

## RESEARCH ARTICLE

## Effect of non-genetic factors on linear type traits score in Sahiwal cattle

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Received: 30 November 2023 / Accepted: 07 May 2024 / Published online: 23 October 2024

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**Abstract:** The aim of the present investigation was to determine if environmental or non-genetic variables may affect linear type scores in Sahiwal cows. For this purpose, 246 observations were obtained from 23 linear type traits on 150 Sahiwal cattle from 2019 to 2021. Data was analyzed by the least squares technique to examine the effect of non-genetic factors on conformation traits. All the data was analyzed by using univariate analysis of variance in the GLM of SPSS. In this study, the season had no statistically significant impact on linear type traits. Parity had a significant ( $p < 0.05$ ) effect on chest width, body depth, rump width, fore udder attachment, udder depth, rear udder width, central ligament, fore teat length and rear teat length. Stage of lactation had a significant ( $p < 0.05$ ) effect on body depth, body condition score, rear udder height and rear udder width. According to the study's findings, the parity, and lactation stages were significant drivers of variance for most features of the linear type. To minimize known animal differences and achieve accurate estimates of the attributes, data must be adjusted for these effects.

**Keywords:** Linear type traits, Parity, Sahiwal cows, Season of scoring, Stage of lactation

### Introduction

To fulfil the demands of future production and reproduction, the dairy sector is faced with the unique problem of continually enhancing the performance of dairy cows. Selection of the best animals forms the cornerstone of advances (Getu and Misganaw, 2015). By incorporating the research on direct information on herd life and indirect information derived from conformation features, selection accuracy may be improved Miglior et al. (2017). Dairy animals' survival is affected by various genetic and non-genetic factors. Genetic factors include higher milk production, normal cyclicity and calving, accuracy of conception, maintaining adequate body condition and resistant metabolic diseases. Non-genetic factors include housing design, stall size, bedding materials and affordability of heifer replacement. The bodily components of a dairy cow that enable her to produce milk and those features that are either directly or indirectly connected to one another are referred to as linear type traits. Culling decisions Kern et al. (2014), longevity Török et al. (2021), and milk production Campos et al. (2015) are all impacted by these features both directly and indirectly. Cattle breeders can spot genetically predisposed functional and structural weaknesses as well as prospective issues brought on by improper breeding practices by monitoring and measuring specific parts of each animal Kumar et al. (2023). As an indirect selection criterion for herd life, conformation attributes have been applied Vukasinovic et al. (2002). In a nutshell, the linear type trait is an important selection criterion for animal breeding. Linear type attributes depend on non-genetic factors including season, parity, and lactation stage, which might be categorized as elements with observable impacts. The quantifiable results may be useful in developing future cattle development programs Javed et al. (2013). To reduce known environmental variations between animals and reliably estimate breeding values, performance records of the animals in these programs should be corrected for the environmental causes of variation Güler et al. (2018). For dairy cows, conformation documentation is not routine in India. However, there is growing motivation among farmers to widen breeding aims and incorporate additional economically significant traits, particularly conformation aspects. Therefore, the present research was carried out to determine the extent to which non-genetic variables

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influence the linear type features in Sahiwal cows at an organized farm in India.

## Materials and Methods

### Experimental animals and area

Data on linear type traits measured and documented from the herd of all lactating Sahiwal cows maintained at Livestock Research Complex, ICAR-National Dairy Research Institute, Karnal (Haryana), India. This institute is situated at latitude 29° 42' N and longitude 72° 54' E on the Indo-Gangetic alluvial plains, 250 meters above sea level. The average annual rainfall is 860 mm, most of which falls between June and August, during the monsoon season. There is a 41 to 85 per cent relative humidity range. A subtropical climate creates temperature extremes in winter (2°C) and summer (45°C) in Karnal. The experimental animals were kept in a system of loose housing. The paddock, which was big, open, and brick paved with a drainage in between covered and open area with an acceptable slope for better drainage. For all lactating animals in the herd, the feeding management practices and feed components (ICAR 2013) were the same. To give the lactating animals the nutrients they needed, finite amount of concentrates and ad libitum green fodders were offered.

### Collection and classification of data

In this study, 246 observations of 150 Sahiwal (*Bos indicus*) cows were gathered. Measurements on type traits were recorded one to two hours before the evening milking at three stages of lactation (20-50 days, 90-130 days and 180-200 days). Body measurements were recorded as per the recommendations made by International Committee for Animal Recording by three classifier (ICAR, 2018). Twenty-three linear type traits were scored on a scale of 1-9 scoring system. These 23 linear type traits included 7 body measurements traits, 6 udder measurements traits, 4 teat measurements traits and 6 visual observation linear type traits generated for each animal. All the measurements were recorded for each animal when standing evenly on her feet and for the same person to avoid the between-scorer effect. Measurements on type traits were recorded one to two hours before the evening milking at three stages of lactation (20-50 days, 90-130 days, and 180-200 days). The non-genetic factors incorporated were the effect of parity (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup>), stage of lactation (1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup>) and season viz., summer (March-June), rainy (July-September), autumn (October-November), winter (December-February).

### Statistical analysis

Least squares analysis of variance for unequal and non-orthogonal data was done to study the effect of non-genetic factors. All the data were analyzed by using univariate analysis of variance in the GLM of SPSS. The model was used under the presumption that all of the factors that were put into it are linear,

independent, and additive. The following is the analytical model for the influence of non-genetic factors on linear-type traits:

$$Y_{ijkl} = \mu + L_i + P_j + S_k + e_{ijkl}$$

Where,

$Y_{ijkl}$  = 1<sup>th</sup> observation of cow in i<sup>th</sup> stage of lactation, j<sup>th</sup> parity and k<sup>th</sup> season at scoring

$\mu$  = Overall mean

$L_i$  = Fixed effect of i<sup>th</sup> stage of lactation (i= 1 to 3)

$P_j$  = Fixed effect of j<sup>th</sup> parity (j= 1 to 5)

$S_k$  = Effect of k<sup>th</sup> season at scoring

$e_{ijkl}$  = Random error NID (0,  $\sigma^2$ )

## Results and discussion

Tables 1-4 are showing the least squares means and associated standard errors for the linear type traits of Sahiwal cows for various seasons, parities, and lactation stages.

### Effect of season of scoring

The season had no statistically significant impact on the linear type traits in the current study (Tables 1 to 4). The results of prior research by Kumar et al. (2023) and Sharma et al. (2022), which revealed that the season had no significant impact on teat-type features, are in agreement with this study. The observed season had no significant impact on the udder and teat-type features in Sahiwal cows, according to Togla et al. (2021). In contrast, Erdem et al. (2017) discovered that the season had a significant ( $p < 0.05$ ) impact on the udder cleft, dairy form (angularity), body depth, rump angle, rump width, teat length, teat placement, udder depth, and rear udder height, whereas the effect of season on fore udder attachment was highly significant ( $p < 0.01$ ).

### Effect of parity

Parity had a significant ( $p < 0.05$ ) effect on chest width, body depth, rump width, fore udder attachment, udder depth, rear udder width, central ligament, fore teat length and rear teat length in Sahiwal cows has been presented in Table 1 to 4. Up to the fourth parity, chest width and body depth significantly increased, but after that, they started to decline until the fifth parity. Wider-chested cows with high scores are often preferred because they provide the heart and lungs more room to operate properly. Greater body capacity is related to a bigger digestive system, which is associated with ingesting more feed and fodder for producing more milk (Roy et al. 2020). These results are in agreement with

Erdem et al. (2017) who revealed that parity had a significant ( $p < 0.05$ ) influence on body depth in Sahiwal cattle. Similarly, according to Yanar et al. (2018), the influence of parity was a significant ( $p < 0.01$ ) source of variation for chest width, but not for body depth ( $p < 0.05$ ), however, Güler et al. (2020) reported the effect of parity had significant ( $p < 0.01$ ) source of variation for chest width and body depth. Up to the third parity, the rump width increased, but for the fourth and fifth parities, it decreased. Similarly, Marinov et al. (2015); Erdem et al. (2017) and Güler et al.

**Table: 1** Least squares mean of average score points (ASP) for linear type traits (ST, CW, BD, RW, RA and ANG) under 1- 9 score system

Effects	Stature (ST)	Chest width (CW)	Body depth (BD)	Rump width (RW)	Rump angle (RA)	Angularity (ANG)
Overall (246)	5.82±0.10	4.69±0.11	5.31±0.11	5.51±0.11	4.42±0.10	4.82±0.11
Season of scoring						
Winter (63)	6.01±0.20	4.76±0.21	5.19±0.21	5.50±0.21	4.25±0.19	5.08±0.21
Summer (33)	5.81±0.27	4.77±0.28	5.35±0.28	5.17±0.28	4.42±0.26	5.19±0.28
Rainy (94)	5.68±0.16	4.49±0.16	5.19±0.17	5.52±0.17	4.64±0.15	4.52±0.17
Autumn (56)	5.81±0.22	4.76±0.22	5.51±0.23	5.83±0.22	4.36±0.20	4.52±0.22
Parity						
P1 (45)	5.66±0.26	3.87 <sup>a</sup> ±0.26	4.26 <sup>a</sup> ±0.27	4.63 <sup>a</sup> ±0.27	4.29±0.24	4.69±0.26
P2 (71)	5.71±0.18	4.44 <sup>ab</sup> ±0.19	5.30 <sup>ab</sup> ±0.19	5.49 <sup>b</sup> ±0.19	4.48±0.17	4.65±0.19
P3 (53)	5.84±0.23	5.18 <sup>bc</sup> ±0.23	5.69 <sup>b</sup> ±0.24	5.95 <sup>b</sup> ±0.24	4.64±0.22	4.37±0.24
P4 (45)	5.87±0.23	5.29 <sup>c</sup> ±0.23	6.06 <sup>b</sup> ±0.24	5.85 <sup>b</sup> ±0.23	4.41±0.21	4.95±0.23
P5 (32)	6.06±0.28	4.80 <sup>bc</sup> ±0.29	5.31 <sup>b</sup> ±0.30	5.78 <sup>b</sup> ±0.29	4.33±0.27	5.35±0.29
Stage of lactation						
L1 (95)	6.02±0.16	4.72±0.16	4.90 <sup>a</sup> ±0.17	5.42±0.17	4.26±0.15	4.85±0.16
L2 (76)	5.79±0.19	4.84±0.20	5.25 <sup>a</sup> ±0.20	5.55±0.20	4.61±0.18	4.79±0.20
L3 (75)	5.66±0.20	4.49±0.20	5.79 <sup>b</sup> ±0.21	5.58±0.21	4.40±0.19	4.80±0.20

Means with different superscripts (a,b,c) indicates significant difference ( $p < 0.05$ ) in the same column

**Table: 2** Least squares mean of average score points (ASP) for linear type traits (RLRV, RLS, FA, BCS, LM and FUA) under 1- 9 score system

Effects	Rear legs rear view (RLRV)	Rear leg set (RLS)	Foot angle (FA)	Body condition score (BCS)	Locomotion (LM)	Fore udder attachment (FUA)
Overall (246)	5.08±0.07	4.67±0.13	4.91±0.12	6.33±0.10	4.84±0.08	4.71±0.13
Season of scoring						
Winter (63)	5.31±0.13	5.01±0.26	4.74±0.23	6.60±0.19	5.05±0.14	4.50±0.26
Summer (33)	4.97±0.18	4.50±0.35	5.09±0.31	6.33±0.25	4.67±0.19	4.70±0.34
Rainy (94)	5.02±0.11	4.53±0.21	4.72±0.18	6.12±0.15	4.89±0.11	5.21±0.20
Autumn (56)	5.03±0.14	4.65±0.28	5.11±0.24	6.27±0.20	4.74±0.15	4.40±0.27
Parity						
P1 (45)	5.43±0.17	4.29±0.33	4.90±0.29	6.40±0.23	4.92±0.18	5.24 <sup>b</sup> ±0.32
P2 (71)	4.91±0.12	5.07±0.24	4.53±0.21	6.33±0.16	4.97±0.13	5.05 <sup>b</sup> ±0.23
P3 (53)	4.96±0.15	4.91±0.30	5.02±0.26	6.59±0.20	4.62±0.16	4.86 <sup>b</sup> ±0.29
P4 (45)	5.07±0.15	4.83±0.29	4.86±0.25	6.35±0.20	4.91±0.16	4.50 <sup>ab</sup> ±0.28
P5 (32)	5.02±0.19	4.30±0.37	5.30±0.32	6.06±0.25	4.72±0.20	3.86 <sup>a</sup> ±0.36
Stage of lactation						
L1 (95)	5.01±0.10	4.74±0.21	4.97±0.18	6.00 <sup>a</sup> ±0.14	4.95±0.11	4.55±0.20
L2 (76)	5.29±0.13	4.67±0.25	4.68±0.22	6.25 <sup>ab</sup> ±0.17	4.91±0.13	4.69±0.24
L3 (75)	4.94±0.13	4.61±0.26	5.09±0.22	6.75 <sup>b</sup> ±0.18	4.65±0.14	4.89±0.25

Means with different superscripts (a,b,c) indicates significant difference ( $p < 0.05$ ) in the same column

(2020) reported the effect of parity had a significant ( $p<0.01$ ) source of variation for rump width. The body growth of an animal with increasing age and subsequent parturition might be a reason for increasing the distance between two pin bones. A higher mean score for fore udder attachment indicated that strong attachment of the udder to the ventral body wall, whereas loose attachment of the udder to the ventral body wall is indicated by a lower mean score of fore udder attachment. Fore udder attachment was stronger in 1<sup>st</sup> parity and then decreased with the advancement of parity. These findings support earlier research studies like Petkov and Stoyanova (2006) also reported a significant impact of parity on fore udder attachment in Black and White cows. Up to the sixth parity, there was a rise in the linear score for rear udder width. The results of rear udder width for parity effect are consistent with Sharma et al. (2022), who found that parity had a significant ( $p<0.05$ ) impact on Sahiwal cows' rear udder width. Because of the udder's growth starting with the first lactation and continuing afterwards, the parity discrepancies were validated (Pawar et al. 2012). This was also the time when the production of cows attained a peak around 6<sup>th</sup> parity, when an animal was 8- to 9 years old and gained adult size. From the first calving onward, the value of the udder depth linear score was steadily dropping. The results of the present study were consistent with Sharma et al. (2022), who showed that parity had a significant ( $p<0.05$ ) impact on udder depth in KF and Sahiwal cattle. The effect of parity on the central ligament was found to be significant ( $p<0.05$ ). These findings support earlier

research by Togla et al. (2021), which revealed that parity had a significant ( $p<0.05$ ) impact on udder cleft in Sahiwal cows. Parity was found to significant ( $p<0.05$ ) effect on fore teat length and rear teat length. This trait showed an increasing trend with the advancement of parity. These findings are consistent with previous research from several workers who indicated that fore teat length in Sahiwal cows was significantly ( $p<0.05$ ) affected by parity (Kumari et al. 2022; Sharma et al. 2022). In another study, fore and rear teat length in multiparous cows with more than three parities increased by 0.55 and 0.44 cm, or 9.61 and 9.32%, compared to primiparous cows (Kuczaj, 2003). Age-related increases in teat length may be explained by the negative effects of machine milking. Stature, rump angle, angularity, rear leg rear view, rear legs set, foot angle, BCS, and locomotion were the only variables for which parity was not a significant source of variation ( $p<0.05$ ) and these results concur with the report of Khan and Khan (2015) on Sahiwal cows.

### Effect of stage of lactation

As shown in Tables 1 to 4, the stage of lactation had a significant ( $p<0.05$ ) impact on the Sahiwal cow's body depth, body condition score, rear udder height, and rear udder width. In the later phases of lactation, the cows had a deeper body, better body condition, and a shallow udder. These findings are somewhat consistent with those of (Khan and Khan 2015), who found that along with body depth, Sahiwal cows' stature increased from the first to the

**Table: 3** Least squares mean of average score points (ASP) for linear type traits (RUH, UD, RUW, CL, FTL and RTL) under 1- 9 score system

Effects	Rear udder height (RUH)	Udder depth (UD)	Rear udder width (RUW)	Central ligament (CL)	Fore teat length (FTL)	Rear teat length (RTL)
Overall (246)	5.55±0.12	5.23±0.08	4.27±0.11	3.97±0.09	3.82±0.12	3.96±0.11
Season of scoring						
Winter (63)	5.60±0.23	5.33±0.15	4.23±0.21	4.27±0.18	4.17±0.24	4.43±0.21
Summer (33)	5.88±0.30	5.17±0.21	4.41±0.28	3.44±0.24	3.64±0.32	3.82±0.28
Rainy (94)	5.38±0.18	5.34±0.12	4.19±0.16	4.00±0.14	3.53±0.19	3.80±0.16
Autumn (56)	5.36±0.24	5.07±0.16	4.22±0.22	4.11±0.19	3.96±0.25	3.81±0.22
Parity						
P1 (45)	5.87±0.29	6.58 <sup>c</sup> ±0.19	3.86 <sup>a</sup> ±0.26	3.24 <sup>a</sup> ±0.23	3.18 <sup>a</sup> ±0.30	3.53 <sup>a</sup> ±0.26
P2 (71)	5.89±0.21	5.34 <sup>b</sup> ±0.14	4.14 <sup>ab</sup> ±0.19	3.70 <sup>ab</sup> ±0.16	3.42 <sup>ab</sup> ±0.21	3.64 <sup>ab</sup> ±0.19
P3 (53)	5.57±0.26	5.14 <sup>b</sup> ±0.17	4.24 <sup>ab</sup> ±0.24	4.33 <sup>bc</sup> ±0.20	3.79 <sup>abc</sup> ±0.26	4.07 <sup>ab</sup> ±0.23
P4 (45)	5.14±0.25	4.79 <sup>ab</sup> ±0.17	4.45 <sup>ab</sup> ±0.23	4.26 <sup>bc</sup> ±0.20	4.35 <sup>bc</sup> ±0.26	4.48 <sup>b</sup> ±0.23
P5 (32)	5.23±0.32	4.20 <sup>a</sup> ±0.22	4.67 <sup>b</sup> ±0.29	4.42 <sup>c</sup> ±0.25	4.62 <sup>c</sup> ±0.33	4.14 <sup>ab</sup> ±0.29
Stage of lactation						
L1 (95)	5.92 <sup>b</sup> ±0.18	5.20±0.12	4.68 <sup>b</sup> ±0.17	3.96±0.14	3.81±0.18	4.15±0.16
L2 (76)	5.52 <sup>a</sup> ±0.21	5.32±0.15	4.27 <sup>ab</sup> ±0.20	3.90±0.17	3.88±0.22	3.94±0.20
L3 (75)	5.18 <sup>a</sup> ±0.22	5.17±0.15	3.82 <sup>a</sup> ±0.21	4.04±0.18	3.90±0.23	3.80±0.20

Means with different superscripts (a,b,c) indicates significant difference ( $p<0.05$ ) in the same column

last lactation stage. Body depth was found to differ significantly ( $p < 0.05$ ) between different stages of lactation in Sahiwal cows. These results concur with those of Yanar et al. (2018), who found that the lactation stage was a significant ( $p < 0.05$ ) source of variation for body depth in Simmental cows. Animals tend to score better from mid to late lactation since the body depth and body size traits are directly related to body weight. These findings are supported by the observation that cows exhibited a negative energy balance during the beginning of lactation, which also happened to be the time of lactation peak Esteves et al. (2004). The effect of the stage of lactation on body condition score was found to be significant ( $p < 0.05$ ). These results are in agreement with the previous studies by Marinov et al. (2015) who reported that in Holstein cattle, the mean of BCS was significantly ( $p < 0.05$ ) affected by stage of lactation. These results could be due to cows having a lower body condition score during the early lactation stage (negative energy balance). The least square means score for rear udder height were consistent with those of Salam and Zia-ul-Haq (2016) and Togla et al. (2021), who found that the lactation stage had a significant ( $p < 0.05$ ) impact on the rear udder height of Sahiwal cows. Several researchers have reported that the stage of lactation had a significant ( $p < 0.01$ )

impact on the height of the rear udder in Holstein, Simmental, and Brown Swiss cows (Liu et al. 2014; Erdem et al. 2017; Yanar et al. 2018; Güler et al. 2020). These findings might be a result of the ligaments becoming weaker and the mammary glands contracting as the lactation stage progresses. In this study, the rear udder width decreased steadily from the first to the third phase of lactation. These results concur with those of Mazza et al. (2013), who also reported that rear udder width decreased significantly ( $p < 0.01$ ) as lactation progressed in Valdostana cattle. This study found that there was not a significant variation in udder diameter and teat circumference across lactation stages. However, this conclusion conflicts with that of Kumar et al. (2023), who found that the lactation stage was a significant source of variance for udder diameter and teat circumference in Sahiwal cows. Additionally, given the impacts of stages of lactation on udder and teat measurements, we may draw an inference from the current data that the stage of lactation does not necessarily affect all udder and teat measurements.

**Table: 4** Least squares mean of average score points (ASP) for linear type traits (TC, TD, UB, FTP and RTP) under 1- 9 score system

Effects	Teat circumference (TC)	Teat diameter (TD)	Udder balance (UB)	Fore teat placement (FTP)	Rear teat placement (RTP)
Overall (246)	4.21±0.13	4.11±0.13	5.24±0.13	4.40±0.09	6.36±0.96
	Season of scoring				
Winter (63)	4.10±0.25	4.22±0.25	4.82±0.25	4.28±0.18	6.38±0.18
Summer (33)	4.03±0.33	3.77±0.33	5.25±0.33	4.34±0.24	6.64±0.24
Rainy (94)	4.24±0.19	4.22±0.19	5.63±0.20	4.51±0.14	6.18±0.14
Autumn (56)	4.45±0.26	4.22±0.26	5.24±0.26	4.46±0.19	6.26±0.19
	Parity				
P1 (45)	4.05±0.31	3.76±0.31	4.96±0.31	4.18±0.23	6.22±0.22
P2 (71)	4.30±0.22	4.04±0.22	5.46±0.22	4.38±0.16	6.29±0.16
P3 (53)	4.31±0.28	4.26±0.28	5.10±0.28	4.39±0.20	6.34±0.20
P4 (45)	4.18±0.27	4.51±0.27	5.20±0.28	4.78±0.20	6.74±0.20
P5 (32)	4.23±0.34	4.03±0.34	5.49±0.35	4.26±0.25	6.33±0.25
	Stage of lactation				
L1 (95)	4.45±0.19	4.35±0.19	5.14±0.20	4.33±0.14	6.62±0.14
L2 (76)	3.96±0.23	3.98±0.23	5.19±0.23	4.44±0.17	6.51±0.17
L3 (75)	4.21±0.24	4.01±0.24	5.41±0.24	4.43±0.17	6.02±0.17

Means with different superscripts (a,b,c) indicates significant difference ( $p < 0.05$ ) in the same column

## Conclusion

The result of our study showed a considerable effect of environmental factors on the linear type traits of Sahiwal cattle. While parity and stage of lactation were the main sources of environmental factors affecting the linear type traits. In livestock improvement programs that will be carried out on conformation traits of Sahiwal cattle, the performance record of animals has to be adjusted for the significant environmental source of variation in order to decrease the known environmental difference between animals and to accurately estimate breeding values.

## Acknowledgements

Sincere acknowledgement goes out to the Director and Joint Director (Research), ICAR-National Dairy Research Institute, Karnal, India, for their support and assistance with this study.

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