

# Standard measurement of the normal forelimb claw dimensions in Egyptian buffalo cows (*Bubalus Bubalis*) before and after functional trimming: a post-mortem study

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## Keywords

Forelimb,  
Claw length,  
Claw trimming,  
Sole,  
Heel bulb,  
Buffalo cow.

## Summary

The aim of this study was to compare forelimb claw dimensions in buffalo cows, and to establish a reference values for functional claw trimming. Medial and lateral healthy front feet claws were evaluated from 20 young (YB) and 20 mature (MB) Egyptian buffalo cows (*Bubalus bubalis*). The dorsal wall length (TL), dorsal wall angle (TA), heel length (HBL), height (HBH) and width (HBW), sole (SL) and claw length (CL) and sole width (SW) were measured. Differences between YB and MB were evaluated using ANOVA test, while those between the lateral and medial claws with a paired t test. Before and after trimming, the HBL, HBW, HBH, SL and CL were significantly higher for both claws in MB, while the TA was significantly lower. Before trimming the lateral HBW and HBH were significantly higher than the medial, while the SL and CL of the medial claw were significantly higher than the lateral claw. After trimming, the lateral claw HBL was significantly higher in MB. The SW of the lateral claw was significantly higher than the medial claw in both YB and MB, and it did not change after trimming. These results can be considered as a guidance during front feet trimming in buffaloes.

## Introduction

The domestic buffalo (*Bubalus bubalis*) represents an important source of meat, skin, traction power and milk, especially in tropical and subtropical countries. Domestic buffalo are represented by river buffalo, mostly used for milking production in India, Pakistan, Egypt, and Europe, and swamp buffalo, especially found in Eastern Asia and used as a draft animal and for meat purposes (De Rosa *et al.* 2009). In many European countries, especially in Italy, buffaloes' milk and milk products are particularly well-known and appreciated by the stakeholders (Borghese and Moioli 2016). Dairy cows and buffaloes are usually bred and managed with similar farming system. This similarity led to an increasing of the buffalo population bred

under intensive management conditions (Khan and Coskun 2018). Intensive farming of buffaloes can increase their production, but it can also predispose to those herd problems typical of dairy cows under intensive management (Cramer *et al.* 2008, Guccione *et al.* 2014, Guccione *et al.* 2016).

Fertility problems, mastitis and Lameness due to foot disorders represent the most important health related cause of economic loss in dairy industry. Financial losses are mostly due to decreasing in milk yield, reducing of reproductive performance, and increasing of culling rate (Guccione *et al.* 2016, Kshandakar *et al.* 2017). Beside the economic aspects, lameness is usually associated with long duration pain and discomfort, thus it represents also

a major concern for dairy animals' welfare (Fjeldaas *et al.* 2007, De Rosa *et al.* 2009).

Claw disorders are considered the main important cause of lameness in dairy animals (Perez-Cabal and Charfeddine 2016). Thus, corrective foot trimming is important as a preventive and therapeutic procedures and needs to be carried out regularly (Greenough *et al.* 1997, Guccione *et al.* 2016). In order to achieve a good trimming procedure and to maintain a good health of the whole buffaloes' herd, hoof measurements need to be established, as it has been suggested for cows (Greenough *et al.* 1997, Nuss and Paulus 2006, Nuss *et al.* 2011).

The aim of the present study was to compare measurements of the forelimb claw dimensions in young and mature buffalo cows, and to establish a reference values for functional claw trimming.

## Materials and methods

All the procedures in this study were conducted at the department of Surgery, Anaesthesiology and Radiology, Faculty of Veterinary Medicine, Kafrelsheikh University, Egypt. This study was performed on a total of 80 front claws obtained at the slaughterhouse from 40 clinically healthy Egyptian water buffaloes. Twenty out of 40 were young buffalo cows (YB), while 20 out of 40 were mature animals (MB). The median age of the YB was 27 months, ranging between 24 and 36 months, while the median age of MB was 90 months, ranging between 60 and 120 months. The median weights for the buffaloes' carcass were 400 kg, ranging between 350 and 450 kg for YB, and 530 kg, ranging between 450 and 600 kg for MB.

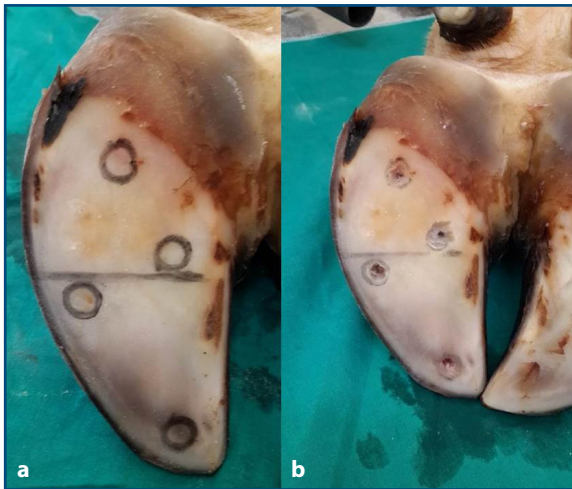
Only the feet without any claw affections were included in this study. Ready after collection, the feet were divided based on the previous mentioned aging categories (40 feet obtained from YB and 40 feet from MB), and they were thoroughly cleaned and the hair around the coronet was clipped (Figure 1, a-d).

The measuring techniques were performed according to previous studies on cattle (Nuss and Paulus 2006, Nuss *et al.* 2011). All the measurements were carried out by a single expert operator (AG) using a goniometer and calipers (Future Electronics, Egypt) with an accuracy of 0.05 mm. The mean value of three consecutive measurements for each variable was taken.

In order to standardize the sole thickness between all claws, two drilling of 10 mm of diameters were performed through the sole at the level of the corium (Figure 2, a-b). The thickness of the sole was measured before trimming. The first step of the applied trimming method was to reduce the claw length. Then, the thickest claw was trimmed and a symmetry between the medial and lateral claws was established. At the level of the axial wall, the trimmer made a dish in order to minimize the local pressure at the solar region. Trimming of the solar aspect was made by proceeding from the heel to the toe, and the cut was made in a sweeping action slightly across the sole in an axial-to-abaxial direction (Toussaint Raven 2002). Ready after trimming, the sole was thinned using a grinder until it reached a 5 mm thickness at the apical end of the hole near the tip and 8 mm thickness at the palmar end of the hole near the heel to create a flat sole surface. The toe was measured from the border between the skin and the coronet to the distal end of the dorsal wall



**Figure 1.** All the feet collected from the slaughterhouse from 20 young buffaloes' cows and 20 mature buffaloes' cows were thoroughly cleaned (a, b) and the hair around the coronet was clipped (c, d).

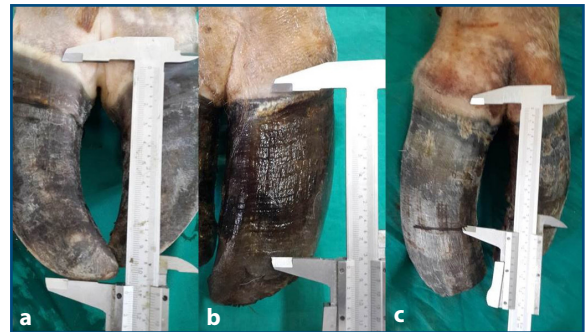


**Figure 2.** The sole was drilled at the level of the corium with 10 mm of diameters holes in order to standardize the sole thickness between all claws (**a, b**).

and parallel to the digital axis (Figure 3a) in order to evaluate the dorsal wall length, or the toe length (TL). Before the evaluation of the toe angle wall (TA), a dotted line was drawn 1 cm from the interdigital space on the dorsal wall of the horn capsule, then the TA was measured between this line and the sole (Figure 3, b-c). The heel bulb length (HBL) was measured between the caudal ends of the sole to the highest area of the heel bulb. Heel bulb height (HBH) was measured along a line perpendicular to an imaginary caudal extension of the sole to the highest point of the heel bulb. Heel bulb width (HBW) was measured from the axial to the abaxial borders between the horn and the haired skin (Figure 4, a-b). The diagonal sole length (SL) was measured from the tip of the claw to the palmar-most point of the sole (Figure 5a). Sole width (SW) was measured following a line that intersected sole length perpendicularly and ran from the axial to the abaxial border of the claw, 25% of the sole length away from the tip of the sole (Figure 5a). Claw length (CL) was measured along the line of the diagonal sole length from the tip of the claw to the heel bulb (Figure 5, b-c).

### Statistical analysis

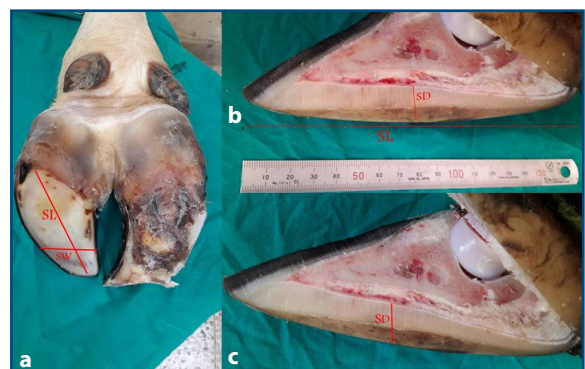
The software used for statistical calculation was SPSS version 20 (SPSS for Windows, version 20.0; SPSS Inc., Chicago, IL, USA). The explorative data analysis and normal distribution with the Kolmogorov-Smirnov test were used for the evaluation of the distribution of data. Differences between YB and MB were evaluated using analysis of variance (ANOVA) and Bonferroni-corrected pair-wise comparisons. The differences between the lateral and medial claws were evaluated using a paired t test. Differences were considered statistically significant at  $P < 0.05$ .



**Figure 3.** Measurement of the toe length was evaluated starting from the border between the skin and the coronet to the distal end of the dorsal wall and parallel to the digital axis (**a**). Measurement of the toe angle wall was evaluated between the dotted line on the dorsal wall of the horn capsule and the sole (**b, c**). The dotted line was marked with a dot 1 cm from the interdigital space.



**Figure 4.** Measurement of the heel bulb length was evaluated between the caudal ends of the sole to the highest area of the heel bulb (**a**). Heel bulb height (HBH) was measured along a line perpendicular to an imaginary caudal extension of the sole to the highest point of the heel bulb (**a**). Heel bulb width was measured from the axial to the abaxial borders between the horn and the haired skin (**b**).



**Figure 5.** Measurement of the diagonal sole length was made from the tip of the claw to the palmar-most point of the sole (**a**). Measurement of the sole width was done following a line that intersected the sole length perpendicularly and ran from the axial to the abaxial border of the claw, 25% of the sole length away from the tip of the sole (**a**). Claw length (CL) was measured along the line of the diagonal sole length from the tip of the claw to the heel bulb (**b, c**).

## Results

All the feet were examined before collection for healthiness; thus, no claws were excluded from the study and measurements took place in a total of 80 forelimb claws. All the measurements of the claws were easy to perform.

Data showed a normal distribution; thus, the results were expressed as mean and standard deviation. Data concerning the TL and the TA, the heel measurements and the sole measurement of the forelimb claw of YB and MB before and after trimming were reported in Table I, II and III, respectively.

Before trimming, the mean TL of the medial claws were significantly longer than the TL of the lateral claw in both YB and MB, while after trimming the medial and lateral TL did not differ. Both the medial and lateral TL were significantly reduced after trimming compared to the measures before trimming. Also, the medial and lateral TL were significantly higher in MB compared to YB before and after trimming.

**Table I.** Toe measurements of the forelimb claw of young buffalo cow (YB) and old buffalo cow (MB) before and after trimming. The sole thickness has been standardized.

Parameter	Before trimming		After trimming		Bonferroni Test
	Medial	Lateral	Medial	Lateral	
<b>Toe length</b>					
YB	113.7 ± 5.6 <sup>f</sup>	101.2 ± 4 <sup>d</sup>	89.95 ± 1.4 <sup>fg</sup>	88.7 ± 1.3 <sup>g</sup>	5.1
MB	144.9 ± 8.7 <sup>a</sup>	124.8 ± 8.7 <sup>b</sup>	95.7 ± 1 <sup>e</sup>	93.8 ± 1.2 <sup>ef</sup>	
<b>Toe angle</b>					
YB	38.9 ± 1.2 <sup>d</sup>	40.7 ± 1.3 <sup>c</sup>	43.1 ± 0.9 <sup>ab</sup>	44.2 ± 1 <sup>a</sup>	1.16
MB	34.4 ± 1.2 <sup>f</sup>	35.6 ± 1.1 <sup>e</sup>	41.1 ± 1.4 <sup>c</sup>	42.2 ± 1.1 <sup>bc</sup>	

YB = Young buffalo cow; MB = Old buffalo cow; Within rows different superscripts denote a significant difference (a ≠ b ≠ c ≠ d ≠ e ≠ f ≠ g; P < 0.05).

**Table II.** Heel measurements of forelimb claw of young buffalo cow (YB) and old buffalo cow (MB) before and after trimming. The sole thickness has been standardized.

Parameter	Before trimming		After trimming		Bonferroni Test
	Medial	Lateral	Medial	Lateral	
<b>Heel bulb length</b>					
YB	46.1 ± 4.3 <sup>c</sup>	49.2 ± 4 <sup>bc</sup>	43.1 ± 4.1 <sup>cd</sup>	46.1 ± 4.1 <sup>c</sup>	3.9
MB	51.9 ± 3.8 <sup>ab</sup>	55.3 ± 3.8 <sup>a</sup>	46.3 ± 3.5 <sup>c</sup>	50.5 ± 3.4 <sup>b</sup>	
<b>Heel bulb height</b>					
YB	39.6 ± 4.7 <sup>cd</sup>	43.4 ± 4.7 <sup>bc</sup>	36.4 ± 4.5 <sup>d</sup>	39 ± 4.5 <sup>d</sup>	4.1
MB	47.3 ± 3.5 <sup>b</sup>	51.4 ± 3 <sup>a</sup>	44.5 ± 4.3 <sup>b</sup>	46 ± 2.7 <sup>b</sup>	
<b>Heel bulb width</b>					
YB	44.7 ± 3.9 <sup>e</sup>	49.9 ± 3.8 <sup>cd</sup>	47.7 ± 2.2 <sup>de</sup>	50.1 ± 3.8 <sup>cd</sup>	3.6
MB	51 ± 4.2 <sup>bcd</sup>	54.8 ± 3.6 <sup>a</sup>	51.8 ± 2.9 <sup>abc</sup>	54.5 ± 4.2 <sup>ab</sup>	

YB = Young buffalo cow; MB = Old buffalo cow; Within rows different superscripts denote a significant difference (a ≠ b ≠ c ≠ d ≠ e; P < 0.05).

Before trimming, the lateral TA were significantly higher than the medial one in both YB and MB, while after trimming, they did not differ. The TA of both the medial and lateral claw was significantly increased after trimming in both YB and MB. The medial and lateral TA were significantly lower in MB compared to YB before and after trimming.

The lateral HBL were not significantly higher than the medial heel bulbs in both YB and MB before and after trimming, while it was significantly higher after trimming in MB. The HBL was significantly higher in MB compared to YB before and after trimming.

Before trimming, the lateral HBW was significantly wider than the medial claw in both YB and MB. The HBW of both medial and lateral claw was not significantly changed after trimming in YB and MB. Before trimming, the HBH of the lateral claw was higher than the HBH of the medial claw in MB. The medial and lateral HBW and HBH were significantly higher in MB compared to YB before and after trimming.

Before trimming, the SL and CL of the medial claw were significantly higher than the SL and CL of the lateral claw in both YB and MB. The SL and CL of both medial and lateral claw were significantly decreased after trimming. The SL and the CL of both medial and lateral claw were higher in MB compared to YB before and after trimming.

Before and after trimming, the SW of the lateral claw was significantly higher than the medial claw in both YB and MB. The SW did not significantly change after trimming.

## Discussion

Buffaloes and dairy cows seem to be predisposed to similar herd problems, probably because the breeding systems and most of breeding technologies

**Table III.** Sole measurements sole length, sole width and claw length measurement of forelimb claw of young buffalo cow and old buffalo cow before and after trimming. The sole thickness has been standardized.

Parameter	Before trimming		After trimming		Bonferroni Test
	Medial	Lateral	Medial	Lateral	
<b>Sole length</b>					
YB	116.8 ± 5 <sup>d</sup>	109.2 ± 4.9 <sup>e</sup>	127.5 ± 3.9 <sup>bc</sup>	122.6 ± 4.2 <sup>cd</sup>	3.9
MB	118.1 ± 10.5 <sup>d</sup>	112.5 ± 10.3 <sup>e</sup>	135.2 ± 11 <sup>a</sup>	130.3 ± 11.2 <sup>ab</sup>	
<b>Sole width</b>					
YB	45.1 ± 1.0 <sup>c</sup>	47.6 ± 3.5 <sup>abc</sup>	45.3 ± 1.5 <sup>bc</sup>	47.8 ± 3.1 <sup>ab</sup>	4.1
MB	47.4 ± 2.6 <sup>abc</sup>	49.8 ± 3.2 <sup>a</sup>	47.4 ± 2.6 <sup>abc</sup>	48.6 ± 4.3 <sup>a</sup>	
<b>Claw length</b>					
YB	166.6 ± 2.6 <sup>a</sup>	154.2 ± 2.6 <sup>c</sup>	149.6 ± 0.8 <sup>de</sup>	146.4 ± 1.2 <sup>e</sup>	3.6
MB	170.5 ± 5.2 <sup>a</sup>	160.4 ± 8.1 <sup>b</sup>	155.2 ± 3.5 <sup>c</sup>	152.8 ± 3.6 <sup>cd</sup>	

YB = Young buffalo cow; MB = Old buffalo cow; Within rows different superscripts denote a significant difference (a ≠ b ≠ c ≠ d ≠ e; P < 0.05).

are the same (Greenough *et al.* 1997). However, only reproductive disorders (Toussaint Raven 2002), and mastitis (Nuss and Paulus 2006) have been recognized as cause of important economic loss in buffalo, so far.

Foot diseases in bovines cause different degrees of lameness, which result in significant production losses (Radišić *et al.* 2012). Corrective trimming leads to maintain the health of the herd if it is performed on a regular base (Radišić *et al.* 2012). Hoof measurements in cows and the relationship between them have been well established (Nuss and Paulus 2006, Radišić *et al.* 2012). On the other hand, literature about foot diseases and their potential role in loosing welfare and economic profit in buffaloes is poor and incomplete (Giuccione *et al.* 2016). Thus, the present study aims to evaluate standard measures of the claws in buffaloes for corrective trimming.

Functional trimming in dairy cows aims to assure that both claws bear the same amount of weight (Toussaint Raven 2002). The dorsal wall of the hind medial claw in a normal Holstein Friesian was 75 mm that became 80 mm in total considering the thickness of the sole. The sole thickness appears to be the more critical measure than the length of the dorsal wall (Toussaint Raven 2002). For this reason, in the present study the standardized thickness of the sole horn was established before performing the measurements. The claw measurements in cows were established at a 5-8 mm sole thickness (Nuss and Paulus 2006). Similarly, in present study the claw measurements in buffalo were determined at a defined sole thickness before and after functional claw trimming.

In this study, the mean average of TL between the lateral and the medial claws at the defined sole thickness showed no significant differences. In the YB the mean average of TL of the lateral and medial claws were 88.7 and 89.9 mm, respectively while in the MB the mean were 93.8 and 95.7 mm, respectively. These findings are slightly different from other studies in which the cut length of the sole during trimming was 79 mm (Tsuka *et al.* 2014), 80 mm (Nuss and Paulus 2006), and 90 mm (Archer *et al.* 2015). The TL has been used as guideline for the front feet trimming. In cattle, Toussaint Raven (Toussaint Raven 2002) established a 75 mm for the dorsal wall length plus 5 mm for the sole thickness. Moreover, the noticeable difference in measurement between cattle and buffalo make the cattle measurements not acceptable in buffalo. In this study, the minimum recommended cut length for trimming the front feet in buffalo cows, starting from the proximal limit of wall horn, was assumed to be 90 mm in YB and 95 mm in MB. Our results are similar to Guccione and colleagues (Guccione

*et al.* 2016) who stated that the normal length of the dorsal wall (the distance from coronet to tip of claw) in buffalo after claw trimming is usually considered 90 mm.

The TA of the horn capsule was similar to a study about cattle (Fessl, 1974), but lower compared to other (Nuss *et al.* 2011). Correct claw trimming resulted in a higher TA which could help the claws stability and to increase the height of the heel reducing some diseases conditions such as the digital dermatitis and the interdigital necrobacillosis (Burgi and Cook, 2008).

In the front feet, the lateral claw was wider than that of the inner claw, and the bulb of the heel was also greater than in the medial claw. However, the front limb lateral claw is the first to hit the ground and the most stressed one, thus a large heel bulb might afford better cushioning (Schmid *et al.* 2009). Despite a smaller size and a lighter body weight, buffaloes might have larger toes compared to dairy cattle, due to an adaptation to their typical environmental conditions. Larger feet may allow toes to spread apart and give them better footing in mud and water pedding area.

Before functional trimming, the lateral digit of the front limbs in buffalo cows was shorter than the medial one. Moreover, the sole thickness of the lateral claws was larger than the medial claw. Thus, the functional trimming should start with paring the sole of the lateral claw in order to achieve an appropriate sole thickness; then the paring of the medial claw sole at the level of the lateral claw need to be performed. These results agreed with those of Nuss and Paulus (Nuss and Paulus 2006) and Muggli and colleagues (Muggli *et al.* 2011) in cattle.

After trimming the sole length was increased, this may be the consequence of cutting the horny part of heel bulb which lead to more exposure of the solar aspect. The trimming of the lateral heel bulb is challenging during a functional claw trimming because cutting the lateral heel bulb at the same level of the medial heel bulb might lead to excessively short heel bulbs, too short dorsal wall, and substantially thinner soles in the lateral claws. Consequently, the animal can be predisposed to digital dermatitis, excessive sole thinning and heel horn erosion of the lateral claw. An over trimmed toe may lead to a thin sole, disruption of bearing weight, corium compression, sole hemorrhage and other claw horn lesions (Tsuka *et al.* 2014, Mahendran and Bell 2015).

In conclusion, the minimum recommended claw length for buffalo cow in functional trimming should be at least 90 mm in YB and 95 mm in MB, measured from the proximal limit of wall horn. These fixed length for buffalo cow's claw can be useful for standardize the functional trimming in this species.

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