Ethiop. J. Agric. Sci. 33(3) 29-40 (2023)

Crossbred Cows Conformation Traits and Milk Yield Correlations in Central Ethiopia

Molla Shumye* and Ulfina Galmessa
Ethiopian Institute of Agricultural Research, Holetta Research Center, Ethiopia
** **Corresponding Author:** mollabrkt@gmail.com*

Abstract

We examined the effects of different genotypes and parities on linear conformation traits and assessed the phenotypic relationship between milk yield and linear conformation traits of crossbred dairy cows. We measured twelve linear conformation traits combined with body weight and body condition score of thirty-one 50% Friesian Boran and thirty-five 75% Friesian Boran crossbred cows from 2019 to 2022. Feeding management practices that are usually used for Holeta research station dairy farms consisting of natural grazing, hay and concentrate supplements at the rate of 4 kg per day/cow were the recommended feeding practices in the farm. The overall means of stature, wither height, heart girth, rump length, body length, body condition score and body weight of Friesian Borana crossbred cows were 134.20 cm, 133.31cm, 172.26 cm, 65.00 cm, 149.26 cm, 2.84 and 424.60 kg, respectively. Crossbred cows having 75% exotic gene inheritance had lower body condition score (2.6) than cows with 50% exotic gene inheritance (3.11). The 75% Friesian Borana crossbred cows had also wider udder circumference before and after milking (32.9 and 29.2 cm) than the 50% Friesian Borana crosses (30.4 and 28.4 cm), respectively. High phenotypic correlations (P<0.01) were observed between milk yield with rump length (r_p=0.91), body length (r_p=0.68), front udder height (r_p=0.92), rear udder height (r_p=0.66), and udder circumference (r_p=0.78). Hence, rump length, body length, front udder height and udder circumference can be taken as better predictors of milk yield of dairy cows and accounting for these traits in the dairy cattle breeding program aids in achieving additional information on selection of cows for milk production.

Keywords: *G*enetic group; milk yield; phenotypic *c*orrelation; udder conformation

Introduction

Udder conformation traits and other body linear measurements in dairy cattle are important in breed improvement programs. Various studies have been carried out to investigate the phenotypic and genetic relationship between dairy conformation and milk production traits in pure dairy cattle breeds (Ibrahim Tapki and Yusuf Ziya Guzey, 2013; Zink et al. 2014; Liu et al. 2014; Bohlouli et al. 2015). Dairy farmers usually judge the merit of dairy cows depending on different body and udder conformation traits (Addis Getu and Godadaw Misganaw, 2015). Conformation traits also help in the selection of the best milk-producing dairy cows to increase the profit of dairy farmers (Valencia et al. 2008).

Assessment of the relationship between linear conformation and production traits of Frisian X Boran (FB) crossbred cows will provide vital information that will help dairy farmers to adjust their breeding and management programs. Several attempts have been made to improve the productivity of some of the most economically important traits such as milk production, growth rate, and reproduction performances of crossbred cattle through crossbreeding. The results of these crossbreeding experiments in Ethiopia have been amply reported in numerous literature (Getahun et al. 2020; Tefera et al. 2020; Shumye et al. 2021; Getahun, 2022; Hunde et al. 2022; Fikadu, 2023). Evaluation of crossbred dairy cattle in tropical countries is exclusively based on data recorded on milk production, reproduction, and growth performances. However, data on confirmation or type traits is scarce. In effect, the relationship of these traits with other production traits such as daily milk and lactation milk yield has not been evaluated in the dairy cattle crossbreeding scheme in sub-Saharan or tropical countries.

Therefore, we aimed to evaluate linear confirmation traits and their relationship with milk yield in crossbred cows so as to assist visual selection of dairy cows under field conditions where performance records are not available.

Material and Methods

Description of the study area:

The study was conducted at Holetta Research Center which is located 34 Km west of Addis Ababa. The area is located at an altitude of 2400 m above sea level (masl) and receives an annual average rainfall of 1100 mm and an average maximum temperature of 21.3^{o}C.

Animal management

The experimental cows were allowed to graze on pasture for 8 h/day and supplemented with hay and concentrate feeds. The concentrate feed supplement was a mixture of wheat middling (32%), wheat bran (32%), noug *(Guizocia abyssinica*) cake (34%), and salt (2%). Milking cows were supplemented with concentrate feed mixture at a rate of 4 kg per day/animal. The animals had free access to clean water all time.

Measurements of linear conformation traits

Twelve linear conformation traits, coupled with body weight (BW) and body condition score (BCS) were measured on thirty-one 50% FB and thirty-five 75% FB crossbred cows between 2019 and 2022. The linear conformation traits comprised five body conformation traits (linear body measurements): stature (ST), heart girth (HG), wither height (WH), body length (BL), rump length (RL), and seven udder conformation traits; front teat length (FTL), rear teat length (RTL), front teat diameter (FTD), rear teat diameter RTD), front udder height (FUH), rear udder height (RUH), and udder circumference (UC). The linear conformation traits were measured in centimeters (cm) using a graduated measuring stick and flexible tape while BW was measured in–kilogram using cattle weighing Bridge (scale). The body condition score (BCS) was evaluated based on a score of 1 to 5 (David Allen, 1990). Linear body measurements (body conformation traits) were recorded monthly on milking cows in the morning before feeding and watering. Udder measurements (udder conformation traits) were measured monthly pre- and post-milking times. Teat length and udder heights were measured with a flexible measuring tape (sewing 150 cm soft tailors). Teat diameters were measured with Vernier-type calipers before and after milking. The details of the measurements and definition of the traits are presented in Table 1

Statistical analysis

Crossbred genotype group and parity were considered as fixed effects in the model whereas – linear and udder conformation traits were dependent variables. Data were analyzed using the general linear model of SAS, (2008). The following model was used:

$Y_{ij} = \mu + G_i + P_j + e_{ij}$

Y_{ij} is the observation of measurement (udder and body linear measurements), μ is the overall mean, G_i is the effect of genetic group (i: 1, 2); P_j is the effect of parity (j: 1, 2, 3.4, and 5); e_{ij} is the random error.

Table 1 shows details of the udder and body conformation trait measurements

Traits	Abbreviation	Description of measurements	Instruments
Stature	ST	Measured from the top of the spine in between hips to the ground	Measuring stick
Heart girth	HG	Measured as a circumference of the body at a point immediately behind the forelegs, perpendicular to the body axis or simply as the smallest circumference.	Measuring stick
wither height	WH	The highest point over the scapulae vertically to the ground or measured from the highest point on the dorsum of the animal to the ground surface at the level of the front legs	Flexible tape
Body length	BL	Measured from the point of the shoulder to the ischium.	Flexible tape
Rump length	RL	Larger and more nearly level from hip to pin bone	Flexible tape
Front teat length	FTL	Length of front teats	Flexible tape
Rear teat length	RTL	Length of rear teats	Flexible tape
Front teat diameter	FTD	The diameter of the front teats	Calipers
Rear teat diameter	RTD	The diameter of the rear teats	Calipers
Front udder height	FUH	Measured perpendicularly from the point of attachment in the ventral abdomen to the lowest point of the front udder.	Flexible tape
Rear udder height	RUH	Measured straight upright from the highest mammary point at the cow's caudal body to the lowest point of the rear udder.	Flexible tape
Udder circumference	UC	Measured based on the largest UC between the two hind legs of the cow.	Flexible tape

Source (IHFA, 2006)

Results and Discussion

Effects of genotype and parity on body conformation traits

The least-square means for linear body measurements (body conformation traits) by genotype and parity are presented in Table 2. Only body condition scores significantly (P < 0.01) varied between genetic groups. Crossbred cows having 75% exotic blood level had lower body condition scores than those having 50% exotic blood level. This result indicated that the level of feeding management in the research dairy farm may not be adequate for 75% FB crosses to attain good body condition since the same level of management is applied to both genotypes regardless of the actual requirement for each. The mean values of ST, WH, BL, BCS, and BW in this study were higher than ST (129.83 cm), WH (126.12 cm), BL (123.52 cm), and BW (391.30 kg) reported by Alphonsus et al. (2012) for Nigerian Friesian X Bunaji crossbred cows. The difference could be ascribed to the genetic difference between experimental animals and the variation of feeding supplements offered to animals.

Parity (lactation number) had a significant (P < 0.01) effect on HG, RL, and BW, but not on other body conformation traits (Table 2). The HG, RL, and BW tend to increase with progressing lactation numbers.

Effects of genotype and parity on udder conformation traits

Means with the standard errors for front and RTL, TD, UH, and UC are given in Table 3. The genetic group had a significant (P < 0.01) effect on FTL and RTL before and after milking time. By contrast, FTD and RTD before and after milking did not significantly vary between genetic groups. Of the FB crosses, 75% had longer front and rear teats pre-and post-milking time than those of 50% FB crosses. This shows that 75% FB crosses have better teats (udder) conformations which indicate better dairy characteristics than 50% FB crosses. Moreover, 75% FB crosses have a higher proportion of Frisian gene inheritance.

Table 2. Least square means and standard errors for linear body measurements, body condition score and body weight of Friesian X Boran crossbred cows.

Variables	N	Stature (cm)	Wither height (cm)	Heart girth (cm)	Rump length (cm)	Body length (cm)	Body condition Score	Body weight (kg)
Overall mean	66	134.20	133.31	172.26	65.00	149.26	2.84	424.60
Genetic group								
50% FB	31	133.36±0.96	131.90±1.15	171.91±1.96	64.22±1.19	145.80±2.30	3.11±0.10[a]	420.17±15.20
75% FB	35	135.11±0.92	134.51±1.10	172.31±1.87	65.83±1.14	152.70±2.20	2.6±0.10[b]	431.59±14.50
LS		NS	NS	NS	NS	NS	**	NS
Parity								
1	11	131.31±1.36	130.72±1.64	163.15±2.78[c]	59.59±1.6[b]	141.1±3.29	2.65±0.1	342.02±21.5[c]
2	13	135.2±1.50	132.2± 1.80	168.37±3.1[bc]	63.73±1.9[ab]	145.8± 3.70	2.8±0.17	390.10±24.4[bc]
3	15	133.9±1.20	134.81±1.50	176.9±2.5 [ab]	65.7±1.5[a]	151.2±3.00	2.9± 0.1	454.3±19.7[ab]
4	14	134.6±1.80	134.15±2.38	174.1±3.8[ab]	66.6±2.3a	153.9±4.50	2.8±0.2	466.3±30.0[a]
5	13	136.00±1.30	134.13±1.50	178.13±2.7[a]	69.4±1.6[a]	154.1±3.19	3.0± 0.1	476.6±20.9[a]
LS		NS	NS	**	**	NS	NS	**

*Means with different superscripts within a column are significantly different (p<0.05) and p<0.01; LS= Level of significance; NS= Non Significant; *= p<0.05; **=p<0.01; 50% FB= Friesian Boran cross with 50% Exotic blood level, 75% FB= Friesian X Boran cross with 75% Exotic blood level; N = number of observations.*

Table 3. Least square means and standard error for udder conformation traits of Friesian X Boran crossbred cows.

Variables	N	FTL(mm)		RTL(mm)		FTD (mm)		RTD (mm)		FUH (cm)		RUH (cm)		UC (cm)	
		BM	AM	BM	AM	BM	AM	BM	AM	BM	AM	BM	AM	BM	AM
Overall Mean	66	49.4	51.6	43.4	44.0	19.2	18.0	18.2	17.1	13.1	11.2	36.6	33.4	31.4	29.5
Genetic group															
50% FB	31	45.5±1.4^{b}	46.4±1.2^{b}	39.1±1.2^{b}	40.4±1.0^{b}	18.7±0.4	17.8±0.3	17.6±0.3	16.9±0.3	12.6±0.4	10.7±0.3	35.5± 0.5	33.3±0.5	30.4±1.3	28.4±1.2^{b}
75% FB	35	52.1±1.3^{a}	54.3±1.2^{a}	46.6±1.2^{a}	46.1±0.9^{a}	19.3±0.4	17.5±0.3	18.1±0.3	16.6±0.3	13.1±0.4	10.9±0.3	36.9±0.5	33.6± 0.5	32.9± 1.5	29.2±1.2^{a}
LS		**	**	**	**	NS	NS	NS	NS	NS	NS	NS	NS	*	*
Parity															
1	11	46.6±2.0^{ab}	47.3±1.8^{b}	40.3±1.8^{b}	41.2±1.4b^{c}	18.2±0.6^{b}	17.4±0.5^{b}	17.6±0.4	16.6±0.4	11.9±0.5^{b}	10.6±0.5^{b}	35.2±0.8^{b}	32.9±0.7^{b}	30.2±1.5^{ab}	28.7± 1.4^{ab}
2	13	48.5±2.5^{ab}	49.2±2.2^{b}	41.9±2.2^{b}	43.0±1.8^{b}	18.6±0.8^{b}	16.5±0.6^{b}	17.4±0.5	15.4±0.5	11.1±0.6^{b}	8.9±0.6^{c}	33.3±0.9^{b}	30.1± 0.9^{c}	29.5±1.6^{b}	27.9±1.4^{b}
3	15	44.2±2.4^{b}	44.5±2.12^{c}	37.9±2.1^{c}	39.5±1.7^{c}	18.5±0.8^{b}	17.2±0.6^{b}	16.6±0.5	16.9±0.5	12.1±0.6 ^{b}	10.0±0.6^{c}	34.7±0.9^{b}	33.2± 0.8^{b}	30.5±1.5^{ab}	28.6±1.5^{ab}
4	14	50.2±1.9^{ab}	51.2±1.7^{b}	44.4±1.7^{b}	41.9±1.4^{bc}	18.7±0.6^{b}	17.1±0.5^{b}	18.2±0.4	16.8±0.4	14.3±0.5^{a}	12.1±0.5^{a}	38.5±0.8^{a}	34.7±0.6^{a}	30.9±1.4^{ab}	29.0±1.3^{ab}
5	13	54.5±1.6^{a}	59.6±1.4^{a}	49.5±1.4^{a}	50.5±1.2^{a}	21.0±0.5^{a}	20.5±0.4^{a}	19.5±0.4	18.0±0.3	14.6±0.4^{a}	12.5±0.4^{a}	39.4±0.6^{a}	36.4±0.5^{a}	32.1±1.4^{a}	30.0±1.5^{a}
LS		*	**	**	**	**	**	NS	NS	**	**	**	**	**	**

Means with different superscripts within a column are significantly different (p<0.05) and p<0.01; LS= Level of significance; NS= Non-Significant; *= p<0.05; **=p<0.01; 50% FB= Friesian Boran cross with 50% Exotic blood level; 75% FB= Friesian Boran cross with 75% Exotic blood level; FTL= Front teat length; RTL= Rear teat length; FTD= Front teat diameter; RTD= Rear teat diameter; FUH= Front udder height; RUH= Rear udder height; UC= Udder Circumference

Parity significantly ($P < 0.05$) affected FTL and RTL and front teat diameter before and after milking. FTL and RTL tend to increase pre- and post-milking with progressing parity. Similar to our current study, FTL and RTL increased with advanced parity (Rasmussen et al. 1998; Tilki et al. 2005). Measurements of FTD and RTD in pre-milking were higher than in post-milking. Teat diameters increased during pre- and post-milking time with advanced parity. Similar results have been demonstrated by reports of researchers (Lin et al. 1987; Tilki et al. 2005).

Higher teat measurement parameters estimates were reported by Tilki et al. (2005) in Brown Swiss cows whose FTL, RTL, FTD, and RTD during pre- and post-milking times were 59.45, 65.33, 49.72, 55.95, 22.14, 20.47, 21.53 and 20.01, respectively. The difference in teat measurement estimates between the present result and the previous reports may be associated with the breed of an animal and the rearing environment.

Except for the udder circumference at pre- and post-milking times, the genotype of crossbred cows had no significant effect on FUH and RUH. Effects of parity on FUH and RUH at pre- and post-milking were significant ($P < 0.01$). This study showed that the 75% FB crossbred cows had wider udder circumference at pre and post-milking than 50% FB crosses. The observed difference between cows in the two genetic groups could be attributed to their differences in exotic (Friesian) gene inheritance levels. Front and rear udder height and udder circumference measurements increased before and after milking times with increased parties. Discordance to this study, Soeharsono et al. (2020) describing higher front udder (37.81 cm) and rear udder (87.86 cm) circumference measurements for HF cows kept by smallholder farmers. This later study in particular utilized pure HF breed with larger body frame size than animals used in our experiment.

Correlation between linear conformations traits and daily milk yield

Phenotypic correlations between linear conformations traits and daily milk yield are presented in Table 4. The ST, WH, HG, FTL, RTL, FTD, and RTD were positively correlated with the daily milk yield of FB crossbred cows. There was also positive and highly significant ($P<0.01$) association of ST with WH; WH with HG and BL; RL with BL, FUH, and RUH; BL with FUH and RUH; FTL with RTL and RTD; FTD with RTD; FUH with RUH, and UC; RUH with UC. In addition, RL, BL, FUH, RUH, and UC were positively and highly significantly ($P<0.01$) correlated with daily milk yield. These findings were similar to the report of Mingoas et al. (2017) who confirmed that udder size was strong and positively correlated to milk yield in White Fulani and Red Mbororo cows.

Table 4. Phenotypic correlation (r_p) between linear conformation traits and daily milk yield of Friesian X Boran crossbred cows

	ST	WH	HG	RL	BL	FTL	RTL	FTD	RTD	FUH	RUH	UC	DMY
ST	1.00	0.84**	0.48*	0.25	0.51*	0.16	0.10	0.14	0.02	0.20	0.30	0.19	0.23
WH		1.00	0.62**	0.30	0.60**	0.06	0.07	0.06	0.06	0.32	0.44*	0.29	0.31
HG			1.00	0.26	0.47*	-0.24	-0.13	-0.01	-0.13	0.28	0.49*	0.22	0.17
RL				1.00	0.75**	0.25	0.29	0.32	0.27	0.89**	0.57**	0.46*	0.91**
BL					1.00	0.09	0.15	-0.04	-0.12	0.71**	0.59**	0.46*	0.68**
FTL						1.00	0.83**	0.56**	0.37	0.18	0.19	0.21	0.32
RTL							1.00	0.52*	0.41*	0.23	0.20	0.22	0.34
FTD								1.00	0.7**	0.34	0.35	0.30	0.39
RTD									1.00	0.33	0.35	0.32	0.31
FUH										1.00	0.68**	0.66**	0.92**
RUH											1.00	0.67**	0.66**
UC												1.00	0.78**
DMY													1.00

*= Significant ($p<0.05$); **= Highly significant ($p<0.01$); (ST)= stature; WH= wither height; HG= heart girth; RL= rump length; BL= body length; FTL= front teat length; RTL= rear teat length; FTD= front teat diameter; RTD= rear teat diameter; FUH= front udder height; RUH= rear udder height; UC= udder circumference; DMY=daily milk yield. The correlation coefficient of udder conformation traits was based on measurements before milking

This study is also in agreement with Soeharsono et al. (2020) who indicated that there was a significant correlation between BL, FUH, RUH, and UC with daily milk production in Holstein Friesian cows. However, teat measurement traits such as FTL, RTL, FTD, and RTD, did not show a significant association with daily milk yield in this study, which is in agreement with Bello *et al.* (2023), who demonstrated a similar result for White Fulani cows in Nigeria.

Conclusions

This study revealed that measurements on HG, RL, and BW tend to increase with advancing parity (lactation number). 75% FB crossbred cows had longer front and rear teats pre- and post-milking than those 50% FB crosses. 75% FB crossbred cows had wider udder circumferences in pre- and post-milking than 50% FB crosses. RL, BL, FUH, RUH, and UC were positively and highly significantly correlated with daily milk yield and they can be taken as better predictors of milk yield of dairy cows, and accounting for these traits in dairy cattle breeding program aids in achieving additional information on selection for milk production. It can also be recommended that further study should be conducted using pedigree records to estimate genetic parameters on confirmation traits for selection of crossbred dairy cattle for milk production.

Acknowledgements

We are thankful to the Ethiopian Institute of Agricultural Research (Holeta Agricultural Research Center) for financing this work. Technical assistance from the Dairy Research Program at Holeta Research Center is also acknowledged for their unreserved support during experiment work.

Contribution of Authors

Corresponding Author designed the experiment and coordinated the study, analyzed the data, and drafted the manuscript. **Second Author** supervised the experiment and took part in critically checking this manuscript. All authors read and approved the final manuscript

References

Allen D.1990. Planned beef production and marketing. BSP Professional Books, British. p.199– 201.

Alphonsus, C., G.W. Akpa, P.P. Barje, H.I. Finangwai, B.D. Adamu. 2012. Comparative evaluation of linear udder and body conformation traits of Bunaji and Friesian X Bunaji cows/World Journal of Life Sciences and Medical Research 2012;2(3).

Bello, O.R., A.E. Salako, A.S Akinade, M. Yakub. 2023. Relationship between Milk Yield and Udder Morphology Traits in White Fulani Cows. *Dairy* **2023**, *4*, 435–444. https://doi.org/10.3390/ dairy4030029.

Bohlouli, M., S. Alijani, M. Rahimi Varposhti. 2015. Genetic relationships among linear type traits and milk production traits of Holstein dairy cattle. Ann. Anim. Sci., Vol. 15, No. 4 (2015) 903–917.

Fikadu Wodajo Tirfie. 2023. Environmental factors influence the lactation performance of crossbred dairy cattle in Ethiopia: A review. *Greener Journal of Agricultural Sciences*, 13(1): 31-36, https://doi.org/10.5281/zenodo.7730552.

Addis Getu and Godadaw Misganaw. 2015. The Role of Conformational Traits on Dairy Cattle Production and Their Longevities. Open Access Library Journal2: e1342. http://dx.doi.org/10.4236/oalib.1101342.

Direba Hunde, Yosef Tadesse, Tesfaye Getachew and Million Tadesse. 2022. Estimation of Genetic Parameters for Crossbred Dairy Cattle in Central Ethiopia. Ethiop. J. Agric. Sci. 32(1) 105-123.

Ibrahim, T., Z. Yusuf. 2013. Genetic and Phenotypic Correlations between Ear Type Traits and Milk Production Yields of Turkish Holstein Dairy Cows. Greener Journal of Agricultural Sciences. Vol. 3 (11), pp. 755-761, November 2013

IHFA. 2006. Irish Holstein Friesian Association. Type classification scheme. Retrieved from http://www.ihfa.ie/bestofbreed/tyupeclassifications cheme.htm

Kefale Getahun, Million Tadesse and Direba Hundie. 2020. Analysis of Genetic Parameters for Reproductive Traits in Crossbred Dairy Cattle Maintained at Holetta Agricultural Research Center. Asian Journal Of Dairy And Food Research, Volume 39 Issue 1 (March: 10-16

Kefale Getahun. 2022. Milk yield and reproductive performances of crossbred dairy cows with different genotypes in Ethiopia: a review paper. *Multidisciplinary Reviews*, *5*(1), 2022003. https://doi.org/10.31893/multirev.2022003

Lin, C.Y., A.J. Lee, A.J. McAllister, T.R. Batra, G.L Roy, A.J. Veseley, J.M. Wauthy, K.A winter.1987. Inter Correlations among Milk Production Traits and Body and Udder Measurements in Holstein Hefiers. *Journal of Dairy Science*, 70, 2385-2393. http://dx.doi.org/10.3168/jds.S0022-0302(87)80299-0

Liu, S., H. Tan, L. Yang, J. Yi. 2014. Genetic parameter estimates for selected type traits and milk production traits of Holstein cattle in southern China. Turk J Vet Anim Sci (2014) 38: 552-556.

Mingoas, K.J., J. Awah-Ndukum, H. Dakyang, P.A. Zoli. 2017. Effects of body conformation and udder morphology on milk yield of zebu cows in North region of Cameroon, Veterinary World, 10(8): 901-905.

Rasmussen, M.D., E.S. Frimer, L. Kaartinen, N.E. Jensen. 1998. Milking performance and udder health of cows milked with two different liners. J. Dairy Res., 1998; 65: 353-363.

SAS. 2008. Statistical Analysis System user's guide, Release 9.1. SAS Institute, Inc., Carey, NC, USA; 2008.

`Molla Shumye, Zewdie Wondatir, Getu Kitaw, and Aemiro Kahaliw. 2021. Growth and Fattening Performances of Friesian-Boran Crossbred Bull Calves Fed on Different Protein Supplements. *Ethiopian Journal of Agricultural Sciences, 31*(4), 57-70.

Soeharsono, S., S. Mulyati, S. Utama, W. Wurlina, P. Srianto, T.I Restiadi, I. Mustofa. 2020. Prediction of daily milk production from the linear body and udder morphometry in Holstein Friesian dairy cows, *Veterinary World*, 13(3): 471-477

Sileshi Tefera1, Direba Hunde, Kefelegn Kebede, and Million Tadesse. 2020. Analysis of Lifetime Traits for Crossbred Dairy Cattle in the Central Highland of Ethiopia. East African Journal of Veterinary and Animal Sciences (2020) Volume 4 (2): 31-38

Tılkı, M., S. İnal, M. Colak, M. Garıp. 2005. Relationships between milk yield and udder measurements in Brown Swiss Cows Türk Veterinerlik ve Hayvancilik Dergisi 29:75-81.

Valencia, M., H.H. Montaldo, F. Ruíz. 2008. Genetic parameters for conformation traits, stay ability and milk yield for Holstein dairy cattle in Mexico. *Revista Técnica Pecuaria en México.* 46, 235-248.

Zink, V., L. Zavadilová, J. Lassen, M. Štípková, M. Vacek, L. Štolc. 2014. Analyses of genetic relationships between linear type traits, fat-to-protein ratio, milk production traits, and somatic cell count in first-parity Czech Holstein cows. Czech J. Anim. Sci., 59, 2014 (12): 539–547.