl	5.38± 0.02	5.56± 0.02	5.70± 0.03	5.92± 0.03
Pendulous	5.63± 0.05	5.81± 0.05	5.99± 0.06	6.18± 0.07
Globular	5.48± 0.04	5.65± 0.04	5.82± 0.05	6.03± 0.07
Goaty	5.37± 0.08	5.55± 0.07	5.70± 0.09	5.87± 0.11
Over all	5.42± 0.02	5.60± 0.02	5.74± 0.03	5.96± 0.02

Table.7 Milk yield according to their udder shapes in Murrah Graded Buffaloes (Mean±S.E)

Udder shape	Teat length (cm)			
	Right Fore	Left Fore	Right Rear	Left Rear
Bowl	2.46± 0.01	2.58± 0.01	2.70± 0.01	2.84± 0.02
Pendulous	2.50± 0.01	2.68± 0.02	2.82± 0.03	3.00± 0.05
Globular	2.51± 0.03	2.65± 0.03	2.78± 0.05	2.96± 0.09
Goaty	2.45± 0.04	2.60± 0.05	2.71± 0.06	2.88± 0.09
Over all	2.48± 0.01	2.60± 0.01	2.72± 0.01	2.87± 0.02

Table.8 Milk yield according to teat shape in Murrah Graded Buffaloes (Mean±S.E)

Teat Shape	No. of Animals	Average milk yield(kg/day)
Bottle	12	8.12±0.40
Conical	24	8.68±0.42
Cylindrical	90	8.59±0.15
Funnel	9	9.97±0.36
Pear	15	8.31±0.50

Table.9 Milk fat and SNF per cent according to udder shapes (Mean±S.E)

Udder shape	No. of animals	Fat percent	SNF percent
Bowl	110	7.41±0.04	9.40±0.01
Pendulous	20	7.71±0.08	9.50±0.03
Globular	11	7.37±0.12	9.37±0.38
Goaty	9	7.65±0.16	9.52±0.03

Table 10 Milk fat and SNF per cent according to their teat shapes in murrah graded buffalo (Mean±S.E)

Teat shape	No. of animals	Fat percent	SNF percent
Bottle	12	7.30±0.12	9.42±0.03
Conical	24	7.40±0.09	9.42±0.35
Cylindrical	90	7.40±0.04	9.41±0.01
Funnel	9	7.82±0.22	9.57±0.05
Pear	15	7.48±0.10	9.40±0.05

Table.11 Correlation of Udder and Teat measurements with daily milk yield, fat and SNF percent in Murrah Graded Buffaloes

		BCS	Udder Length	Udder width	Udder depth	Teat lengths				Teat diameters				daily Milk Yield	Fat Percent	SNF Per cent
						Right fore	Left Fore	Right Rear	Left Rear	Right Fore	Left Fore	Right Rear	Left Rear			
BCS		1	0.34**	0.34**	0.23**	0.26**	0.28**	0.28**	0.29**	0.20*	0.15	0.12	0.18**	0.41**	0.25**	**0.44****
Udder Length			1	0.92**	0.67**	0.30**	0.35**	0.26**	0.32**	0.26**	0.25**	0.29**	0.31**	0.62**	0.42**	**0.49****
Udder Width				1	0.68**	0.31**	0.34**	0.23**	0.29**	0.24**	0.24**	0.25**	0.27**	0.59**	0.44**	**0.53****
Udder Depth					1	0.28**	0.30**	0.19**	0.24**	0.21**	0.23**	0.24**	0.25**	0.48**	0.48**	**0.46****
Teat length	Right Fore					1	0.94**	0.73**	0.81**	0.51**	0.53**	0.51**	0.50**	0.44**	0.30**	**0.24****
	Left Fore						1	0.75**	0.88**	0.53**	0.56**	0.54**	0.54**	0.50**	0.30**	**0.25****
	Right Rear							1	0.71**	0.41**	0.44**	0.41**	0.43**	0.40**	0.24**	**0.25****
	Left Rear								1	0.59**	0.61**	0.59**	0.57**	0.51**	0.25**	**0.24****
Teat diameter	Right Fore									1	0.87**	0.81**	0.77**	0.49**	0.20*	**0.16***
	Left Fore										1	0.87**	0.82**	0.52**	0.28**	**0.23****
	Right Rear											1	0.90**	0.53**	0.25**	**0.17***
	Left Rear												1	0.60**	0.27**	**0.15**
Daily Milk Yield														1	0.49**	**0.45****
Fat percent															1	**0.78****
SNF percent																**1**

Fig.1 Measurement of udder length (cm)

Fig.2 Measurement of Udder Width (cm)

Fig.3 Measurement of Udder Depth (cm)

Fig.4 Measurement of Teat length (cm)

Fig.5 Measurement of Teat diameter (cm)

Fig.6 Various udder shapes

Fig.7 Various teat shapes

Fig.8 Occurrence of various udder shapes in Murrah Graded Buffalo

GLOBULAR 8%
GOATY 6%
PENDULOUS 13%
BOWL 73%

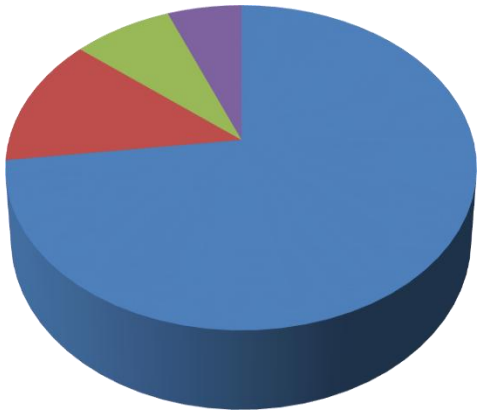


Fig.9 Average udder measurements in various udder shapes in murrah Graded Buffaloes

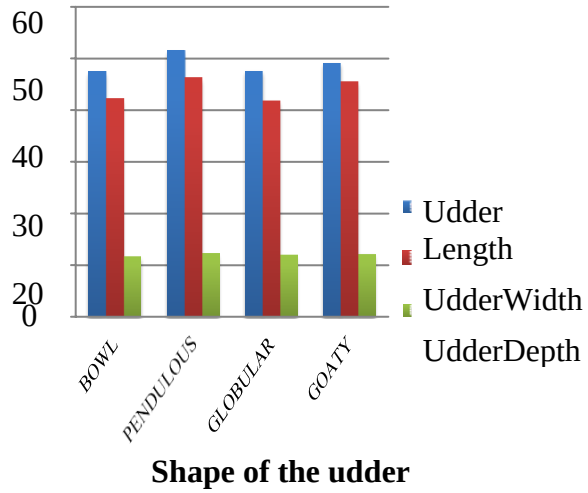


Fig.10 Occurrence of different teat shapes in murrah Graded Buffaloes

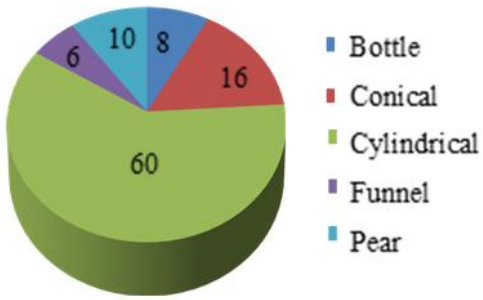


Fig.11 Average of various teats length in Murrah Graded Buffaloes

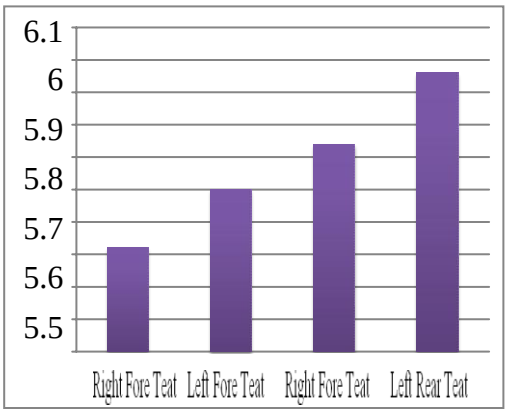


Fig.12 Average of various teats diameter of teats in Murrah Graded Buffaloes

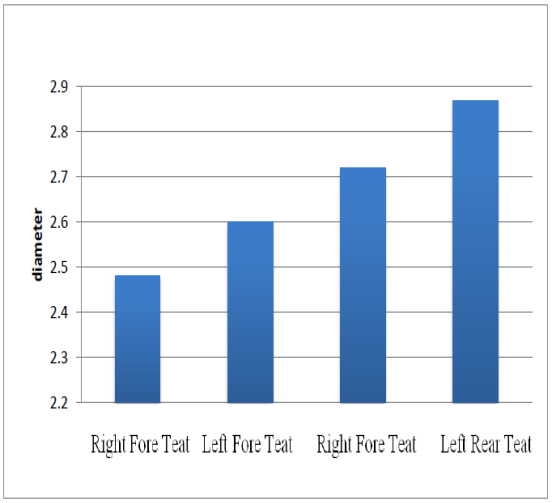


Fig.13 Average milk yield (kg/day) in different udder shapes in Murrah Graded Buffaloes

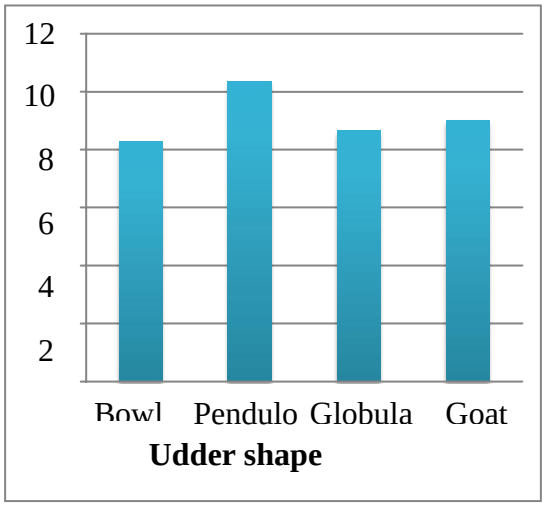


Fig.14 Average milk yield according to teat shapes in Murrah Graded Buffaloes

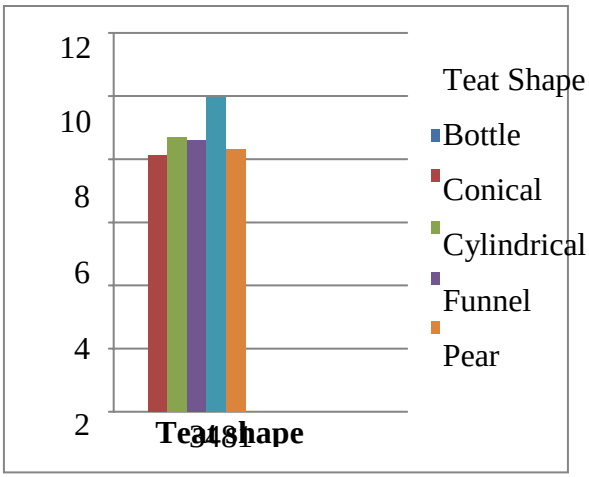


Fig.16 Average Fat and SNF per cent according to teat shape in murrah Graded Buffaloes

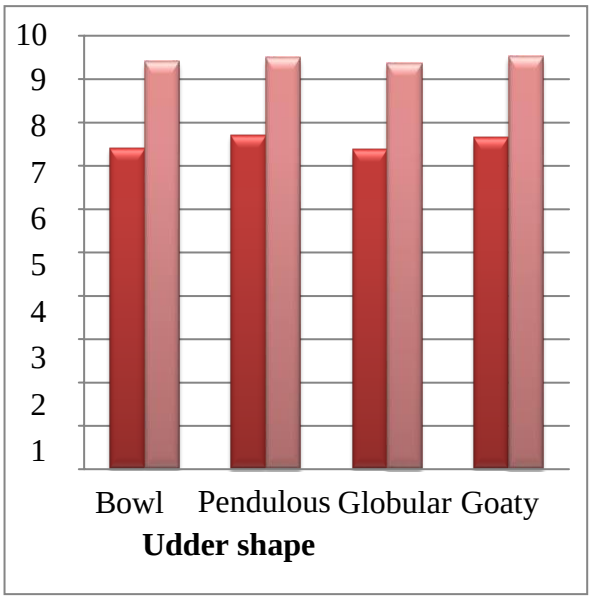
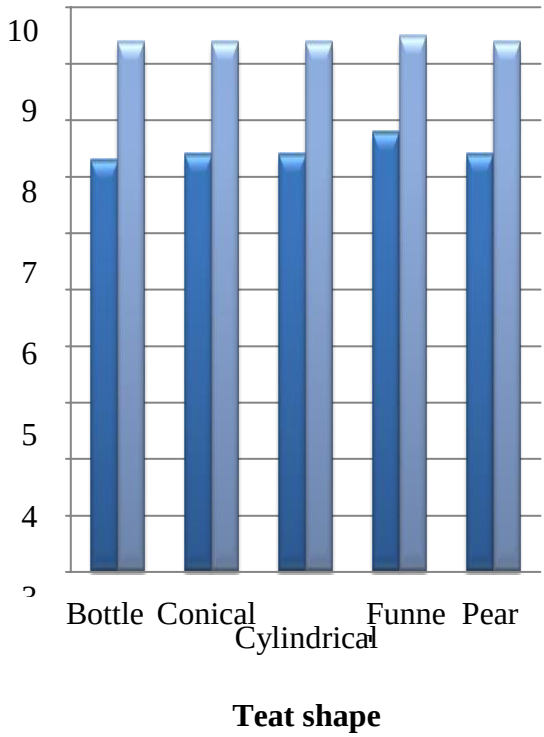


Fig.16 Average Fat and SNF per cent according to teat shape in murrah Graded Buffaloes



Correlation of udder and teat morphology and measurements with milk yield, fat and SNF percent

Correlation of various udder and teat measurements with test day milk yield, fat per cent, SNF per cent has been presented in the Table 11. The Daily milk yield, fat and SNF per cent showed positive correlation with udder length, udder width, udder depth, right fore teat length, left fore teat length, right rear teat length, left rear teat length, right fore teat diameter, left fore teat diameter, right rear teat diameter and left rear teat diameter.

Udder conformation in murrah graded buffaloes

Udder shape

The present study revealed that the mostly observed shape of udder in Murrah Graded Buffaloes was bowl shape udder with the frequency of about 73 per cent. Occurrence of Udder shape like Bowl, Pendulous, Globular and Goaty were 73 per cent, 13 per cent, 8 per cent and 6 per cent, respectively depicted in Figure 8. The results were accordance with Sonwane *et al.,* (2002) reported that bowl; round and pendulous shaped udder were common in Marathwadi, Nagpur and Murrah Buffaloes respectively. Bainwad *et al.,* (2007) indicated that Marathwadi (44.04 per cent) and Pandharpuri (43.24 per cent) breed has predominantly bowl and Surti pendulous (41.18 per cent) shape of udder respectively.

Prasad *et al.,* (2010) concluded that bowl type udder was common in Murrah Buffaloes followed by globular, pendulous and goaty and their occurrence were 61.0 %, 17.0%, 13.0% and 9.0 %, respectively. Patel and Trivedi *et al.,* (2018) observed trough(bowl) type were highest followed by round, goaty and pendulous type udder with the frequency of trough (bowl), round, goaty and pendulous shaped udder were 56.5 %, 19.5 %,7.5 % and 16.5 %, respectively in crossbred cows.

The results were not accordance with Akhtar *et al.,* (1998) who found that the majority of swamp Buffaloes were observed with round shaped udders followed by bowl, flat, goat and bath-shaped udders. Bhuiyan *et al.,* (2004) found that number of round shaped udder was maximum when compared to the bowl and goaty type of udders dairy cows.

Udder measurements

It was observed that the Mean±S.E of udder length, udder width and udder depth for bowl udder was 47.44±0.37 cm, 42.08±0.34 cm and 11.67±0.05 cm, for pendulous udder 51.55±0.90 cm, 46.15±0.94 cm and 12.3±0.16 cm, for globular udder 47.54±1.03 cm, 41.81±1.18 cm and 12.3±0.16 cm and for goaty udder 49.11±0.97 cm, 45.44±0.94 cm and 12.16±0.20 cm, respectively presented in Figure 9. The overall average udder length, udder width and udder depth were 48.1±0.33 cm, 42.80±0.32 cm and 11.80±0.05 cm respectively. So it was concluded that maximum udder length, udder width and udder depth was observed in pendulous udder.

Akhtar *et al.,* (1998) Observed that the mean values of udder length, width, were40.56 ± 0.15, 35.11 ± 0.16, respectively which are less than the findings of the present study. Prasad et al, (2010) investigated mean length, width of udder in different lactations ranged from 52.21±0.61 to 55.71±0.59, 48.61±0.60 to 53.87±0.70, respectively which were higher than the present findings. Lavania *et al.,* (2011) analysed that the overall least square means of udder length and udder width were 45.0± 0.7, 49.4 ±1.4 respectively. The udder length was lower than the present findings whereas the udder width was higher than the present findings. Deng *et al.,* (2012) observed the average udder length, Fore depth and hind

depth was 44.8±7.43 cm, 23.7±3.11 cm and 23.6±3.71 cm respectively which these were not accordance with the present findings. Espinosa-Nunez *et al.,* (2013) observed the average values in the udder traits were 38.46, 21.54 cm for length and width, respectively which were lower than the present findings. Khatri *et al.,* (2017) recorded the average length, width and depth of udder were58.24 ± 0.68 cm, 65.45 ± 0.70 cm and 23.06 ± 0.34 cm which were higher than the present findings. Modh *et al.,* (2017) observed the average udder length, width, depth were 61.95±1.20, 62.99±1.17, 25.62±0.43 cm respectively in Gir cows which were higher than the present findings. Patel and Trivedi (2018) observed the mean udder length, width and depth ranged from 50.87 ± 2.57 cm in goaty udders to 64.86 ± 1.89 cm in pendulous udders, 57.94± 2.31 cm in goaty udders to 73.02 ± 2.05 cm in pendulous udders and 20.43 ± 0.92 cm in goaty udders to 27.18 ± 1.01 cm in pendulous udders, respectively which were higher than the present findings of the study.

Teat shape

It was observed that among all the shapes, cylindrical shaped teats were commonly observed. Out of 150 animals 90 animals were having cylindrical shape of teats followed by conical, pear, bottle and funnel. Percentage of occurrence according to different teat shapes was cylindrical, conical, pear, bottle and funnel were 60 per cent, 16 per cent, 10 per cent, 8 per cent and 6 per cent, respectively presented in Figure 10.

It was concluded that cylindrical teats were commonly observed and about 60 per cent of Graded Murrah Buffaloes possess cylindrical teats. The results were in accordance with Bainwad *et al.,* (2007) concluded that 53.50 per cent of Marathwadi Buffaloes, Pandharpuri Buffaloes and Surti Buffaloes were having cylindrical shape teats. Prasad *et al.,* (2010) observed that the cylindrical teats were more frequent with a percentage of 52.5 followed by pear, bottle, conical and funnel shape of teats with 18.0, 11.0, 10.5 and 8.0% respectively. Susanta *et al.,* (2013) found that cylindrical and pointed teat ends were comparatively higher in Desi cows and crossbred cows.

The results were in contrary with Espinosa-Nunez *et al.,* (2013) found that 56.46% of them were conical, 31.18% cylindrical and 12.36% in bottle shaped teats. Patel and Trivedi (2017) showed the frequencies of cylindrical, funnel, bottle and pear-shaped teats were 24.75%, 48.63 %, 22.13 % and 4.5 %, respectively.

Teat measurements

It was observed that highest value was observed in Left Rear Teat, while the lowest value was observed in Right Fore Teat with the values 5.42±0.02 cm, and 5.96±0.02 cm. The overall mean±S.E of teat lengths of Right Fore, Left Fore, Right Rear, Left Fore were 5.42±0.02 cm, 5.60±0.02 cm, 5.74±0.03 cm and 5.96±0.02 cm, respectively presented in Figure 11.Similarly highest diameter was observed in Left Rear Teat and the lowest was observed in Right Fore Teat with the value of 2.48±0.01 cm and 2.87±0.02 cm. The overall mean±S.E of diameter of the Right Fore teat, Left Fore teat, Right Rear teat, Left Rear teat were 2.48±0.01 cm, 2.60±0.01 cm, 2.72±0.01 cm and 2.87±0.02 cm, respectively depicted in Figure 12. Muammer Tilki *et al.,* (2005) observed the mean values before milking for front and Rear teat length, front and Rear teat diameter, were 59.45 and 49.72 mm, 22.14 and 21.53 respectively. The present findings were higher than these findings except Fore teat length. Prasad *et al.,* (2010) inferred that the average lengths of Left Fore, Right Fore, Left hind and Right hind teats were 7.37 ±

0.15, 7.53 ± 0.16, 8.23 ± 0.18 and8.12 ± 0.17 cm, respectively, and the mean diameters in the same order were 2.65 ± 0.02,2.71 ± 0.03, 2.80 ± 0.03 and 2.89 ± 0.04 cm which were higher than the present findings.

Zwertvaegher *et al.*, (2012) had shown that hind teats (47.2 mm) were significantly shorter than front teats (54.9 mm) which were contrary to present results. Singhai *et al.*, (2013) observed the average teat length and diameter found in this study were 7.07±0.42 and 3.49±0.21cm respectively which were higher than the present findings. Espinosa-Nunez *et al.*, (2013) inferred that length of the cranial and caudal teats were 6.54cm, 7.33cm respectively which were higher than present findings and diameter of the cranial and caudal teats were 2.54 and 2.76 cms.

Correlation of udder and teat morphology with daily milk yield, fat per cent and SNF per cent in murrah graded buffaloes

Average milk yield in different udder and teat shape in Murrah Graded Buffaloes

It was observed that Pendulous Udder yielded maximum milk yield when compared to other types of Udders and the values of milk yield were 8.27±0.14 kg, 10.36±0.35 kg, 8.66±0.46 kg and 9.01±0.47 kg in Bowl, Pendulous, Globular and Goaty type of udders is presented in Figure 13. It was revealed that the highest milk yield was observed in funnel shaped teats when compared to other types of Teats. The Mean±S.E of milk yield of various teat shapes were found to be 9.97±0.36 kg in funnel shape teats, 8.68±0.42 kg in conical shape teats, 8.59±0.15 kg in Cylindrical shape teats, 8.31±0.50 kg in Pear shape teats and 8.12±0.40 kg in Bottle shaped teats depicted in Figure 14.

Ghosh and Prasad (1999) studied the influence of udder measurements and udder shape on test day milk yield on comparison between 3lactational stages, 3 parities, and 4 udder types found that significantly higher TDMY was recorded in pendulous and bowl type udders than in a goaty udder. Uddershape found to be determining factor for milkability which were in agreement with the present results. Ozbeyaz *et al.*, (1998) recorded and analysed the data of udder and teat measurement in brown swiss cows of different lactation number and milk yield at three stages of lactation (60, 150, 240 days) and reported that the funnel shape teat had the best milkability traits. The means of 305 day milk yield reported for bottle, cylindrical and funnel teat shape groups were 5786.60kg, 5556.55kg, and 5276.77 kg respectively. Riera *et al.*, (2008) concluded that cows with funnel teat shape should be recommended in crossbreeding programme as milk yield increased in cows with funnel shaped teat and decreased in cows with bottle shape.

Chaki *et al.*, (1999) studied the frequency of udder and teat type in primiparous cross bred cows and found that the bowl-shaped udders yielded more milk compared to the round and goat types of udders which was contrary to present findings. Singh *et al.*, (1999) evaluated the milkability of cross bred cows with different types of udder shape and teat shape under hand milking and found that milk yield of trough, round and pendulous udder types were 9.68±0.20kg, 7.04±0.16kg, and 5.05±0.47kg respectively. Highest milk flow rate was observed in the cows with trough cylindrical udder teat combination.

Average fat per cent and SNF per cent according to udder and teat shape in Murrah Graded Buffaloes

It is revealed that maximum and minimum Fat per cent was observed in Pendulous and Globular Udders with a mean value of 7.71±0.08 and7.37±0.12. Similarly, maximum

and minimum SNF per cent was observed in Goaty and Globular Udders with a mean value of 9.52±0.03 and 9.37±0.38 was presented in Figure 15. From Table 10 it was found that maximum and minimum Fat per cent was observed in funnel shaped Teats and Bottle Teats with a mean value of 7.82±0.22 and 7.30±0.12 respectively. Similarly, maximum and minimum SNF per cent was observed in funnel shaped Teats and Pear-shaped Teats with a mean value of 9.57±0.05 and 9.40±0.05 respectively showed in Figure 16.

Ghosh and Prasad (1998) studied the effect of udder measurements on milk yield and composition in Jersey X Red Sindhi crosses and found that the milk Fat% was highest in goat-type udders followed by round, bowl-shaped and pendulous types. SNF% did not differ significantly between the udder types. Rao (2006) assessed the influence of udder and teat dimensions and their relationship with milk yield and composition in Karan fries cows and reported that the Fat% in trough shaped udder was higher on '0' day (4.04 ± 0.80), 7th day (4.24 ± 0.23) 25 and 15th day (3.99 ± 0.14) as compared to round shaped udder, while on 30th day Fat % of milk in both udder types was almost same. Fat % was non-significant with regard to shape of udder and teat shape which were contrary to present findings.

Correlation of udder and teat morphology with dailymilk yield, fat per cent and SNF percent

It was found that the average daily milk yield, Fat per cent and SNF per cent showed positive correlation with udder length, udder width, udder depth, teat length and teat diameter. The present study revealed that there is positive correlation with all the measurements of udder with milk yield, Fat percent and SNF per cent. The results were in accordance with Prasad et al, (2010) found positive correlation was found among the udder length, udder width and udder depth and between these measurements and the average daily milk yield. Singhai *et al.,* (2013) found that the correlation was significant among udder length, udder width and milk yield (kg) and also between various teat measurements and milk yield. Khan and Khan (2016) found that the udder length had the highest phenotypic correlation with milk yield 0.45±0.02at first stage of lactation followed by udder width (0.39±0.03), udder circumference (0.31±0.03) and udder depth (0.29±0.03). Khatri *et al.,* (2017) derived that there is correlation between milk yield and various udder measurements like udder length (0.499), udder width(0.413), and udder depth (0.178) were found positive and significant (<0.05) to highly significant (P<0.01). Mingoas *et al.,* (2017) conducted a study and concluded that positive and highly significant correlations were observed between udder depth and milk yield. Tilki *et al.,* (2005) concluded that teat measurements were significantly affected milk yield. Espinosa-Nunez *et al.,* (2013) inferred that length and diameter of the cranial and caudal teats were 6.54, 7.33, 2.54 and 2.76 cms respectively and showed low to moderate correlations (0.13 to 0.32). Javed *et al.,* (2013) found the average Fat% and SNF% were 5.98±1.5, 8.67±0.54. Fat percentage was found to be negatively (P<0.01) correlated with milk production which was contrary to the present findings. AurifWagay *et al.,* (2017) observed the findings of Fat% and SNF % showed a negative, significant (P<0.05) to highly significant (P<0.01) correlation with udder length.

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