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EVALUATION AND VARIABILITY OF LINEAR CLASSIFICATION INDICATORS IN THEIR RELATIONSHIP WITH MILK YIELD OF COWS OF HOLSTEIN BREED OF REGIONAL SELECTION

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Abstract

Researches have been conducted to study conformation type of firstborn Holstein breed cows of Ukrainian selection. Cows at the age of first lactation were evaluated in the period of 2-4 months of its course using two systems of linear classification as recommended by ICAR. The 9-score system described 18 conformation traits. Four groups of conformation traits that characterize dairy type, body, limbs and udder, were assessed on a 100-score scale. It was found that firstborn cows have a good development of exterior traits that characterize dairy type, with an average estimate of 83.8 score, body condition (score 84.4), limbs (score 83.3) and udder quality (score 84.2). Evaluation of descriptive traits of firstborn cows showed that the degree of their development, compared with group, has a significantly higher variability in the herd with coefficients of variation of 11.2-31.4%. According to the final assessment, firstborns of Holstein breed Ukrainian selection corresponded to the desired type on the international scale "good plus" (score 84). By the 100-score system of linear assessment, all group traits and final score were positively correlated with yield at the age of first (0.233-0.455) and third (0.203-0.356) lactation and for lifetime (0.278-0.468). About sufficient level for effective selection testified relationship with milk yield: height (0.211-0.341), body depth (0.282-0.369) angularity (0.338-0.475), rump width (0.211-0.368), fore udder attachment (0.263-0.367), rear udder attachment (0.224-341), central ligament (0.233-0.362) and locomotion (0.221-0.382).

Key words**:** *Holstein breed, linear classification, type, conformation, correlation*

INTRODUCTION

There is no need to prove that the best specialized dairy breed in the world is Holstein. Animals of this breed, along with high milk productivity, are characterized by excellent conformation qualities. In fact, it was thanks to the purposeful selection of animals by exterior type that Holstein cattle were created as they are now (Eklz, 1960) [13].

Type of body structure Holstein breed, along with indicators of dairy productivity, is the main breeding trait, which is constantly used in animal improvement. The long practice of linear classification of Holstein cattle has proved the existence of a positive dependence of the level of productivity and functional use on a well-defined conformation type of cows (Liu et al., 2014; Zink et al., 2014; Campos et al., 2015; Otwinowska-Mindur et al., 2016;) [9, 22, 27, 37].

In the second half of the twentieth century began the intensification of combined livestock in the direction of specialized dairy type. Due to the unique properties of Holstein breed, its gene pool has been involved to improve a significant number of breeds of cattle in almost all countries. This allowed, already in the first stages of crossbreeding, along with increasing milk productivity, to significantly improve the exterior, morphological and functional properties of the cows udder of breeding breeds: Black-and-White Holland (Krabbenborg, 1978) [20], Poland (Pasierbski and Romer, 1978) [28] and Germany (Boie and Gravert, 1983) [7], Red-and-White Poland (Pawlina, 1980) [29] and Germany (Brilling, 1977) [8], Norman cattle of France (Flamberd, 1986) [14], Black-and-White cattle of Belgium (Leroy, 1977) [21], Red cattle of Norway (Skjervold and Odegard, 1978) [33], cows of Brown Austrian breed (Haiger et al., 1981) [16], Spotted

Slovak (Chrenek and Plesnik, 1981) [10], Black-and-White breed of Italy (Bianchini, 1982) [5], Yugoslavia (Romcevic et al., 1984) [30] and Hungary, Simmental of Switzerland (Rüegscger, 1978) [31].

A similar situation developed in Ukraine, where at that time breeds of combined type of productivity were bred and which became maternal basis for creation of new specialized dairy breeds. New Ukrainian breeds were created by the method of reproductive crossing, which provided at the final stage of their consolidation, breeding hybrid animals "in itself". Conditional blood by Holstein breed was planned to be dominant (not less than 62.5–87.5%, and in the active part of population even more) (Zubets et al., 1990; Zubets et al., 2001) [38, 39]. The peculiarity of creation of Ukrainian Black-and-White dairy breed in Sumy region was that the parent Lebedyn cattle served basis (Lobanov, 1991) [23]. The Lebedyn breed was created by the method of reproductive crossing of aboriginal Gray Ukrainian cattle with Brown Swiss (Yatsenko, and Kirichenko, 1959) [36].

Animals of Lebedyn breed of combined type, high growth, with a proportional, strong body structure and well-developed muscles and broad chest. They have dense and heavy elastic skin, thick, medium thickness and length of hair. Legs well set, strong. Cattle of Lebedyn breed are characterized by good meat qualities, endurance, adaptation to local conditions, resistant to diseases, longevity. In addition to low productivity, it was not adapted to machine milking technology, so it needed to be transformed.

At the time of 2009, Ukrainian Black-and-White dairy breed was created by the method of reproductive crossing of Lebedyn cattle with sires of Holstein and Black-and-White breeds. It was an array of animals with different conditional blood by Holstein breed. Later, in the absence of bulls of their own breeding, Holstein sires of foreign origin began to be used en masse in the selection to high-blooded crossbreeds. In accordance with the current situation, Ukrainian Black-and-White dairy breed passed in status Holstein. According to the selection program, animal's conformation of created Holstein breed should be as close as possible to the desired type and become a direct indicator of the body's adaptation to environmental conditions, good health and strength of body structure. A linear assessment of cow's conformation will help to answer this question. In this regard, the aim of research was to study features of exterior type of firstborn Holstein cows of domestic selection to determine the relationship of linear traits with milk productivity of animals in a particular herd.

MATERIALS AND METHODS

Scientific and economic research was conducted in the herd of enterprise by breeding Holstein breed of private enterprise "Burynske" Pidlisniv branch in Sumy district. Evaluation of conformation type of firstborn cows (n = 135) was performed by the method of linear classification (Khmelnychyi et al., 2008) [18] in accordance with the latest recommendations of ICAR (ICAR, 2018) [17].

Cows at the age of first lactation were evaluated in the period of 2-4 months of its course using two systems of linear estimation – 9-score, describing 18 traits of body structure, and 100-score, taking into account four groups of conformation traits that characterize harmonious development of dairy type, body development, limbs condition and udder morphological qualities. Estimation of udder linear traits was performed not earlier than one hour before milking. The average severity of linear traits was estimated at five score. At biological deviation of a trait towards the minimum development estimation decreased to one score. If the development of trait approached to the maximum manifestation, estimate increased to nine score. The maximum number of score for firstborn cows was not more than 89 for each set of traits. Each group of conformation body parts was evaluated separately and given appropriate weighting factor in the total assessment of animal: dairy type – 15%, body – 20%; limbs – 25% and udder – 40%.

The final score of type was determined by the formula:

FS = (DT × 0.15) + (B × 0.20) + (L × 0.25) + (U × 0.40),
where:
DT - dairy type
B - body
L - limbs
U - udder
The coefficient of linear phenotypic correlation was determined by the Pearson formula:

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

where:
x_i – value for variable *X;*
y_i – value for variable *Y;*
$\bar{x}$ – average for *X;*
$\bar{y}$ – average for *Y.*
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. The level of reliability was determined by comparisons with standard indicators of the criteria. Results were considered statistically significant for the first – P <0.05 (^{1}), second – P <0.01 (^{2}) and the third – P <0.001 (^{3}) thresholds reliability. Statistical calculation of data experimental researches was performed by methods of biometric statistics according to formulas given by E.K. Merkurevoi [26] in Microsoft Excel.

RESULTS AND DISCUSSIONS

Studies on the linear classification of cows firstborn Holstein breed in controlled herd suggest that development of animals by conformation type was moving in the direction of desired dairy type. This statement was based on the results of estimation by 100-score system, which represented by indicators of four sets conformation traits and final score (Table 1).
Slight variability (1.62-1.93%) of average scores for all exterior complexes indicated a certain consolidation of animals by conformation type. The severity of traits that characterize dairy type of firstborn cows (score 83.8) indicated about biological ability of animal to high milk productivity. Aptitude to withstand in the difficult conditions of mechanization of production processes, physiological load during long term productive use, while maintaining good health. Dairy type was harmoniously combined with well and proportionally developed body parts that characterize body condition (score 84.4) and limbs (score 83.3). Obtained high level of udder assessment in herd cows (score 84.2) testified about good development of morphological traits that characterize its quality, from which will depend on high milk yield, adaptability to machine milking, in addition, high-quality udder is less vulnerable to injury and diseases (Campos et al., 2015; Otwinowska-Mindur et al., 2016) [9, 27].
The most objective idea about development of important for selection individual body parts of cow's exterior allowed composing descriptive system of linear classification. In this case, according to recommendation ICAR [17], each linear trait described unique cow body part, which was separated from other traits. This system must describe ICAR-approved traits of cow's conformation, which included to the group traits characteristics of dairy type, body, limbs and udder taking into accounts a certain list of defects that are most common in dairy cattle.
Estimation of descriptive traits of firstborn cows in controlled herd showed that degree of their development, compared with group, had a significantly higher variability in the herd interior with coefficients of variation 11.2-31.4%. This is a biologically justified phenomenon, because their development, in addition to genetic, was significantly influenced by paratypic factors (Mazza et al., 2013; Marinov et al., 2015; Güler et al., 2018) [15, 24, 25].
Estimation level of descriptive traits indicated about good growth of firstborn cows in height (score 6.8), they had a deep body (score 7.4), excellent angularity (score 7.7), which indicated about good development of dairy-type traits. Good limbs posture (score 7.7), optimal hock angle (score 5.3) and a sufficient feet angle will ensure their strength. From

udder traits, the highest score firstborns received for attachment the fore (score 7.5) and rear (score 7.1) udder parts and developing central ligament (score 7.8), which will keep udder at a sufficient height from the floor.

Increasing the genetic potential of cows' productivity was due to the corresponding improvement of functional conformation. Cows with a better appearance were able to maximize their milk production potential during more lactation.

This is convincingly evidenced by studies examining the relationship between linear type traits and dairy productivity of Holstein cattle in China (Liu et al., 2014) [22], Brazil (Campos et al., 2015) [9], the Czech Republic (Zink et al., 2014) [37], Poland (Sawa et al., 2013) [32], and Turkey (Tapki and Ziya, 2013) [34].

Table 1. Estimation and variability of linear classification indicators Holstein firstborn cows in connection with milk yield

Conformation trait	Variability of indicators				Correlation coefficient between linear type trait and milk yield:		
	x ± S.E.	Desirable score	σ	Cv, %	first lactation	third lactation	life
Set of traits that characterize: dairy type	83.8 ± 0.09	80-84 < Good plus	1.51	1.80	0.412[3]	0.269[3]	0.395[3]
body	84.4 ± 0.11		1.38	1.64	0.384[3]	0.266[3]	0.366[3]
limbs	83.3 ± 0.12		1.44	1.73	0.233[2]	0.203[2]	0.278[3]
udder	84.2 ± 0.14		1.37	1.62	0.447[3]	0.244[2]	0.455[3]
Final score	84.0 ± 0.10		1.62	1.93	0.455[3]	0.356[2]	0.468[3]
Descriptive traits: height	6.8 ± 0.12	7-8	1.08	15.9	0.322[3]	0.211[2]	0.341[3]
chest width	5.5 ± 0.13	7	1.12	20.4	0.074	0.059	0.095
body depth	7.4 ± 0.11	8-9	1.11	15.0	0.342[3]	0.282[2]	0.369[3]
angularity	7.7 ± 0.12	8-9	1.09	14.2	0.468[3]	0.338[3]	0.475[3]
rump angle	5.2 ± 0.05	5	0.72	13.8	0.076	0.101	0.093
rump width	6.8 ± 0.08	8-9	1.03	15.1	0.356[3]	0.211[1]	0.368[3]
hock angle	5.3 ± 0.11	5	1.06	20.0	0.144	0.122	0.094
pelvic limbs posture	7.7 ± 0.10	8-9	1.02	13.2	0.215[2]	0.167[1]	0.232[2]
feet angle	6.4 ± 0.11	8-9	1.07	16.7	0.173[1]	0.096	0.202[1]
fore udder attachment	7.5 ± 0.12	8-9	0.84	11.2	0.367[3]	0.263[2]	0.354[3]
rear udder attachment	7.1 ± 0.13	8-9	1.05	14.8	0.274[2]	0.224[2]	0.341[2]
central ligament	7.8 ± 0.11	8-9	0.87	11.2	0.347[3]	0.233[2]	0.362[3]
udder depth	6.5 ± 0.12	5-6	0.93	14.3	-0.119[1]	-0.232[2]	-0.144[1]
fore teats position	4.4 ± 0.11	5-6	1.38	31.4	-0.107[1]	-0.168[2]	-0.123[1]
rear teats position	5.2 ± 0.09	5-6	1.32	25.4	-0.092[1]	-0.145[1]	-0.073
teats lenght	5.1 ± 0.06	5-6	0.75	14.7	-0.144[2]	-0.061	-0.047
locomotion	5.8 ± 0.08	8-9	1.24	21.4	0.355[3]	0.221[2]	0.382[3]
body condition	7.5 ± 0.07	5-6	0.84	11.2	-0.346[3]	-0.201[2]	-0.266[3]

Note: [1] $P < 0.05$; [2] $P < 0.01$; [3] $P < 0.001$
Source: Own calculations.

According to the final assessment of linear classification of cows firstborn Holstein breed of Ukrainian selection, they corresponded to the desired type by the international scale

"good plus". All group traits and final score were positively correlated with milk yield at the age of the first and third lactation and for lifetime. The variability and reliability of correlations depend on the cow's age and group of linear traits. Almost the same level of correlations between group traits and final score and milk yield at the age of first lactation and during life indicated the possibility of effective selection of dairy cows at an early age (Weigel et al., 1998) [35].

According to (Atkins et al., 2008) [2], in the past the main direction of classification system was the final score. Therefore, attention was paid to the individual animal and its direct ancestors, who received the marks "Good plus", "Very good" or "Excellent". In contrast, today the classification emphasis is on a detailed assessment of individual functional traits that can be used as a tool to improve the herd to enhance the longevity and ability of cow to express its genetic productive and reproductive potential.

The functional individual linear type traits of cows in the controlled herd, which were positively correlated with the amount of milk for evaluated lactations and for lifetime, include height, body depth, angularity, rump width, fore and rear udder attachment, central ligament and locomotion.

Holstein cows of desired dairy type should be characterized by angular, open, well-rounded ribs, with sufficient body depth to be able to convert a large amount of roughage into high productivity. In this regard, studies have shown a relationship between milk yield and body depth (r = 0.282-0.369) and angularity (r = 0.338-0.475). According to results of studies by a number of authors (De Haas et al., 2007; Tapki and Ziya, 2013; Zink et al., 2014; Bilal et al., 2016) [6, 11, 34, 37], variability of correlations between body depth and milk yield varied widely from 0.09 [6] to 0.56 (De Haas et al., 2007; Khmelnychyi et al., 2020) [11, 19]. The same authors testified to the high potential of milk productivity of Holstein cattle with correlations between angularity and milk yield from moderate (0.29) (Tapki and Ziya, 2013) [34]) to high (0.75) (De Haas et al., 2007) [11].

Of particular note was the assessment of morphological udder traits, which is associated with productivity, health and longevity of cows. Over a long period of time, due to genetic selection, anatomical structure of cow's udder has changed. Productivity selection has led to an increase in udder size and weight. As a result, the center of gravity of udder shifted caudally, strengthened suspension apparatus, which is represented by the strength of central ligament, attachment of fore and rear parts. The good development of these traits in Holstein cows in controlled herd, respectively, was evidenced by their score - 7.8; 7.5 and 7.1. The level of correlations for evaluated lactations and for lifetime and central ligament (0.233-0.362), fore (0.263-0.367) and rear udder parts (0.224-0.341) attachment and indicators of assessment these traits of cows was a guarantee of increased productivity and health udder in the selection process.

The relationship between the linear udder traits, which are responsible for strength of its attachment, with milk productivity of cows, has been reported by many scientists. However, this relationship was significantly volatile in strength and direction. The correlation between fore udder parts attachment and milk yield in most studies in Holstein cows around the world is negative: -0.45 (DeGroot et al., 2002) [12], -0.23 (Tapki and Ziya, 2013) [34], -0.11 (Zink et al., 2014) [37], -0.09 (Campos et al., 2015) [9]. The antithetic correlation between fore udder parts attachment and milk yield was due to the coincidence of assessment time (2-4 months of lactation) and the peak of lactation, when high productivity was observed. Under the weight of a large amount of milk, the udder is lowered and score is reduced. However, a positive rather strong correlation between these traits in Holsteins of Turkey (0.32) (Berry et al., 2004) [4]) indicated about possibility of breaking this negative connection.

The validity of this conclusion regarding the udder height position relative to the hocks, depending on its filling with milk, was confirmed by established negative correlations between udder depth and amount

of milk. The correlation between these traits for all above-mentioned researchers varied from -0.65 (DeGroot et al., 2002) [12] to -0.05 (Yatsenko and Kirichenko, 1959) [36].

As for relationship between the height of rear udder part attachment with milk yield, it is, on the contrary, usually positive: from 0.12 (Tapki and Ziya, 2013) [34], 0.15 (Sawa et al., 2013; Zink et al., 2014) [32, 37], 0.19 (Campos et al., 2015) [9], 0.27 (Liu et al., 2014; Otwinowska-Mindur et al., 2016) [22, 27] to 0.48 (Berry et al., 2004) [4]. A negative association between these traits was reported in a study of Bunaji-Holstein cows (-0.30) (Alphonsus et al., 2010) [1]). The authors of above publications, in studying the relationship between the udder central ligament and yield, found a large variability of correlations in direction and strength, from -0.18 (Alphonsus et al., 2010) [1] to 0.79 (Liu et al., 2014) [22].

According to our studies, score for fattening was negatively correlated with amount of milk yield for evaluated lactations. This reality in most cases was consistent with studies of Holstein cows with genetic correlation coefficients between these traits -0.45 (De Haas et al., 2007) [11], - 0.38 (Bilal et al., 2016) [6], -0.20 (Tapki, and Ziya, 2013) [34] and -0.34 (Zink et al., 2014) [37]. As for negative relationship between fattening and milking, this situation was explained by existence of a negative energy balance of high-yielding cows in the first 100 days of lactation (Banos et al., 2005) [3]. This was exactly the time when a linear assessment was performed in accordance with requirements of the methodology. In general, from the point of view of desired conformation type of dairy cows, there is an objective, generally accepted understanding that cows of specialized dairy breeds, which belong to the intensive type, have never been fattened.

CONCLUSIONS

The use of linear classification method in the selection process - very effective means of objectively determining the breed features of dairy cows conformation type. The high level of variability coefficients of individual descriptive body parts of the exterior indicated about need for their improvement in some animals of studied breed at present stage of breeding through appropriate selection of bull improvers, estimated by their daughter's type. A reliable correlation of linear traits of conformation with milk yield for number of lactations and for lifetime confirmed the urgent need for indirect selection of dairy cattle by type, which will get not only constitutionally strong and healthy animals, but also highly productive by yield. The use of the modern method of linear classification will make it possible to control the biological patterns of the conformation type formation of cows Holstein breed of domestic selection.

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