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Studies on udder and teat shape in relation with milk production in indigenous Kankrej cows at organized herd

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Abstract
An investigation was undertaken to assess the variation in udder and teat morphology and their association with test day milk yield in Kankrej cows. The study utilized 305 lactating Kankrej cows maintained at the Livestock Research Station, Sardarkrushinagar. The morphological characteristics of the udder and teats were visually inspected and their relationship with test day milk yield was evaluated. Among the various udder types observed, the bowl shape udder was most prevalent with 57.70%, followed by round (26.57%), pendulous (9.84%) and goaty shape (5.90%) udders. The cylindrical shape teats were most commonly observed with frequency of 56.06%, followed by funnel, pear and bottle shape teats with 24.91%, 15.73% and 3.28% frequency, respectively. The mean test day milk yield corresponding to different udder shapes was 9.61±0.37 kg for round, 9.32±0.54 kg for pendulous, 7.52±0.29 kg for bowl and 7.32±0.69 kg for goaty shape udders. Cows with round shape udders produced the highest milk yield, which was 31.28% more than those with goaty udders, 27.79% more than bowl-shape, and 3% more than pendulous udders. The differences in test day milk yield among the various udder shapes were highly significant ($p<0.01$), indicating a strong influence of udder conformation on milk production. Kankrej cows with pear shaped teats produced the highest milk yield, followed by funnel, cylindrical, and bottle shape teats, though the differences were non-significant. Milk yield increases with parity up to the fourth parity after which it tends to decline. Hence, dairy farmers may be advised to purchase the cows either in first or second lactation. It may be concluded from the present study that Kankrej cows with round shape udder and pear shaped teats produced significantly higher milk, hence cows with round shape udder, pear shaped teats and either in first or second lactation should be selected for improving milk production at dairy farm.

Keywords: Morphology, test day milk yield, Kankrej, udder shape, teat shape

Introduction

The primary objective of selection in dairy cattle is to enhance milk yield. The udder of the cow plays a vital role in determining milking potential. In many parts of India, particularly in rural areas, local brokers and animal husbandry personnel often rely on udder conformation as the first criterion for assessing a cow's milking ability. The shape of the udder plays a crucial role in the selection of high milk-yielding cattle, as variations in udder shape and size may be influenced by genetic heritability (Liebenberg and Jannermann, 1958) [10]. According to Tilki *et al.* (2005) [25] physiological characteristics of the udder and teats are critical for ensuring sustainable and high-quality milk production, further, udder and teat structures directly affect both productivity and udder health in dairy cows (Sinha *et al.*, 2022). The morphometric traits and conformational features of the udder and teats are key factors in selecting animals for dairy purposes as these characteristics have a direct impact on milk yield (Bhuiyan *et al.*, 2004) [3].

Kankrej is a breed of dual purpose zebu cattle. Total estimated population of Kankrej cattle in the country is 3028.3 thousand and the share of Kankrej cattle in total Indigenous cattle population is 2.0 percent (Srivastava *et al.*, 2019) [23]. They are well adapted to the geo-climatic conditions of Saurashtra and Kutch, have immense draught power and are known for yielding good quantity of milk with high fat content even in stress conditions (Srivastava *et al.* 2023) [24].

Despite their importance, limited research has been conducted on the relationship between udder and teat morphology and milk yield in cows, particularly in the indigenous breeds. Hence, the present study was undertaken to investigate the morphological variations in udder and teat shapes and their association with test day milk yield in Kankrej cows at an organized farm.

Material and Methods

A total of 305 lactating Kankrej cows, maintained at the Livestock Research Station, Sardarkrushinagar, were randomly selected for the present study. The data available for the study were classified based on parity, udder shape and teat shape. All the cows were categorized in five the following five groups, First, Second, Third, Fourth, Fifth and above parity based on the lactation number of the cow. Udder conformation was categorized into four distinct types: bowl (trough), round, goaty, and pendulous (Table 1 and Fig.1) as per Cerkascenko (1958) [4].

Table 1: Classification of udder shapes

Sr. No.	Shape of Udder	Description
1	Bowl shape udder	Rear udder high, wide strong and smooth in attachment with moderate depth and large capacity, giving the shape of a bowl.
2.	Round shape udder	Slight deviation from the bowl type with the increased depth.
3.	Goaty shape udder	The shape of the udder resembles closely the udder of goat where it is pushed forwards than backwards.
4.	Pendulous shape udder	An udder with a broken fore attachment, i.e., broken suspensory ligaments assuming a hanging loosely position.

Teat shapes in this study were categorized as: cylindrical, funnel, bottle, and pear shaped (Table 2 and Fig. 2) as per Ovesen (1972) [12]. The shapes of teats and udders of all the cows were examined the first author. All animals were kept under a semi-loose housing system with pucca flooring and were provided with green fodder, dry roughages and a concentrate mixture according to ICAR (2013) Feeding Standards. Clean drinking water was made available ad libitum throughout the day. Milking was performed twice daily at 3:00 AM and 3:00 PM at 12-hour intervals using both hand and machine milking methods. The daily milk production from cow was recorded for 3 consecutive days (Badekar, 2016) and the average of this was considered as Test day milk yield (TDMY). Restricted suckling system is followed at the farm in which calves were allowed to suckle prior to milking for letdown of milk. After let down of the milk, udder and teats were sanitized with a 1% potassium permanganate solution before actual milking. Milk yield was recorded during each milking session.

Table 2: Classification of teat shapes

Sr. No.	Teat shapes	Description
1	Cylindrical shape teat	The width of the teat from the base at point of attachment to the tip almost remains the same throughout its length
2.	Funnel shape teat	Wider at the base and tapering towards to tip as if to end in a point giving the shape of a funnel
3.	Pear shape teat	An abrupt constriction just below the base and again bulging towards the entire length giving the shape of a pear
4.	Bottle shape teat	Thick and enlarged throughout the length, resembling a bottle-wide at both the base and tip.

The Chi-square (χ^2) test of independence was performed to evaluate the relationship between Parity with Udder shape as per Snedecor and Cochran (1994) [21]. The least squares analysis of variance for unequal subclass numbers (Harvey, 1990), considering five Parities, four udder shapes and four teat shapes, were used to analyze the data using the following statistical model:

$$Y\_ijk = \mu + Ai + Bj + Ck + eijk$$

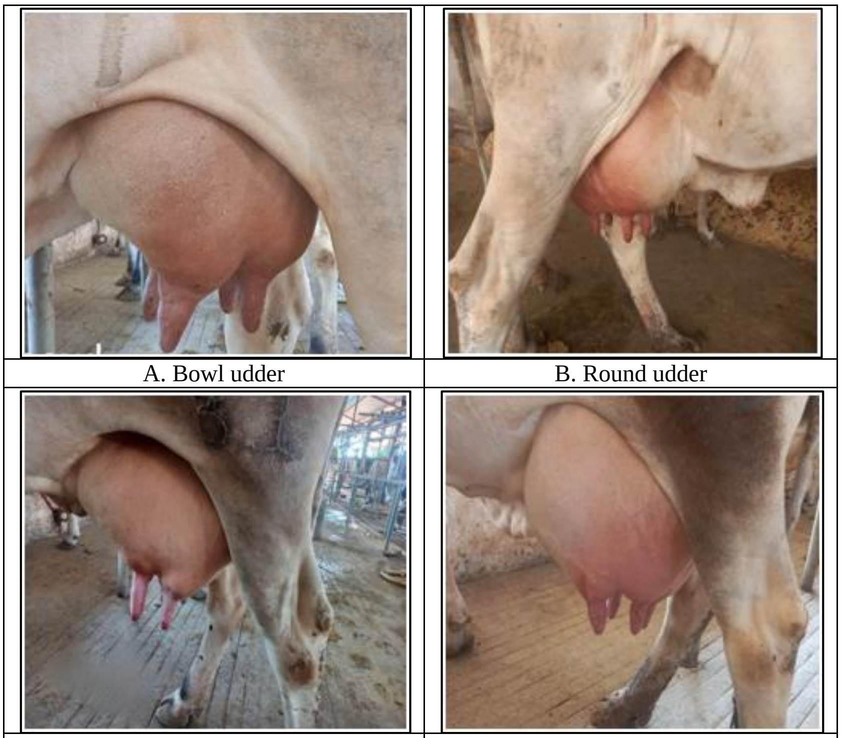
Where,
Yijk = Performance and udder morphometric traits
μ = Population mean
Ai = Fixed effect of ith Parity
Bj = Fixed effect of jth Shape of the Udder
Ck = Fixed effect of kth Shape of the Teat
eijk = Random error assumed to be normally and independently distributed .

Results and Discussion

Udder shape and Milk Production

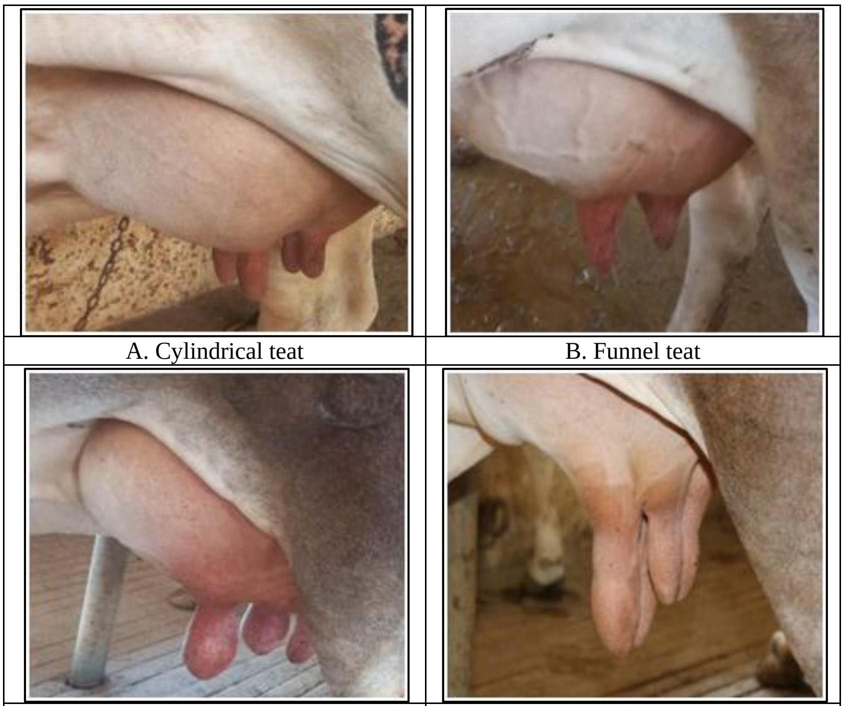
The analysis of udder shape distribution among 305 Kankrej cows indicated that bowl shaped udders were the most prevalent with a frequency of 57.70% of the total cows, followed by round, pendulous, goaty shape udders (Table 3). In indigenous cows, there is predominance of bowl shaped udders in Gir cows (59.6%; Tripathi *et al.*, 1982) [26]; Kankrej cows (49.56%; Prajapati *et al.*, 1995) [16] and Red Kandhari cattle (58.25%; Manoj, 2018) [11]. Similarly, Patel and Trivedi (2018) [13] also documented a higher frequency of bowl-shaped udders (56.5%) in crossbred cows, followed by round (19.5%), goaty (7.5%), and pendulous (16.5%) types. In contrast Gajbhiye *et al.* (2007) [6] and Asghar *et al.* (2024) [1] found round-shaped udders to be the most frequent in crossbred and dairy cattle, with frequencies of 53.64% and 50%, respectively. Additionally, Sampathkumar (2018) [19] reported a markedly higher proportion of goaty shape udders (59.18%) in Ongole cattle, deviating from the present observations in Kankrej cows. The differences in the udder shape of various indigenous breeds might be due to breed difference.

The overall test day milk yield (TDMY) was recorded 8.44±0.30 kg (Table 3). The mean test day milk yield varied with different udder shapes as bowl shape (7.52±0.29 kg), goaty (7.32±0.69 kg), pendulous (9.30±0.54 kg) and round shape (9.61±0.37 kg) and difference was found highly significant ($p<0.01$) among the groups. The Kankrej cows with round shape udders produced the highest milk yield, which was 31.28% more than those with goaty udders, 27.79% more than bowl-shape, and 3% more than pendulous udders.



A. Bowl udder | B. Round udder | C. Goaty udder | D. Pendulous udder

Fig 1: Various shapes of Udder in Kankrej cows



A. Cylindrical teat | B. Funnel teat | C. Pear teat | D. Bottle teat

Fig 2: Various shapes of teat in Kankrej cows

The Kankrej cows with round shape udders produced the significantly higher average milk yield among various udder shapes. These results align with the findings of Tilki *et al.* (2005) [25], who reported a significant influence of udder morphology on average milk yield in Brown Swiss cows and Poudel *et al.* (2022) [15] found higher daily milk yield in the round-shaped udder in Murrah buffalo at Nepal. However, Prasad *et al.* (2010) [17] and Patel *et al.* (2016) [14] observed non-significant differences in daily milk yield among different udder shapes in Murrah buffaloes and crossbred cows, respectively. The results of the present study indicate that while selecting the Kankrej cows, the animals with round shape udders should be selected.

Table 3: Occurrence of udder shape and association with test day milk yield in Kankrej cows

Udder Shape	Frequency	Test day milk yield (kg) (Mean ± S.E.)
Bowl	176 (57.70%)	7.52^{a}±0.29
Goaty	18 (05.90%)	7.32^{a}±0.69
Pendulous	30 (09.84%)	9.32^{b}±0.54
Round	81 (26.57%)	9.61^{b}±0.37
Overall µ	305 (100%)	8.44±0.30

Means with different superscripts in columns differ significantly (p<0.01)
Figures in parenthesis represent the percentage

Effect of parity on Udder shape and Milk production

Parity-wise distribution of udder shapes (Table 4) indicated that the round shaped udders were more common than bowl-shaped (29 Vs. 23) in the first parity, but from the second parity onward, the bowl shape became more prevalent. The frequency of bowl shaped udders increased progressively, and peaked in the second parity, and remained higher in subsequent parities than the other shapes. Interestingly, pendulous udders were not observed in cows of the first and second parities but began to appear from the third parity onward, with a notable increase in cows of fifth and above parities, accounted for 9.84% of total observations. This is likely due to the weakening of suspensory ligaments over successive lactations with advancement of age. The Chi-square test revealed a statistically significant association between udder shape and parity (χ^2 = 74.672, df = 12, p<0.001), indicating that changes in udder conformation are not random but are significantly influenced by the number of parity. Similar observations for pendulous udder have been reported by Patel and Trivedi (2018) [13] in crossbred cows. Goaty shaped udders were absent in first-parity cows and showed a consistent occurrence from the second to fourth parities, followed by a slight decline in cows of the fifth and above parities. The round shaped udder showed a declining trend with increasing parity, from 9.51% in first parity cows to decrease up to third parity (1.97%) then increases with increase in the lactation of the cows. These findings highlight the need for careful breeding and management, as the rise in pendulous udders with parity may affect udder health and milking efficiency. Selecting for desirable udder traits can improve productivity and longevity in Kankrej cows.

Table 4: Parity-wise distribution of udder shape in Kankrej cows (n=305)

Udder shape Parity	Bowl	Goaty	Pendulous	Round	Total	Test Day Milk Yield (Kg)
1	23 (7.54%)	0 (0.00%)	0 (0.00%)	29 (9.51%)	52 (17.05%)	6.79^{a}±0.51
2	44 (14.43%)	7 (2.29%)	0 (0.00%)	24 (7.87%)	75 (24.59%)	8.21^{a}±0.40
3	30 (9.84%)	4 (1.31%)	4 (1.31%)	6 (1.97%)	44 (14.43%)	9.68^{b}±0.46
4	41 (13.44%)	6 (1.97%)	6 (1.97%)	8 (2.62%)	61 (20.00%)	9.68^{b}±0.42
≥5	38 (12.45%)	1 (0.33%)	20 (6.56%)	14 (4.59%)	73 (23.93%)	7.85^{a}±0.40
Total/Overall	176 (57.70%)	18 (5.90%)	30 (9.84%)	81 (26.56%)	305 (100%)	8.44±0.30

Note: Figure in parenthesis denotes percentage frequency of total no. of cows (n=305) in the study.

An increasing trend in TDMY was noted with progression of parity (Table 4), rising from 6.79±0.51 kg in the first parity to a peak 9.68±0.42 kg during the third and fourth parities, followed by a decline in the fifth and above parities. Statistical analysis revealed that parity had a significant effect on TDMY (p<0.01). The higher milk yield was recorded in the fourth parity, which was statistically at par with the third parity but differed significantly from the first, second, and fifth parities. These findings align with the reports of Ahmad *et al.* (2011) [5] and Utrera *et al.* (2013) who observed a progressive increase in milk yield from the first to the third parity in indigenous and crossbred cows, respectively. Furthermore, Wondifraw *et al.* (2013) and Potdar *et al.* (2024) also noted a significant effect of parity on daily milk yield in HF × Deoni crossbred cows and in Ongole cattle, respectively. Conversely, Patel *et al.* (2016) [14] (2021) reported non-significant differences in milk yield across parities in Gir cows, Crossbred and Sahiwal, respectively.

Kankrej cows in their first parity produce less milk compared to mature cows in their fifth and above parities. This aligns with observations in other breeds, where younger cows tend to produce less milk due to their physiological systems not being fully developed for optimal production. Milk yield declines after the 4th or 5th parity in the Kankrej cows was observed may be due to age related decline of mammary gland functions and reduced metabolic efficiency. Overall, the present study confirms that test day milk yield increases with parity up to the fourth parity after which it tends to decline. Hence, dairy farmers may be advised to purchase the cows either in first or second lactation.

Occurrence of Teat shape and effect on Milk Production

In the present study, the distribution of teat shapes (Table 5) among Kankrej cows revealed that cylindrical shaped teats were the most predominant, accounting for 56.06% of the total observations. The predominance of cylindrical teats is consistent with findings by Kadam (2018) [8], who reported a similar frequency of cylindrical (57.75%) teat in Deoni cattle followed by funnel (29.75%), pear (10.75%), and bottle (2.25%) shape teat. Comparable results reported by Tripathi *et al.* (1982) [26] who observed a 39% frequency of cylindrical teats in Gir cows and Saiyed (1987) [18] reported a much higher frequency (83.73%) in Jersey × Kankrej crossbreds. Similar frequencies for cylindrical teats were documented by Sampathkumar (2018) [19] in Ongole cattle (57.82%), Manoj (2018) [11] in Red Kandhari cattle (43.50%), and Basavraj *et al.* (2019) in Deoni cattle (42.96%). However, Kamboj *et al.* (2007) [9] observed funnel shaped teats (48.27%) as the most prevalent type in Karan-Fries cows. Patel *et al.* (2018) [13] and Danish *et al.* (2018) [5] reported higher frequencies of funnel shaped (48.63%) teats in crossbred and (58.82%) in Sahiwal cows, respectively. The frequency of pear shaped teats in the present study was recorded 15.73%, which is in close agreement with Kadam (2018) [8] who found (10.75%) in Deoni cattle and Danish *et al.* (2018) [5] reported (14.71%) pear shape teat in Sahiwal cows. However, a markedly higher frequency of pear shaped teat (35.48%) was reported by Sonwane *et al.* (2002) [22] in crossbred cows. Bottle shaped teats were the least common in this study (3.28%), a finding consistent with those of Saiyed (1987) [18], who recorded 3.57% in Jersey × Kankrej crossbreds, and Kadam (2018) [8] reported 2.25% in Deoni cattle.

Table 5: Occurrence of teat shape and association with test-day milk yield in Kankrej cows

Teat Shape	Frequency	Test day milk yield (kg) (Mean ± S.E.)
Bottle	10 (03.28%)	7.07±0.85
Cylindrical	171(56.06%)	8.67±0.27
Funnel	76 (24.91%)	8.80±0.35
Pear	48 (15.73%)	9.23±0.45
Overall µ	305 (100%)	8.44±0.30
	-	NS

Conclusion

It is concluded that bowl shape udders and cylindrical teats were the most prevalent among Kankrej cows. Udder shape had a significant influence, whereas, teat shape have non-significant effect on milk production milk production increases with parity up to the fourth parity in Kankrej cows. It may be concluded from the present study that the Kankrej cows in first or second parity, with bowl by round shape udder and pear shape teats should be selected for higher milk production. These findings highlight the need for careful breeding and management, selecting the cows for desirable udder traits can improve productivity and longevity in Kankrej cows.

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