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Evaluation of claw dimensions in crossbred heifers of Kerala

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Abstract

Hoof disorders markedly reduce productivity and overall performance of ungulates, with lameness posing a significant challenge in the dairy sector. This study aimed to assess the dimensions of claws in crossbred heifers in Kerala and to establish essential foundational data in this domain. The study, involving six crossbred heifers, encompassed the measurement of parameters like toe length, toe height, toe angle, sole length, sole width, and heel height using a defined methodology. The mean toe length in the forelimb (6.16 ± 0.03 cm) was significantly greater than that in the hindlimb (5.84 ± 0.05 cm). Among the heifers, the highest toe height was recorded in the right lateral claw of the forelimb (5.40 ± 0.03 cm), while the lowest was in the left medial claw of the hindlimb. The overall mean sole length of the forelimb (9.11 ± 0.10 cm) was significantly greater than that of the hindlimb (8.67 ± 0.10 cm). Preserving an ideal claw conformation in line with optimal dimensions is critical for averting claw-related challenges and promoting animal welfare, underscoring the importance of regular hoof maintenance.

Keywords: Claw dimensions, Crossbred heifers, Kerala

1. Introduction

The hoof is a crucial organ responsible for weight bearing and movement in animals. There are significant variations in its shape, size, histology, and blood supply across different animal species. The outer layer of the hoof is termed the hoof wall or horn, resembling a hard surface comparable to human fingernail in structure; but similar to the epidermis of skin in function. The horn is composed of cells generated by the tissue immediately beneath it, known as the corium, which is a well-nourished tissue within the hoof containing vital blood vessels and nerves. As cells move away from the corium, they undergo keratinisation or cornification, resulting in the formation of the hard outer growth. Bovine hooves generally grow at a rate of about 1/5 to 1/4 of an inch per month. Beneath the hoof lies a somewhat softer area called the sole, with the front portion referred to as the toe and the opposite end housing two bulbs known as the heel bulbs. The hoof serves as a crucial link connecting the animal with its environment. Internally, it is influenced by metabolic substances, while externally, it is exposed to mechanical, chemical, and biological elements from the surroundings (Webster, 2001) [1].

When hoof problems arise in animals, the peak production and overall performance of animals are compromised, the extent of which is determined by the seriousness of the ailment. In the dairy sector, lameness stands as a considerable concern both in economic terms and for animal well-being. Claw horn disruption lesions (CHDL) are one among the primary causes of lameness in cattle, significantly impacting milk production, fertility rates, and necessitating higher culling rates (Enting *et al.*, 1997; Chapinal *et al.*, 2010; Machado *et al.*, 2010; Newsome *et al.*, 2017; Thomas *et al.*, 2023) [2, 3, 4, 5, 6].

Vermunt and Greenough (1995) [7] noted the use of claw dimension assessment to evaluate claw conformation in dairy cattle. It has been established that claw dimensions hold clinical correlations with incidence of lameness, longevity, and production traits in dairy cattle. Changes in claw dimensions and shape were observed as cows matured, underscoring the significant influence of age in shaping claw morphology and altering claw dimensions.

(Vermunt and Greenough, 1996) [8]. Alterations in claw dimensions can be impacted by several factors such as anatomy, physiology, nutrition, environment, seasons, and management approaches. When any or a combination of these factors strays from the recognised standard conditions, it can result in changes in claw conformation of the animal, increasing the vulnerability to development of CHDL. Therefore, this study was conducted to evaluate the claw dimensions of crossbred heifers in Kerala, aiming to establish foundational data in this area.

2. Materials and Methods

The study was conducted on six crossbred heifers that were slaughtered at the Meat Technology Unit (MTU), Mannuthy, Kerala Veterinary and Animal Sciences University (KVASU). The crossbred heifers bought for slaughter at the MTU, Mannuthy were subjected to a thorough clinical examination of feet prior to slaughter and those with medium to good body condition score and sound claws were selected. Once the slaughter procedure was completed, the hooves were separated from the carcass by cutting at the level of carpal joint in forelimb and at the level of tarsal joint in hindlimb. After collection, the hooves were thoroughly cleaned to remove the dirt and dung particles and were stored at -20 °C. Toe length, toe height, toe angle, sole length and width and heel height of the claws were measured using the procedure described by Nuss and Paulus (2006) [9].

2.1 Toe Length: Toe length (cm) was measured (Fig. 1) along the dorsal border from the tip of the toe to the proximal end of the claw capsule at the coronary band, using a digital sliding calliper Digimatic digital caliper, Mitutoyo Europe GmbH, Germany.

2.2 Toe Height: Toe height (cm) was measured (Fig. 2) by a digital sliding calliper at the abaxial wall as the distance between the dorsal skin horn junction (periople) and the sole wall border.

2.3 Toe Angle: The toe angle was measured (Fig. 3) using a goniometer (Nisco, New Delhi), positioned at the proximal end of the dorsal border, angle near the tip of the toe, and extending to the sole surface.

2.4 Sole length and sole width: Sole length (cm) was measured (Fig. 4 and 5) from the palmar point of the heel bulb to the tip of the claw using a digital sliding caliper. Sole width (cm) was measured along a line that intersected sole length perpendicularly and ran from the axial to the abaxial border of the claw.



Fig 1: Toe length



Fig 2: Toe height



Fig 3: Toe angle

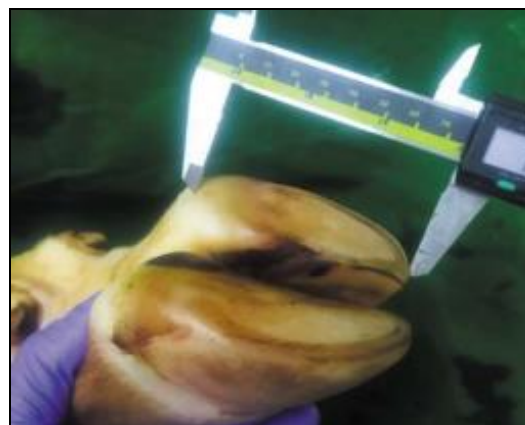


Fig 4: Sole length

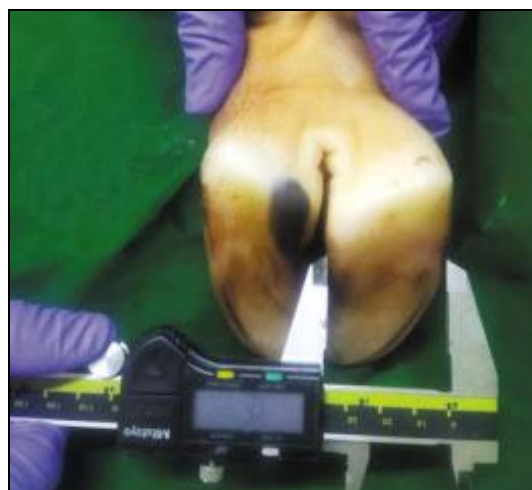


Fig 5: Sole width



Fig 6: Heel height

2.5 Heel Height: The height of the heel (cm) was measured (Fig. 6) along a line perpendicular to an imaginary caudal extension of the sole to the highest point of the heel using a digital sliding calliper.

Table 1: Claw dimensions (Mean \pm SE) in heifers

Parameter	Right lateral claw			Right medial claw			Left lateral claw			Left medial claw		
	Forelimb	Hindlimb	T Value	Forelimb	Hindlimb	t value	Forelimb	Hindlimb	T Value	Forelimb	Hindlimb	T Value
Toe length (cm)	6.16 \pm 0.06	5.96 \pm 0.08	2.198 ^{NS}	6.16 \pm 0.05	5.91 \pm 0.07	2.903*	6.17 \pm 0.19	5.82 \pm 0.21	3.046*	6.15 \pm 0.08	5.83 \pm 0.12	2.267*
Toe Height (cm)	5.40 \pm 0.03	5.28 \pm 0.06	1.822 ^{NS}	5.33 \pm 0.07	5.24 \pm 0.09	0.782 ^{NS}	5.30 \pm 0.20	5.23 \pm 0.19	0.613 ^{NS}	5.35 \pm 0.09	5.23 \pm 0.11	0.910 ^{NS}
Toe angle ($^{\circ}$)	48.67 \pm 0.49	45.17 \pm 0.70	4.072**	46.67 \pm 0.61	46.67 \pm 0.56	0.000 ^{NS}	47.67 \pm 1.63	47.67 \pm 0.52	0.000 ^{NS}	48.00 \pm 0.26	46.67 \pm 0.21	4.000**
Heel height (cm)	2.49 \pm 0.03	2.46 \pm 0.08	0.324 ^{NS}	2.57 \pm 0.03	2.44 \pm 0.06	1.958 ^{NS}	2.60 \pm 0.15	2.40 \pm 0.17	2.146 ^{NS}	2.61 \pm 0.04	2.43 \pm 0.08	2.161 ^{NS}
Sole length (cm)	9.07 \pm 0.22	8.69 \pm 0.22	1.185 ^{NS}	9.28 \pm 0.16	8.70 \pm 0.21	2.244*	8.93 \pm 0.54	8.70 \pm 0.53	0.746 ^{NS}	9.11 \pm 0.20	8.64 \pm 0.23	1.519 ^{NS}
Sole width (cm)	4.21 \pm 0.10	3.93 \pm 0.16	1.502 ^{NS}	4.19 \pm 0.08	3.95 \pm 0.19	1.207 ^{NS}	4.24 \pm 0.17	3.99 \pm 0.31	1.716 ^{NS}	4.23 \pm 0.11	3.86 \pm 0.23	1.488 ^{NS}

** Significant at 0.01 level of significance; * Significant at 0.05 level of significance; NS - Non-significant

Table 2: Comparison between overall claw dimensions (Mean \pm SE) of forelimb and hindlimb in heifers

Parameter	Forelimb	Hind limb	t value
Toe length (cm)	6.16 \pm 0.03	5.84 \pm 0.05	5.358**
Toe Height (cm)	5.33 \pm 0.04	5.23 \pm 0.04	1.733 ^{NS}
Toe angle ($^{\circ}$)	47.58 \pm 0.25	46.92 \pm 0.18	2.138*
Heel height (cm)	2.60 \pm 0.02	2.42 \pm 0.03	4.470**
Sole length (cm)	9.11 \pm 0.10	8.67 \pm 0.10	3.105**
Sole width (cm)	4.22 \pm 0.04	3.91 \pm 0.09	3.040**

** Significant at 0.01 level of significance; * Significant at 0.05 level of significance; NS - Non-significant

3.2 Toe Height

The mean toe height of the right lateral, right medial, left lateral and left medial claws of the forelimb in heifers showed no significant difference ($p < 0.05$) from that of the hindlimb. The overall mean toe height of forelimb (5.33 \pm 0.04 cm) was greater than that of the hindlimb (5.23 \pm 0.04 cm) with no significant difference (Table 2). Among the heifers, the highest toe height was documented in the right lateral claw of the forelimb (5.40 \pm 0.03 cm), while the lowest toe height was observed in the left medial claw of the hindlimb (5.23 \pm 0.11 cm) (Table 1). Sasidharan *et al.* (2019) [11] reported that the average toe height of fore and hind limbs in the buffalo were 5.535 \pm 0.472 cm and 5.20 \pm 0.48 cm, respectively. In Indian hog deer, the average toe height of forelimbs and hindlimbs were 1.84 \pm 0.14 cm and 1.747 \pm 0.15 cm, respectively (Savitha *et al.*, 2022) [12].

3. Results and Discussion

3.1 Toe length: The mean toe length of right lateral claw in heifers did not exhibit any significant difference ($p < 0.05$) between the forelimb and hindlimb. Mean toe length of the right medial, left lateral and left medial claws showed significant difference ($p < 0.05$) between the forelimb and hindlimb. Toe length was highest in the left lateral claw of the forelimb (6.17 \pm 0.19 cm), while it was lowest in the left lateral claw of the hindlimb (5.82 \pm 0.21 cm) (Table 1). The overall mean toe length in the forelimb (6.16 \pm 0.03 cm) was greater than that in the hindlimb (5.84 \pm 0.05 cm) and this difference was significant at 0.01 level (Table 2).

Similarly, Vermunt and Greenough, (1996) [8] observed a significant difference in toe length between forelimb and hindlimb in heifers, with the forelimb exhibiting a slight higher value.

Nuss *et al.* (2011) [10] reported that in the forelimbs of heifers, the medial claws were significantly longer than the lateral. In contrast, in the present study the greatest toe length was recorded in the left lateral claw of the forelimb, while the lowest toe length was observed in the left lateral claw of the hindlimb. However, significant difference could not be detected between the lateral and medial claws of forelimb and hindlimb.

3.3 Toe Angle

A significant difference ($p < 0.01$) was noted between the toe angles of the right lateral and left medial claws in the forelimb and hindlimb. But no significant difference ($p < 0.05$) was noticed between in the toe angles of right medial and left lateral claws (Table 1) of the forelimb and hindlimb. Among this group, the right lateral claw of the forelimb exhibited the highest toe angle (48.67 \pm 0.49 $^{\circ}$), whereas the lowest toe angle was found in the right lateral claw of the hindlimb (45.17 \pm 0.70 $^{\circ}$). The forelimb exhibited slightly wider mean toe angle (47.58 \pm 0.25 $^{\circ}$) than that of the hindlimb (46.92 \pm 0.18 $^{\circ}$) and this difference was significant at 0.05 level (Table 2).

3.4 Heel Height

The mean heel height of the right lateral, right medial, left lateral and left medial claws in heifers did not show any significant difference ($p < 0.05$) between the forelimb and hindlimb (Table 1). The highest heel height was documented in the left medial claw of the forelimb (2.61 \pm 0.04 cm), while the lowest heel height was recorded in the left lateral claw (2.40 \pm 0.17 cm) of the hindlimb. Significant difference ($p < 0.01$) existed between the overall mean heel height of forelimb (2.60 \pm 0.02 cm) than that of the hindlimb (2.42 \pm 0.03 cm) (Table 2). Nuss *et al.* (2011) [10] reported that in heifers, the heel height of the lateral claws in the forelimbs was 42.5 \pm 3.9 mm in the right claw and 40.1 \pm 3.4 mm in the left claw.

3.5 Sole Length

The mean sole length of right lateral, left lateral and left medial claw in heifers did not exhibit any significant difference ($p < 0.05$) between the forelimb and hindlimb. However, the mean toe length of the right medial claw showed significant difference ($p < 0.05$) between the forelimb and hindlimb. The maximum sole length was documented in the right medial claw of the forelimb (9.28 ± 0.16 cm), while the minimum value (8.64 ± 0.23 cm) was observed in the left medial claw of the hindlimb (Table 1). In heifers, significant difference ($p < 0.01$) existed between the overall mean sole length of the forelimb (9.11 ± 0.10 cm) and hindlimb (8.67 ± 0.10 cm) with the forelimb exhibiting a little more sole length (Table 2). Contrary to this findings, Vermunt and Greenough (1996)^[8] reported that in heifers the sole length of the forelimb claws was less (9.5 ± 0.6 cm), when compared to that of the hind limb (9.7 ± 0.7 cm). Nuss *et al.* (2011)^[10] reported that in heifers the sole length of the lateral claws in the forelimbs measured 106.1 ± 6.5 mm, whereas the medial claws measured 113.7 ± 6.2 mm.

3.6 Sole Width

The mean \pm SE sole width of all individual claws in the forelimb and hindlimb of heifers did not differ significantly at 0.05 level. Maximum sole width was documented in the left lateral claw of the forelimb (4.24 ± 0.17 cm), while the minimum (3.86 ± 0.23 cm) was observed in the left medial claw of the hindlimb (Table 1). Overall mean sole width of forelimb was 4.22 ± 0.04 cm, while in the hindlimb, it measured 3.91 ± 0.09 cm. Significant difference ($p < 0.01$) existed between the sole width of the forelimb and hindlimb with the forelimb measuring a little wider sole (Table 2).

Similar observations were made by Vermunt and Greenough (1996)^[8] in heifers, who reported the width of the lateral claw as 4.5 ± 0.4 cm, and that of the medial claw as 4.3 ± 0.4 cm in the forelimb. In the hind limb, the width of the lateral and medial claws were 4.4 ± 0.4 cm, and 4.1 ± 0.4 cm, respectively, and the front claws had a wider sole. Nuss *et al.* (2011)^[10] reported that in heifers the sole width for the lateral claws was 41.2 ± 2.5 mm, while that of the medial claws was 36.9 ± 3.0 mm.

All claw dimensions exhibit interconnections, and deviation in any one dimension can influence the overall hoof conformation. An increase in toe length, for example, results in a reduction of both toe angle and toe height, consequently shifting weight-bearing points towards the heel region. This shift leads to a decrease in heel height and a potential reorientation of the pedal bone. The reorientation can cause sinking of the pedal bone into the digital cushion and corium, particularly at the level of the flexor process. If such animals are experiencing negative energy balance and fat depot depletion, there are chances of thinning of the digital cushion, rendering them susceptible to the development of CHDL.

4. Conclusion

Maintaining a claw conformation closely aligned with the ideal dimensions is of paramount importance. This can be achieved through regular hoof trimming, both as a preventive and therapeutic measure, and the same has gained popularity among large animal practitioners as well as farmers. The findings of this study might serve as a reference range for determining the extent to which hooves can be trimmed, in crossbred cattle of Kerala.

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