Evaluation of Claw Conformation by Using Two Methods of Measuring-by Ruler and Image Analysis

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Summary

The healthy claws with the correct shape are needed for non-problematic locomotion and welfare of dairy cows. Into the study 120 Slovak spotted dairy cows were included. Cows were kept on one farm in west part of Slovakia. Claws of right hind legs were evaluated after the regular functional trimming in October 2016. Claw measures as claw angle, claw length, heel depth, claw height, diagonal and claw width were analysed. Firstly, after the functional trimming the measures by ruler were taken. Secondly, the digital images of the bottom and right lateral side with ruler by digital camera Olympus SP-600 UZ were taken. Computer image analysis of digital images was performed by using NIS Elements 3.0. In addition to 6 claw parameters, total and functional claw areas were obtained from image analysis. The statistical analysis, t test and correlation between two types of measurements were performed in SAS. The correlations and the differences between measurements obtained by image analysis and taken by hand were calculated. Obtained correlation ranged from 0.11 to 0.74. Except claw angle, all correlations were significant ($P<0.01$). The lowest correlations were found in claw angle. The highest were found in claw width. The highest differences were found in claw angle a diagonal. The mean claw length was lower than is optimal for similar breed. Total claw area was 46.85±7.19 cm^2 and functional claw area was 26.79±6.05 cm^2. The higher number of observations for one parameters (for example 3) is necessary to obtain more precise comparison between both applied methods. In the future, this technique could be use as objective and very effective tool to measure claw shape.

Key words

claw measure, dairy cow, image analysis, Slovak spotted cattle

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Introduction

The healthy claws with the correct shape are needed for good locomotion and welfare of dairy cows. The lameness in cows leads to decrease of milk production, worse reproduction parameters, and earlier culling from herd. The lameness has negative impact on economy of dairy cow herds. For the definition a "gold standard" of trimming for cattle breeds kept under the present conditions the observations of claw measurements after hoof trimming are required. For more effective selection higher number of observations and more accurate data are necessary in animal breeding and livestock. The possible solution, how to obtain these data can be the implementation of new techniques. Flower et al. (2005) used kinematic gait analysis of dairy cows from video records for describing the differences between healthy cows and cows affected by claw pathologies. Ouweltjes et al. (2016) used the roentgen stereophotogrammetric analysis (RSA) to measure motions and deformations in loaded claws. Tsuka et al. (2014) used computer tomography to determine how the variety of shapes of untrimmed claws (dorsal wall lengths, toe angles and heel heights) correlates with the internal structure of claws. From these studies is evident that the image analysis can be used efficiently in livestock. Also Archer et al. (2015) used X-ray for measuring of the dorsal wall of Holstein cows. Nuss and Paulus (2006) and Nuss et al. (2011) observed the claw parameters in Simmental cows. In both studies they used thickness of 5 mm at the apex and 8 mm at the heel for the standardisation of the observations. Somers et al. (2005) monitored the claw parameters of Holstein cows kept on the different floor systems. Radišić et al. (2012) observed the measures of claws and their relations with body mass in Simmental bulls.

The aims of this study were to compare the claw parameters after functional trimming measured by ruler and by digital image analysis, to say if it is possible to use the digital image analysis to evaluate the claw conformation and to discuss the optimal claw measures for normal locomotion.

Materials and methods

In total of 120 Slovak spotted dairy cows were included into the study. Cows were kept on one farm in west part of Slovakia. Claws of right hind legs were evaluated after the regular functional trimming during the fixation in cage during the October 2016. Claw measures as claw angle, claw length, heel depth, claw height, diagonal and claw width on the lateral side of claw according to the methodology of Vermunt and Greenough (1995) were analysed. Firstly, after the functional trimming the measures by ruler were used. Secondly, the digital images of the bottom and right lateral side with ruler by digital camera Olympus SP-600UZ (Olympus Imaging Corp., Tokyo, Japan) were taken. At least two digital images were made for each animal. Digital image analysis was performed by using NIS Elements 3.0 (Laboratory Imaging, Praha). Moreover, the total and functional areas of claw were taken from image analysis. The data resulting from both methods of measurements were compared by using t test and the Pearson correlation. The statistical analysis was performed in SAS (version 9.2, SAS Institute Inc., Cary, NC).

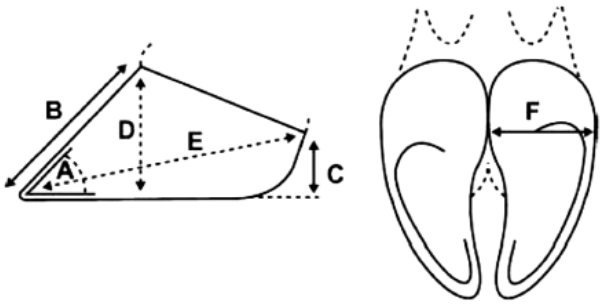

Figure 1. Claw measurements (Vermunt and Greenough, 1995); A- claw angle, B- claw length, C- heel depth, D- claw height, E- diagonal, F- claw width

Results

Totally, 120 Slovak spotted cows were used to compare the claw parameters after functional trimming measured by ruler and by digital image analysis. The average number of lactation was 2.81±1.72 with the maximum 8. The average days in milk was 191.74±122.84 (min=7, max=563). Not all cows had data about milk yield due to the calving after the test day. The average milk yield of 106 dairy cows from the last test day was 22.27±8.92 (min=3.9, max=42.5) kg per day. In group of primiparous cows 31 animals were found with average age of 26.43±1.66 (min=24.66, max=32.07) month. In group of multiparous cows 89 were obtained with average age of 56.85±20.16 (min=34.18, max=116.43) month. The claw measures observed within both groups of cows are presented in table 1 and 2.

The figure 2 presents the claw parameters of the right hind claws of Slovak spotted cows measured by both applied methods. Coefficients of variation were lower in all measures by ruler than in measures by image analysis, except the claw width. The non-significant correlation between two types of measurements

Table 1. Comparison of claw measures of first parity cows (means and standard deviations)

Parameter	Fore feet lateral claw (n=34) Nuss et al.(2011)	Hind feet, lateral claw (=20) Nuss and Paulus (2006)	Hind feet, lateral claw (n=31) present study (image analysis)	Hind feet, lateral claw (n=31) present study (ruler)
Claw angle	53.1±4.6	51.4±2.3	54.91±6.22	47.81±3.17
Claw length	73.9±3.7	75.6±3.5	70.19±8.23	71.19±5.04
Heel depht	41.3±3.2	33.6±2.7	35.33±3.93	36.87±4.01
Total area of claw	42.9±4.7	44.2±5.4	42.92±5.09	–
Claw lenght/heel depth	1.80:1	2.25:1	1.99:1	1.93:1

Table 2. Comparison of claw measures of second and higher parity cows (means and standard deviations)

Parameter	Fore feet lateral claw (n=26) Nuss et al. (2011)	Hind feet, lateral claw (=20) Nuss and Paulus (2006)	Hind feet, lateral claw (n=89) present study (image analysis)	Hind feet, lateral claw (n=89) present study (ruler)
Claw angle	52.4±3.8	48.2±2.7	54.96±5.84	49.51±4.68
Claw length	74.8±5.1	78.0±5.5	72.36±6.46	71.46±5.03
Heel depht	42.7±3.9	34.1±4.7	40.68±5.57	38.76±5.25
Total area of claw	49.1±10.2	57.7±10	48.23±7.33	–
Claw lenght/heel depth	1.77:1	2.28:1	1.78:1	1.84:1

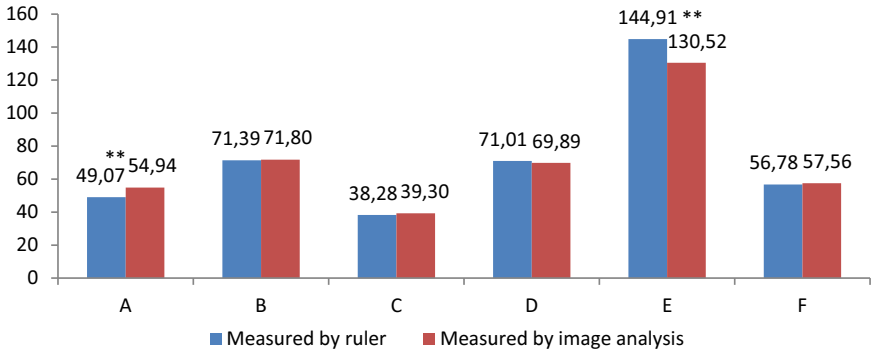

Figure 2.
Claw parameters of Slovak spotted cows measured by two methods; A- claw angle (°), B- claw length(mm), C- heel depth (mm), D- claw height (mm), E-diagonal (mm), F- claw width (mm), **P<0.01

Table 3. Phenotypic correlations between ruler and digital image analysis measurements of claw parameters

	A_r	B_r	C_r	D_r	E_r	F_r
A_dia	0.11253	-0.0299	0.07555	0.0475	-0.19946	0.13831
	0.2211	0.7458	0.4122	0.6064	0.029	0.1319
B_dia	-0.13781	0.35792	0.28349	0.3359	0.14948	0.02577
	0.1334	<0.0001	0.0017	0.0002	0.1032	0.7799
C_dia	0.06526	0.08495	0.41585	0.32105	0.3931	0.22187
	0.4788	0.3563	<0.0001	0.0003	<.0001	0.0149
D_dia	-0.04341	0.29337	0.31551	0.59518	0.2517	0.14462
	0.6378	0.0011	0.0004	<0.0001	0.0056	0.115
E_dia	-0.01947	0.01744	0.20343	0.22423	0.56591	0.13887
	0.8328	0.85	0.0259	0.0138	<0.0001	0.1304
F_dia	0.02243	0.0913	0.01268	0.18469	0.43668	0.73579
	0.8078	0.3213	0.8907	0.0434	<.0001	<0.0001
Total area_dia	-0.02064	0.03407	0.05492	0.15673	0.59739	0.50291
	0.8237	0.713	0.553	0.0887	<.0001	<.0001
Functional area_dia	-0.12151	0.15546	0.12131	0.19176	0.19395	0.30911
	0.188	0.0914	0.1888	0.0367	0.0346	0.0006

A- claw angle, B- claw length, C- heel depth, D- claw height, E-diagonal, F- claw width, _r- measured by ruler, _dia- measured by digital image analysis

was found only in claw angle (r=0.11). The significant correlations (P<0.01) were found in other 5 claw parameters (Table 3). The highest one (r=0.74) was found in claw width and the lowest for claw length. The significant differences in claw parameters between two methods of measurement were found only in claw angle and diagonal (Figure 2).

Discussion

In present study the smallest correlation was found in claw angle (r=0.11). Also Goodenough et al. (2012) found extreme variability in angular measurements. This can be a common issue where shape, rather than size, is measured on the biological specimens (Zelditch et al., 2004).

Goodenough et al. (2012) reported that biometrics measured from digital image on a computer tend to be less variable than measurement taken by hand. But it was not concluded in present study. One of the possible solutions could be to do each measurement three times and then take the average value for comparison of the mentioned methods for measuring.

Within analysed animals the average claw length was at level 71.80 mm. For example, in Holstein cows Tsuka et al. (2014) found that dorsal wall length of 75 and 76.2 mm (typically

recommended for functional trimming) should not be applied to all claws. They reported that the dorsal wall length of 73 mm as minimum for maintaining a sole thickness of >5 mm in the apex area. But dorsal wall length of 79 mm was needed to maintain a sole thickness of 7 mm based on the protective function of the soles. On the other hand, Archer et al. (2015) found that in adult Holstein cows 90 mm and in younger cows 85 mm dorsal wall length is recommended as a minimum.

Nuss et al. (2011) reported that dorsal wall length of 75 mm can be used as a guideline when trimming front and hind feet in Simmental cattle. From this point of view the sole thickness was across evaluated cows smaller than the recommendation of Nuss et al. (2011) mainly due to the fact that the Slovak Spotted cattle is genetically not pure Simmental breed. Moreover, the observations of Nuss and Paulus (2006) and Nuss et al. (2011) have been performed *post mortem*. The comparison between those studies and obtained results are presented in table 1 and table 2.

Somers et al. (2005) found that between the claw parameters of Holstein cows housed on other floors were no differences, except for the claw angle. Cows in this study were housed on straw yard and no information about the housing in studies of Nuss and Paulus (2006) and Nuss et al. (2011) were available.

Total claw areas of observed cows are shown in table 1 and table 2. The total claw area of Simmental bulls was analysed for example by Nuss and Paulus (2006), Nuss et al. (2011), and Radišić et al. (2012). Compared to our methodology Radišić et al. (2012) calculated the claw surface from claw diagonal and claw width. Our results of claw area in hind feet were similar to the results of Nuss and Paulus (2006). Several studies reported that the image analysis belongs to useful and accurate tools for measuring of animal body parameters (Flower et al., 2005; Tsuka et al., 2014; Outweltjes et al., 2016). Based on previous studies as well as our results it can be conclude that the digital image analysis is one of possible way how to analyse the claw parameters.

Conclusion

Correct claw shape is necessary for good locomotion and animal welfare. Generally, image analysis belongs to useful and accurate tools for measuring of animal body parameters. In this study the differences and correlations between claw measurements obtained by ruler and image analysis were analysed. The lowest correlations were found in case of claw angle. The highest differences were found in claw angle a diagonal. The mean claw length was lower than is optimal for similar breeds which means that the sole thickness can be not enough high for protect function of claw. This indicated the need of claw shape correction in following trimming. Moreover, the higher number of observations for one parameters (for example 3) is necessary to obtain more precise comparison between both applied methods. In the future, this technique could be use as objective and very effective tool to measure claw shape.

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