Effect of parity and lactation stage on milk yield, udder and teat morphometric traits of Friesian-Bunaji crossed cows

N.P. Achi*1, J.N. Achi2, I. Mallam3

1Dairy Research Programme, National Animal Production Research Institute/Ahmadu Bello University, Shika, Zaria
2Department of Agricultural Education, School of Vocational Studies, Nuhu Bamali Polytechnic, Zaria
3Department of Animal Science, Kaduna State University, Kafanchan Campus

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Abstract. Data for this study were collected from 40 multiparous (F1) Friesian x Bunaji cows at the dairy herd of the National Animal Production Research Institute (NAPRI) Shika, Nigeria, to assess the effect of parity and lactation stage on milk yield, udder and teat morphometric traits of Friesian-Bunaji crossed cows as well as to assess the relationships between the parameters measured. The data collected include udder circumference (UC), udder depth (UD), udder width (UW), fore teat length (FTL), and hind teat length (HTL) and were subjected to Analysis of Variance (ANOVA). The means with significant difference were separated using Duncan Multiple Range Test modelled in SAS (2004) statistical package and the correlation analysis was performed using correlation procedure in SAS to identify relationships between morphometric traits and milk yield. The results obtained showed that parity had significant (p<0.05) effect on udder circumference, hind teat length and milk yield. The highest udder circumference (23.60±2.50 cm) and hind teat length (2.80±0.34 cm), respectively, were found in parity 5 and the least ones were obtained in parity 1. Parity 2 had significantly (p<0.05) higher milk yield (8.60±0.72 litres) followed by parity 4 (7.13±1.14 litres) but similar to parity 3 (6.67±0.58 litres) and the least (6.20±1.24 litre) was obtained in parity 5 (6.20±1.24 litres). The results for lactation stage revealed no significant (p>0.05) difference in all the parameters except milk yield. The early lactation stage had significantly (p<0.05) higher milk yield (8.15±0.35 litre) followed by mid lactation stage (5.80±0.58 litre) but similar with the milk yield (4.38±0.86 litre) at late lactation stage. The results obtained for correlation indicated that the udder and teat morphometric traits and the milk yield measured showed varying degrees of relationships. The phenotypic correlations were positive and negative, low to high ranging from 0.00 to 0.69. The highest correlation coefficient (r=0.69; p<0.01) was obtained between udder circumference and udder depth. All the udder and teat morphometric traits measured were negatively correlated with the milk yield except udder width (UW) and had no significant (p>0.05) difference. Based on the results in this study, it can be concluded that parity has effect on udder circumference, hind teat length and milk yield with second parity having the highest milk yield 8.60±0.72 litre/day, while lactation stage had no effect in all the morphometric traits except on milk yield with the early stage having the highest milk yield (8.15±0.35 litre/day). The second parity and early lactation stage are recommended for high milk yield in Friesian x Bunaji cows in the studied area.

Keywords: parity, lactation stage, milk yield, udder, teat, morphometric, Friesian-Bunaji cows
Introduction

The dairy industry plays a crucial role in the global economy, and understanding the factors influencing milk yield and udder morphology is essential for optimizing dairy production (FAO, 2017). The Friesian-Bunaji cross is a promising breed known for its adaptability to various environmental conditions and desirable milk-producing characteristics. The udder and teat morphometric traits of Friesian-Bunaji crossed cows include udder circumference, udder depth, udder width, fore teat length, hind teat length and their relationship to milk yield (Alphonsus et al., 2010). Studies have shown that these morphometric traits, such as udder and teat measurements, are related to milk production, and the Friesian-Bunaji crossbred cows were found to be superior to Bunaji in milk yield characteristics (Alphonsus et al., 2012). The specific morphometric traits can vary, but they generally encompass a range of physical and physiological characteristics that are relevant for dairy production and animal breeding purposes.

According to Tawah and Rege (1996), the White Fulani (Bunaji) cattle are the most numerous and widespread of all the Nigerian cattle breeds. They represent about 37% of the National cattle population in Nigeria and are mainly owned by the Nomadic Fulani people who occupy the belt between the Sahara and the coastal rainforest from the west of the river Senegal to the east of Lake Chad, including parts of Southern Mauritania, Northern Nigeria and Cameroon. In Nigeria, Friesian sires are the most predominant dairy breed of cattle used in upgrading the milk production of the Bunaji cows (Alphonsus, 2018). This has produced a stabilized crossbred. However, very little information is available on the effect of parity and lactation stage on milk yield, udder and teat morphometric traits of Friesian-Bunaji crossed cows.

The development of the skill to visually appraise cattle and subsequently evaluate condition that contributes to herd productivity has traditionally been a key to successful cattle breeding. However, emphasis had shifted from a subjective method of appraising cattle to a more objective method such as the use of linear measurement of body parts (Essien and Adesope, 2003). Parity often has a significant effect on milk yield. Generally, cows tend to produce more milk with each successive lactation. Studies have shown that milk yield increases with increasing parity, but this improvement comes at the cost of higher incidences of reproductive health problems and reduced body condition (Lee and Kim, 2006). First-lactation cows may have lower milk yields compared to mature cows with multiple lactations. The initial lactation is often considered a period of adaptation, and as cows go through subsequent lactations, they tend to reach their peak milk production (Lee and Kim, 2006). Udder conformation, including factors like udder depth, udder width, and teat placement, may change with parity and lactation based on genetic factors, management practices, and environmental conditions. Specific research studies on Friesian-Bunaji crossed cows would provide more accurate and detailed information on the effect of parity and lactation stage on milk yield, udder and teat morphometric traits of Friesian-Bunaji crossed cows.

Understanding the impact of parity and lactation stage on milk yield is crucial for optimizing dairy production. By identifying the patterns and variations in milk production based on parity and lactation stage, farmers can implement targeted management practices to maximize milk yield. Also, the udder is a key component in milk production, and its morphometric traits play a significant role in determining milk quality and quantity. Investigating the influence of parity and lactation stage on udder and teat traits such as udder circumference, udder depth, udder width, fore teat length, hind teat length and milk yield, udder depth, width, and teat size provides a comprehensive understanding of the anatomical factors affecting milk production. This knowledge can guide selective breeding programmes to improve udder conformation, leading to enhanced milk quality and increased efficiency in dairy operations and is crucial for optimizing milking practices. Improved teat traits contribute to better milking hygiene, reduced mastitis risks, and increased overall efficiency in the milking process. This information is particularly important for dairy farmers aiming to enhance their herd management practices and ensure the well-
being of the animals. The White Fulani (Bunaji) is the most numerous (about 37%) and widespread of all the Nigerian cattle breeds. The Friesian sires in Nigeria are the most predominant dairy breed of cattle used in cross breeding the Bunaji cows (Alphonsus et al., 2010). However, there is little information on the effect of parity and lactation stage on milk yield, udder and teat morphometric traits of Friesian-Bunaji crossed cows. Therefore, the objective was to determine the effect of parity and lactation stage on milk yield, udder and teat morphometric traits of Friesian-Bunaji crossed cows.

**Material and methods**

**Experimental site**

The study was conducted on the dairy herd of dairy research programme, National Animal Production Research Institute (NAPRI)/Ahmadu Bello University, Shika-Zaria, Nigeria, located between latitude 11° and 12°N at an altitude of 640 m above sea level, and lies within the Northern Guinea Savanna Zone (Oni et al., 2001 as cited by Alphonsus et al., 2012). The mean annual rainfall in this zone is 1,100 mm, which commences from May and lasts till October, with 90% falling between June and September. The harmattan period of dry, cool weather that follows, marks the onset of the dry season and extends from mid-October to January. The dry season (February – May) is characterized by very hot weather conditions. At this period daily temperatures range from 21 to 36°C, the mean relative humidity is 21 and 72% during harmattan and the rainy season, respectively.

**Animals and managements**

Data for this study were collected from 40 multiparous Friesian x Bunaji cows. The animals were allowed to graze on pastures (*Digitaria smutsi*), crop residues under the supervision of herdsmen/grazers for about 7–9 hours per day and supplemented with a concentrate diet, consisting of 48% cotton seed cake, 13.7% wheat bran, 35.3% maize, 2% bone meal, 1% common salt; the diet comprised about 88% dry matter, 15% crude protein and 55% total digestible nutrients. Water and salt lick was provided ad libitum. All the experimental animals were ear-tagged for ease of identification. The animals were dipped once a week during the dry season and twice a week during the wet season for effective control of ectoparasites.

**Morphometric traits of udder and teat measured**

The udder and teat parameters measured were udder circumference, udder depth, udder width, fore teat length, hind teat length as well as the milk yield. All the traits taken were measured using measuring tape in centimeters except milk yield which was taken in litres.

- **Udder circumference (UC):** Measured as distance (perimeter) round the four quarters of the udder (cm).
- **Udder depth (UD):** The distance from the base to the lowest point of the udder at the place of attachment of the teats (cm).
- **Udder width (UW):** The distance across the rear quarters of the udder. It was measured at the widest point of the udder (cm).
- **Teat length (TL):** The distance from the teat insertion base to the teat orifice (cm).

**Early lactation stage:** This stage begins immediately after calving and typically from 1 to 90 days post-calving.

**Mid lactation stage:** Mid lactation follows the early lactation stage and generally lasts from around 91 to 180 days post-calving.

**Late lactation stage:** Late lactation occurs approximately 181 days post-calving until the cow is dried off, usually around 60 days before the next expected calving.

**Milk Yield (MY)**

Cows were milked twice daily (morning and evening) and milk yield was recorded on daily basis in litres. The time of milking was between 06:30 and 08:30 hours and between 16:30 and 18:30 hours. The daily milk yield record was used to calculate the total milk yield per day.

**The statistical model**

\[ Y_{ijk} = \mu + P_i + L_j + e_{ijk} \]

Where: \( Y_{ijk} \) = Observation; \( \mu \) = Overall mean;
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\[ P_i = \text{Fixed effect of the } i^{th} \text{ parity}, \ i = (1, 2, 3...5); \ L_j = \text{Fixed effect of the } j^{th} \text{ lactation stage}, j = (1, 2 \text{ and } 3); \ e_{ijk} = \text{Random error}=\text{Niid}(0, \sigma^2), \text{ independently and identically normally distributed with zero mean and constant variance.} \]

**Statistical analysis**

The data collected were subjected to Analysis of Variance (ANOVA) to assess the significance of differences (means±standard errors) in milk yield, udder, and teat morphometric traits among different parities and lactation stages using Duncan Multiple Range Test (Duncan, 1955) modelled in SAS (2004) statistical package. Correlation analysis was performed to identify relationships between morphometric traits and milk yield.

**Results and discussion**

The least square means (±SE) of milk yield, udder and teat morphological traits of Friesian-Bunaji crossed cows are presented in Table 1. The results showed that parity had significant (p<0.05) effect on udder circumference, hind teat length and milk yield while the udder depth, udder width and fore teat length were not affected by parity.

The highest udder circumference (23.60±2.50 cm) and hind teat length (2.80±0.34 cm), respectively, were found in parity 5 and the least ones were found in parity 1. Parity 2 had significantly (p<0.05) higher milk yield (8.60±0.72 litres) followed by parity 4 (7.13±1.14 litres) but similar to parity 3 (6.67±0.58 litres) and the least (6.20±1.24 litre) was obtained in parity 5 (6.20±1.24 litres) but similar with parity 1 (6.25±0.75 litres).

The results showed that the udder circumference and hind teat length significantly increased (p<0.05) as the parity increased with the highest value at fifth parity. This result agrees with findings reported for Holstein cows that udder height, udder circumference, teat length and udder depth increase with parity (Zwertvaegher et al., 2012). This can be explained by progressive udder hypertrophy with respect to cow’s age and parity (Abdou et al., 2012).

The increase in udder circumference as parity increases could be due to the fact that as cows go through successive pregnancies, their udders and teats develop and mature. This development process typically leads to an increase in size and dimensions of the udder and teats. However, the no significant difference in udder depth (UD), udder width (UW) and fore teat length (FTL) obtained in this current study is in agreement with the report by Marai et al. (2001) that udder and teat morphology did not vary with parity in Egyptian Buffalo cows. This could be due to genetic characteristics.

The significant differences in milk yield in this study are similar with the report by Sabek et al. (2021) who reported that parity has effect on milk production traits. The possible reason for having higher milk at second parity could be that cows typically reach peak milk production during their second lactation, which corresponds to their second parity. This is because they are still relatively young and have reached full maturity, but their bodies haven’t yet started to decline in efficiency as they might in later parities (Sabek et al., 2021).

**Table 1.** Effect of parity on milk yield, udder and teat morphological traits of Friesian-Bunaji crossed cows

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Parity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>LOS</th>
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<tbody>
<tr>
<td>UC (cm)</td>
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<tr>
<td></td>
<td>1</td>
<td>17.25±0.97c</td>
<td>19.70±0.97bc</td>
<td>17.44±0.60c</td>
<td>21.50±0.46b</td>
<td>23.60±2.50a</td>
<td>*</td>
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<tr>
<td>UD (cm)</td>
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<td></td>
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<tr>
<td></td>
<td>2</td>
<td>19.70±0.97bc</td>
<td>17.44±0.60c</td>
<td>21.50±0.46b</td>
<td>23.60±2.50a</td>
<td>*</td>
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<tr>
<td>UW (cm)</td>
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<tr>
<td></td>
<td>3</td>
<td>17.44±0.60c</td>
<td>21.50±0.46b</td>
<td>23.60±2.50a</td>
<td>*</td>
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<td>FTL (cm)</td>
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<tr>
<td></td>
<td>4</td>
<td>2.10±0.17b</td>
<td>2.10±0.09</td>
<td>2.19±0.15</td>
<td>2.23±0.09</td>
<td>2.34±0.22</td>
<td>NS</td>
</tr>
<tr>
<td>HTL (cm)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2.10±0.17b</td>
<td>2.10±0.09</td>
<td>2.19±0.15</td>
<td>2.23±0.09</td>
<td>2.34±0.22</td>
<td>NS</td>
</tr>
<tr>
<td>Milk yield (litre/day)</td>
<td></td>
<td>2.10±0.17b</td>
<td>2.10±0.09</td>
<td>2.19±0.15</td>
<td>2.23±0.09</td>
<td>2.34±0.22</td>
<td>NS</td>
</tr>
</tbody>
</table>

UC=Udder circumference, UD=Udder depth, UW=Udder width, FTL=fore teat length (cm), HTL=hind teat length (cm), LOS=level of significance, NS=No significant.
Health plays a significant role in milk production. Cows in their second parity may experience fewer health issues compared to older cows.

Table 2 shows the least square means (±SE) of milk yield, udder and teat morphological traits of Friesian-Bunaji crossed cows at different lactation stages. There is no significant (p>0.05) difference in all the parameters except milk yield. The udder circumference, udder depth, udder width, fore teat length, hind teat length range from 17.70±0.97 to 20.63±1.98 cm, 7.80±0.92 to 8.93±0.48 cm, 7.20±1.16 to 8.69±0.38 cm, 2.14±0.17 to 24±0.17 cm and 2.39±0.09 to 2.56±0.34, respectively. The early stage had significantly (p<0.05) higher milk yield (8.15±0.35 litre) followed by mid lactation stage (5.80±0.58 litre) but similar with the milk yield (4.38±0.86) at late lactation stage.

The results indicated that lactation stage does not have effect on udder and teat morphological traits of Friesian-Bunaji crossed cows and has effect on milk yield. The lack of differences in lactation stage in udder and teat morphological traits agreed with the findings of Patel and Trivedi (2018), who reported that lactation has no effect on udder length, udder width and udder depth in crossbred cows. The result is contrary to the report by Milerski et al. (2006) who stated that lactation has effect on udder and teat morphological traits. The differences observed by the authors could be due to variation in the age of the animals, genotype, stage of lactation and parity and other environmental factors as reported. The values obtained in the current study for udder circumference, udder depth, udder width are lower than the values reported by Mallam et al. (2021) who reported 40.23±0.50 cm, 22.44±0.25 cm and 13.19±0.27 cm for udder circumference, udder depth and udder width, respectively.

However, the higher milk yield in early stage over mid and late stages of lactation could be associated with better body condition score (BCS) at early stage than when the cows are getting older as reported by Alphonsu et al. (2012) who stated that milk yield and fertility of Friesian x Bunaji dairy cows are affected by body condition score. The milk yield/day in the current study at early stage is higher than the values reported by Alphonsus et al. (2012) but within the ranges observed in mid and late stage who found that daily milk yield in Friesian x Bunaji cows varied between 2.90 and 6.70 kg/day.

The higher milk yield in the early stage than mid and late stages could be due to the fact that the amount of milk produced by a cow varies throughout the lactation cycle, with generally higher production levels occurring in the early stages. During early lactation, the demand for milk is typically high due to the needs of the growing calf. Frequent and effective milking during this period stimulates continued milk production (Hutjens, 2002). Also, mastitis, inflammation of the udder, can decrease milk yield. Cows are more susceptible to mastitis during mid to late lactation, which can contribute to reduced milk production during these stages, while at the beginning of lactation, hormonal changes stimulate the mammary glands to produce more milk. The hormone prolactin, for example, plays a crucial role in milk synthesis and is typically elevated during early lactation ((Hutjens, 2002).

### Table 2. Effect of lactation stage on milk yield, udder and teat morphological traits of Friesian-Bunaji crossed cows

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Early</th>
<th>Mid</th>
<th>Late</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UC (cm)</td>
<td>19.56±0.97</td>
<td>17.70±0.97</td>
<td>20.63±1.98</td>
<td>NS</td>
</tr>
<tr>
<td>UD(cm)</td>
<td>8.93±0.48</td>
<td>7.80±0.92</td>
<td>8.63±0.89</td>
<td>NS</td>
</tr>
<tr>
<td>UW (cm)</td>
<td>8.69±0.38</td>
<td>7.20±1.16</td>
<td>8.25±1.15</td>
<td>NS</td>
</tr>
<tr>
<td>FTL (cm)</td>
<td>2.14±0.17</td>
<td>2.24±0.17</td>
<td>2.24±0.13</td>
<td>NS</td>
</tr>
<tr>
<td>HTL (cm)</td>
<td>2.39±0.09</td>
<td>2.56±0.34</td>
<td>2.53±0.15</td>
<td>NS</td>
</tr>
<tr>
<td>Milk yield (Litre/day)</td>
<td>8.15±0.35^a</td>
<td>5.80±0.58^b</td>
<td>4.38±0.86^b</td>
<td>*</td>
</tr>
</tbody>
</table>

UC=Udder circumference, UD=Udder depth, UW= Udder width, FTL=fore teat length (cm), HTL= hind teat length (cm), LOS= level of significance, NS= No significant
Coefficients of correlation for milk yield, udder and teat morphological traits of Friesian-Bunaji crossed cows are shown in Table 3. The results obtained indicate that the udder and teat morphometric traits and the milk yield measured showed varying degrees of relationships. The phenotypic correlations were positive and negative, low to high ranging from 0.00 to 0.69. The highest correlation coefficient ($r=0.69$; $p<0.01$) was obtained between udder circumference and udder depth followed by fore teat length and hind teat length ($r=0.58$; $p<0.05$). All the udder and teat morphometric traits measured were negatively correlated with the milk yield except udder width (UW) and had no significant ($p>0.05$) difference.

The results obtained showed both positive and negative, low to high correlations among some of the various udder and teat morphological traits and ranged from 0.00 to 0.69 and significant ($p<0.05$; $p<0.01$) difference and no significant ($p>0.05$) difference with milk yield. The results between the udder and teat morphological traits are similar with the report of Patel et al. (2016), who reported positive and significant ($p<0.05$, $p<0.01$) relationship between udder width and udder depth as well as udder length. The authors also observed significant relationship among udder length, udder width and udder depth with overall teat length and overall teat diameter in crossbred cows. The results of the current study of the relationship between udder width and udder depth as well as the fore teat length agreed with the report of Sinha et al. (2021) who reported that udder width had a weak but positive correlation with udder depth (0.06) but contrary with that of udder circumference and udder depth which was high ($r=0.69$) in the current study. Meanwhile, the authors reported a strong and positive correlation between udder width and udder length (0.90). Some of the variations in the current study could be due to environment or genetic factors.

The high and positive correlation ($r=0.58$) between fore teat length and hind teat length results in this study disagreed with the report of Sinha et al. (2021) who reported a weak and negative correlation (-0.01) between fore and hind teat length in Sahiwal cows. The variation could be due to differences in breed, age and environmental factors.

The correlation coefficients between the udder and teat morphological traits in this study are generally lower than the values ($r=0.54$ to 0.77) reported by Mallam et al. (2021) in White Fulani cows in Southern Kaduna.

In the present study, all the udder and teat measurements showed a non-significant relation with the milk yield and this is in agreement with the report of Modh et al. (2017) who reported no significant difference between udder circumference, udder depth, and teat length with milk yield.

The negative correlations between udder and teat morphological traits and milk yield are contrary to the report of Eisa et al. (2010) who reported positive correlations between udder circumference, udder depth and udder width with milk yield of Lahween Camel. This could be due to differences in species, age, and environment among other factors. The negative and no significant ($p>0.05$) difference between the udder and teat morphological traits measured and milk yield means that as any of them increases, the milk yield will not necessarily increase.

Table 3: Coefficient of correlation for milk yield, udder and teat morphological traits of Friesian-Bunaji crossed cows

<table>
<thead>
<tr>
<th></th>
<th>UC</th>
<th>UD</th>
<th>UW</th>
<th>FTL</th>
<th>HTL</th>
<th>MY</th>
</tr>
</thead>
<tbody>
<tr>
<td>UC</td>
<td>X</td>
<td>0.69**</td>
<td></td>
<td>0.48**</td>
<td>0.26NS</td>
<td>0.27NS</td>
</tr>
<tr>
<td>UD</td>
<td>X</td>
<td>0.32NS</td>
<td></td>
<td>0.21NS</td>
<td>0.28NS</td>
<td>-0.03NS</td>
</tr>
<tr>
<td>UW</td>
<td>X</td>
<td>0.22NS</td>
<td></td>
<td>0.33*</td>
<td>0.00NS</td>
<td></td>
</tr>
<tr>
<td>FTL</td>
<td>X</td>
<td></td>
<td></td>
<td>0.58*</td>
<td>-0.21NS</td>
<td></td>
</tr>
<tr>
<td>HTL</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>-0.19NS</td>
<td></td>
</tr>
<tr>
<td>MY</td>
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<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

UC=Udder circumference, UD=Udder depth, UW= Udder width, FTL= fore teat length (cm), HTL= hind teat length (cm), MY= Milk yield, NS= No significant, *= Significant at 0.05, **= Significant at 0.01.
as there is no positive correlation. It implies that as these traits increase in size or certain characteristics, the milk yield tends to decrease. This suggests that the udder and teat morphology traits measured do not have impact on milk yield as obtained in this study.

**Conclusion**

Parity has effect on udder circumference, hind teat length and milk yield with second parity having the highest milk yield (8.60±0.72 litre/day). Lactation stage had no effect in all the morphological traits except on milk yield with the early stage having the highest milk yield (8.15±0.35 litre/day). The highest correlation coefficient (r=0.69; p<0.01) was obtained between udder circumference and udder depth. All the udder and teat morphological traits measured were negatively correlated with the milk yield except for udder width (UW) although with no significant (p>0.05) difference. Therefore, understanding these correlations between the morphometric traits can be crucial for dairy farmers and breeders. It allows them to make informed decisions regarding breeding programmes, management practices, and selection criteria to optimize milk production efficiency while maintaining the health and welfare of the animals.

**Recommendations**

For better udder and hind teat length, fifth parity is recommended.

For best milk yield, second parity is hereby recommended.

For udder and teat morphological traits, any of the lactation stage can be selected.

Early lactation stage is recommended over mid and late lactation stages for better milk yield.

Research on the relationship between udder and teat shapes on milk yield should be conducted in cattle.

**References**


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