Journal of Animal Research: v.12 n.06, p. 957-965. December 2022

DOI: 10.30954/2277-940X.06.2022.19

Relationship between Morphometric and Performance Traits in Crossbred Cows under Field Condition

Waghmare Vijay Kumar[1], P.P. Dubey[1,2*], S.K. Dash[1,2], Puneet Malhotra[1,2] and Navdeep Singh Ratta[2]

[1]Department of Animal Genetics and Breeding. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, INDIA
[2]Directorate of Livestock Farms, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, INDIA

**Corresponding author: PP Dubey; E-mail: prakashagb@gmail.com*

Received: 07 Sept., 2022 **Revised:** 30 Oct., 2022 **Accepted:** 08 Nov., 2022

ABSTRACT

The aim of the present study was to describe and establish the relationship between morphometric and performance traits in crossbred cattle under filed condition. The performance data and body measurements were collected for 453 progenies sired by 30 bulls as test mating under AICRP on cattle project during the period from 2015-2022**.** A total of 110 villages were included with socioeconomic status of farmers. Least squares mean for various traits has shown significant effect of farmer's status on performance of crossbred cattle. The mean of FLMY and AFC was estimated to be 3893.35 kg and 953.6 days. The production traits were found to be influenced by occupation, fodder land, education level and number of animals of the farmers. The heritability estimation paves way for improvement in reproductive traits like AFC (h^2 = 0.14) by better managemental practices and incorporation of traits like FLMY (h^2 = 0.40) in selection methodology. The significant and positive correlations among the studied morphometric and performance traits have suggested high predictability between diverse traits. Regression model depicting R^2 value of 0.677 may be helpful for early selection of crossbred cows on the basis of morphometric traits under field condition. Present findings also suggest that BL, HG, BD, HW and early body weights may be used for selection of rural HF crossbred cattle for the prediction of milk yield.

HIGHLIGHTS

- Study was done to establish association between morphometric and performance traits in crossbred cattle.
- Influence of farmers status on the performance of progeny was assessed to sustain the production of crossbred progenies.
- Significant correlations were observed among the studied traits and also with the status of farmers.

Keywords: Crossbred cattle, First lactation milk yield, Heritability, Morphometric traits, performance traits

Efforts of crossbreeding indigenous cattle with exotic breeds are very well evident in terms of their production. In 2021, India has produced 209.9 million tons of milk with crossbred cattle contributing 28% and indigenous cattle contributing 20% of the total milk produced (20th livestock census 2019). Crossbred cattle are more competent over indigenous with hybrid vigour of better growth, early maturity and better productive and reproductive performance. For genetic growth and to sustain exotic inheritance in crossbreeds, young bulls have to be progeny tested for use in artificial insemination (AI) and extend this program to farmers herds to produce extra number of progenies (Das *et al*., 2017). Making use of the different agro-climatic regions of the country AICRP (All India Co-ordinated Research Project) in collaboration with ICAR (Indian Council of Agricultural Research) and SAU (State Agricultural Universities) have started field progeny testing (FPT) program in advancing the performance of crossbred cattle under field condition and improving the farmers economy.

How to cite this article: Waghmare, V.K., Dubey, P.P., Dash, S.K., Malhotra, P. and Ratta, N.S. (2022). Relationship between Morphometric and Performance traits in Crossbred Cows under Field Condition. *J. Anim. Res.*, **12**(06): 957-965.

Source of Support: Non; **Conflict of Interest:** None

Rural farmers with limited records on their animals are left with no choice but to visually assess their animal's production worth (Wakchaure *et al*., 2008). This demands a quick evaluation method to assess the worth of their animal. As per International Committee on Animal Recording (ICAR), evaluation of linear type traits is done by measuring specific type traits that are genetically correlated (ICAR-International Committee for Animal Recording, 2018). Morphometric characters associating with economic traits improve animals confirmative, reproductive and functional traits in supporting increased production (Bahonar *et al*., 2009) specifically, heart girth (HG) has been found to be influencing live weight of the animal (Gallo *et al*., 2001) and also, udder structure influences their milk yield in terms of volume and capacity besides aesthetic value (Bardakcioglu *et al*., 2011). Liveweight is important to know growth rate, determine feed requirements, reproductive and productive performance. Calves size and weight at birth influences calving ease and plays an important role on dam's subsequent lactation (Bicalho *et al*., 2007). Body weight grows with age and lactation so, it is important in selection and breeding of heifers at ideal weight reducing age at first calving and calving interval changing a non-productive heifer into highly economic animal (Atashi and Asaadi, 2019).

This study was conducted to associate morphometric and performance traits in crossbred cattle under field progeny testing program and its impact on improving farmers economy.

MATERIALS AND METHODS

Source of data and Area under study

The information on different performance traits and morphometric traits for the present study was collected from 453 progenies of 30 bulls that were part of AICRP on cattle Field Progeny testing program conducted by ICAR-CIRC, Meerut at Directorate of Livestock Farms, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab.

Collection of data and recording of parameters

The data pertaining to morphometric traits like heart girth (HG), body length (BL), body depth (BD), height at withers (HEW), rear height (RH), shoulder width (SW), rump width (RW), rump length (RL), udder circumference (UC), loin width (LW), hip width (HW) and thorax width (TW) was recorded using a simple measuring tape. 300-days first lactation milk yield (FLMY), test peak yield (TPY), age at first calving (AFC) and first calving interval (FCI) was collected from the project report (AICRP on Cattle: Field progeny testing). Body weight traits like weight at birth (WB), six months (W6), 12 months (W12), weight at calving (WC) and live weight (LWt) was calculated using Schaeffer's formula at different ages using morphometric measurements on each animal as follows.

$$\text{Live Weight (LWt) in kg} = L \times G^2/10815$$

where, L = Body Length in cm, G = Heart Girth in cm

Farmers attributes were recorded in a prescribed format to collect information on education level, occupation, fodder land holding, feeding system and herd size. The records on the progenies of only known bull sires with date of birth and date of calving were considered in the study. The daily milk yield records during the whole lactation were used for computing 300-day milk yield. The maximum milk yield recorded in a single month during the course of lactation was taken as the "test day peak yield". Progenies that produced above 2000 kg MY were only considered. Incomplete lactation records of progenies due to premature birth, still birth, sickness, death, sale or transfer during the course of lactation were considered as abnormal and have not been considered in the study.

STATISTICAL ANALYSIS

The data pertaining to the farmers attributes was statistically examined for least-squares analysis of variance. Duncan's Multiple Range Test (DMRT) was used to determine whether significant disparities in degrees of effects exist.

The heritability of the production and morphometric traits was estimated using Paternal Half-sib analysis.

The basic formula of multiple linear regression equations with several independent variables according to (Freedman, 2005) was used as follows:

$$Y_i = b_0 + b_1X_1 + b_2X_2 + ... + b_nX_n + e_i$$

Where: Y_i = the dependent variable of estimated milk production for i, b_0 to b_n = regression coefficient, X_1 to X_n = independent variables of linear character for *i* (Weight, AFC, HG, HEW, BL, BD, RH, RW, RL, UC etc.,), e_i = residual error between the independent and dependent variables were observed.

RESULTS AND DISCUSSION

Results for least squares mean with Duncan's multiple range test for significances are presented in the table 1(a) and 1(b) for performance traits and table 2(a) and 2(b) for morphometric traits. The mean of FLMY was estimated to be 3893.35±19.9 kg and was significantly ($p<0.05$) influenced by occupation and herd size of farmers. Present estimate was similar to (Kumar *et al*., 2016). The higher estimates were reported by (Gokhale *et al*., 2017) and (Panja and Trapdhar, 2012) whereas, lower estimates were studied by (Duplessis *et al*., 2015).

Estimates of AFC averaged at 953.6±8.2 days and were significantly ($p<0.05$) influenced by fodder land, education level of the farmers and herd size. Present least squares mean values were desirably lower than (Rahman *et al*., 2015) and (Singh *et al*., 2016). Weight at different ages were not affected by farmers status except for W6 that was influenced by education level of farmers and WC by feeding system. Present study reported higher values than those estimated by (Gaur *et al*., 2006) but lower values for least square means were reported by (Rahbar *et al*., 2016).

Table 1(a): Least squares mean of Performance traits

Category	N	WB kg	W6 kg	W12 kg	WC kg
Fodder land		NS	NS	NS	NS
≤ 1 acre	158	29.8±0.17	142.4±0.52	297.1±0.81	420.0±1.58
1-2 acre	176	29.9±0.15	141.9±0.44	296.6±0.70	416.6±1.66
>2 acre	119	30.0±0.19	142.9±0.54	298.0±0.79	420.3±1.96
Total	453	29.9±0.19	142.3±0.28	297.2±0.44	418.7±0.99
Education		NS	*	NS	NS
Pre-Primary	13	30.3±0.69	**144^{ab}±1.84**	296.6±3.14	421.6±7.63
Primary	62	30.1±0.27	**143.1^{ab}±0.83**	297.9±1.25	421.0±2.59
Matric	318	29.7±0.11	**142.4^{ab}±0.34**	297.3±0.52	418.0±1.18
Secondary	43	30.4±0.28	**141.5^{ab}±0.81**	296.9±1.29	422.3±3.07
Graduate	17	29.7±0.35	**139.2^{b}±1.05**	293.5±2.68	412.2±4.93
Total	453	29.9±0.09	142.3±0.28	297.2±0.44	418.7±0.99
Occupation		NS	NS	NS	NS
Agricultural Farmer	388	29.8±0.10	142.2±0.30	297.0±0.47	417.8±1.06
Agricultural labour	20	28.9±0.41	142.3±1.6	295.4±2.8	415.9±3.7
Service	7	31.0±0.65	142.7±1.2	298.2±2.9	433.7±7.4
Dairy business	38	30.9±0.32	143.1±1.14	299.8±1.4	426.7±3.6
Total	453	29.9±0.09	142.3±0.28	297.2±0.4	418.7±0.9
Feeding system		NS	NS	NS	*
Stall feeding	383	29.9±0.11	142.2±0.3	297.3±0.4	**419.7^{a}±1.9**
Grazing	25	29.7±0.3	141.2±1.1	294.0±2.1	**409.2^{b}±3.9**
Supplementary feeding	45	29.8±0.2	143.6±0.8	297.8±1.3	**417.2^{ab}±2.7**
Total	453	29.9±0.09	142.3±0.2	297.2±0.4	418.8±0.9
Herd size		NS	NS	NS	NS
1 to 5 animals	68	29.8±0.2	142.3±0.7	296.0±1.3	418.2±2.6
>5 to 15 animals	171	29.8±0.15	141.9±0.4	297.0±0.73	418.8±1.5
>15 to 25 animals	126	29.9±0.18	142.8±0.5	297.6±0.78	419.1±1.8
>25 animals	88	30.2±0.2	142.5±0.6	297.8±0.9	419.0±2.5
Total	453	29.9±0.09	142.3±0.2	297.2±0.4	418.8±0.9

Significance at 0.05 level is represented by (*); Non-significant is represented by NS.

Table 1(b): Least squares mean of Performance traits

Category	N	AFC DAYS	FLMY (300 days) kg	TPY kg	FCI Days (N=89)
Fodder land		*	NS	NS	NS
≤ 1 acre	158	**978.1[a]±14.1**	3877.1±35.2	15.1±0.13	414.53±1.4 (N= 30)
1-2 acre	176	**925.1[b]±12.2**	3889.3±31.0	15.1±0.11	417.89±1.90 (N= 38)
>2 acre	119	**963.4[ab]±16.4**	3920.8±38.6	15.3±0.14	417.28±1.93 (N= 21)
Total	453	**953.6±8.2**	3893.35±19.9	15.1±0.07	416.61±1.05 (N= 89)
Education		*	NS	NS	NS
Pre-primary	13	**861.6[a]±29.21**	3975.1±152.59	14.9±0.45	414±3.05 (N= 3)
Primary	62	**928.4[b]±22.23**	3916.3±59.51	14.8±0.20	413.8±2.7 (N= 10)
Matric	318	**954.1[b]±9.79**	3888.4±23.93	15.2±0.09	416.8±1.5 (N= 59)
Secondary	43	**1005.0[c]±25.73**	3919.3±48.9	15.4±0.19	417±1.1 (N= 10)
Graduate	17	**977.5[c]±44.66**	3772.08±87.1	14.6±0.32	419.5±0.9 (N= 7)
Total	453	**953.6±8.17**	3893.3±19.9	15.1±0.07	416.6±1.05 (N= 89)
Occupation		NS	*	NS	NS
Agricultural farmer	388	954.5±9.0	**3880.5[ab]±21.1**	15.1±0.078	415.8±0.9 (N= 74)
Agricultural labour	20	966.7±34.9	**3684.7[a]±96.7**	14.3±0.34	416.5±1.8 (N= 6)
Service	7	932.7±59.5	**4057.7[b]±132.2**	15.7±0.57	417±1.0 (N= 2)
Dairy business	38	941.8±24.8	**4104.8[b]±73.3**	15.9±0.30	424.5±1.9 (N= 7)
Total	453	953.6±8.1	**3893.6±19.9**	15.1±0.07	416.6±1.05 (N= 89)
Feeding system		NS	NS	NS	NS
Stall feeding	383	955.0±8.9	3898.3±22.2	15.1±0.08	416.9±1.1 (N= 81)
Grazing	25	957.0±35.3	3762.6±67.0	14.9±0.3	418.5±2.5 (N= 2)
Supplementary feeding	45	945.4±23.4	3914.4±54.2	15.3±0.2	411.1±3.2 (N= 6)
Total	453	954.2±8.1	3892.3±19.9	15.1±0.07	416.6±1.05 (N= 89)
Herd size		*	*	NS	NS
1 to 5 animals	68	**970.8[b]±22.1**	**3813.5[a]±57.7**	14.8±0.21	415±2.2 (N= 13)
>5 to 15 animals	171	**923.9[a]±12.5**	**3860.4[a]±31.0**	15.0±0.11	415.2±1.1 (N= 35)
>15 to 25 animals	126	**974.2[b]±15.8**	**3913.7[b]±36.6**	15.2±0.13	418.04±1.8 (N= 23)
>25 animals	88	**971.7[b]±18.5**	**3985.8[b]±45.5**	15.4±0.18	418.5±3.8 (N= 18)
Total	453	**954.2±8.1**	**3892.3±19.9**	15.1±0.07	416.6±1.05 (N= 89)

Significance at 0.05 level is represented by (*); Non-significant is represented by NS.

Table 2(a): Least squares mean of Morphometric traits

CATEGORY	N	BL cm	BD cm	HG cm	HEW cm	RH cm	SW cm	UC cm
Fodder land		NS	NS	NS	NS	NS	NS	NS
≤ 1 acre	158	146.7±0.2	196.7±0.3	175.1±0.2	125.6±0.2	128.4±0.18	26.5±0.1	75.7±0.9
1-2acre	176	146.5±0.1	196.1±0.3	174.7±0.2	125.2±0.1	128.1±0.14	26.1±0.1	76.4±0.9
>2 acre	19	146.8±0.2	196.4±0.4	175.2±0.3	125.3±0.2	128.2±0.22	26.1±0.1	76.7±1.2
Total	453	146.7±0.1	196.4±0.2	175.0±0.1	125.4±0.1	128.2±0.10	26.2±0.0	76.2±0.5
Education		NS	NS	NS	NS	NS	NS	NS
Pre-primary	13	146.3±0.9	196.7±1.5	175.5±1.1	125.8±0.5	128.5±0.48	27±0.45	77±3.7
Primary	2	147.1±0.3	196.4±0.4	175.4±0.4	125.4±0.3	128.2±0.29	26.4±0.2	76.7±1.7
Matric	318	146.6±0.1	196.3±0.2	174.8±0.1	125.3±0.1	128.2±0.12	26.2±0.1	76.2±0.7
Secondary	43	146.8±0.3	197.5±0.6	175.5±0.4	125.9±0.3	128.7±0.37	26.3±0.3	76.9±1.7
Graduate	17	146.4±0.5	195.2±1.1	173.8±1.0	125.6±0.4	128.2±0.46	26.7±0.3	72.4±2.6
Total	453	146.7±0.1	196.4±0.2	175.0±0.1	125.4±0.10	128.2±0.10	26.2±0.09	76.2±0.5
Occupation		NS	NS	NS	NS	NS	NS	NS
Agricultural farmer	388	146.6±0.1	196.4±0.2	174.8±0.1	125.3±0.1	128.2±0.10	26.2±0.1	76.0±0.6

Agricultural labour	20	146.1±0.6	196.2±0.7	174.9±0.6	125.0±0.5	127.7±0.52	26.1±0.4	76.4±2.6
Service	7	148.0±0.9	198.1±1.4	177.2±1.0	125.8±0.9	128.5±0.97	27.5±0.6	70.8±3.2
Dairy business	38	147.2±0.5	196.7±0.9	175.7±0.5	126.1±0.4	128.6±0.48	26.8±0.3	79.1±2.6
Total	53	146.7±0.1	196.4±0.2	175.0±0.1	125.4±0.1	128.2±0.10	26.2±0.09	76.2±0.5
Feeding system		NS	NS	*	NS	NS	NS	NS
Stall feeding	383	146.7±0.1	196.6±0.2	**175.1^{a}±0.1**	125.4±0.1	128.3±0.11	26.2±0.1	76.6±0.6
Grazing	25	146.3±0.4	194.4±0.7	**173.2^{a}±0.7**	125.4±0.2	127.9±0.2	26.3±0.4	73.6±1.9
Supplementary feeding	45	146.4±0.4	196.2±0.5	**174.5^{ab}±0.4**	125.5±0.3	128.3±0.3	26.7±0.2	75.1±1.7
Total	453	146.7±0.1	196.4±0.2	**175.0±0.15**	125.4±0.1	128.2±0.10	26.2±0.09	76.3±0.5
Herd size		NS	NS	NS	NS	NS	NS	NS
1 to 5 animals	68	146.6±0.3	196.3±0.4	175.0±0.4	125.4±0.2	128.3±0.25	26.2±0.2	76.1±1.5
>5 to 15 animals	171	146.6±0.1	196.2±0.3	174.9±0.2	125.3±0.1	128.2±0.16	26.3±0.1	75.4±0.8
>15 to 25 animals	126	146.8±0.2	196.7±0.3	175.0±0.2	125.5±0.2	128.4±0.20	26.2±0.1	76.4±1.0
>25 animals	88	146.7±0.3	196.5±0.5	175.0±0.3	125.4±0.2	128.1±0.25	26.1±0.2	77.9±1.5
Total	453	146.7±0.1	196.4±0.2	175.0±0.1	125.4±0.1	128.2±0.10	26.2±0.09	76.3±0.5

Significance at 0.05 level is represented by (*); Non-significant is represented by NS.

Table 2(b): Least squares mean of Morphometric traits

Category	N	RW cm	RL cm	LW cm	HW cm	TW cm	WT kg
Fodder land	NS	NS	NS	NS	NS	NS	NS
≤ 1 acre	158	44.9±0.13	8.4±0.14	36.9±0.10	22.5±0.09	24.2±0.12	416.7±1.60
1-2 acre	176	44.7±0.11	48.1±0.12	36.7±0.12	22.5±0.09	24.3±0.13	414.0±1.66
>2 acre	119	44.4±0.16	48.1±0.15	36.6±0.14	22.5±0.12	24.1±0.14	417.1±2.0
Total	453	44.7±0.07	48.2±0.07	36.7±0.07	22.5±0.05	24.2±0.07	415.8±1.0
Education	NS	NS	NS	NS	NS	NS	NS
Pre-primary	13	45.6±0.3	48.5±0.4	36.8±0.4	22.6±0.33	23.8±0.5	417.6±7.6
Primary	62	44.7±0.2	48.1±0.2	36.6±0.2	22.4±0.14	24.0±0.19	418.9±2.7
Matric	318	44.6±0.09	48.2±0.09	36.7±0.08	22.5±0.06	24.2±0.09	415.0±1.1
Secondary	43	44.9±0.2	48.1±0.2	37.1±0.18	22.7±0.18	24.8±0.2	418.7±3.0
Graduate	17	44.8±0.3	48.1±0.4	36.6±0.3	22.4±0.30	23.2±0.3	409.6±5.9
Total	453	44.7±0.07	48.2±0.07	36.7±0.05	22.5±0.05	24.2±0.07	415.8±1.0
Occupation	NS	NS	NS	NS	NS	NS	NS
Agricultural farmer	388	44.7±0.08	48.1±0.08	36.7±0.07	22.5±0.06	24.2±0.08	415.1±1.07
Agricultural labour	20	44.8±0.34	48.5±0.32	36.6±0.4	22.5±0.2	24.4±0.3	413.6±4.1
Service	7	44.7±0.35	47.4±0.36	36.4±0.5	22.5±0.3	24.4±0.9	430.3±7.0
Dairy business	38	44.9±0.36	48.9±0.36	36.8±0.2	22.4±0.27	23.9±0.25	421.1±3.8
Total	453	44.7±0.07	48.2±0.07	36.7±0.07	22.5±0.05	24.2±0.07	415.8±1.0
Feeding system	NS	NS	NS	NS	NS	NS	*
Stall feeding	383	44.6±0.08	48.1±0.08	36.7±0.075	22.5±0.06	24.3±0.08	416.9^{a}±1.0
Grazing	25	44.2±0.3	47.9±0.3	36.4±0.3	22.3±0.2	23.8±0.3	406.7^{b}±4.4
Supplementary feeding	45	45.4±0.2	49.0±0.2	37.3±0.2	22.7±0.1	23.8±0.2	412.5^{ab}±2.9
Total	453	44.7±0.07	48.2±0.07	36.7±0.07	22.5±0.05	24.2±0.07	415.9±1.0
Herd SIZE	NS	NS	NS	NS	NS	NS	NS
1 to 5 animals	68	44.6±0.21	48.1±0.19	36.7±0.17	22.3±0.14	24.1±0.20	415.7±2.7
>5 to 15 animals	171	44.7±0.12	48.1±0.13	36.7±0.11	22.5±0.08	24.2±0.13	415.6±1.5
>15 to 25 animals	126	44.9±0.14	48.2±0.14	36.9±0.13	22.7±0.10	24.3±0.14	416.3±1.8
>25 animals	88	44.5±0.20	48.3±0.18	36.5±0.17	22.5±0.15	24.2±0.16	416.2±2.5
Total	453	44.7±0.07	48.2±0.07	36.7±0.07	22.5±0.05	24.2±0.07	415.9±1.0

Significance at 0.05 level is represented by (*); Non-significant is represented by NS.

Estimates of heritability (table 3) in this study ranged from 0.04 ± 0.02 to 0.51 ± 0.04 for all the traits studied. Lower h^2 was found for weight at different ages along with AFC, BL, BD, HG, HW, RL and LW ranging from 0.04 ± 0.02 to 0.19 ± 0.03. Similar reports regarding the body weights were reported by (Neser *et al*., 2012) and (Kumar *et al*., 2015) in HF crossbred. Our results for AFC (0.14±0.2) were in accordance with (Boligon *et al*., 2010) in Nellore cattle.

In production traits FLMY and FCI had highest h^2 of 0.40±0.04 and 0.38±0.04 respectively, while heritability estimates of morphometric traits ranged from 0.07±0.02 to 0.48±0.04 indicating the presence of additive genetic variance and suggesting their reliability to evaluate animals. Similar results were observed by (Dubey and Singh 2005) and (Kumar *et al*., 2015) in crossbred cattle for FLMY and FCI. The heritability estimates of morphometric traits were in agreement with (Lagrotta *et*

Table 3: Pearson's Correlation Coefficients among morphometric and performance traits in crossbred cattle

	AFC Days	**WB**	**W6**	**W12**	**WC**	**FLMY**	**TPY**	**FCI Days**	**BL cm**	**BD cm**	**HG cm**	**HEW cm**	**RH cm**	**SW cm**	**UC cm**	**RW cm**	**RL cm**	**LW cm**	**HW cm**	**TW cm**	**WT kg**
AFC Days	**0.14 ± 0.02**	-.129**	-.196**	-0.072	-0.049	-.100*	0.035	0.057	-.106*	0.006	-0.014	0.009	0.050	0.017	-0.003	0.044	.106*	.144**	.120**	0.033	-0.049
WB		**0.11 ± 0.02**	.443**	.488**	.561**	.770**	.581**	-.431**	.490**	.428**	.494**	.273**	.243**	.299**	.215**	.209**	.089*	.089*	0.073	.126**	.548**
W6		.	**0.04 ± 0.02**	.438**	.285**	.479**	.324**	-.277**	.281**	.267**	.250**	.136**	.105*	.111*	.147**	.124**	.104*	0.010	-0.001	0.017	.290**
W12				**0.12 ± 0.02**	.440**	.560**	.442**	-.317**	.306**	.387**	.457**	.186**	.208**	.257**	.177**	.184**	.154**	0.079	0.050	.136**	.447**
WC					**0.14 ± 0.02**	.365**	.246**	-.151**	.812**	.701**	.912**	.444**	.406**	.615**	.246**	.421**	.335**	.153**	.095*	.155**	.975**
FLMY						**0.40 ± 0.04**	.781**	-.596**	.309**	.334**	.328**	.193**	.185**	.144**	.236**	.152**	0.045	0.083	0.074	.101*	.359**
TPY							**0.28 ± 0.03**	-.463**	.186**	.257**	.230**	.153**	.172**	.098*	.190**	.120**	0.059	0.057	.115**	.130**	.240**
FCI Days								**0.38 ± 0.04**	-.090*	-.132**	-.163**	-0.020	-0.039	-0.043	-.155**	-0.036	0.029	-0.029	-0.026	-.134**	-.155**
BL cm									**0.07 ± 0.02**	.439**	.581**	.534**	.451**	.532**	.157**	.421**	.303**	0.072	0.016	-0.032	.801**
BD cm										**0.16 ± 0.03**	.797**	.275**	.341**	.383**	.347**	.317**	.233**	.209**	.272**	.424**	.753**
HG cm											**0.16 ± 0.03**	.298**	.316**	.526**	.273**	.332**	.265**	.188**	.163**	.296**	.952**
HEW cm												**0.24 ± 0.03**	.920**	.434**	0.021	.496**	.361**	.136**	.151**	-0.050	.420**
RH cm													**0.16 ± 0.03**	.405**	0.086	.493**	.361**	.172**	.237**	0.061	.401**
SW cm														0.48 ± 0.04	.096*	.483**	.366**	.276**	.145**	-.095*	.584**
UC cm															**0.29 ± 0.03**	.138**	.212**	.174**	.187**	.230**	.263**
RW cm																**0.25 ± 0.03**	.804**	.554**	.505**	-0.012	.402**
RL cm															.		**0.40 ± 0.04**	.443**	.458**	0.031	.308**
LW cm																		**0.19 ± 0.03**	.439**	.091*	.165**
HW cm																			**0.11 ± 0.02**	.312**	.127**
TW cm																				**0.24 ± 0.03**	.208**
WT kg																					—

The values above the diagonal represent phenotypic correlation; The values at the diagonal represent heritability estimates; Significance at 0.05 level is represented by (*) and at 0.01 level is (**).

Table 4: Regression model for prediction of FLMY from morphometric traits

Model	Variables	Coefficients		T	Sig.	R^2	Adjusted R^2
		B	SE				
10	Constant	-1259.616	671.011	-1.877	0.061	**0.677**	**0.672**
	WB	134.70	6.844	19.684	0.000		
	W6	7.374	2.034	3.626	0.000		
	W12	10.938	1.390	7.870	0.000		
	HG cm	-16.355	4.331	-3.776	0.000		
	SW cm	-16.047	6.645	-2.415	0.016		
	UC cm	3.142	0.946	3.320	0.001		
	RW cm	24.120	11.599	2.080	0.038		
	RL cm	-24.620	10.993	-2.240	0.026		

B= Regression coefficients, SE= standard error.

al., 2010; Campos *et al*., 2015; Almeida *et al*., 2017) in HF crossbred.

AFC was negatively correlated with WB, W6, FLMY, BL, HG and WT while positively correlated with TPY, FCI and other morphometric traits. There was significantly positive and moderate correlation of WB with W6, W12, WC, TPY, FCI, BL, BD, HG and strong correlation of 0.77 with FLMY. Correlation of FLMY was moderate to strong (0.365 to 0.781) with performance traits and significantly negative with AFC and FCI respectively. 300-days FLMY was significantly ($p \leq 0.01$) positive and strongly correlated with WB and moderately correlated with live weight. FCI was negatively correlated with performance traits except for AFC which was positively correlated. Similar correlation estimates for production and reproduction traits were reported by (Kruszy´nski *et al*., 2006; Sawa *et al*., 2013) and (Soeharsono *et al*., 2020).

Among morphometric traits, the correlation of TPY was significantly positive with production traits, especially FLMY. Significantly higher correlation of WC was found with BD, BL, HG and Live weight. There was significantly strong correlation between HG with BL and BD and very strong and positive correlation between HG and LW. BL, HG, BD, WB, WC and WT were highly correlated with FLMY and can be considered in selection program for FLMY. Similar results were observed by (Melo *et al*., 2018; Kumar *et al*., 2018) and (Yakubu *et al*., 2021) for various morphometric traits.

The regression model was run for 17 traits with backward elimination method to develop the most fit model equation with highly correlated independent variables to predict 300-days FLMY which was taken as dependent variable. Initially all the traits were included for regression that run 10 models with backward elimination and retaining only 8 variables in the 10^{th} model with their regression coefficients ranging from (-16.035 ± 4.33) to (134.708 ± 6.84) for HG and weight at birth (WB). Results for regression in the 10^{th} model had an R^2 value of (0.677) given in table 3, for prediction of 300-days FLMY with 8 morphometric traits viz., weight at birth (WB), (W6), (W12), heart girth (HG), shoulder width (SW), udder circumference (UC), rump width (RW) and rump length (RL) as the most correlated predictor variables given in the table 4. Variables that are less correlated were eliminated stepwise in each model and variables with high correlation were used to develop the best fitted functional regression model by considering coefficients of determination (R^2).

Lesosky *et al*. (2012) found higher results in Shorthorn Zebu cattle for prediction of Live weight from HG with an R^2 value of (0.98). (Tariq *et al*., 2013) in Nili Ravi observed higher results for Live weight prediction using HG and BL with R^2 = 0.95 and 0.86 respectively. There is not much literature on associating correlation of morphometric traits with performance traits in HF crossbred cattle under field conditions. This study may help in further research and advancement of cattle performance.

CONCLUSION

Present findings in the study suggest that BL, HG, BD, HW and early body weights may be used for selection of rural HF crossbred cattle for the prediction of milk yield. Rural farmers, as they lack any mechanical and electronic scales to check body weights of their animals regularly can rely on and combine simple morphometric dimensions (HG and BL) to determine the feed supplies, assess growth, age for breeding, assess performance for marketing and estimate the animals worth in terms of cash or sale price.

REFERENCES

20th Livestock Census. 2019. Government of India. (20th Livestock Census-2019). *Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture.* Key Result (1): 11-14.

Almeida, T.P., Kern, E.L., Daltro, S., Braccini, J., Mcmanus, C., Neto, A.T. and Cobuci, J.A. 2017. Genetic associations between reproductive and linear-type traits of Holstein cows in Brazil. *Revista Brasileira de Zootecnia*, **46**(2): 91–98.

Atashi, H. and Asaadi, A. 2019. Association between gestation length and lactation performance, lactation curve, calf birth weight and dystocia in Holstein dairy cows in Iran. *Anim. Reprod.,* **16**(4): 846-852.

Bahonar, A.R., Azizzadeh, M., Stevenson, M.A., Vojgani, M. and Mahmoudi, M. 2008. Factors Affecting Days Open in Holstein Dairy Cattle in Khorasan Razavi Province, Iran; A Cox Proportional Hazard Model. *J. Anim. and Vet. Adv.,* **8**(4): 747-754.

Bardakcioglu, H.E., Sekkin, S. and Toplu, H.D. 2011. Relationship between some teat and body measurements of Holstein cows and sub-clinical mastitis and milk yield. *J. of Anim. and Vet. Adv.,* **10**(13): 1735-1737.

Bicalho, R.C., Galvão, K.N., Cheong, S.H., Gilbert, R.O., Warnick, L.D. and Guard, C.L. 2007. Effect of stillbirths on dam survival and reproduction performance in holstein dairy cows. *J. Dairy Sci.,* **90**(6): 2797-2803.

Boligon, A.A., Albuquerque, L.G. De., Zerlotti, M.E. and Lôbo, R.B. 2010. Study of relations among age at first calving, average weight gains and weights from weaning to maturity in Nellore cattle Estudo das relações entre a idade ao primeiro parto ganhos em peso e pesos da desmama à maturidad. *Revista Brasileira de Zootecnia*, **39**(4): 746–751.

Campos, R.V., Cobuci, J.A., Kern, E.L., Costa, C.N. and McManus, C.M. 2015. Genetic parameters for linear type traits and milk, fat, and protein production in Holstein cows in Brazil. *Asian-Australasian J. Anim. Sci.*, **28**(4): 476–484.

Das, A. K., Ravinder, K., Rathee, S. K., Prakash, B., Anilkumar, K., Dubey, P. P., Bhagat, R. L., Singh, C. B., Kumar, U., Tyagi, A., Bhasin, S. and Vineet. 2017. Genetic improvement of cattle through field progeny testing programme: An evaluation of achievement. *Indian J. Anim. Sci.,* **87**(12): 1445-1451.

Dubey, P.P., Singh, C.V. and Prasad, R.B. 2006. Relationship between sire's estimated breeding values for first lactation and life time traits and ranking of sires in Sahiwal and its cross. *Indian J. Anim. Sci.,* **76**(10): 824–828.

Duplessis, M., Cue, R.I., Santschi, D.E., Lefebvre, D.M. and Lacroix, R. 2015. Weight, height, and relative-reliability indicators as a management tool for reducing age at first breeding and calving of dairy heifers. *J. Dairy Sci.*, **98**(3): 2063–2073.

Freedman, D.A. 2005. *Statistical Models: Theory and Practice*. New York: Cambridge University Press. **3**(36): 138-140.

Gallo, L., Carnier, P., Cassandro, M., Zotto, R.D. and Bittante, G. 2001. Test-Day Genetic Analysis of Condition Score and Heart Girth in Holstein Friesian Cows. *J. Dairy Sci*., **84**(10): 2321-2326.

Gaur, G.K., Kumar, A., Singh, U., Rathi, S.K., Singh, K. and Biswas, B.B. 2006. Physical and morphometric characterization of Frieswal cattle. *Indian J. Anim. Sci.,* **76**(12): 1030–1032.

Gokhale, S.B., Bhagat, R.L., Gokhale, R.B. and Pande, A.B. and Pande. 2007. Farmer attributes affecting crossbred cows production performance in rural areas of Western Maharashtra. *International J. Trop. Agric.*, **25**(3): 605–608.

International Committee for Animal Recording, Special Rules, General Report. 2018. *International Committee for Animal Recording.* Netherlands, pp. 1-44.

Kruszyński, W.; Pawlina, E. and Szewczuk, M. 2013. Genetic analysis of values, trends and relations between conformation and milk traits in Polish Holstein-Friesian cows. *Archiv. Tierzucht.,* **56**: 536-546.

Kumar, K., Nanavati, S., Joshi, S.K., Singh, A., Choudhary, N.S. and Choudhary, R. 2018. Studies of Effect of Parity and Stage of Lactation on various Body Measurements, Body Weight and their Relationship with Each Other in Frieswal Cows. *J. Anim. Res.*, **8**(4): 697–701.

Kumar, R., Rathee, S.K., Das, A.K., Raja, T.V. and Dubey, P. 2016. Impact of field progeny testing on cattle performance in Punjab. *Indian Farming*, **66**(3): 31-33.

Kumar, S.A. and Rani, A., Singh, U., Kumar, A. and Das, A. 2015. Comparative performance evaluation of Frieswal bulls in organized farms and farmers' herds. *Indian J. Anim. Sci.,* **85**(3): 316-319.

Lagrotta, M.R., Euclydes, R.F., Verneque, R. da S., Santana Júnior, M.L., Pereira, R.J. and Torres, R. de A. 2010. Relationship between morphological traits and milk yield in Gir breed cows. *Pesquisa Agropecuaria Brasileira*, **45**(4): 423–429.

Melo, B.A., Nascimento, I.M., Santos, L.T.A., Lima, L.G., Araújo, F.C.T., Rios, R.R.S., Couto, A.G. and Fraga, A.B. 2018. Body morphometric measurements in Murrah crossbred buffaloes (*Bubalus bubalis*), *J. Appl. Anim. Res.,* **46**(1): 1307-1312,

Neser, F.W.C., Wyk van, J.B., Fair, M.D., Lubout, P. and Crook, B.J. 2012. Estimation of genetic parameters for growth in Brangus cattle. *South Afric. J. Anim. Sci.,* **42**(15): 469-473.

Panja P. K. and Taraphder S. 2012. Optimization of age at first calving in Karan Fries cattle. *Explor. Anim. Med. Res.*, **1**(2), 124-130.

Rahbar, R., Abdullahpour, R. and Sadeghi-Sefidmazgi, A. 2016. Effect of calf birth weight on milk production of holstein dairy cattle in desert climate. *J. Anim. Behav. Biometeorol.*, **4**(3): 65–70.

Rahman, M., Arafat, Y., Jalil, M.A., Rasel, I. H., Ahmed, S. and Islam, M.A. 2015. Morphometric, productive and reproductive characteristics of cattle at Magura district. *Int. J. Natur. Soc. Sci.*, **2**(1): 113–117.

Sawa, A., Bogucki, M., Krężel-Czopek, S. and Neja, W. 2013. Relationship between Conformation Traits and Lifetime Production Efficiency of Cows. *ISRN Vet. Sci.*, **2013**(6): 1–4.

Schaeffer, L.R., Hunt, M.S. and Burnside, E.B. 1978. Evaluation of Holstein-Friesian dairy sires for conformation of their daughters. *Can. J. Anim. Sci*., **5**(E): 409-417.

Singh, B., Sawant, P., Sawant, D., Todkar, S. and Jain, R. 2016. Factors affecting weight and age at first calving, first lactation milk yield in Gir cows. *I. J. of Ani. Res.*, **50**(5): 804–807.

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

Tariq, M., Younas, M., Khan, A. B. and Schlecht, E. 2013. Body Measurements and Body Condition Scoring as Basis for Estimation of Live Weight in Nili-Ravi Buffaloes. *Pakistan Vet. J.*, **33**(3), 325–329.

Wakchaure, R., Ganguly. S., Ahmad. P.P., Praveen. K., Avinash. K. and Subhash. S. 2008. Development of Crossbred Cattle in India: A Review. *Int. J. Emerg. Technol. Adv. Engin.,* **5**(10): 75-77.

Yakubu, A., Abdullah, A.R., Raji, A.O. and Oseni, S.O. 2021. Multivariate principal component analysis of the morphometric traits of some cattle breeds in Nigeria. *J. Anim. Plant Sci.*, **31**(3): 681–689.