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Full length article

The effects of parity and lactation stages on udder and teats measurements in crossbred dairy cows

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ABSTRACT

The aim of the study was to evaluate the effect of parity, lactation on udder, teat traits and milk yield of crossbred cows at the educational farm field, University of Khartoum, Sudan. Twenty-eight lactating crossbred cows apparently healthy with different parties and ages were selected and investigated between January and November of 2022. The external udder and teat measurements were taken in centimeters(cm); while milk yield in liter (L) after fifteen days' post calving. The udder parameters measured were udder length (UL), udder circumference (UC), udder depth (UD), udder width (UW); whereas, the teat measurements were front teat length (FTL) and rear teat length (RTL), Front teat width (FTW), rear teat width (RTW) and the distance between teats (DBT). All investigated traits were measured in centimeters using measuring transparent ruler and tape meter. The result revealed that, there were significant differences ($p<0.05$) among udder and teat mean values measurements(cm) at different parities and lactation stages with exception the width of udder and distance between teats (front and rear sides) traits. Similarly, milk yield (liter) was also influenced by parity and lactation stages, in particular, at 1st lactation stage. In conclusion, parity and lactation stages have significant impact on parameters of udder, teats measurements; and milk yield in crossbred cows. These findings could be useful and ought to be taken in to account in dairy cows breeding. Similar studies should be carried out on other breed of cows in in study area and different geographical regions of the country.

INTRODCTION

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). Body measurements are phenotypic markers of the genetic makeup of an animal. Consequently, udder morphology traits are promising indicators of milk yield in dairy cattle (Achi et al., 2024). The size and shape of the udder are important conformation traits that could play a vital role in assessing a dairy animal's suitability for commercial milk production and should be considered in selection (Bhuiyan et al., 2004).

Variations in udder and teat characters are observed between breeds and individuals in the same herd with respect to parity and lactation stages. Hence, udder is the first site for judging the milking ability of

animals by local brokers and animal husbandry stakeholders. Therefore; it is more important to have knowledge of morphometry of udder and teats (Khatri *et al.,* 2017; Patel & Trivedi, 2018).

The udder and teat morphometric traits of cows include udder circumference, udder depth, udder width, fore teat length, hind teat length and their relationship to milk yield (Alphonsus et al., 2018). There are several factors which may affect udder traits and chemical composition of milk in dairy animals which include breed, parity, order and stage of lactation, weight, size, body condition, animal and udder sanitary state, breeding system and udder types (Rovai, 2001).

Inferior udder health can be a source of economic loss for both dairy farmers and milk processors. It can result in reduced milk yield and milk quality (Bartlett et al., 1991), changes in milk composition (Auldist et al., 1995), increased involuntary culling (Berry et al., 2005), and veterinary and treatment costs (Berry and Amer, 2005). The present study was undertaken with the aim to investigate the effect of location and parity on udder and teats measurements of crossbred cows.

MATERIALS AND METHODS

Study area

This cross-sectional study was conducted on crossbred cows at the educational farm field, University of Khartoum, Sudan between January and November of 2022. Khartoum is located between longitudes 31.5 to 34°E and latitudes 15 to 16°N. It is surrounded by River Nile State in the north-east, in the north-west by the Northern State, in the east and southeast by the states of Kassala, Qadarif, Gezira and White Nile State, and in the west by North Kurdufan (Anonymous, 2025). Khartoum, experiences a hot desert climate characterized by extremely high temperatures and very low precipitation. The city has two distinct seasons - a hot, dry season from October to April and a scorching hot season from May to September. During the summer months, temperatures can exceed 40°C (104°F) regularly. It receives minimal rainfall, with most of it occurring in the form of sporadic heavy showers between June and September (Anonymous, 2025).

Study animals and managements

Twenty-eight lactating crossbred cows apparently healthy with different parities (15 animals were multiparous and 13 animals were Primiparous**)** and ages ranged between 3-12 years old were selected and investigated in this study. The cows were raised by educational farm field, University of Khartoum, Sudan. The animals were appropriately marked with ear-tagged for ease of identification. The animals (cows) were kept under similar administrative management and nutrition conditions.

Morphometric traits of udder and teat measurements

The udder traits/parameters measured were Udder Length (UL), udder circumference (UC), udder depth (UD), udder width (UW); whereas, the teat measurements include front teat length (FTL) and rear teat length (RTL), Front teat width (FTW), rear teat width (RTW) and the distance between teats (DBT). All investigated traits were measured using measuring transparent ruler and tape. Centimeter is used as unit measurement. The parameters(traits) measurements were carried out according to the techniques described by (Kuczaj, 2003; Kul et al*.,* 2006).

Milk yield evaluation

Milk yield evaluation of the cows was commenced at day 15 post birth (postpartum). All cows were stimulated for milk ejection by manually massaging the udder after washing. Udders and teats were washed with clean water and wiped off with towels soaked in antiseptic solution and allowed to dry. Morning (12:00 AM) and evening (12:00 PM). Milk yields of individual cow were recorded to arrive at the total daily milk yield. The collected samples were transported to the laboratory immediately in a cool box with maintained temperature of < 4°C for process and further necessary action following the method described by Singhai et al. (2013).

Statistical Analysis

A completely randomized design (CRD) was employed to assess the impact of lactation stage and parity on udder morphology traits and milk yield. The data were analyzed using the following statistical model: $Yij = u + ai + bj + eij$

Where: Yij = examined dependent variables (UL, UW, UD, CU, TL, TW, and TDB), u = overall mean, ai = the impact of parity (i = primiparous and multiparous), bj = lactation stage (j = early, mid, and late), eij = random experimental error.

Duncan test was used to determine the associations between measurements, which was declared at $P < 0.05$; using the LSD test (SAS, 2012).

RESULTS AND DISCUSSION

Dairy cows' production is a significant sector of livestock production worldwide. The demand for milk in developing countries is projected to rise by 25 percent by 2025 (FAO, 2018). Unfortunately, the dairy sector in developing countries is challenged by poor yields from local breeds and high production costs on commercial

farms with exotic breeds. Dairy farmers are unaware of knowledge on udder morphometry and its relationship with milk production, parity and lactation stages. They are not maintaining proper production records of their animals in an organized manner (Sathiyabarathi and Kumar, 2020). Body measurements are phenotypic markers of the genetic makeup of an animal. Consequently, udder morphology traits are promising indicators of milk yield in dairy cattle and play a vital role in assessing a dairy animal's suitability for commercial production (Bhuiyan et al., 2005).

This study was carried out on crossbred cow at educational farm field, University of Khartoum with main objective to determine the effect of parity and lactation stage on udder and teat morphometric traits and milk yield of crossed cows. The results of the effect of parity and lactation stage on udder and teat morphometric traits and milk yield of crossed cows are presented in Table 1. As shown, the results revealed that parity have significant ($p<0.05$) effect on udder length, udder width, udder depth, udder circumference and milk yield. The mean values recorded were 53.20 ±0.76 & 66.67 ±0.73 cm; 30.80 ±0.59 & 36.56 ±0.69 cm; 36.47 ±0.55 & 44.11 ±0.48 cm; 90.22 ±1.11 & 110.25 ±1.22 cm; 7.59 ±0.10 & 10.73 ±0.13 (L) for Primiparous and Multiparous respectively. Furthermore, the result raveled that, the results indicate that multiparous cows have a significant ($P<0.005$) higher means values of udder measurement and milk yield compared to primiparous cows. These results are in agreement either completely or partially with previous studies (Achi et al., 2024; Sathiyabarathi; Kumar, 2020). The reason behind variations of udder morphological measurements could be explained in the view of Abdu et al, (2012) who suggested that progressive udder hypertrophy with respect to cow's age and parity.

The impact of lactation stages on udder morphological traits and milk yield crossbred cows are also depicted in Table 1.

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Table 1. Effect of parity and lactation stage on udder measurements and milk yield in crossbred cows(n=28)

	Parameters (Traits)				
Variables	**MY (L)**	**UL (cm)**	**UW (cm)**	**UD (cm)**	**CU (cm)**
Parity					
Primiparous	7.59±0.10^{b}	53.20±0.76^{b}	30.80±0.59^{b}	36.47±0.55^{b}	90.22±1.11^{b}
Multiparous	10.73±0.13^{a}	66.67±0.73^{a}	36.56±0.69^{a}	44.11±0.48^{a}	110.25±1.22^{a}
Lactation Stage					
Early (1-3 M)	10.76±0.31^{a}	62.93±1.56^{a}	36.56±1.25^{a}	42.34±1.40^{a}	103.74±2.53^{a}
Mid(4-M)	9.62±0.22^{b}	58.33±1.61^{ab}	34.04±1.12^{a}	39.70±1.02^{ab}	100.24±2.16^{ab}
Late (7 M- drying)	8.83±0.17^{c}	56.93±1.58^{b}	30.25±1.70^{b}	36.87±1.40^{b}	94.65±2.34^{b}

^{a,b} means with different superscripts in the same column differ significantly ($P<0.05$); milk yield= MY, Udder Length= UL; Udder Width =UW; Udder Depth= UD; circumference Udder= CU, M=Month.

As shown, there are significant differences ($p>0.05$) between lactation stages and all morphological parameters studied which include udder length, udder width, udder depth, udder circumference. In the term of influencing of milk yield by lactation stage, results revealed that, the early stage had significantly ($p<0.05$) higher milk yield (10.76 ±0.31 liter) and lower mean value was recorded in late lactation stage (8.83 ±0.17 liter). The results are in line with findings of Milerski et al. (2006) who stated that lactation has effect on udder morphological traits and in contrast with findings of Achi et al., 2024. The contrary and consistent between the results of current study and findings of above workers could be attributed to variation in the age of the animals, genotype, stage of lactation and parity and environmental & management factors.

The Table 2. Displayed the results of the effect of parity on teats traits measurements in crossbred cows. As shown, the means values of fore and rear teat lengths were (7.97 ±0.59 & 7.09 ±0.65 cm) and (7.35 ±0.50 & 6.37 ±0.60 cm) for multiparous and Primiparous cows respectively. Similarly, the mean ±SE values of fore and rear teat width were (2.97 ±0.27& 2.81 ±0.22cm) and (2.91 ±0.18 & 2.83 ±0.15cm) for multiparous and Primiparous respectively. The mean valued of right and left Distance Between Teats were 7.15 ±0.22 & 4.70 ±0.20; 7.13 ±0.20 & 4.33 ±0.16 for Multiparous and Primiparous respectively.

The statistical analysis showed that significant differences($P<0.05$) observed among mean values of teat length and right & left distance between teats; while, none with width, front and rear sides of teats

measurements during different parities in experimental animals investigated. These results are in consistent either in complete or partially with findings of previous studies (Kuczaj, 2003; Singh et al*.,* 2010; Singhai et al*.,* 2013; Achi et al., 2024). However, these results are in contrast with findings of Alkhateeb et al. (2021) who studied the impact of parity on teats measurements of lactating buffaloes in Iraq. The contrary or consistent in the results among current study and previous studies could be attributed to breed of animals, management, genetically factors and the techniques of milking used.

Table. 2. Effect of parity on teats measurements of crossbred cows(n=28)

	Parity	
Parameters	Multiparous(n=15)	Primiparous(n=13)
Teat's length		
Front	7.97±0.59[a]	7.09±0.65[b]
Rear	7.35±0.50[a]	6.37±0.60[b]
Teat's width		
Front	2.97±0.27	2.81±0.22
Rear	2.91±0.18	2.83±0.15
Distance Between Teats		
Right	7.15 ±0.22[a]	4.70±0.20[b]
Left	7.13 ±0.20[a]	4.15±0.33[b]
Front	11.99±0.35	10.63±0.23
Rear	4.43±0.13	3.84±0.14

[a,b]: means in the same row with different superscripts differ significantly (P < 0.05); n= number cows

The effect of lactation stages on teats measurement and milk yield in crossbreed cows are presented in Table 3. As shown, there are steadily increase in mean values of teat traits/parameters in different lactation stages, namely, length (TL) and teats width (TW). The means values are 7.38 ±0.29 - 7.90 ± 0.27; 2.56 ±0.12 - 2.95 ±0.12 for front teats; while 6.69 ±0.27; 04 ±0.25; 2.87 ±0.10-2.89 ±0.07 for rear teat. Significant differences (P<0.05) were observed among mean values of length rear teat and lactation stages; while, none with length front teat. The mean values of Distance Between Teats (DBT) parameters were not significant different(P<0.05) with exception rear side parameter. These results are in complete or partial in agreement with findings of previous studies (Tiki et al., 2005; Zwertvaegher et al., 2012; Sathiyabarath and Kumar, 2022). The contrary and harmony among results of this study and above worker's findings may be due to the breed of cows, shape & size of teats, and different measuring methods used.

Considering the effect of lactation stages on milk yield, the results revealed that the higher means values was recorded at 1st lactation stage, followed by mid and late stages. Significant differences were observed between the means values of milk yield and 1st lactation stage only. These results are in parallel with findings of other researchers (Ahmad et al., 2011; Ceyhan et al., 2015; Achi et al., 2024). The reason for reduction in milk yield with advanced stages of lactation may be due to morphological changes on dimensions of udder and teats and hormonal factors.

Table 3. Effect of lactation stage on teats measurements and milk yield in crossbreed cows (n=28)

	Lactation stages		
Traits	**Early (1-3 M)**	**Mid (4 -6 M)**	**Late (7 M –raying)**
Milk yield (MY)	10.76±0.31[a]	9.62±0.22[b]	8.83±0.17[c]
Teat's length			
Front	7.38±0.29	7.45±0.31	7.90±0.27
Rear	6.69±0.27[b]	6.50±0.27[c]	7.04±0.25[a]
Teat's width			
Front	2.56±0.12	2.84±0.13	2.95±0.12
Rear	2.87±0.10	2.84±0.10	2.89±0.07
Distance Between Teats			
Right	6.09±0.56	5.58±0.48	5.29±0.48
Left	6.09±0.53	5.50±0.45	5.20±0.43
Front	11.6±0.64	11.12±0.73	10.84±0.51
Rear	4.24±0.25[a]	3.54±0.27[b]	3.49±0.19[b]

[a,b] Means in same row within a factor carrying different superscripts, differ significantly (P < 0.05); Milk yield=MY; Month=M

CONCLUSIONS

It could be concluded from this study, that parity and lactation stages have significant impact on parameters of udder, teats measurements; and milk yield in crossbred cow. The knowledge of such data is required for selection and breeding of dairy cows. further studies should be carried out on other breed of cows in different geographical regions of the countries.

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AUTHOR CONTRIBUTIONS:

Hayani A.A, **Tayib T.A.A.** and Nikhaila. A.M. authors equally contributed on protocol proposal, collection, processing, analyzed, interpretation of data and wrote first & final version of Manuscript. All Authors have approved this version of the manuscript.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

ETHICAL STANDARDS

The Faculty of Animal Production, University of Khartoum, Sudan, approved the study.

DATA AVAILABILITY:

All data generated and analysed during this study are included in this published article.

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تأثير عدد الولادات ومراحل الرضاعة على قياسات الضرع والحلمات في الأبقار الحلوب المهجنة

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الملخص

هدفت الدراسة إلى تقييم تأثير عدد الولادات ومرحلة الرضاعة على صفات الضرع والحلمات وإنتاج الحليب للأبقار المهجنة في حقل المزرعة التعليمية بجامعة الخرطوم بالسودان. تم اختيار ثمانية وعشرين بقرة هجينة حلوب مرضعة تبدو سليمة متعددة الولادات والأعمار وتم فحصها في الفترة من يناير إلى نوفمبر من عام 2022. تم أخذ قياسات الضرع الخارجي والحلمة بالسنتيمتر (سم)؛ بينما تم قياس إنتاج الحليب باللتر (لتر) بعد خمسة عشر يومًا من الولادة. كانت معلمات الضرع التي تم قياسها هي طول الضرع (UL) ومحيط الضرع (UC) وعمق الضرع (UD) وعرض الضرع(UW) ؛ بينما كانت قياسات الحلمة هى طول الحلمة الأمامية (FTL) وطول الحلمة الخلفية (RTL) وعرض الحلمة الأمامية (FTW) وعرض الحلمة الخلفية (RTW) والمسافة بين الحلمات .(DBT) تم قياس جميع الصفات التي تم فحصها بالسنتيمتر باستخدام المسطرة والشريط القماشي. أظهرت النتيجة وجود فروق ($p<0.05$) معنوية ذو دلالة احصائية بين متوسط قيم قياسات الضرع والحلمة (سم) وعدد الولادات ومراحل الرضعة المختلفة باستثناء عرض الضرع والمسافة بين الحلمات (الجانبين الأمامي والخلفي). وبالمثل، تأثر إنتاج الحليب (لتر) ($p<0.05$)أيضًا بعدد الولادات ومرحلة الرضاعة، ولا سيما في مرحلة الإرضاع الأولى. خلصت الدراسة الى ان عدد الولادات ومرحلة الرضاعة لها تأثيرًا كبيرًا على قياسات الضرع والحلمات وإنتاج الحليب في الأبقار المهجنة. يمكن الاستفادة من نتائج هذه الدراسة واخذها بعين الاعتبار عند اختيار وتربية الأبقار الحلوب. كما يوصي أيضا بإجراء مزيدا من دراسات مماثلة على سلالات أخرى من الأبقار في منطقة الدراسة ومناطق جغرافية مختلفة من البلاد.

الكلمات المفتاحية: الأبقار المهجنة، مراحل الرضاعة، إنتاج الحليب، الحلمة، عدد الولادات، الضرع

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