Scientific Papers. Series D. Animal Science. Vol. LXVII, No. 1, 2024
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

CHARACTERISTICS OF HOOF GROWTH AND WEAR OF BULGARIAN RHODOPEAN CATTLE RAISED ON MANURE AND PASTURE IN THE TROYAN REGION IN THE CENTRAL BALKAN MOUNTAIN

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Abstract

The study examined two groups of Bulgarian Rhodopean Cattle with differing genotypes, focusing on their hoof horn qualities and analyzing the effects of both internal and external factors on these traits. Employing a blend of visual, metric, anatomical, and topographical techniques, the research measured various aspects of the cows' hooves, including length, width, overall width, height, and the angle of the hooves on both the front and back legs. These measurements were taken during periods when the cows were housed in barns and while grazing in pastures. The study also calculated the hoof's weight-bearing surface in square centimeters and the ratio of the cow's live weight per unit area of this weight-bearing surface. Results indicated that for both genotypes, cows grazing in pastures had a higher weight-bearing area relative to their live weight. The research highlights the importance of cow mobility for their health, productivity, and longevity. A key finding is that the even growth of the hoof horn, which is crucial for the animal's well-being, depends on how the body weight is distributed across the limbs. Additionally, variations in hoof growth throughout different seasons were noted.

Key words*: angle, breed, growth, hoof horn, length, width.*

INTRODUCTION

The Bulgarian Rhodopean Cattle (BRC) is a domestic breed developed through the sophisticated reproductive crossbreeding of Rhodopean, Grey, Brown Alpine, and Jersey cattle. This breed is known for its substantial milk production, averaging between 2800-3500 kg with a high milk fat content of 5.12-5.59% and protein content of 3.6-3.7%. The BRC is characterized by its small size, pronounced mammary glands, high fertility, efficient fodder utilization, and strong adaptive capacity. Predominantly located in the mountainous regions of Bulgaria such as Kardzhali, Smolyan, Blagoevgrad, Rila, Troyan, Targovishte, and Strazhitsa, the breed was officially recognized in 1981. It is currently listed as at risk of extinction by the FAO (Gergovska & Panayotova, 2016).

The growth of the hoof horn in cattle is influenced by a range of external and internal factors, including breed, sex, management practices, dietary sufficiency, seasonal changes, and physiological state (Mohamadia & Khaglani, 2013; Zemlyanukhina, 2016; Lomonov & Skorkina, 2020). The condition of the hoof horn is an important indicator of the constitutional strength of cattle in adapting to new conditions of rearing and nutrition (Ulimbashev & Adigirova, 2016).

The use of concrete floors in farming operations is associated with accelerated growth of the hoof horn and a notable decrease in hoof angle due to increased wear. This highlights the importance for farmers to be highly aware of the environmental conditions in which livestock are raised and the growing need to ensure comfort for the cows. Investing in hoof maintenance and providing a balanced diet can yield significant long-term benefits (Marinov, 2016; Fedoseeva et al., 2016; Longova et al., 2020).

Bystrova (2008) argues that the hooves of cattle are a critical part of their exterior and that their formation is an important process that begins during their individual development.

Biomechanical principles are universal across species. In the context of cattle, it is crucial to recognize that the body weight is evenly distributed across all limbs, which is essential for understanding the biomechanics of cattle

hooves (Hernandez-Mendo et al., 2007; Homin et al., 2017; Hamzaev, 2019).
This research aimed to examine the growth and wear of the hoof horn among two groups of Bulgarian Rhodopean Cattle during the barn and pasture phases in the region of Troyan in the Central Balkan Mountain.

MATERIALS AND METHODS

The experimental study spanned from late May to late November 2023 and was conducted at two distinct locations: the farms of the Experimental Base of RIMSA-Troyan and those owned by Ivan Dimitrov, an agricultural producer in the village of Shipkovo. The research involved forming two groups, each consisting of seven Bulgarian Rhodopean Cattle (BRC), designated as Group I and Group II. The selection process for these groups was meticulously carried out using the method of analogues.
During the winter months, the cows were housed in barns that allowed for free movement, with each animal being allocated its own bed. Additionally, an outdoor courtyard was made available for the cows to roam and exercise during the colder season. The dietary regimen for the cows throughout the duration of the experiment was uniform and carefully rationed to ensure consistency.
The study focused on recording and analyzing various physical dimensions of the cows, specifically targeting the thoracic and pelvic limbs. Measurements taken included length, width, total width, height, and hoof angle. These measurements were conducted using precise instruments such as a retractable tape measure, measuring tape, plumb line, and angle ruler, adhering to the Pesechtkin methodology for assessing hoof characteristics. All collected data were meticulously documented.
Furthermore, the live weight of each cow was measured with high precision using an electronic scale accurate to 0.01 kg. Calculations were also performed to determine the weight-bearing area in square centimeters and the ratio of live weight (in kilograms) to this area.
The study employed a diverse array of methods including visual, metric, anatomical, and topographical techniques to ensure comprehensive data collection. The data were then statistically analyzed using the Statistika software (version 2010) and the results were systematically organized into tabular forms for clearer presentation and analysis. This biometrical processing utilized variational statistical methods to ensure the reliability and accuracy of the findings.

RESULTS AND DISCUSSIONS

Cattle have their peculiarities of anatomical-orthopedic features. The hoof represents an adaptation of the limb's skin, encasing the third and fourth toes in a slipper-like structure. Its lateral wall is comparatively thicker than the medial wall. The wall is about 7 mm thick in the interdigital cleft, and about 5 mm in the heel part (Marinov, 2016; Black & Krawczel, 2016; Lomonov & Skorkina, 2020).
Growth and wear of the horn layer characterize hoof horn condition in cows (Kennedy et al., 2007; Cook et al., 2009). The hoof horn colour of the experimental cows was deep black with various shades. Studies indicate that the most significant acceleration in the growth of hoof horn is observed during the grazing season, reaching up to 0.62 cm. Depending on the experimental groups, the growth of hoof horn ranges between 0.2 cm and 0.62 cm (Table 1).
Table 1 shows the data from the study of Bulgarian Rhodopean Cattle, cows from both genetic groups exhibited increased hoof horn growth rates at the conclusion of both pasture and barn periods. Specifically, in Group I (first genotype) cows raised on pasture, thoracic limb hoof measurements increased: length by 0.3 cm, width by 0.2 cm, and total width by 0.3 cm. When housed in a barn, these increases were slightly less: length by 0.2 cm, width by 0.1 cm, and total width by 0.11 cm. For pasture-raised cows in Group II (second genotype), increases were more pronounced: length by 0.62 cm, width by 0.31 cm, total width by 0.36 cm, and height by 0.1 cm. In contrast, the barn-raised counterparts showed increases of: length by 0.57 cm, width by 0.17 cm, total width by 0.38 cm, and height by 0.17 cm, with a statistical significance ($P<0.05$).
During the comprehensive study of Bulgarian Rhodopean Cattle, it was observed that cows from both genetic groups demonstrated

enhanced hoof horn growth by the end of their respective pasture and barn periods. More specifically, for Group I, which comprises the first genotype, cows that were grazed in pasture environments showed noticeable increases in their thoracic limb hoof dimensions: length grew by 0.3 cm, width by 0.2 cm, and total width also by 0.3 cm. When these same cows were housed in barn settings, the increments in their hoof measurements were somewhat less extensive, with length increasing by 0.2 cm, width by 0.1 cm, and total width by 0.11 cm. In Group II, which represents the second genotype, the pasture-raised cows exhibited more significant growth in their hoof dimensions: the length increased by 0.62 cm, width by 0.31 cm, total width by 0.36 cm, and height by 0.1 cm. Meanwhile, their barn-raised counterparts also showed noticeable growth, but with slightly different metrics: length increased by 0.57 cm, width by 0.17 cm, total width by 0.38 cm, and height by 0.17 cm. These changes in hoof dimensions were found to be statistically significant with a $P < 0.05$, highlighting the impact of rearing conditions on the hoof growth of Bulgarian Rhodopean Cattle.

Table 1. Characteristics of hoof horn, in groups (genotypes), cm

Sizes, cm	Period			
	Spring/Pasture/		Autumn/Barn/	
	Beginning of experiment	End of experiment	Beginning of experiment	End of experiment
Bulgarian Rhodopean Cattle (I group)				
Front hooves of thoracic limbs				
Length, cm	10.1±0.05	10.4±0.05**	10.51±0.01***	10.71±0.05
Width, cm	4.9±0.05	5.1±0.05	5.4±0.05	5.5±0.05
Total width, cm	13.2±0.05	13.5±.0.05**	5.43±0.05	5.54±0.05
Height, cm	5.9±0.05	6.0±0.06	6.1±0.05***	6.23±0.05
Angle of the interdigital cleft	45±0.25*	45±0.30*	45±0.30	45±0.30
Rear hooves of the pelvic limbs				
Length, cm	10.12±0.04	10.56±0.07**	10.71±0.23	10.4±0.03
Width, cm	5.1±0.05*	5.34±0.05	5.89±0.04	5.57±0.04
Total width, cm	13.65±.0.04	13.88±0.05	13.72±0.05***	13.97±0.02
Height, cm	5.8±0.04	6.0±0.02***	6.2±0.01***	6.3±0.03
Angle of the interdigital cleft	53±0.30	53±0.30*	53±0.05	53±0.04*
Bulgaria Rhodopean Cattle (II group)				
Front hooves of thoracic limbs				
Length, cm	11.02±0.03**	11.64±0.05	11.31±0.02**	11.78±0.04
Width	5.5±-0.03	5.81±0.04	6.5±0.04*	6.64±0.03*
Total width, cm	13.87±0.02*	14.23±0.03**	14.0±0.05*	14.38±0.04*
Height, cm	6.4±0.02**	6.5±0.03*	6.6±0.03**	6.77±0.04
Angle of the interdigital cleft	45±0.01**	45±0.02**	45±0.02**	45±0.04**
Rear hooves of the pelvic limbs				
Length, cm	11.62±0.03**	11.64±0.04	12.33±0.04	1278±0.02
Width, cm	6.14±0.03	6.21±0.04**	7.15±0.03	7.34±0.02**
Total width, cm	13.99±0.04	14.89±0.03*	14.24±0.04	14.53±-0.02
Height, cm	6.5±0.05**	6.8±0.06	6.6±0.03**	6.9±0.04
Angle of the interdigital cleft	54±0.4*	54±0.4***	55±0.5	55±0.4*

P<0.05*, P<0.01**, P<0.001***

In the experiment, the impact of different rearing environments on the hoof growth of cows was assessed. In Group I, cows that were housed on premises with concrete brick and cement flooring exhibited relatively minor growth in the dimensions of their pelvic limb hooves. Specifically, there was an increase in length of 0.02 cm, width by 0.07 cm, and total width by 0.90 cm. In contrast, cows raised in barn conditions demonstrated more substantial growth, with increases in hoof length by 0.55 cm, width by 0.19 cm, and total width by 0.29 cm.

Similarly, in Group II, the hoof growth patterns also varied depending on the rearing conditions. Cows that were raised in pasture settings showed similar minimal increases in hoof measurements as the concrete-raised cows in Group I: length by 0.02 cm, width by 0.07 cm, and total width by 0.90 cm. Conversely, cows that were raised in barn conditions exhibited more notable increases in their pelvic limb hoof measurements: length by 0.55 cm, width by 0.19 cm, and total width by 0.39 cm. These observations suggest that the type of flooring and the environment significantly affect the growth rates of hoof dimensions in cows.

This intensive growth of the hoof horn in cattle is influenced by various factors including breed, sex, technology, feed quality and quantity, seasonal variations, physiological state, and others. (Kvochko et al., 2010; Zemlyanukhina, 2016; Lomonov & Skorkina, 2020).

Table 2. Live weight, weight-bearing area, and the ratio between them of dairy cows of different genotypes of the Bulgarian Rhodopean Cattle breed

Raising period	Number (n)	Live weight, kg	Weight-bearing area, cm^2	Weight-bearing area/live weight ratio, kg/cm^2
Bulgarian Rhodopean Cattle (I group)				
Pasture	7	417.43±0.67*	218.86	1.9073
Barn	7	421.67±0.94*	231.24	1.8235
Bulgarian Rhodopean Cattle (II group)				
Pasture	7	423.62±1.13*	291.70	1.4522
Barn	7	434.46±1.95	363.92	1.1938

(P<0.05*)

The hoof height varied from 5.9 cm to 6.3 cm in the cows of group I, and from 6.4 cm to 6.9 cm in the cows of II group, and the angle of the interdigital cleft in both genotypes showed acceptable values of 45 cm for thoracic limbs and 53-55 cm for pelvic limbs (P<0.05).

The visual assessment, measurements, and calculations of the weight-bearing area of both groups of examined cows give a real description of their limbs and hooves (Muliug & Creenough, 2007; Rauibar et al., 2016; Longova et al., 2020). From Table 2, there was a higher coefficient (ratio) per unit of weight-bearing area in pasture-raised cows in both genotypes, compared to live weight, respectively 1.9073 points for I group, or by 9.6% and 1.4522 points for Group II, or a difference of 8.2%.

The data obtained in the present study are close to the results obtained by Homin et al. (2017), Longova et al. (2020), and Lomonov & Skorkina (2020), and in some indicators they complement them.

CONCLUSIONS

Several factors influence the growth of hoof horn in cattle, including the animal's innate resistance to disease and stress, the load distributed per unit area on the hoof, and varying environmental conditions. Observations from the study indicate that pigmented hoof horn, present in both groups examined, exhibits a slower rate of wear compared to its non-pigmented counterpart. Additionally, the growth of the hoof horn demonstrates noticeable seasonal variations: it tends to decelerate during the colder winter months and accelerates in the warmer summer months.

A crucial aspect of hoof health is the even growth of the hoof horn, which relies heavily on the uniform distribution of the cow's body

weight across its distal limbs. This balanced distribution is vital for maintaining the structural integrity and functionality of the hoof, which in turn reflects the overall condition of the hoof horn.

The health and maintenance of the hoof are not merely aspects of animal welfare but are integral to a cow's mobility. Effective mobility is essential for the animal's health, productivity, and longevity, which directly impact its economic value to the farming operation. Therefore, managing hoof health is a critical component of agricultural technology and practices, emphasizing the need for regular and thorough care and maintenance protocols to ensure the optimal well-being and productivity of cattle.

ACKNOWLEDGEMENTS

We would like to thank the management of RIMSA-Troyan for their logistic and financial support.

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