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Claw statistics and conformation in relation to age, lactation, body weight, heart girth, rump width and lesions score in dairy cattle and buffaloes

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ABSTRACT

Claw measurement is necessary to evaluate the effect of claw size on the lameness. A study was conducted on 54 crossbred cattle and 82 Murrah buffaloes maintained under similar feeding and management practices at university dairy farm. The animals were first evaluated for lameness on a five point scale. Each animal was then restrained in a lameness chute and claw measurements, viz. foot angle, claw length, length of the dorsal border, coronary band, abaxial groove and base were measured. Besides these, animal age, lactation number and body weight, heart girth and rump width were recorded. Claw volume (cm^3) was calculated using Scott *et al.* (1999) formula. Multiple linear regression analysis of the data revealed that claw volume of the cattle increased with increasing age, lactation number, heart girth and rump width but not with the increasing body weight. In buffaloes, claw volume increased as the age, lactation number, rump width, heart girth and body weight of the animal increased. The cumulative effect of all the independent variables was more evident in cattle ($R^2 = 0.67$) as compared to buffaloes ($R^2 = 0.42$). Claw volume/body weight ratio was significantly more in buffaloes, whereas lameness score was more in cattle as compared to buffaloes. A significant positive correlation between lameness score and claw volume/body weight ratio was observed in cattle (r=0.36). Total lesion score showed a significant negative correlation with claw volume/body weight ratio indicating buffaloes with more claw volume per unit body weight have less lesion score. Buffaloes were having smaller foot angles therefore having more claw lengths and lengths of the dorsal border as compared to cows.

Key words: Buffalo, Cattle, Claw statistics, Claw volume, Conformation, Heart girth

Lameness, an important herd problem, causes heavy economic losses to the dairy farmers (Bennett *et al.* 1999). Estimates across the world revealed lameness incidence in dairy cattle as high as 69% (Hedges *et al.* 2001). A recent comprehensive study in India revealed clinical lameness in 8.92% of crossbred cattle and 2.26% of Murrah buffaloes however the subclinical lesions were observed in about 50% of animals (Randhawa 2006). Alone in UK, the losses due to lameness were estimated at about £ 90 million annually (Bennett *et al.* 1999). The importance of claw size and other biomechanical factors such as angle of the toe or foot angle, length of the dorsal border and heel height were investigated (Distl *et al.* 1990, Phillips *et al.* 1996, Scott *et al.* 1999). The prevalence of the vertical fissures was found to be greater in heavy cows (Goonerwardene and Hand 1995). A similar aetiology was assumed in Murrah buffaloes after an incidence of 16.57% sole haemorrhages was observed (Randhawa 2006). Moreover, there was not a single study available regarding prevalence of claw disease in buffaloes. So the study was planned to compare the various biomechanical parameters and claw measurements between crossbred dairy cattle and Murrah buffaloes and to evaluate the claw disease in relation to claw size. Also, this is the first effort to study the claw volume in live animals including cattle and buffaloes.

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MATERIALS AND METHODS

Selection of animals: Crossbred cattle (54) and Murrah buffaloes (84) maintained under similar feeding and management practices at the dairy farm of the University were used. All the crossbreds are crosses of Sahiwal and Holstein Friesian cattle.

Feeding and management practices: Lactating cattle were provided with additional concentartes @ 1 kg concentrate/2 kg of milk up to 4 months and 1 kg per 2.5 kg of milk thereafter. Buffaloes were provided @ 1kg concentrate/1.5 kg of milk up to 4 months and 1 kg/2 kg milk thereafter in addition to the maintenance ration of 1 kg. Pregnant animals were given 1 kg additional ration except

for the last trimester of pregnancy when they were given 2 kg additional ration. Oat silage was routinely fed to all the animals for half of the year and maize/*bajra* for another half of the year. All the animals were reared in loose housing system. Average milk yield of crossbred cattle was 5,000 kg and of Murrah buffaloes 2,300 kg/lactation.

Lameness scoring: All the animals were scored on numerical scoring scale from 0 to 4 (Wells *et al.* 1993) by walking them on flat surface.

Measurement of claw parameters and volume: Each animal was restrained in the trimming chute and claw parameters, viz. length of dorsal border, claw length, coronary band, abaxial groove and base of the claw were measured with measuring tape. Foot angle of each claw was measured with the help of protractor (Figs1,2). After that the claw volume was calculated with respect to claw position using Scott *et al.* (1999) formula.

Claw volume (cm^3) = [(17.192 × Base)+(7.467 × Abaxgroove) + (45.270 × Corband) –798.5]

Claw volume/body weight ratio (cm^3/kg) =

Total claw volume of the animal (cm^3)/Body weight of the animal (kg)

After measuring, trimming was done in all the animals to evaluate different foot lesions. At the same time other measurements like heart girth and rump width were done using measuring tape whereas age, lactation and body weight were taken from the monthly records.

Statistical analysis: Multiple linear regression analysis was done to evaluate the effect of independent variables, viz. age, lactation, heart girth, body weight and rump width on the claw volume in the crossbred dairy cattle and Murrah buffaloes. Foot angle, claw length and length of the dorsal border of fore and hind digits were compared with respect to respective claw position i.e. fore outer claws with hind outer claws, fore inner claws with hind inner claws and overall fore claws with overall hind claws using students t-test. Overall fore and hind claw statistics were also compared between cattle and buffaloes. Lesion score specific to different claw lesions and total lesion score were compared between cattle and buffaloes using Kruskal Wallis test. Claw volume per unit body weight was calculated and evaluated for both crossbred cattle and buffaloes. Association between lameness score and claw volume per unit body weight was analyzed using rank correlation to evaluate any relationship between the 2 variables. Similarly correlation was assessed between total lesion score and claw volume per unit body weight to observe any relationship between them.

RESULTS AND DISCUSSION

Housing, nutrition, genetics, social and physiological changes have been considered to influence claw conformation in cattle (Vermunt and Greenough 1995) but not even a single study is available till date in buffaloes. In the present study despite taking all the fore claws and hind claws together, there was not much difference in claw measurements in cattle, but a significant difference between claw measurements between fore and hind digits with respect to claw position, i.e. lateral or medial implies that the measurements of both lateral and medial claws separately is necessary to characterize accurately the conformation of the bovine claw not only in cattle (Hahn *et al.* 1977) but also in buffaloes. In both cattle and buffaloes, fore lateral claws have significant more foot angles ($P < 0.001$) as compared to hind lateral claws, which were having greater claw lengths and lengths of the dorsal border (Tables 5, 6). On the contrary, fore medial claws in cattle had significantly small foot angles and claw lengths, but more lengths of the dorsal border (Table 5). Fore medial claws and hind medial claws in buffaloes were having almost equal foot angles and lengths of dorsal border but fore medial claws were significantly longer than the hind medial claws (Table 6). Overall, a nonsignificant difference in foot angle, claw length and lengths of the dorsal border was observed between fore and hind claws in cattle though foot angles ($P < 0.001$) and lengths of the dorsal border ($P < 0.01$) varied significantly between fore and hind claws in buffaloes. Lengths of the dorsal border and claw lengths were greater in buffaloes which were having smaller foot angles as compared to cattle ($P < 0.0001$) (Table 7). The significant difference between cattle and buffaloes in foot angle, claw length and length of the dorsal border indicates that as the claw length and length of the dorsal border increases, the foot angle get skewed due to more tapering of the dorsal border. The difference between cattle and buffaloes in the present study is obvious due to inter-species comparison but the intra-species difference between lateral and medial

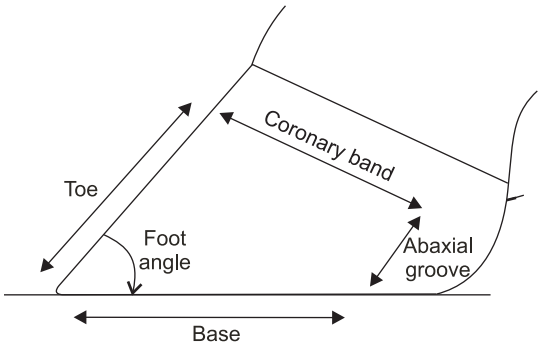

Fig. 1. Measurement of claw parameters.

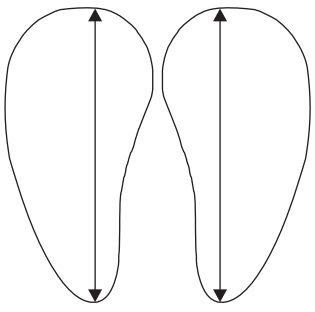

Fig. 2. Measurement of hoof length.

Table 1. Association of claw volume with age, lactation, body weight, heart girth and rump width in crossbred cows

Parameter	Estimate	t-value
Constant	–956.17	1.188*
Age	107.37	2.819*
Lactation	–71.73	1.441*
Body weight	1.16	1.214
Heart Girth	7.89	1.295*
Rump width	10.61	0.981*

*Significant at P< 0.05.

Table 2. Association of claw volume with age, lactation, body weight, heart girth and rump width in Murrah buffaloes

Parameter	Estimate	t-value
Constant	–145.17	0.155
Age	–25.56	0.731*
Lactation	64.27	1.406*
Body weight	2.27	2.164*
Heart girth	11.41	1.749*
Rump width	–9.56	0.769*

*Significant at P< 0.05.

Table 3.Comparison of lesion score with respect to different lesions in crossbred cattle and Murrah buffaloes

Lesion type	χ^2-value	P-value
HE	12.709*	< 0.001
SH	15.153*	<0.001
SA	11.843*	0.001
WLH	0.126	0.723
SU	4.624*	0.032
AWO	0.096	0.757
AWD	5.035*	0.025
WLF	5.007*	0.025
US	0.103	0.749
DS	0.0	1.00
OH	13.070*	<0.001
OS	0.0	1.00
CH	0.659	0.659
TH	0.194	0.659
IDD	14.508*	<0.001
IDH	3.060	0.080
Total lesion	36.632*	<0.001

HE, Heel erosions; SH, sole hemorrhage; SA, sole avulsions; WLH, white line hemorrhage; SU, sole ulcer; AWO, abaxial wall overgrowth; AWD, abaxial wall degeneration; WLF, white line fissure; US+ underrun sole; DS, double sole; OH, overgrown hoof; OS, overgrown sole; CH, corkscrew hoof; TH, toe hemorrhage; IDN, interdigital dermatitis; IDH, interdigital hyperplasia.

claws looks to be due to difference in the weight bearing with respect to claw position.

The results of the present study revealed that the claw volume is directly proportional to age ($P < 0.05$); lactation ($P < 0.05$), heart girth ($P < 0.005$) and rump width ($P < 0.05$) in dairy cattle (R^2=0.67) whereas the claw volume in dairy cattle is independent of body weight (Table 1). In buffaloes, claw volume of the animals is significantly dependent on age, lactation, heart girth, rump width as well as body weight (R^2=0.42; $P < 0.05$) (Table 2). It means as the age of the animal increases, its claws grow and the volume of the claws increases. Claw volume per unit body weight was significantly high in Murrah buffaloes (5.34 cm^3/kg) as compared to crossbred dairy cattle (4.35 cm^3/kg) ($P < 0.01$). The nonsignificant association between claw volume and body weight in crossbred dairy cattle might be due to the fact that dairy cattle in the present study have more lesion score as compared to buffaloes. More of the lesions in cattle might be a cause of decreased body muscle mass in turn body weight of the animals due to pain and distress. Cows with more lesions might have eaten less due to increased lying time due to pain resulting in loss of body weight and condition (O'Callaghan 2002).

Analysis of lesion score showed significant high lesion score owing to heel erosions ($P < 0.01$), sole hemorrhages ($P < 0.01$), sole avulsions ($P < 0.01$), sole ulcers ($P < 0.05$), abaxial wall degeneration ($P < 0.05$), white line fissures ($P < 0.05$) and interdigital dermatitis ($P < 0.01$) in dairy cattle as compared to buffaloes whereas overgrown hooves were significantly high ($P < 0.01$) in Murrah buffaloes (Table 3) in comparison to cattle. All the other lesions, viz. white line hemorrhages, abaxial wall overgrowth, under run soles, double soles, overgrown soles, corkscrew hooves, sleeper foot, toe hemorrhages and interdigital hyperplasia vary non-significantly between crossbred cattle and Murrah buffaloes. Overall or total lesion score is significantly high in crossbred cattle as compared to buffaloes. Significant high scores of heel erosions, sole hemorrhages, sole avulsions, sole ulcers, abaxial wall degenerations, white line fissures and inter digital dermatitis were observed in crossbred cattle as compared to buffaloes. First and foremost reason for that is Murrah buffaloes are resistant to most of the disorders because they originate and grow up in this particular region whereas crossbred dairy cattle were observed innately sensitive owing to the exotic germplasm they have. The more milk production in crossbred cattle might put a further burden/negative effect on the protein, energy and mineral status of these animals and they might have consumed more concentrates daily which could have predisposed them to more ruminal acidotic fluctuations and in turn to recurrent insults of subclinical laminitis. Secondly it could be due to less claw volume per unit body weight in dairy cattle due to which their claws could have to bear more ground reaction force as compared to buffaloes which have significantly more claw volume per unit body weight. Thirdly it could be due to innate poor quality hooves in Friesian cattle (Murphy 1979) and crossbreeding with this breed may thus be the cause of higher lesion score in crossbred cattle in the present study. Lesion score due to overgrown hooves was significantly high in Murrah buffaloes which are similar to the previous studies (Singh

Table 4. Percentage of claw volume in relation to claw position in crossbred cattle and Murrah buffaloes

Claw	Claw position	Claw volume (cm^3) cattle	Percentage of claw volume in cattle	Claw volume (cm^3) buffaloes	Percentage of claw volume in buffaloes
Fore claws	LF	506.119	54.68	777.19	55.75
	RF	500.63		747.52	
Hind claws	LH	417.89	45.32	611.51	44.25
	RH	416.74		598.53	

LF, Left fore; RF,right fore; LH, left hind; RH, right hind.

Table 5. Claw parameters in crossbred cattle

Parameters	Fore lateral digits	Hind lateral digits	P- value	Fore medial digits	Hind medial digits	P- value	Overall fore digits	Overall hind digits	P- value
Foot angle	52.69 ± 0.52	49.90 ± 0.50	p < 0.001	47.64 ± 0.50	49.40 ± 0.54	p <0.001	50.16 ± 0.49	50.53 ± 0.43	NS
Hoof length	9.33 ± 0.11	10.50 ± 0.50	p < 0.0001	10.54 ± 0.13	11.31 ± 0.25	p < 0.0001	9.94 ± 0.11	9.72 ± 0.11	NS
Toe length	6.54 ± 0.08	6.68 ± 0.08	p < 0.02	7.1 ± 0.10	6.90 ± 0.09	p < 0.002	6.82 ± 0.09	6.76 ± 0.08	NS

Table 6. Claw parameters in Murrah buffaloes

Parameters	Fore lateral digits	Hind lateral digits	P- value	Fore medial digits	Hind medial digits	P- value	Overall Fore digits	Overall hind digits	P- value
Foot angle	50.31 ± 0.45	47.02 ± 0.61	p < 0.001	44.71 ± 0.45	44.23 ± 0.44	NS	48.56 ± 0.43	46.44 ± 0.53	p < 0.001
Hoof length	10.70 ± 0.48	11.21 ± 0.38	P< 0.05	12.05 ± 0.18	11.68 ± 0.19	p < 0.001	11.38 ± 0.28	11.51 ± 0.11	NS
Toe length	7.36 ± 0.08	7.80 ± 0.12	p < 0.0001	7.48 ± 0.11	7.67 ± 0.11	NS	7.42 ± 0.10	7.62 ± 0.12	p < 0.01

Table 7. Comparison of claw parameters in crossbred dairy cattle and Murrah buffaloes

Parameters	Overall fore digits			Overall hind digits		
	Cattle	Buffaloes	P-Value	Cattle	Buffaloes	P-value
Foot angle	50.16 ± 0.49	48.56 ± 0.43	P < 0.0001	50.53 ± 0.43	46.44 ± 0.53	P < 0.0001
Hoof length	9.94 ± 0.11	11.38 ± 0.28	P < 0.0001	9.72 ± 0.11	11.51 ± 0.11	P < 0.0001
Toe length	6.82 ± 0.09	7.42 ± 0.10	p < 0.0001	6.76 ± 0.08	7.62 ± 0.12	p < 0.0001

1996, Kalsi *et al.* 2002). It was observed that the buffalo hooves grow more as compared to cattle. It could be a unique property of buffalo hooves to grow as overgrown hooves were usually observed more in them. It could be further attributed to more overloading forces due to more body weight in Murrah buffaloes as compared to crossbred cattle. Nonsignificant difference between crossbred dairy cattle and Murrah buffaloes was observed with respect to white line hemorrhages, abaxial wall overgrowth, underrun soles, double soles, overgrown soles, corkscrew hooves, slipper foot, toe hemorrhages and inter digital hyperplasia. This could be due to reason that these lesions, though occur in cattle, but their incidence is very low.

The fore claws occupied about 54.68% of the total claw volume compared to 45.32% for the hind claws in dairy cattle (Table 4). These percentages are similar to those reported by Phillips *et al.* (1996) and Scott *et al.* (1999). Interestingly, these findings also correspond well with the findings that forelimbs bear approximately 60% of the body weight (Fessl 1968). In Murrah buffaloes, the fore claws occupied about 55.75% of the total claw volume as compared to 44.25% for hind claws (Table 4). These findings also fit well with previous findings in dairy cattle. Moreover the present study may be the first study on claw parameters in Murrah buffaloes.

Rank correlation between claw volume per unit body weight versus lameness score revealed a positive significant correlation ($r = 0.36$; $P < 0.01$) in crossbred dairy cattle whereas in buffaloes, there is no significant correlation between lameness score and claw volume per unit body weight. A positive association between lameness score and claw volume per unit body weight in dairy cattle indicated that as the lameness score increased, the claw volume of the cattle increases or the claw volume is more in those animals which are having more lameness. This could be due the fact that when the animal became lame, their claws grow more as compared to the time when the animal is having normal gait. A nonsignificant association between lameness score and claw volume per unit body weight in buffaloes might be indicating that there is not much effect of the lameness score on claw volume or vice versa. That might be the reason that clinical lameness was observed only in 2.26% of buffaloes as compared to 8.92% in dairy cattle on organized farms (Randhawa 2006).

Overall lesion score versus claw volume per unit body weight in crossbred cattle revealed though nonsignificant but a negative correlation which is significant in buffaloes ($r = –0.24$, $P < 0.05$) indicating that more claw volume could be the reason for the less lesion score in buffaloes. However, these findings are contrary to the previous findings in which the odds of developing vertical fissure were 8.0 times greater in claws having claw volume bigger than 390 cm^3 (Clark *et al.* 2004).

In conclusion, it can be said that Scott's formula can be very well applied to calculate the claw volume of live animals either dairy cattle and buffaloes. Crossbred dairy cattle have a more overall lesion score owing to more heel erosions, sole hemorrhages, sole avulsions, sole ulcers, abaxial wall degenetration, white line fissures and inter digital dermatitis as compared to Murrah buffaloes. Claws

of buffaloes are less vulnerable to various lesions except overgrown hooves due to more claw volume per unit body weight which could be a reason for low lameness in buffaloes as compared to crossbred dairy cattle. Claw parameters should be measured with respect to claw position i.e. lateral or medial and fore or hind to accurately characterize the claw conformation. The results of the present study clearly suggested the role of claw size or volume in protecting the animal from claw disease. But the effect of claw volume on occurrence of different lesions needs to be studied in the future.

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