RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

ISSN 2221-1896 (PRINT) www.roavs.com ISSN 2223-0343 (ONLINE)

Relationship between udder dimensions and milk yield of Kenana × Friesian crossbred cows

M. P. Deng[1], T. M. Badri[2], M. Atta[3] and M. E. Hamad[4]

[1]College of Animal Production, Upper Nile University, South Sudan; [2]College of Animal Production, University of Bahri, Sudan; [3]Department of Animal Resources, Ministry of Environment, State of Qatar; [4]College of Animal Production Science and Technology, Sudan University of Science, Sudan

Abstract

An investigation was carried out to study the effects of parity order, lactation stage and milking time on dairy cows' udder dimensions (circumference, length, fore and hind depths, fore and hind teats lengths and udder capacity). The relationship of milk yield with these measurements was also aimed. 118 Kenana × Friesian crossbred cows of the farm of the Armed Forces Cooperative Corporation, were grouped according to parity order (1-8 parities) and lactations stage (early, mid and late). The udder measurements were taken before and after morning and noon milking for consecutive 15 days. Three-way analysis of variance was used for the statistical analysis. Correlations and linear regressions of milk yield on the different udder measurements were also examined. The average milk yield was 6.03±2.71 kg/milking, whereas udder measurements before milking averaged 105±15.0 cm, 44.8±7.43 cm, 23.7±3.11 cm, 23.6±3.71 cm, 6.78±1.81 cm and 5.99±1.66 cm, for udder circumference, length, fore depth, hind depth, fore teat length and hind teat length, respectively. The average calculated udder capacity before milking was 1067±265 cm^3. The results revealed that all the studied udder measurements increased with parity order. The udder measurements were higher before the morning milking than before the noon milking. Stage of lactation did not affect the udder measurements. The study concluded that these Kenana × Friesian crossbred cows had good shaped udder but relatively long teats. It also concluded that when evaluating the udder measurement factors such as period between milking and cows' age should be put into consideration. It is worth mentioning that the length of the udder before milking is the most udder measurement variable with milk yield (correlation coefficient = 0.64) and each cm change in udder length represent 0.22 kg milk yield change.

Keywords: Capacity, Circumference, Length, Measurements, Teats, Udder

Introduction

Desirable dairy conformation involves functional traits associated with high milk production over a long and trouble-free productive life. The morphological characteristic of the udder is one of the genetic characteristics in dairy cattle and it is one of the fundamental criteria of selection. Bhuiyan et al. (2004) reported that size and shape of udder are very important conformation traits which could play a vital role for the suitability of milking and economical milk production and they should be considered for selecting dairy cows. Sid Ahmed and El Barbary (2000) reported a selection based on a control table that gives 50% of the score for udder traits. Seykora and Hansen (2000) noted that the udder is 40% of the judging scorecard and often becomes the deciding factor in close placings. Bardakcioglu et al. (2011) noted that udder structure and frame size of milking cows are not only important to demonstrate the aesthetic characteristics, but also the high milk output and the low mastitis risk incidence. Moreover, Boettcher et al. (1998) noted that excessively pendulous teats reduced milking speed. They added that dairy farmers should put considerable emphasis on milking speed, because slow milking cows are hindering the milking process of the herd, especially in milking parlours.

According to Sid Ahmed and El Barbary (2000), udder evaluation depends on its dimensions which affect production performance. The reported udder dimensions are shown in Fig. 1. It was also noted that there was a strong correlation between

Corresponding author: M. Atta, Department of Animal Resources, Ministry of Environment, State of Qatar

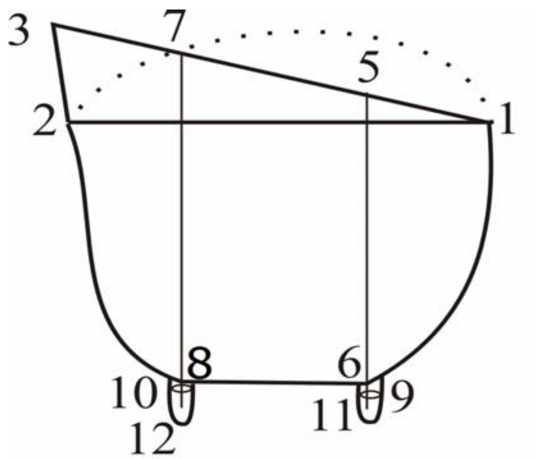

Fig. 1: Udder dimensions measurements (Sid Ahmed and El Barbary 2000)

The diameter 1 to 2 is the udder circumference, line 1 to 3 is the udder length, line 5 to 6 is the fore-quarter depth, line 7 to 8 is the hind-quarter depth, line 6 to 11 is the fore-teat length, line 8 to 12 is the hind-teat length and diameters 9 and 10 are the fore- and hind-teat diameters

udder measurements and milk yield. The udder measurements usually show variation between breeds and individuals in the same herd according to age and lactation stages. The udder shape was described according to the average length, circumference, fore-quarter depth and hind quarter depth as cup (32.6, 106, 29.2 and 33.7 cm, respectively), round (29.5, 91.9, 27.4 and 31.2 cm, respectively) or goat-shaped (21.3, 75.6, 25.2 and 27.9 cm, respectively).

This study aimed at documentation for the possible effects of parity order, stage of lactation and time of milking of Kenana × Friesian crossbred cows on udder measurements when used as criteria for selection of this type of dairy cattle and to test and quantify the relationship between these measurements and milk yield.

Materials and Methods

This study was conducted at the farm of the Armed Forces Cooperative Corporation, Khartoum North, Sudan during August 2008. The dairy herd in the farm consisted of crossbred Kenana × Friesian cows. The lactating cows were housed in open pens in groups according to their production level. The herd was fed concentrate ration composed of wheat bran, beans crust, cotton seeds cake, crushed sorghum grains, molasses and salt. The concentrate was offered twice daily after milking at the rate of 9 kg per cow. The green fodders, *Sorghum bicolor* and *Medicago sativa*, were offered directly after the concentrate ration at the rate of 30 kg/cow. The cows were allowed to be served after two months post calving. All animals were usually vaccinated against the major infectious livestock diseases in Sudan, particularly, Hemorrhagic Septicemia, Anthrax and Contagious Bovine Pleuropneumonia**.** Monthly mastitis and theileriosis testing and acaricide spraying were carried out.

For the purpose of this study, 118 cows (of matching body condition score of range 3–3.5 out of 5 score) from the lactating herd of the farm were used. The cows were classified according to parity order (1–8 parities) and stage of lactation (early stage: first 3 months after calving, mid stage: 3–6 months after calving and late stage: after 6 month post calving). The cows were hand milked twice a day (morning and noon milking). Using a measuring tape, udders of cows were measured in morning and noon just before and after milking for 15 consecutive days. The udder measurements were: circumference (cm), length (cm), fore quarter depth (cm), hind quarter depth (cm). The examined teats measurements were the average fore teat length (cm) and the average hind teat length (cm). Udder capacity (cm^3) was calculated according to Sid Ahmed and El Barbary (2000) equation:

$$\text{Udder capacity} = \frac{\text{fore udder depth} + \text{hind udder depth}}{2} \times \text{udder length}$$

Statistical Analysis

The statistical computer package StatSoft (2011) was used for data analysis. Overall means and standard deviations for the udder and teats measurements were calculated. The data of udder and teats measures and milk yield of the 118 cows milked twice for 15 days (3540 observations) were tested by 3-way analysis of variance to examine the effect of parity order (1-8 parities), stage of lactation (early, mid and late) and milking time (morning and noon). The animal model used was:

$$Y_{ijkl} = \mu + PO_i + SL_j + MT_k + AN_l + e_{ijkl}$$

Where Y_{ijkl} is the observation for each trait; μ is the overall mean; PO_i is the effect of the i^{th} parity order; SL_j is the effect of the j^{th} stage of lactation; MT_k is the effect of the k^{th} milking time; AN_l is the random effect of the l^{th} animal and e_{ijkl} is the residual.

The correlations and regressions of milk yield (kg) per milking on the examined udder measurements (circumference, length, fore depth and hind depth) and udder capacity before milking were calculated.

Results

The overall mean and standard deviations of milk yield per milking, udder and teats measurements before and after milking are shown in Tables 1. Table 2 shows that milk yield was not affected by parity order. The table also shows that the udder circumference, udder length, fore udder depth, hind udder depth and udder capacity before and after milking were affected significantly (P<0.05) by parity order. The 6th parity showed the highest before and after udder circumference than the other parities. The udder lengths, hind depths and capacity before and after milking increased as parity order increased. Milk yield, udder circumference, length, fore udder depth and udder capacity before and after milking were not affected significantly by lactation stages (early, mid and late). The stage of lactation affected only the hind depth (P<0.05) after milking. Table 2 also illustrates that milk yield; udder circumference, length and capacity before milking in the morning milking were significantly (P<0.05) higher than in the noon milking, whereas these measurements after milking were not affected by the milking time. The time of milking had no effect on the fore and hind udder depths. Table 3 shows that most of teats measurements were affected significantly (P<0.05) by cows' parity order. Fore teats length before milking increased with parity order. Only fore teats lengths before and after milking were affected significantly (P<0.05) by stage of lactation. Time of milking did not affect teat length measurements.

Table (4) represents the correlation coefficient (R), intercepts (a), coefficients of regression (b) and coefficients of determination (R^2) of regressions of milk yield on the examined udder measurements and capacity before milking. All the correlations were significant (P<0.05) and positive. The regression on udder length had the highest R^2.

Table 1: Means and standard deviation of udder measurements of the crossbred Kenana × Friesian cows before and after milking

Item	Mean	SD
Milk Yield (kg/milking)	6.03	2.71
Circumference before (cm)	105	15.0
Circumference after (cm)	89.3	4.44
Length before (cm)	44.8	7.43
Length after (cm)	36.6	6.24
Fore depth before (cm)	23.7	3.11
Fore depth after (cm)	22.1	3.43
Hind depth before (cm)	23.6	3.71
Hind depth after (cm)	21.5	3.45
Udder capacity before (cm^3)	1067	265
Udder capacity after (cm^3)	808	224
Fore teats length before (cm)	6.78	1.81
Fore teats length after (cm)	6.91	1.93
Hind teats length before (cm)	5.99	1.66
Hind teats length after (cm)	6.04	1.43

Number of observations = 3540. SD = Standard deviation

Discussion

The calculated coefficients of variation (CV% = 100×SD/mean) revealed the low level of discrepancies among individuals for the udder measurements indicating that they are apparently genetically controlled traits. Similarly, Bhuiyan et al (2004) noted 21.0% CV for udder length after milking (32.2 ± 0.71 cm) and 24.1% CV for udder depth after milking (12.6 0.32 cm). The present milk yield per lactation was comparable to that reported by Antalík and Strapák (2010) when evaluating the milk ability of Slovak Pinzgau cattle, using mobile lactocorder (8.13 ± 2.42 kg per milking). The present result of udder circumference was similar to that reported by Sid Ahmed and El Barbary (2000) for cup shaped udder of Friesian breeds, whereas the udder length was higher than that reported for the same udder shape. The present fore udder depths was lower than those of cup (29.2 cm), round (27.4 cm) and goaty (25.2 cm) udder shapes of Friesian breeds reported by Sid Ahmed and El Barbary (2000) and it was higher than 17.2 cm of Romanian Black Spotted cows reported by Avarvarei (2007). The hind udder depth results were much lower than 33.7cm, 31.2cm and 27.9 cm that reported for cup; round and goat udder shapes of Friesian dairy cows, respectively (Sid Ahmed and El Barbary 2000). It was also lower than 28.3 cm that reported by Avarvarei (2007) in Romanian Black Spotted cows. The present cows' fore and hind teats lengths were comparable to that reported by Antalík and Strapák (2010) for Brahman crosses (50.8 ± 9.19 mm). The current teat lengths were longer than that reported by Kuczaj *et al* (2000) fore teat length (4.9 ± 0.6 cm) and hind teat length (4.0 ± 0.5). Milne (1977) noted that morphology of the teat is recognized as part of the passive defense mechanism against intra-mammary infection so short teats are more favorable for milk production than long teats.

Similar to that observed in the current study (Table 2), Tilki *et al* (2005) reported that all the udder measurements were affected by lactations number. They stated that the udders tissues might be continuously developing up to 6th parity, after that the tissues started to regress as cow's age advanced. Consistently, Bhuiyan et al (2004) found that udder length was less in 1st lactation and gradually increased up to the 6th lactation. Singh et al (2010) reported that all udder and teat measurements had almost increasing trend up to the 5th parity. For teats measurements, Antalík and Strapák (2010) observed that length of the teat increased with parity order advancement. Similar to the current results, Tilki et al (2005) and Antalík and Strapák (2010) reported that stage of lactation did not exert any effects on the udder or teat measurements. The udder circumference, length and udder capacity before milking in the morning milking were higher than those in the noon milking this could be referred to the milk forming duration that was longer for morning milking than for noon milking. After milking these measurements were not affected by the milking time (morning or noon milking) and

Table 2: Udder measurements and capacity before and after milking of the crossbred Kenana × Friesian cows for the examined parity order, lactation stages and milking time

	No. of observations	Milk Yield (kg/milking)	Circumference Before (cm)	Circumference after (cm)	Length before (cm)	Length After (cm)	Fore Depth before (cm)	Fore depth after (cm)	Hind depth Before (cm)	Hind Depth after (cm)	Udder capacity before (cm^3)	Udder capacity after (cm^3)
Parity order												
1st	360	5.25	107^{a}	88.8^{a}	42.8^{b}	32.6^{b}	21.7^{b}	19.2^{b}	21.5^{b}	19.3^{b}	927^{b}	621^{b}
2nd	330	3.50	85.5^{b}	81.5^{b}	36.5^{c}	33.5^{b}	24.5^{a}	22.0^{a}	20.0^{c}	19.0^{b}	815^{c}	687^{b}
3rd	450	6.16	93.5^{b}	77.7^{b}	42.3^{b}	34.1^{b}	21.9^{b}	20.5^{a}	21.0^{b}	18.7^{b}	908^{b}	666^{b}
4th	570	5.92	107^{a}	89.1^{a}	46.1^{b}	37.3^{b}	23.7^{a}	22.7^{a}	23.3^{b}	21.9^{a}	1085^{a}	842^{a}
5th	600	5.93	102^{a}	86.6^{b}	43.9^{b}	36.6^{b}	23.8^{a}	22.1^{a}	24.9^{a}	23.0^{a}	1074^{a}	826^{a}
6th	450	5.80	112^{a}	98.3^{a}	43.5^{b}	34.6^{b}	23.9^{a}	22.8^{a}	23.4^{b}	21.7^{a}	1034^{b}	783^{a}
7th	450	6.83	111^{a}	96.1^{a}	46.7^{b}	40.0^{a}	25.8^{a}	23.0^{a}	26.9^{a}	22.3^{a}	1252^{a}	931^{a}
8th	330	7.38	103^{a}	94.0^{a}	52.3^{a}	42.8^{a}	25.0^{a}	22.5^{a}	22.5^{b}	21.0^{a}	1240^{a}	927^{a}
SEM		0.508	3.67	3.56	1.9	1.56	0.779	0.879	0.877	0.852	67.2	57.1
P.		0.202	0.000	0.000	0.002	0.000	0.000	0.006	0.000	0.000	0.000	0.000
Lactation stages												
Early stage	1560	6.07	105	90.2	45.4	37.3	23.3	22.0	23.3	$22.^{4a}$	1070	810
Mid stage	1200	5.98	105	88.6	44.7	36.2	24.1	22.6	24.1	$21.^{5a}$	1085	826
Late stage	780	6.05	105	88.6	43.6	35.8	23.9	21.8	23.4	20.8^{b}	1033	776
SEM		0.318	1.82	1.75	0.895	0.751	0.374	0.413	0.446	0.409	31.9	27.0
P.		0.971	0.677	0.351	0.299	0.283	0.124	0.328	0.465	0.003	0.684	0.593
Milking time												
Morning	1770	8.19^{a}	110^{a}	90.9	48.3^{a}	37.2	23.9	22.3	23.7	21.6	1158^{a}	824
Noon	1770	3.88^{b}	99.4^{b}	87.5	40.9^{b}	36.0	23.5	21.9	23.4	21.3	967^{b}	790
SEM		0.151	1.32	1.36	0.608	0.587	0.294	0.324	0.35	0.235	23.3	21.1
P.		0.000	0.000	0.112	0.000	0.099	0.075	0.564	0.224	0.620	0.000	0.180

No. = Number of observations. SEM = Standard error of means. ^{abc} = Means on the same column with different superscripts were different

Table 3: Teat measurements before and after milking of the crossbred Kenana × Friesian cows for the examined parity order, lactation stages and milking time

Item	No. of observations	Fore teat length before (cm)	Fore teat length after (cm)	Hind teat length before (cm)	Hind teat length after (cm)
Parity order					
1	360	6.67^{b}	7.67^{ab}	6.00	6.67^{abc}
2	330	6.50^{b}	5.00^{c}	6.00	5.00^{d}
3	450	6.56^{b}	6.56^{b}	5.88	5.38^{d}
4	570	6.33^{b}	6.63^{b}	5.97	6.05^{bcd}
5	600	6.10^{b}	6.25^{bc}	5.70	5.75^{cd}
6	450	7.00^{b}	6.81^{b}	5.69	5.69^{cd}
7	450	8.62^{a}	8.87^{a}	6.69	6.94^{ab}
8	330	7.50^{ab}	6.50^{b}	6.50	7.50^{a}
SEM		0.312	0.331	0.313	0.253
P.		0.000	0.000	0.266	0.000
Lactation stages					
1	1560	6.62^{b}	6.40^{b}	6.04	5.96
2	1200	6.45^{b}	7.00^{b}	5.78	5.90
3	780	7.63^{a}	7.77^{a}	6.23	6.42
SEM		0.206	0.218	0.194	0.167
P.		0.000	0.000	0.286	0.090
Milking time					
Morning	1770	6.85	6.95	6.03	6.07
noon	1770	6.72	6.86	5.95	6.02
SEM		0.167	0.178	0.153	0.132
P.		0.592	0.737	0.696	0.786

No. = Number of observations. SEM = Standard error of means. ^{abc} = Means on the same column with different superscripts were different

Table 4: Correlations and regressions of milk yield (kg) on the examined udder measurements (cm) and capacity (cm3) before milking

Udder measurement	R	a	b	SE of b	R^2	P
Circumference	0.46	-2.61	0.08	0.01	0.22	0.000
Length	0.64	-3.90	0.22	0.02	0.41	0.000
Fore udder depth	0.14	3.25	0.12	0.06	0.02	0.003
Hind udder depth	0.16	3.24	0.12	0.05	0.03	0.002
Udder capacity	0.52	0.57	0.01	0.001	0.27	0.000

Number of observations = 3540. R = correlation coefficient. a = intercept. b = regression coefficient. R^2 = coefficient of determination

this may be attributed to that reported by Sid Ahmed and El Barbary (2000). They noted that good udder size depended on the existence of milk, where the udder enlarged with milk secretion and shrink after milking. They also noted that milk yield directly related to the udder length and circumference rather than the depth. Seykora and Hansen (2000) noted that udder depth is the physical trait of the udder that is evaluated as the relationship of the udder floor relative to the hocks. They added that higher udders are related with less mastitis, less udder injury, and greater longevity. They also noted that udder below the hock is a serious defect. In the same context, the low correlations coefficients o (R) of milk yield with fore udder depth (0.14) and hind udder depth (0.16) reflected that these measurements of week relations with milk yield. The relatively strong relationship between milk yield and udder length was indicated by the high coefficient of correlation (0.64). So the length of udder should be one of the important basic aspects for selection of a dairy cow and can be used with a satisfactory precision on prediction of milk yield. The regression of milk yield on udder length indicated that each cm change in udder length represent 0.22 kg (coefficient of regression = b) change of milk yield. The regression of milk yield on the udder capacity indicated that when the udder depth was added to the length would reduce rather than increase the precession of milk yield prediction. Singh et al (2010) reported the higher accuracy of prediction for the regression on udder width measurement. They reported 0.51, 0.51 and 0.55 coefficients of determinations for the regressions of total milk yield, 305 days milk yield and peak yield, respectively on udder width.

Conclusions

- Kenana × Friesian crossbred cows of the farm of the Armed Forces Cooperative Corporation had good shaped udder but relatively long teats.
- When assessing shape or function of udders, factors such as cows' age and period between milking should be put into consideration.
- Udder length is the measurement that is the most related to the milk yield and can be used for prediction of milk yield with the highest level of precision according to the formula: $y = 0.22x - 3.90$, where: y = is the milk yield (kg), x = is the udder length (cm).
- Addition of other udder measurement to the udder length in the regression will not add to the precision of the prediction equation.

References

Antalík, P. and Strapák, P. 2010. The evaluation of milkability of Slovak Pinzgau cattle by lactocorder. *Slovak Journal of Animal Science*, 43 (4): 173–178.

Avarvarei, B.V. 2007. Researches regarding the development and shape of romanian black spotted cow's udder exploited in the condition of S.C.D.A. PODU-ILOAIE,IASI County. Bulletin USAMV-CN, Pp: 63 - 64.

Bardakcioglu. H.E., Sekkin, S. and Oral Toplu, H.D. 2011. Relationship between some teat and body measurements of Holstein cows and sub-clinical mastitis and milk yield. *Journal of Animal and Veterinary Advances*, 10(13): 1735-1737.

Bhuiyan, M.M., Islam, M.R., Ali, M.L., Hossain, M.K., Kadir, M.A., Lucky, N.S. and Das, B.R. 2004. Importance of mammary system conformaftion traits in selecting dairy cow on milk yield in Bangladesh. *Journal of Biological Sciences* 4(2): 100 – 102.

Boettcher, P.J., Dekkers, J.C.M. and Kolstad, B.W. 1998. Development of an udder health index for sire selection based on somatic cell score, udder conformation, and milking speed. *Journal of Dairy Science*, 81: 1157 - 1168.

Kuczaj, M., Kruszyński, W., Pawlina, E. and Akińcza, J. 2000. Relations between milk performance and udder dimensions of Black-White cows imported from Holland, Electronic *Journal of Polish Agricultural Universities* EJPAU 3(2), #01. Available Online: http://www.ejpau.media.pl/ volume3/issue2/animal/art-01.html

Milne, J.R. 1977. Natural defence mechanism against mastitis. In National Mastitis Council. Proceedings of 16th Annual Meeting. Washington, D.C. Pp: 19-38.

Seykora, T. and Hansen, L. 2000. Judging dairy cattle. Department of Animal Science, University of Minnesota.

http://www.aphis.usda.gov/animal_health/emergingissues/compensation/content/judgingdairycattle.pdf

Sid Ahmed, I.A. and El Barbary, A.S.A. 2000. Dairy and meat cattle. College of Agric. Un. of Alexandria, Egypt, Dar El-Maarif Printing Press. Pp: 73-99.

Singh, R.R., Dutt, T., Singh, M. and Kumar, A. 2010. Association of udder and teat dimensions with production traits in Vrindavani cattle. *Indian Journal of Dairy Science*, 63 (6): 455 – 458

StatSoft, Inc. 2011 STATISTICA (data analysis software system), version 10. www.statsoft.com.

Tilki, M., Inal, Ş., Çolak, M. and Garip, M. 2005. Relationships between milk yield and udder measurements in Brown Swiss cows. *Turkish Journal of Veterinary and Animal Sciences*, 29: 75-81.