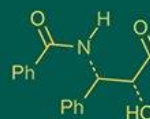


## International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693  
ISSN Online: 2617-4707  
NAAS Rating (2026): 5.29  
IJABR 2026; 10(7): 78-83  
[www.biochemjournal.com](http://www.biochemjournal.com)

Received: 01-04-2026  
Accepted: 06-05-2026

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## Comparative growth performance and morphometric assessment of Hariana and Sahiwal calves under similar management conditions

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i7b.8929>

### Abstract

Growth performance in neonatal calves is a critical determinant of their future productivity, health status and overall animal efficiency. The present study was conducted to compare the growth performance of newborn Hariana and Sahiwal calves maintained under similar management conditions at Instructional Livestock Farm Complex (ILFC), DUVASU, Mathura, from March to early September in 2024. A total of 14 newborn calves (7 from each breed) were selected after completion of the colostrum feeding phase and monitored over a defined experimental period. Body weight and morphometric parameters including wither height, heart girth, abdominal girth, inguinal girth, face length, pole-croup length and muzzle length were recorded at fortnightly intervals. ADG was calculated based on body weight changes. The results indicated that body weight, ADG and all recorded morphometric traits did not differ significantly ( $p > 0.05$ ) between Hariana and Sahiwal calves. The findings suggest that under similar feeding and management conditions, both breeds exhibit comparable growth potential during initial life stages. Furthermore, the study highlights the importance of morphometric measurements as practical tools for assessing growth, body weight and supporting management decisions in field conditions. Early growth performance and physical development indicators can serve as valuable predictors of future productivity, health and welfare in dairy animals.

**Keywords:** Body measurements, growth performance, Hariana calves, morphometric traits, Sahiwal calves

### Introduction

Early life growth in dairy calves is an important determinant of future productivity, health status, and reproductive performance. The pre-weaning period represents a critical developmental stage during which growth is influenced by the interaction of genetic potential, nutrition, environmental conditions, and management practices (Roy, 1980; Khan *et al.*, 2011) [7, 5]. Adequate growth during this phase supports proper development of vital organs, enhances immune competence and establishes the biological foundation for improved lifetime performance in dairy animals. Although body weight is traditionally considered the primary indicator of calf growth, morphometric traits including wither height, heart girth, body length and other linear measurements provide additional information regarding skeletal development, body conformation, and physiological maturity. These parameters are closely associated with growth efficiency and developmental status (Heinrichs *et al.*, 1992) [3]. Among morphometric traits, heart girth has been widely recognized as a practical indicator for estimating body weight, particularly under field conditions where weighing facilities may be limited. Therefore, systematic evaluation of morphometric measurements offers a simple and non-invasive approach for monitoring growth performance in young calves.

The significance of early growth extends beyond immediate body development and contributes directly to long-term productive and functional performance. Calves exhibiting improved average daily gain (ADG) during early life have been associated with earlier attainment of reproductive maturity and improved milk production during later stages of life (Soberon *et al.*, 2012) [10]. In addition, optimal growth contributes to improved immune function, reduced disease susceptibility, and enhanced survivability (Drackley, 2008) [2].

Consequently, growth performance serves as an important biological indicator of future productivity, economic efficiency and animal welfare. In recent years, morphometric traits have gained increasing importance in phenotypic characterization, growth evaluation, and breeding programs. These traits may also be utilized for developing predictive approaches. These traits may also be utilized for developing predictive approaches for body weight estimation and growth assessment, especially under resource-constrained production systems (Yakubu *et al.*, 2010) [13]. Furthermore, regular recording of morphometric parameters contributes to breed characterization and supports conservation and genetic improvement efforts in indigenous cattle populations. Among indigenous cattle breeds of India, Haryana and Sahiwal are recognized for their adaptability and suitability to tropical production environments. Haryana cattle are generally categorized as dual-purpose animals with desirable body conformation, efficient feed utilization, and moderate milk production, whereas Sahiwal cattle are considered one of the leading indigenous dairy breeds due to their superior milk yield, heat tolerance and reproductive performance. Such breed characteristics may influence growth and morphometric development during early life.

However, comparative information regarding early growth performance and morphometric characteristics of Haryana and Sahiwal calves under uniform feeding and management conditions remains limited. Therefore, the present study was undertaken to evaluate and compare growth performance and morphometric development in Haryana and Sahiwal calves reared under similar management conditions. In addition, the study aimed to examine the utility of morphometric traits as supportive indicators for growth assessment and their potential relevance in future breeding, selection and calf management strategies.

### Materials and Methods

The present study was conducted at the Instructional Livestock Farm Complex (ILFC), DUVASU, Mathura, from March to the first week of September in 2024 to evaluate the growth performance of Haryana and Sahiwal calves. A total of 14 newborn calves, comprising 7 from each breed, were randomly selected after completion of the colostrum feeding phase and maintained under similar feeding and management conditions throughout the experimental period. The initial observations were recorded on day 0, i.e., four days after birth when the calves were shifted from the calving shed to the calf shed. All measurements were recorded in the morning before feeding and watering to minimize variation due to gut fill. Body weight was recorded immediately after birth and subsequently at fortnightly intervals for a period of three months. The body weight was measured using a digital weighing balance by recording the combined weight of the handler and calf and then subtracting the weight of the handler. Average daily gain (ADG) was calculated at 15-day intervals by dividing the difference between consecutive body weights by the number of days. Fortnightly weight gain was determined as the increase in body weight over a 15-day period.

In addition to body weight and average daily gain (ADG), morphometric measurements were recorded at fortnightly intervals using an inch tape and expressed in centimeters. Withers height (Fig 1) was measured from ground level near the forefeet to the highest point of the withers. Heart girth

(Fig 2) was recorded around the chest region just behind the forelegs, while abdominal girth was measured at the level of the navel around the abdominal region. Inguinal girth was measured around the body anterior to the hind limbs covering the inguinal region. Face length was measured from the poll to the tip of the muzzle, whereas pole-croup length was recorded from the poll to the pin bone. Muzzle length was measured as the distance covering the projecting facial region including the nose and mouth. All measurements were recorded with calves maintained in a normal standing posture and proper handling was ensured throughout the study to minimize stress and maintain measurement accuracy.



**Fig 1:** Measurement of Withers height (cm) of Sahiwal calves



**Fig 2:** Measurement of Heart girth of Haryana calves.

### Statistical analysis

The recorded data were analyzed using standard statistical procedures as described by Snedecor and Cochran (1980) [9] and the results were expressed as Mean  $\pm$  Standard Error (SE) and comparisons between Haryana and Sahiwal calves were made using the Independent Samples *t*-test.

### Results and Discussion

The results pertaining to body weight, average daily gain (ADG) and various morphometric parameters of Haryana and Sahiwal calves recorded at fortnight intervals are presented in Table 1 to Table 4. The observations revealed a progressive increase in body weight and body measurements

with advancing age in both breeds. However, the differences between Hariana and Sahiwal calves for all the studied parameters were found to be statistically non-significant ( $p > 0.05$ ).

#### A) Body weight

The body weight of Hariana and Sahiwal calves at different fortnight intervals is presented in Tables 1 and Fig 3. The initial body weight (day 0) was recorded as  $25.42 \pm 0.57$  kg in Hariana calves and  $23.70 \pm 0.51$  kg in Sahiwal calves. A

gradual increase in body weight was observed in both breeds throughout the experimental period, reaching  $50.45 \pm 1.63$  kg and  $46.72 \pm 2.74$  kg at day 90, respectively. Although Hariana calves exhibited comparatively higher body weight at most intervals, the differences between the two breeds were found to be non-significant ( $p > 0.05$ ). The range, minimum, and maximum values also indicated a similar growth pattern in both breeds, suggesting comparable growth performance under identical management conditions.

**Table 1:** Comparison of Body weight (kg) of Hariana and Sahiwal calves at fortnight interval

| Days    | Hariana |         |         |                  | Sahiwal |         |         |                  |
|---------|---------|---------|---------|------------------|---------|---------|---------|------------------|
|         | Range   | Minimum | Maximum | Body weight (kg) | Range   | Minimum | Maximum | Body weight (kg) |
| 0       | 3.9     | 23.1    | 27      | 25.42 ± 0.57     | 4.1     | 21.8    | 25.9    | 23.70 ± 0.51     |
| 15      | 4.59    | 30      | 34.59   | 32.19 ± 0.58     | 12.2    | 26      | 38.2    | 30.26 ± 1.66     |
| 30      | 4.2     | 33      | 37.2    | 35.42 ± 0.72     | 14.6    | 26.9    | 41.5    | 33.08 ± 2.18     |
| 45      | 9.9     | 35      | 44.9    | 39.74 ± 1.45     | 17.2    | 29      | 46.2    | 36.05 ± 2.69     |
| 60      | 12.6    | 37.4    | 50      | 43.91 ± 1.71     | 17.6    | 30.5    | 48.1    | 39.02 ± 2.86     |
| 75      | 14.5    | 39      | 53.5    | 46.64 ± 1.72     | 17.8    | 33      | 50.8    | 42.35 ± 2.80     |
| 90      | 13.7    | 41.5    | 55.2    | 50.45 ± 1.63     | 15.2    | 38      | 53.2    | 46.72 ± 2.74     |
| Overall |         |         |         | 34.08 ± 1.32     | Overall |         |         | 35.88 ± 1.32     |

Different letters in the same column indicate Range, Minimum, Maximum of Body weight (kg.).

#### B) Withers height and Average daily gain:

The data on withers height and average daily gain of Hariana and Sahiwal calves are presented in Table 2 and Fig 3. Withers height increased progressively with age in both breeds, with Hariana calves showing slightly higher values compared to Sahiwal calves at all intervals. The overall mean withers height was recorded as  $88.53 \pm 0.87$  cm in

Hariana and  $80.56 \pm 0.75$  cm in Sahiwal calves.

The average daily gain (ADG) varied across intervals, with an overall mean of  $0.27 \pm 0.02$  kg/day in Hariana and  $0.25 \pm 0.02$  kg/day in Sahiwal calves. However, the differences between breeds for both withers height and ADG were found to be non-significant ( $p > 0.05$ ).

**Table 2:** Withers height (Mean  $\pm$  SE, cm) and Average daily gain (Mean  $\pm$  SE, kg) of Hariana and Sahiwal calves at fortnight interval

| Fortnight intervals | Withers height (cm) |                  |                  | Average daily gain (kg/day) |                 |
|---------------------|---------------------|------------------|------------------|-----------------------------|-----------------|
|                     | No. of calves       | Hariana          | Sahiwal          | Hariana                     | Sahiwal         |
| First               | 7                   | $81.85 \pm 0.82$ | $75.14 \pm 0.91$ | $0.45 \pm 0.02$             | $0.43 \pm 0.09$ |
| Second              | 7                   | $84.85 \pm 1.18$ | $78.04 \pm 1.60$ | $0.21 \pm 0.02$             | $0.18 \pm 0.05$ |
| Third               | 7                   | $87.28 \pm 1.18$ | $79.91 \pm 1.58$ | $0.28 \pm 0.05$             | $0.19 \pm 0.05$ |
| Fourth              | 7                   | $89.12 \pm 1.52$ | $81.42 \pm 1.49$ | $0.27 \pm 0.03$             | $0.19 \pm 0.04$ |
| Fifth               | 7                   | $92.28 \pm 1.56$ | $83.41 \pm 1.38$ | $0.18 \pm 0.03$             | $0.22 \pm 0.04$ |
| Sixth               | 7                   | $95.78 \pm 1.52$ | $85.42 \pm 1.36$ | $0.25 \pm 0.05$             | $0.29 \pm 0.06$ |
| Overall             | 42                  | $88.53 \pm 0.87$ | $80.56 \pm 0.75$ | $0.27 \pm 0.02$             | $0.25 \pm 0.02$ |

#### C) Heart, Abdominal and Inguinal Girths:

The heart girth, abdominal girth and inguinal girth measurements of Hariana and Sahiwal calves are presented in Table 3 and Fig 3. All girth measurements showed a consistent increasing trend with age in both breeds. Hariana calves exhibited slightly higher values for heart girth, while abdominal and inguinal girth values were comparable

between the two breeds.

The overall mean values for heart girth, abdominal girth, and inguinal girth were  $87.11 \pm 0.88$ ,  $84.88 \pm 1.04$ , and  $81.14 \pm 0.79$  cm in Hariana calves and  $83.64 \pm 0.93$ ,  $86.24 \pm 1.17$ , and  $82.97 \pm 0.82$  cm in Sahiwal calves, respectively. The differences between the breeds were statistically non-significant ( $p > 0.05$ ).

**Table 3:** Heart, Abdominal and Inguinal Girths (Mean  $\pm$  SE, cm) of Hariana and Sahiwal calves at fortnight interval

| Fortnight Intervals | Heart girth (cm) |                  | Abdominal girth (cm) |                  | Inguinal girth (cm) |                  |
|---------------------|------------------|------------------|----------------------|------------------|---------------------|------------------|
|                     | Hariana          | Sahiwal          | Hariana              | Sahiwal          | Hariana             | Sahiwal          |
| First               | $78.42 \pm 0.42$ | $77.71 \pm 1.12$ | $75.00 \pm 1.63$     | $78.42 \pm 2.52$ | $76.12 \pm 0.76$    | $77.28 \pm 1.58$ |
| Second              | $82.85 \pm 0.40$ | $80.28 \pm 1.68$ | $81.42 \pm 0.92$     | $80.71 \pm 2.03$ | $77.71 \pm 1.01$    | $80.14 \pm 1.54$ |
| Third               | $86.28 \pm 0.60$ | $82.85 \pm 1.81$ | $83.57 \pm 0.61$     | $84.14 \pm 1.83$ | $80.00 \pm 1.48$    | $82.27 \pm 1.63$ |
| Fourth              | $88.85 \pm 0.85$ | $83.71 \pm 1.91$ | $86.85 \pm 1.49$     | $87.50 \pm 1.88$ | $81.32 \pm 1.82$    | $84.14 \pm 1.50$ |
| Fifth               | $91.57 \pm 0.97$ | $86.42 \pm 1.82$ | $89.14 \pm 1.31$     | $92.10 \pm 1.58$ | $84.28 \pm 1.50$    | $85.72 \pm 1.53$ |
| Sixth               | $94.71 \pm 0.86$ | $90.85 \pm 1.94$ | $93.28 \pm 1.58$     | $94.57 \pm 1.90$ | $87.42 \pm 1.32$    | $88.28 \pm 1.65$ |
| Overall             | $87.11 \pm 0.88$ | $83.64 \pm 0.93$ | $84.88 \pm 1.04$     | $86.24 \pm 1.17$ | $81.14 \pm 0.79$    | $82.97 \pm 0.82$ |

#### D) Face length, Pole-croup length and Muzzle length:

The data on face length, pole-croup length and muzzle length are presented in Table 4 and Fig 3. All parameters

increased progressively with age in both Hariana and Sahiwal calves. Hariana calves showed slightly higher face length and pole-croup length, whereas Sahiwal calves

exhibited marginally higher muzzle length values at later stages. The overall mean values indicated comparable

growth trends between the two breeds and the differences were found to be non-significant ( $p > 0.05$ ).

**Table 4:** Face length, Pole-croup length and Muzzle length (Mean  $\pm$  SE, cm) of Hariana and Sahiwal calves at fortnight interval

| Fortnight intervals | Face length      |                  | Pole-croup length |                  | Muzzle length   |                 |
|---------------------|------------------|------------------|-------------------|------------------|-----------------|-----------------|
|                     | Hariana          | Sahiwal          | Hariana           | Sahiwal          | Hariana         | Sahiwal         |
| First               | 25.74 $\pm$ 0.58 | 26.28 $\pm$ 0.42 | 82.00 $\pm$ 1.06  | 76.64 $\pm$ 1.21 | 6.74 $\pm$ 0.15 | 6.51 $\pm$ 0.21 |
| Second              | 27.00 $\pm$ 0.53 | 26.92 $\pm$ 0.41 | 85.57 $\pm$ 1.32  | 79.28 $\pm$ 1.32 | 7.03 $\pm$ 0.13 | 7.11 $\pm$ 0.18 |
| Third               | 28.10 $\pm$ 0.47 | 27.62 $\pm$ 0.43 | 87.94 $\pm$ 1.22  | 82.00 $\pm$ 1.43 | 7.14 $\pm$ 0.16 | 7.47 $\pm$ 0.16 |
| Fourth              | 29.54 $\pm$ 0.57 | 28.70 $\pm$ 0.37 | 90.81 $\pm$ 1.13  | 84.61 $\pm$ 1.60 | 7.40 $\pm$ 0.11 | 7.72 $\pm$ 0.15 |
| Fifth               | 30.54 $\pm$ 0.45 | 29.65 $\pm$ 0.28 | 92.64 $\pm$ 1.03  | 87.18 $\pm$ 1.53 | 7.58 $\pm$ 0.10 | 7.98 $\pm$ 0.19 |
| Sixth               | 31.82 $\pm$ 0.33 | 30.87 $\pm$ 0.40 | 95.14 $\pm$ 1.12  | 89.57 $\pm$ 1.25 | 7.80 $\pm$ 0.13 | 8.23 $\pm$ 0.25 |
| Overall             | 28.79 $\pm$ 0.37 | 28.34 $\pm$ 0.28 | 89.01 $\pm$ 0.81  | 83.27 $\pm$ 0.87 | 7.28 $\pm$ 0.07 | 7.51 $\pm$ 0.11 |

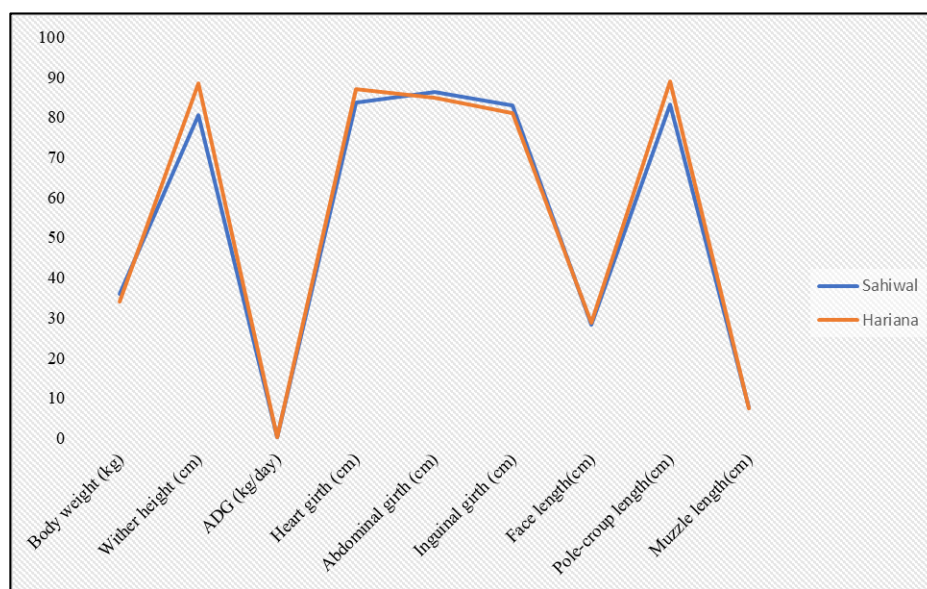


**Fig 3:** Hariana and Sahiwal calves overall comparison (Mean  $\pm$  SE) after 90 days

## Discussion

### A) Body Weight (BW)

The overall body weight of Hariana and Sahiwal calves recorded at different fortnightly intervals did not differ significantly ( $p > 0.05$ ), indicating comparable growth performance under similar feeding and management conditions. Although Sahiwal calves exhibited numerically higher body weight (35.88  $\pm$  1.32 kg) than Hariana calves (34.08  $\pm$  1.32 kg), the variation was not sufficient to produce statistical differences between breeds. The progressive increase in body weight observed throughout the study period reflects normal physiological growth and adaptation during early calf development. The present findings agree with previous reports in indigenous cattle breeds including Khillar calves (Jagdale, 2018) [4], Deoni cattle (Yadav, 2008) [12], and Red Kandhari cattle (Magar, 2013) [6], where similar growth trends during early developmental stages were reported. The absence of significant breed differences suggests that under standardized rearing conditions, environmental and nutritional factors may exert a greater influence on body weight gain than genetic variation during the post-colostrum phase. The close similarity observed between body weight and body measurement traits in both breeds may further indicate coordinated skeletal and body mass development during early life. In particular, morphometric traits such as heart girth are widely recognized as supportive indicators for estimating growth performance and body development under field conditions (Heinrichs *et al.*, 1992) [3].

### B) Average Daily Gain (ADG)

Average daily gain (ADG) did not differ significantly ( $p > 0.05$ ) between Hariana and Sahiwal calves. Numerically, Hariana calves showed slightly higher ADG (0.27  $\pm$  0.02 kg/day) than Sahiwal calves (0.25  $\pm$  0.02 kg/day), suggesting a comparable growth response under identical rearing conditions. The observed variations in ADG across intervals may be associated with normal differences in feed intake, nutrient utilization, metabolic activity, and physiological growth patterns during the early stages of life. Similar observations were reported by Zhang *et al.* (2022) [14], who emphasized the role of housing and management practices in influencing growth performance in calves. The comparable ADG recorded in the present study indicates similar efficiency of nutrient utilization in both breeds under uniform management conditions. Furthermore, the lack of significant variation suggests that growth responses during the post-colostrum period may be influenced more strongly by feeding and management practices than by breed-related differences under controlled rearing environments (Khan *et al.*, 2011) [5].

### C) Withers Height (WH)

Withers height increased progressively with advancing age in both Hariana and Sahiwal calves, indicating continuous skeletal growth and normal structural development. Although Hariana calves exhibited numerically greater values (88.53  $\pm$  0.87 cm) compared with Sahiwal calves (80.56  $\pm$  0.75 cm), the differences remained statistically

non-significant ( $p > 0.05$ ). Comparable growth patterns have been reported in Khillar calves (Jagdale, 2018) <sup>[4]</sup> and Red Kandhari cattle (Magar, 2013) <sup>[6]</sup>. The similarity observed in the present study suggests that skeletal development during early growth may be regulated more by nutritional and management conditions than by breed-specific influences. The progressive increase in wither height also reflects healthy musculoskeletal development under the prevailing management system.

#### **D) Girth Measurements**

##### **a) Heart Girth (HG)**

Heart girth increased consistently with age in both breeds without significant differences ( $p > 0.05$ ). Numerically higher values were observed in Hariana calves ( $87.11 \pm 0.88$  cm) than in Sahiwal calves ( $83.64 \pm 0.93$  cm). Similar observations have been reported in Khillar calves (Jagdale, 2018) <sup>[4]</sup>, whereas slightly lower values were documented in Red Kandhari (Magar, 2013) <sup>[6]</sup> and Deoni cattle (Yadav, 2008) <sup>[12]</sup>. Heart girth is considered an important morphometric indicator because of its close relationship with body weight and overall body development. The comparable values observed between breeds indicate similar body frame growth and developmental progression under standardized management conditions.

##### **b) Abdominal Girth (AG)**

Abdominal girth increased steadily with age and did not differ significantly between breeds. However, Sahiwal calves exhibited slightly higher values ( $86.24 \pm 1.17$  cm) than Hariana calves ( $84.88 \pm 1.04$  cm). Comparable findings have been reported by Jagdale (2018) <sup>[4]</sup> in Khillar calves. Since abdominal girth reflects digestive tract development and body condition, the observed similarity suggests comparable physiological growth and feed utilization patterns in both breeds during early development.

##### **c) Inguinal Girth (IG)**

Inguinal girth also increased progressively with age in both breeds, with no significant differences. Numerically higher values were observed in Sahiwal calves ( $82.97 \pm 0.82$  cm) than Hariana calves ( $81.14 \pm 0.79$  cm). These findings are consistent with previous reports indicating that linear body measurements increase with age and largely reflect general growth patterns rather than breed differences alone (Stephens *et al.*, 2007) <sup>[11]</sup>. The results further indicate similar body conformation and developmental responses under comparable rearing conditions.

##### **E) Face Length (FL)**

Face length increased gradually with age and did not differ significantly ( $p > 0.05$ ) between Hariana and Sahiwal calves. The values obtained in the present study agree with reports in indigenous breeds such as Red Kandhari (Shinde, 2013; Magar, 2013) <sup>[8, 6]</sup> and Khillar calves (Jagdale, 2018) <sup>[4]</sup>. The gradual increase in face length reflects uniform craniofacial growth and supports the observation that morphometric development follows a comparable pattern across breeds when raised under similar environmental and nutritional conditions.

##### **F) Pole-Croup Length**

Pole-croup length showed a continuous increasing trend in both breeds and remained statistically non-significant ( $p >$

0.05). However, Hariana calves recorded numerically greater values ( $89.01 \pm 0.81$  cm) compared with Sahiwal calves ( $83.27 \pm 0.87$  cm). Similar findings have been reported in indigenous cattle breeds including Red Kandhari and Deoni cattle (Bainwad, 2017; Yadav, 2008) <sup>[1, 12]</sup>. Variations among studies may be attributed to differences in genetic background, management systems, environmental conditions, and age at measurement. The present findings indicate that both breeds maintain comparable longitudinal body growth during the early rearing period. Collectively, the observed trends across body measurements indicate synchronized structural development and suggest that morphometric traits may serve as useful indicators for monitoring early growth and evaluating developmental performance in young calves.

##### **G) Muzzle Length**

Muzzle length increased progressively with age in both Hariana and Sahiwal calves and did not differ significantly ( $p > 0.05$ ) throughout the study period. The overall values remained comparable between Hariana ( $7.51 \pm 0.11$  cm) and Sahiwal calves ( $7.28 \pm 0.07$  cm), indicating a similar pattern of facial growth and morphometric development under identical feeding and management conditions. The gradual increase in muzzle length reflects normal craniofacial growth associated with advancing age and overall body development. The absence of significant breed differences suggests that facial growth traits during the early post-colostrum phase may be influenced more by environmental and management conditions than by breed-related variation. The comparable muzzle development observed in both breeds further supports the overall finding of uniform morphometric progression and balanced structural growth during early calf rearing.

#### **Conclusion**

The present study revealed that Hariana and Sahiwal calves exhibited comparable growth performance and morphometric development during the post-colostrum phase when maintained under similar feeding and management conditions. Statistical analysis indicated no significant differences ( $p > 0.05$ ) between the two breeds with respect to body weight, average daily gain, and linear body measurements throughout the study period, suggesting a similar pattern of early growth under standardized rearing conditions. Although slight numerical variations were observed, with Hariana calves showing a tendency toward better skeletal growth and Sahiwal calves exhibiting relatively greater body capacity, these differences were not pronounced enough to influence overall growth performance at this stage of development. The steady increase observed across growth and body measurement traits in both breeds reflects normal physiological progression and adaptation under the prevailing management system. The findings further indicate that environmental and managerial factors, particularly feeding practices, housing conditions, and general calf care, may exert a greater influence on early growth performance than breed-related variation during the initial growth period. In addition, the growth and morphometric parameters generated through this study may provide useful baseline information for future research on breed evaluation, growth prediction, calf management strategies, and long-term assessment of productive performance under similar production environments.

### Acknowledgement

I want thank to livestock farm complex Incharge DUVASU, Mathura for letting us observe their cows and calves. I pay my thankfulness to my guide Dr. Mamta and other teaching faculties of the Department of Livestock Production Management Dr. Rajneesh Sirohi, and Dr. Ajay Kumar and to Dr. S.P Singh for data and statistical analyses during the entire study. I also want to thank to Dr. Shubham Nayak for kindly helping me in reviewing and editing of this research article manuscript.

### Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. All funding sources and affiliations are transparently disclosed and the study was carried out independently to ensure objectivity and integrity in the research findings.

### Funding

This research was supported and funded by DUVASU, Mathura. The authors are grateful for the financial support that made this study possible.

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