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MEASUREMENTS OF THE UDDER OF COWS-FIRSTBORN OF BLACK-AND-WHITE CATTLE OF THE UKRAINIAN BREEDING, THE LEVEL OF THEIR HERITABILITY AND CORRELATIVE VARIABILITY WITH MILK YIELD

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Abstract

The udder of first-born Holstein (n = 86) and Ukrainian Black-and-White dairy (UBWD) breed (n = 112) in the Burynske herd of Sumy region of the Ukraine was evaluated. The following morphological udder traits were measured, cm: girth, length, width, depth of the front part, and distance from bottom to floor, front quarter length, conditional volume, length, diameter and shape of teats, distance between teats. Heritability coefficients of udder measurements cows of Holstein (h^2 = 0.125-0.488) and UBWD (h^2 = 0.113-0.464) breed testified that most udder traits are controlled by heredity. Correlation between udder measurements and milk yield for 305 lactation days cows of both breeds was -0.054… 0.568 in Holstein and -0.075… 0.493 in UBWD breed. A negative relationship was found between distance from udder bottom to floor and milk yield, -0.295 and -0.258, respectively. Heritability level and correlations of measurements with milk yield will allow obtaining genetic progress of udder improvement because of indirect selection.

Key words**:** *Holstein, measurements, udder, heritability, correlation*

INTRODUCTION

The study of the dairy cattle udder according to measurements that characterize its structure has never lost its relevance from the point of view of breeding and production technology. Intrabreed comparisons indicated about significant variability of measurements and the udder and teats forms of cows of different breeds [1, 4, 9], the malformation of which caused deep economic losses and had a significant influence on the welfare and productivity of cows dairy [14, 18, 24].

Other researchers have found that cows with malformation of the udder and teats were more susceptible to infection by pathogens that cause mastitis [5, 31].

Due to the established positive correlations between measurements and forms of the udder with traits of milk productivity [23, 27, 30], there is a possibility of indirect breeding of cows, which will be effective for improving these traits.

It should also be noted that the traits of the udder and teats structure were characterized by a high degree of heritability [8, 15, 19, 20, 34]therefore, they can serve as an additional selection marker for their improvement in dairy cattle [10].

The aim of the study was to assess the udder structure by measurements and form in a comparative analysis of two breeds: Ukrainian Black-and-White dairy (UBWD) with Holstein heredity of 75.0-87.5% and Holstein domestic selection, with the determination of heritability and correlative variability with milk productivity.

MATERIALS AND METHODS

The material for this research were first-born cows of Holstein (86 heads) and Ukrainian Black-and-White dairy breeds (112 heads) in the controlled herd of PE "Burynske", Sumy region of Ukraine. Measurements and visual assessment of the udder were carried out in

1.0-1.5 hours before morning milking, 30-40 days after calving. The measures of the udder and teats were performed at the points shown in Fig. 1 using a measuring tape, compass, caliper and ruler, expressed in centimeters (cm).

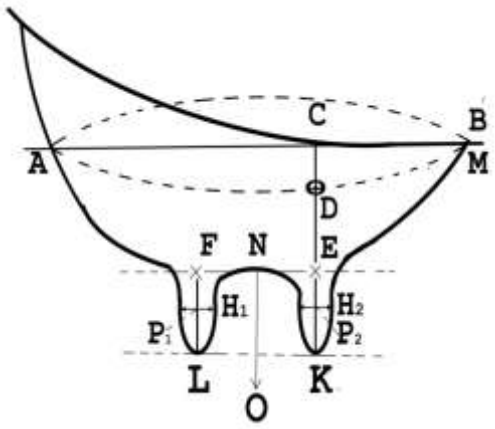

Fig. 1. Points of udder and teats measurements
Legend:
AB – udder girth along a horizontal line at the level of front edge (by tape);
AM –udder length from the back bulge to its front edge (by compass);
CM – front quarter length;
D–maximum udder width above teats of front parts (by compass);
CE – front part depth - vertically from the abdominal wall to the upper teat part (by tape);
EK, FL – front and rear teats length (by ruler);
H_1, H_2– front and rear teats diameter (by caliper);
P_1P_2– distance between front and rear teats (by ruler);
NO – distance from the udder bottom to the floor (by tape).
Source: Own design.

The nominal udder volume (cm^3) was determined as the sum of udder girth multiplied by its front part depth.
Basic statistical data of the udder measurements include the average value (x) and the standard error ($S.E.$).
From statistical indicators, the average value of measurements(x) and standard error ($S.E.$) were studied.

$$S.E. = \frac{\sigma}{\sqrt{n}} \quad \text{.....(1)}$$

where:
σ – standard deviation;
n – number of variants.

The coefficient of linear phenotypic correlation was determined by the Pearson formula:

$$r_{xy} = \frac{\sum(x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \times \sum(y_i - \bar{y})^2}} \quad \text{.....(2)}$$

where:
x_i – value for variable x;
y_i – value for variable y;
$\bar{x}$ – average value for x;
$\bar{y}$ – average value for y.
The heritability (h^2) of udder measurements assessed as calculating the father's influence force indicator (η_x^2) in a one-factor variance complex [28] according to the formula:

$$h^2 = \eta_x^2 = \frac{C_x}{C_y} \quad \text{.....(3)}$$

where:
C_x – factorial variance;
C_y – total variance.
The reliability of obtained data was evaluated by calculating the errors of statistical values (S.E.) and Student's reliability criteria (td) for correlation analysis and Fisher (F) for variance analysis. The probability level was classified by comparison with standard criteria values. The results were considered statistically significant for the first – $P<0.05$ (^{1}), the second – $P<0.01$ (^{2}), and the third – $P<0.001$ (^{3}) probability thresholds. Statistical processing of experimental studies was performed by the methods of mathematical statistics using formulas given by Merkur'eva [22] in Microsoft Excel.

RESULTS AND DISCUSSIONS

The Ukrainian Black-and-White dairy breed in the Sumy region of Ukraine was created by crossing method of aboriginal Lebedinsky breed of the combined type with Holstein sires of foreign selection. The obtained crossbred genotypes of animals with Holstein's conditional blood 62.5-67.5% were bred "in itself" (Burkat, 2003) [7]. The Holstein breed was created by absorbing crossing of hybrid UBWD genotypes with Holstein breeders of foreign selection. It was the task of these studies to determine how much the morphological udder traits of cows-

firstborn of UBWD breed improved as a result of its absorption by Holsteins.

Table 1 shows the results of assessing the morphological udder traits by measurements in comparison of two experimental breeds.

Table 1. Characteristics of cows-firstborn in dairy cattle by udder morphological traits (x ± S.E.)

Measurement name of udder traits, cm		Breed	
		Holstein	Ukrainian Black-and-White dairy
udder girth		144.7 ± 0.52***	141.5 ± 0.48
front part depth		24.8 ± 0.33**	23.4 ± 0.29
distance from bottom to floor		62.4 ± 0.42	61.6 ± 0.33
front quarter length		15.3 ± 0.29	14.8 ± 0.25
udder length		44.5 ± 0.26***	42.3 ± 0.23
udder width		35.2 ± 0.28***	33.1 ± 0.24
conditional udder volume, cm^3		3,589 ± 49.3***	3,309 ± 45.4
teats length	front	5.0 ± 0.10	5.5 ± 0.08***
	rear	4.2 ± 0.08	4.5 ± 0.06**
teats diameter	front	2.3 ± 0.03	2.4 ± 0.02
	rear	2.3 ± 0.03	2.3 ± 0.02
distance between teats	front	17.2 ± 0.29**	16.1 ± 0.25
	rear	8.5 ± 0.19	8.2 ± 0.15
	front and rear	12.6 ± 0.15***	10.9 ± 0.12
shape, %	bath-like	86	81
	cupped	14	19
teats shape, %	cylindrical	92	86
	conical	8	14
stepped udder, %		3	7

Source: Own calculations.

Udder measurement indices showed the superiority of cows-firstborn of the Holstein breed over their peers of the UBWD in terms of udder girth by 3.2 cm (P<0.001), front part depth – 1.4 (P<0.01), distance from bottom to ground – 0.8, front quarter length – 0.5, udder length – 2.2 (P<0.001), udder width – 2.1 (P<0.001), conditional udder volume 280 cm^3 (P<0.001).

According to important technological udder traits, cows-firstborn of the Holstein breed turned out to be the best. The length of the front teats in first-calf Holstein cows was significantly shorter by 0.5 cm (P <0.001), and the rear teats by 0.3 cm (P <0.01). Between the location of the front teats, the distance was greater in cows-firstborn of Holstein breed by 1.1 cm (P <0.01), the rear teats – 0.3, and between the front and rear – 1.7 cm (P <0.001). The diameter of the front and rear teats in Holstein cows decreased by 0.1 cm (P <0.01).

Among the estimated total number of Holstein cattle, 86% of cows-firstborn had the desired bath-like udder form and 92% – cylindrical teats shape, which was 5% and 6% more than the UBWD, respectively. Only 3% of cows were found with stepped udders among Holsteins, or 4% less than among UBWD cows.

So, a comparative analysis of cows of both breeds has shown the best indicators of udder development in Holstein cows. About the improving effect of Holsteins when crossed with other breeds has been reported in other studies [6, 9, 12, 17, 26, 32]. At the same time, the results of assessment cows-firstborn of the Ukrainian Black-and-White dairy breed according to udder measurements testified to its good development by most of the traits, both in terms of shape and manufacturability. According to such important traits that characterize the udder size – length and width, they meet the target parameters of measurements of the desired type (42 and 33 cm) for cows-firstborn of the UBWD breed [13, 16].

From population-genetic parameters, the most important for selection by quantitative traits is heritability and the correlation between them. High coefficient indicators of heritability and correlation variability of breeding traits make

it possible effectively select to them and improve more quickly in animals [11]. Heredity is a key parameter in quantitative genetics because it determines the response to selection. Since the quantitative traits of milk production of cows were characterized by polymer inheritance, the efficiency of selection for them was significantly determined by heritability [29]. Breeding based on the trait with a high degree of heritability will be effective even through mass selection.

The values of heritability of most udder morphological traits of cows-firstborn of experimental breeds, estimated by measurements, indicate about the possibility of effective mass selection by them (Table 2).

Table 2. Heritability of udder measurements of cows-firstborn Black-and-White cattle and correlation variability with milk yield

Measurement name of udder traits, cm		Breed			
		Holstein (n=86)		Ukrainian Black-and-White dairy (n=112)	
		$r \pm m_r$	h^2	$r \pm m_r$	h^2
udder girth		0.406±0.091[3]	0.488[3]	0.349±0.083[3]	0.464[3]
front quarter depth		0.364±0.096[3]	0.395[3]	0.261±0.092[2]	0.374[3]
distance from bottom to floor		-0.295±0.089[3]	0.275[3]	-0.258±0.088[2]	0.264[3]
front quarter length		0.259±0.097[2]	0.312[3]	0.212±0.090[1]	0.268[2]
udder length		0.453±0.086[3]	0.474[3]	0.348±0.083[3]	0.456[3]
conditional udder volume, cm^3		0.433±0.88[3]	0.468[3]	0.376±0.091[3]	0.475[3]
udder width		0.452±0.086[3]	0.482[3]	0.336±0.084[3]	0.383[3]
teats length	front	0.017±0.108	0.125[1]	0.045±0.107	0.113[1]
	rear	0.022±0.106	0.128[1]	0.039±0.109	0.116[1]
teats diameter	front	-0.054±0.092	0.144[1]	-0.083±0.094	0.126[1]
	rear	-0.066±0.091	0.137[1]	-0.075±0.093	0.131[1]
distance between teats	front	0.036±0.101	0.085	0.029±0.097	0.094
	rear	-0.056±0.103	0.092	-0.063±0.105	0.089
	front and rear	-0.086±0.104	0.081	-0.074±0.104	0.088
shape	udder	0.568±0.082[3]	0.474	0.493±0.081	0.379
	teats	0.284±0.095[2]	0.232	0.321±0.083	0.267

[1] – P < 0,05; [2] – P < 0,01; [3] – P < 0,001

Source: Own calculations.

The heritability degree of udder measurements of cows-firstborn in the conditions of one herd did not differ by significant variability between breeds. The values of heritability coefficients of measurements at the level of reliability (P <0.05-0.001) testified that most of the udder morphological traits of Holstein cows were controlled according to heredity by 12.5-48.8%. These indicators for UBWD cows were 11.3-46.4%.It's important to note that the level of heritability coefficients for such traits as girth, length and width of the udder, front quarter depth, distance from udder bottom to floor, front quarter length, conditional volume, shape of the udder and teats in cows of Holstein (h^2 = 0.232-0.488) and UBWD (h^2 = 0.264-0.434) breeds – sufficient for effective selection to improve the udder structure of cows.

Since it will be almost impossible effectively select animals for one trait, it is important to know how a change in one trait will affect the development of other biological and economically useful animal traits associated with it.Therefore, the next from the parameters of population genetics, characterizing the possibility of effective selection, may be a correlation between traits. Scientific studies with cattle have repeatedly proved that there is a correlation between udder conformation traits and milk productivity of different focus and strength [23, 26, 27].

The correlation between udder measurements and milk yield for 305 days of first lactation in cows of both breeds was differed by significant variability with coefficients in the range of -0.054 ... 0.568 for Holstein and -0.075 ... 0.493 for UBWD breed. The traits

that characterize the udder development in size and the udder form were closely correlated with milk yield.

A negative reliable relationship was found between the distance from the udder bottom to the floor and milk yield, -0.295 and -0.258, respectively, which was consistent with other studies [2, 3, 21, 25, 33], who also received negative correlations (r=-0.129… -0.310). As for the correlations between milk yield and diameter, length and location of teats, they were insignificant and unreliable, so the selection will be ineffective.

CONCLUSIONS

Comparative analysis of cows-firstborn of the Holstein and UBWD breeds by measurements of udder morphological traits revealed the advantage of Holstein cows. This indicates about positive breeding effect for the further absorption of crossbred cows by Holstein sires, which will lead to improved udder development in their offspring. Due to the moderate heritability of the udder qualitative traits, genetic progress will be ensured, and their improvement in cows of Holstein and UBWD breeds. A close and moderate level of correlations of measurements with milk yield will ensure the effectiveness of indirect selection to improve these traits.

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