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ORIGINAL ARTICLE

Strength of limbs and hoof horn from local Ukrainian cows and their crossbreeding with Brown Swiss and Montbeliarde breeds

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This work aimed to study the strength of the hoof horn of the first-calf cows of domestic breeds (Black-Spotted and Red-Spotted breeds) and their crossbreeds of the first generation (F_1) with Brown Swiss and Montbeliarde breeds. The study was performed with first-calf cows during increasing the milk yield (60-70 days of lactation). Two groups of purebred and local analogs were formed. It was found that local cows left behind purebred analogs in the primary measurements of the hooves and biotechnological and biophysical features of the strength of the hoof horn. Domestic cows of the Ukrainian Black-Spotted and Brown Swiss breeds predominated purebreds in length, width, girth, height, and diagonal by an average of 0.44 cm, 0.27, 0.17, 0.12, and 0.39 cm. Respectively, crossbreeds of Ukrainian Red-Spotted and Montbeliarde breeds dominated over the purebred analogs by the same indicators by 0.51 cm, 0.38, 0.78, 0.27, and 0.51 cm. In some ways, the crossbreed first-calf cows surpassed the purebred cows by the indexes of hardness and turgidity of hoof horn. Live weight while increasing the milk yield in purebred Black-Spotted first-calf cows was higher by 18.35 kg. Regarding the crossbreeds of Red-Spotted with Montbeliarde breed, all the estimated indicators of body measurements showed a significant advantage over purebred Red-Spotted analogs. It was found that local first-calf cows had better indexes of area and strength of the hoof horn compared with purebreds. Also, Red-Spotted crossbreeds with Montbeliarde breeds had a higher live weight during increasing the milk yield: by 21.22 kg ($P \geq 0.95$).
Keywords: crossbreeding, dairy cows, limbs, hoof horn, limb strength.

Introduction

Intensive milk production technology involves the use of animals that meet the morpho-physiological characteristics of the planned volume of productivity and have good resistance to adverse environmental conditions and pathological factors (Ruban et al., 2017; Borshch et al., 2019; Ruban et al., 2020; Sobolev et al., 2020).

Modern dairy farming is characterized by the breeding of highly productive livestock under rather severe technological conditions, when the animal's body is affected by various types of stresses (Olehnowicz et al., 2010; Borshch et al., 2017; Grymak et al., 2020; Roman et al., 2020; Slivinska et al., 2020; Mazur et al., 2020; Fedorovych et al., 2021; Borshch et al., 2021). Features of metabolism, the process of growth and development, the level of reactivity are illustrated by many constitutional parameters, among which the most indicative is the morpho-functional state of the hoof horn (Borshch et al., 2018).

Among the main reasons for the outbreak of limb diseases in cattle are active Holsteinization of local breeds and the purchase of imported cows, which have imperfectly developed musculoskeletal systems and soft hoof horns with a large live weight. Many researchers point out that selection methods can improve the morphological and biophysical parameters of the cows' hoof horn, and that they also depend on the breed.

Holstein cattle, along with the obvious advantages, has disadvantages – one of which is the frequent diseases of the extremities, which reduces the period of productive use of cows and increases the percentage of their culling (Telezhenko et al., 2009; Borshch et al., 2020a; Borshch et al.,2020b).

One of the main reasons for the early departure of cows from the herd is limb disease. In some industries, hoof disease reaches up to 80%, significantly affecting milk productivity (Philips et al., 1998).

Clinically lame cows reduce milk yield four months before determining a diagnosis. The reasons for this are often hygienic conditions and feeding errors (unbalanced diet, lack of zinc, which is involved in the formation of the hoof horn) (Baird et al., 2009).

At the same time, some researchers believe that the strength of the limbs is formed hereditarily (Capion et al., 2009). There are the following anomalies: incorrectly straightened angles of the hocks and other joints, thickening of the bones of the extremities, interdigital growths, lameness, and some types of deformation of the distal extremities. It is known that the hooves are deformed under the influence of environmental factors.

The researches aimed to study the strength of hoof horns of domestic cows and their crossbreeds with Brown Swiss and Montbeliarde breeds in the conditions of farms with different milk production technology.

Materials and Methods

The research was conducted at the dairy farm "Mikhailivske", Mikhailivka village (49°11′52'' North latitude, 28°43′29'' East longitude) of Vinnytsia region with the cows of the Ukrainian Black-Spotted dairy breed and crossbred cows of the first-generation obtained as a result of crossing with Brown Swiss breed and at the dairy farm "Azorel", village Mukhivka (48°57′01'' North latitude, 28°47′09'' East longitude) of Vinnytsia region with the cows of the Ukrainian Red-Spotted dairy breed and crossbred cows of the first-generation obtained from crossing of the URS dairy breed with Montbeliarde breed. In both farms, there were two groups of pure-breed and crossbred cow analogs. Twenty cows were used in the each group.

Hoof measurements were studied on the pelvic limbs according to Hahn et al. (1984). The load index was calculated by the live weight ratio to the hooves' length and width. Hardness and elasticity of the hoof horn – according to the methods proposed by Bystrova I. Yu., 2008.

The obtained data were statistically processed using STATISTICA (Version 11.0, 2012) software. The Student's *t*-test was used to estimate the statistical significance of the obtained values. Data were considered significant at $P < 0.05$, $P < 0.01$, $P < 0.001$.

Results and Discussion

It was determined that crossbreeding influenced the measurements of hooves in cows (Table 1). Thus, crossbreed cows of Ukrainian Black-Spotted and Brown Swiss breeds outstripped purebreds in length, width, girth, height, and diagonal by an average of 0.44 cm, 0.27, 0.17, 0.12, and 0.39 cm. A similar situation was observed; crossbreeds of Ukrainian Red-Spotted and Montbeliarde breeds prevailed over purebred analogs in length, width, girth, height, and diagonal by 0.51 cm, 0.38, 0.78, 0.27, and 0.51 cm. The girth of the wrist characterizes the degree of bone tissue development and may indicate the type of constitution. The value of this indicator is selectively crucial because it has a direct relationship with the percentage of culling of cows due to limb problems, hence the duration of productive longevity of animals.

Live weight while increasing the milk yield at purebred Black-Spotted first-calf cows was higher by 18.35 kg (Table). Regarding the crossbreeds of Red-Spotted with Montbeliarde breed, all the estimated indicators of body measurements showed a significant advantage over purebred Red-Spotted analogs. Also, Red-Spotted crossbreeds with Montbeliarde breeds had a higher live weight during the increasing milk yield period: 21.22 kg ($P \geq 0.95$).

An important indicator that indicates the strength of the limbs and the optimal ratio of live weight and exterior features of the hoof horn is the load index. The higher load index was at domestic cows compared to purebreds. At crossbreeds of Ukrainian Black-Spotted and Brown Swiss breeds and Ukrainian Red-Spotted and Montbeliarde load index was 0.2 kg/cm2 higher than purebred counterparts.

Table 1. Measurements of limbs and hooves of first-calf cows

Indexes	Ukrainian Black-Spotted dairy	½ of Ukrainian Black-Spotted dairy and ½ of Brown Swiss	Ukrainian Red-Spotted dairy	½ of Ukrainian Red-Spotted dairy and ½ of Montbeliarde
Wrist circumference, cm	20.36±0.13	20.77±0.13*	19.92±0.12	21.04±0.15***
Length of hooves, cm	11.78±0.19	12.22±0.21	11.85±0.16	12.36±0.13*
Width of hooves, cm	11.12±0.12	11.39±0.14	11.18±0.17	11.56±0.21
Circumference of hooves cm	41.06±0.52	42.23±0.55	41.59±0.50	42.37±0.43
Height of hooves, cm	7.18±0.09	7.30±0.12	7.27±0.04	7.54±0.06**
Diagonal of hooves, cm	12.04±0.08	12.43±0.13*	12.21±0.11	12.72±0.14***

* P≥0.95,** P≥0.99, ***P<0.001 as compared with Ukrainian Black-Spotted dairy and Ukrainian Red-Spotted dairy breeds

The strength of the hoof horn is essential for the animal. All its weight should be proportional to the hooves' load, which is due to their quality. It depends on several factors: the age of the animal, heredity, breed, level of feeding, housing conditions, and

environment. The strength of the hoof horn and the shape determine the quality of the hooves. The duration of economic use of animals depends on the indicators of strength, quality, and individual characteristics of the animals' hoof horns. It was found that crossbreed first-calf cows had better indexes of area and strength of the hoof horn compared with purebred ones. Thus, the index of the hooves of Black-Spotted crossbreeds with Brown Swiss breed prevailed by 3.97 compared with purebred counterparts. In Red-Spotted crossbreeds with Montbeliarde breed, this figure was higher by 0.08

Table 2. Live weight and biophysical parameters of the hoof horn of first-calf cows

Indexes	Ukrainian Black-Spotted dairy	½ of Ukrainian Black-Spotted dairy and ½ of Brown Swiss	Ukrainian Red-Spotted dairy	½ of Ukrainian Red-Spotted dairy and ½ of Montbeliarde
Live weight, kg	507.95±7.17	489.60±6.58	510.39±6.25	531.61±7.54*
Load index, kg/cm^2	3.87±0.08	3.89±0.11	3.96±0.14	3.98±0.15
Hoof area index,%	40.26±0.24	44.23±0.31***	40.42±0.36	42.50±0.39***
Hoof strength index,%	6.43±0.08	6.71±0.14	6.70±0.05	6.79±0.05
Shin load index,%	24.94±0.13	23.58±0.10***	25.62±0.07	25.26±0.06***
Hoof horn hardness, HB	89.11±1.46	93.64±1.58*	92.37±1.30	96.25±1.89
The elasticity of the hoof horn (Young's modulus), 10^{10} N/m^2	2.829±0.044	2.947±0.052	2.858±0.031	3.104±0.079**

* P≥0.95,** P≥0.99, ***P<0.001 as compared with Ukrainian Black-Spotted dairy and Ukrainian Red-Spotted dairy breeds

The hardness coefficient of the hoof horn indicates the natural stability of the limbs. Cows with a hard hoof horn have a higher elasticity, and therefore their hooves are less intensively rubbed. At the crossbreeds of Ukrainian Black-Spotted and Brown Swiss and Ukrainian Red-Spotted and Montbeliarde breeds, the hardness coefficient of the hoof horn by 4.53 and 3.88% prevailed over purebred analogs. Similar values were observed for the index of hoof strength. In Black-Spotted crossbreeds with the Brown Swiss breed, the advantage over purebred analogs was 0.28%, and in the case of Red-Spotted crossbreeds with the Montbeliarde breed – 0.09%. The index of the load index on the shin, which indicates the correspondence of live weight to the measurements of the extremities, was 1.36% and 0.36% higher at purebred Black-Spotted and Red-Spotted cows compared to crossbreds.

One of the criteria for assessing the strength of the hoof horn is considered its elasticity. It has been detected that crossbreed cows of Ukrainian Black-Spotted and Brown Swiss and Ukrainian Red-Spotted and Montbeliarde breeds had higher elasticity of hoof horn compared to purebred cows, by 0.118 0.246 10^{10} N/m^2, respectively.

Conclusions

Thus, crossbreed first-calf cows (F_1) left behind purebred analogs in measurements of hooves and limbs, biotechnological and biophysical features, indicators of hoof horn strength, which is very important in terms of intensive milk production technologies.

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