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Assessment of the Adaptive Stability of the Holstein Cows in the Conditions of the Ecological Plasticity in Northern Steppe of Ukraine

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ABSTRACT

Background: Dnipropetrovsk region of Ukraine is located in the northern steppe subzone, where livestock is actively developing, including dairy farming. Cows, imported from other ecological and climatic conditions undergo appropriate acclimatization to new conditions of exploitation. The current research was based on the assessment of the adaptive properties of Holstein cows of different ages to manage and control the level of their milk productivity and reproductive function during exploitation.

Methods: All researches were carried out on the milk complex of "Agro-Soyuz". The information base was data on productive qualities in individual cards of cows, results of assessment of zootechnical and veterinary accounting. To achieve this goal, an analysis was conducted from the first to the seventh lactation of Holstein cows.

Result: Our researches allowed establishing the adaptability of Holstein cows of different ages in terms of ecological plasticity of the northern steppe of Ukraine. With a slight imbalance of the organism and the environment cows show high productive qualities at unsatisfactory reproductive function. This work will be a complementary the comprehensive study the adaptation of Holstein cows in different climatic conditions.

Key words: Adaptation index, Ecology, Holstein, Lactation, Milk fat, Milk protein, Milk yield.

INTRODUCTION

The steppe zone of Ukraine is divided into three physical-geographical subzones: the north, middle and south steppes. The territory of Dnipropetrovsk region is located in the North-steppe subzone, where agriculture is developed and industrial livestock is actively developing. The high plowing of the land makes it possible to grow a variety of forage resources, which are formed in the ecological and climatic conditions of the steppe and determine the state of health and the level of productivity of livestock.

The urgent task of the agro-industrial complex is to increase the milk production of cows. It is no coincidence that lactation of cows over a long period is widely studied at morphological, physiological and even genetic levels (Bionaz and Loor, 2011).

Scientists have studied the patterns of realization of the genetic potential of dairy productivity of cows of the Holstein breed (Merkur'eva, 1970), evaluated the breeding-genetic parameters of productive qualities (Movchan and Danko, 2004).

Imported animals from other environmental and climatic conditions are undergoing acclimatization to new conditions. There is evidence to suggest that the interaction of genotype and harmful environmental factors directly has a negative impact on milk productivity and leads to a reduction in the efficiency of the breeding process by 49-69% (Doherty *et al*., 1987). Similarly, it is quite problematic to develop and implement new technological solutions for the production of cows' milk on an industrial basis, aimed at improving the level of productivity and economic efficiency, without assessing adaptive properties and the degree of genetic destabilization of the norm reaction (Zabrodin *et al.,* 2004). Siratskyi *et al.* (2001), proposed to establish an animal adaptation index, which allows assessing the level of development of specific characteristics of one individual or the population as a whole.

In this case, it is very important to study the adaptive capacity of animals with their age (Horan *et al.,* 2005).

MATERIALS AND METHODS

All researches were condacted on the basic milk complex of "Agro-Soyuz" of Dnipro State Agrarian and Economic

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University during 2011-2019. The territory of milk complex is located in the north-steppe subzone of the steppe of Ukraine in Dnipropetrovsk region. Animals of the Holstein breed were housed in light cowsheds with rest boxes and a feed table for consumption of mixed rations. Cows were milked in the milking parlor on the Parallel installation.

The information base consisted of individual form-2 cards, the results of appraisal of zootechnical records, veterinary documents (Tamarova, 2016). To achieve this aim was carried out an analysis of Holstein cows of the first (4610), the second (2839), the third (1456), the fourth (629), the fifth (524), the sixth (103) and the seventh (47) lactation, totaling 9938 heads of different lactation.

The norm reaction of Holstein animals in the genotype-environment interaction were determined by the adaptation index Siratskyi, *et al.* (1994):

$$I = [(365 - \text{period between calving, days}) / \text{Milk fat, kg})] \times 27.4$$

Where,

I - Adaptation index; Period between calving (days); 365 - duration of the year; Milk fat - milk production of cows for the finished (shortened) or 305 days of lactation, expressed in kilograms of milk fat; 27.4 - coefficient.

For objective assessment of productive qualities obtained milk-yield was converted to 4% (Kembell and Marshal, 1980).

RESULTS AND DISCUSSION

The use of a promising global gene pool, which is expressed in the importation of animals of different genetic breeding, creates certain problems of adaptation to different natural and climatic conditions (Kuznetsov *et al.,* 2011). The study of adaptation features of cattle in the conditions of intensive technology of exploitation is a very relevant problem today (Kushnir and Vystavnoy, 2008).

An analysis of the index of adaptation of Holstein cows by intensive technology of exploitation at an industrial complex for milk production in the ecological zone of the northern steppe of Ukraine, depending on their age in lactation, showed (Table 1) that this indicator is less than neutral, is zero, so it is negative. At the same time, if in the cows of the second-fifth lactations the adaptation index was practically equal and averaged -5.5, -5.4, -5.7 and -5.7, then in animals of the sixth lactation it was higher an average of 24.7 ($P<0.05$), 26.0 ($P<0.05$) and 21.9%, respectively.

The lowest indicator of adaptation index was characterized by cows at the seventh lactation, which averaged 64.6 units, which was inferior to the animals of the sixth lactation by 36.9% ($P<0.05$). The low adaptation index was observed in the first lactation cows, which averaged 17.1 units and had high variability, which indicated a rather different reaction to the same conditions of the industrial complex.

Scientists indicate that the size of cows and accordingly, their live weight, has a major impact on feed consumption, which determines the level of dairy productivity (Kennedy *et al.,* 2003). Animals of different ages and the corresponding indicator of adaptation index were characterized by quite good indices of live weight, which indicated satisfactory conditions of feeding and exploitation, which, however, did not fully satisfy the needs of the organism.

In animals of the first lactation, the live weight averaged 593.4 kg in the second, it increased by 7.2% ($P<0.001$) to 639.2 kg and in the third by 4.1% ($P<0.001$) to the level of 672.2 kg. After the third lactation, probably due to some exhaustion and a negative value of the adaptation index, the live weight of cows in the fourth lactation decreased by 8.6% ($P<0.001$) relative to the indicator of the third lactation and averaged 618.9 kg. In the sixth and seventh lactations, the live weight of the cows stabilized at an average of 578.0-578.4 kg.

The analysis of the duration of the productive period in cows of the first to the seventh lactation showed that it exceeds the norm (305 days) by 1.33-1.50 times, that is, exceeds 400 days, which is obviously indicative of low reproductive ability and long, respectively, service period and period between calving.

Researchers (Kolver *et al.,* 2007) indicate that lactation in dairy cows can be continued beyond the standard (305 days) due to low efficacy artificial insemination, leading to an extended interval between calving. Several researchers have suggested that the causes of prolonged lactation may lie in the negative interrelation between milk secretion and cow fertility (Friggens *et al.,* 2010).

However, a prolonged lactation period provided a high overall level of milk productivity. Thus, in the first, second and third lactation period from animals was received, on average 10056.8, 10339.8 and 10495.6 kg of milk, which in terms of 4% was respectively 9789.7, 10068.7 and 10264.0 kg. In the fourth to fifth lactation, dairy production relative to the third lactation increased by 3.4% ($P<0.001$) and 3.3%.

During the sixth to seventh lactations, the level of milk productivity of animals reached the maximum value and averaged 11682.6 and 11124.3 kg of physical milk or 1155.3 and 10952.0 kg, respectively, of 4% milk.

The level of productivity of cows in terms of 305 days of lactation shows their genetic potential and to the greatest extent can characterize its realization with age that is in the context of lactations. In the first lactation cows were characterized by a relatively low level of milk yield, since it averaged 7868.1 kg of physical or 7648.4 kg of 4% milk, in the second lactation - increased by 9.6% ($P<0.001$) to 8705.8 kg of physical or 8479.8 kg of 4% milk, in the third lactation - increased by 2.4% ($P<0.001$) to 8919.5 kg of physical or 8729.0 kg of 4% milk.

After that, the adjusted level of cow productivity in the fourth lactation increased again by an average of 2.7% ($P<0.01$) and amounted to 9165.2 kg of physical or 8992.8 kg of 4% milk. Already at the fifth, sixth and seventh lactations, the level of animal productivity stabilized at 8956.6-9065.8 kg of physical or 8815.2-8909.6 kg of 4% milk.

Table 1: Adaptation index and productive quality of cows of different lactations, M±m.

Lactation of animals	Adaptation index	Live weight, kg	Duration of lactation, days	Dairy productivity, kg			
				Lactation		305 days	
				Physical milk	4% milk	Physical milk	4% milk
The first, n=4610	-7.1±7.09	593.4±0,35	433.8±2,26	10056.8±49.24	9789.7±48.68	7868.1±21.16	7948.4±20.97
Second, n=2839	-5.5*[1]±0,15	639.2±0,69	405.9±2.37	10339,8±58.143	10068.7±56.90	8705.8±31.56	8479,8±31.56
Third, n=1456	-5.4*[2]±0,23	672.2±0,98	404.6±3.53	10495,6±84.15	10264.0±81.10	8919.5±46.64	8729.0±45.24
Fourth, n=629	-5.7*[3]±0.34	618.9±2,01	412.3±5.40	10859.6±127.96	10650.6±124.63	9165.2±68.68	8992.8±67.48
Fifth, n=254	-5.7±0.52	583.7±1.49	411.3±7.53	10854.6±197.34	10665.3±194.59	9065.8±106.80	8909.6±106.61
Sixth, n=103	-7.3[1-3,4]±0.78	578.4±1.83	458.8±16.06	11682.6±372.50	11505.3±371.33	8956.6±166.52	8815.2±169.61
Seventh, n=47	-4.6**[4]±0.80	587.0±2.36	407.1±18.07	11124.3±483.76	10952.0±476.94	9028.5±194.73	8893.9±202.25

Footnote: 1. *[1-3] - P<0.05; ** [4] - P<0.05.

Over the last four decades, milk production per cow has increased dramatically in North America and Europe thanks to successful breeding programs, as well as improved feeding and containment systems (Bauman *et al.,* 2006).

Scientists indicate that milk composition depends on the feeding methods and genetic characteristics of the cows (Roca-Fernández *et al.*, 2012), as well as seasonal changes throughout the year (Heck *et al.,* 2009).

Analysis of the qualitative composition of cow's milk at different lactations showed that the mass fraction of fat was high enough and at the first and second lactations were at the level of 3.82 and 3.83%, respectively. In the subsequent, in the third - seventh lactation, this figure did not fall below, although it did not rise above the indicator of 3.89%, which was higher than the values of the first and second lactations in absolute terms, respectively by 0.07 and 0.06%.

The mass fraction of protein in cows' milk was substantially inferior to fat and averaged by seven lactations averaging 3.23-3.28%. The ratio of fat to protein in milk of lactating cows remained at the normal level, which ranged from 1.17-1.20.

According to the indices of milk yield and mass fraction of fat and protein in milk, their products were obtained from animals, the amount of which increased dynamically from the first to the seventh lactations. The dynamics of cow's milk protein production over seven lactations practically repeated the curve of milk fat production. Considering the total production of milk fat and protein from cows in different lactations, it should be noted that it also increased from the first to the sixth lactation and in the seventh only decreased slightly.

According to the size of the milk yield and live weight, the animals had different indicators of milk yield. In the second and third lactation, the indicator of the milk coefficient of animals was, on average, 1580.5 and 1564.1 kg. In the fourth lactation of cows, this ratio was higher by 9.4% (P<0.001) and 10.4% (P<0.001), respectively.

Significantly higher milk yields were in cows in the fifth lactation, which was at the level of 1863.2 kg and exceeded the value of animals in the fourth lactation by 6.3% (P<0.01). Animals in the seventh and sixth lactations had high milk yields, respectively, in 1921.9 and 2021.9 kg, which was higher than the fifth lactation cows by 3.1 and 7.8% (P<0.05). At the same time, the milk coefficient in animals of the first lactation was high enough, but the error of the mean indicated a large discrepancy in this indicator.

The intensity of exploitation of cows in different lactations shows that in the third to sixth lactations their coefficient does not exceed 23 kg of milk per day of period between calving and ranges from 23.2 to 23.9 kg. At the same time, this indicator in animals of the second lactation averaged 22.9 kg of milk, which is less than the value of cows in the third lactation by 2.4% (P<0.001). The highest rate of cow intensity exploitation was in the seventh lactation, where it averaged 24.2 kg, which was 5.2% more than animals in the second lactation (P<0.05). The lowest intensity of exploitation was in the first-heifers, where this figure did not exceed 21.0 kg.

For dairy cows, reproductive function will be high if effective artificial insemination occurs within the first three to four months after calving (De Vries, 2006). This is consistent with the negative genetic correlation between milk production and cow health (Ingvartsen *et al.,* 2003) and by production and reproduction (Berry D.P. *et al.,* 2003), although this negative association is not universal (Bello *et al.,* 2012).

A significant excess of normal lactation duration in Holstein cows indicated that a certain amount of loss of calves. Thus, animals in the second and third lactations received, on average, 0.32 head of calves and in the seventh - 0.33 heads. In the fourth to fifth lactations, these losses were slightly higher, averaging 0.34 heads. The highest loss of calves were in cows in the sixth lactation and averaged 0.51 heads, which was higher than the rate of cows of the fourth to fifth lactations by 33.3% (P<0.01) and the value of animals of the second and third lactations - by 37.3% (P<0.01). Large of loss of calves from a prolonged lactation period were observed in cows in the first lactation.

Delayed reproduction improves lactation resistance because the development of pregnancy has a negative effect on milk yield, especially in the last trimester of lactation (Brotherstone *et al.,* 2004). Infertility, which is a consequence of high metabolism, is a predicted physiological response

of the organism, not a pathological condition (Knight *et al.*, 1999).

Heredity determines and conditions of life make the development of the organism. However, in animals with approximately the same heredity under the influence of different environmental conditions (feeding, care and maintenance, features of operation), the formation of traits is not equally (Lopez *et al.,* 2015).

The large variability of such averages, such as adaptation index, milk yield and loss of calves at first-heifers, indicated that these indicators were not even. To clarify this issue, all first-heifers livestock have been formed into four groups, depending on the level of productivity.

At the first level of productivity (>12000 kg of milk, n=412), the index of adaptation of first-calf heifers averaged -16.6±0.27, at the second (8100-12000 kg, n=1442) -11.4±0.19, at the third (5100-8000 kg, n=2677) -3.4±0.014 and at the fourth (5000 kg, n=79) -5.5±1.59 units.

Scientists conclude that early identification of cows that are sensitive enough to adaptation problems allows the use of certain herd management strategies (Steeneveld *et al.,* 2013). Today, there is a wealth of knowledge about the early diagnosis of diseased cows (Trevisi *et al.,* 2012), but very little is known about the identification of animals with good ability to adapt to new lactation in specific ecological and natural conditions.

CONCLUSION

Holstein cows during adaptation to the industrial complex for milk production in ecological plasticity of the northern steppe of Ukraine provoke adaptation stability, under which the adaptation index does not fall below -7.1. In this case, in first-heifers this figure ranges from -3.4 to -16.6.

It is established that a slight disturbance of the organism and environment balance still provides the realization of productivity potential at the level of 7868.1 kg in the first standard lactation, 8705.8-8919.5 kg - in the second and third and in the seventh - 9028.5 kg. Annual loss of calves from low reproductive function is 0.32-0.51 heads for each Holstein cow.

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