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Cardiac rhythm variability method - an innovative decision in the area of modern dairy cattle breeding

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Abstract. The article discusses the method of heart rate variability as a test for early forecast of the potential of animal milk productivity. The correlation dependence of the milk productivity of cows of the Jersey breed with a stress index is provided. The article discusses the reduction of milk productivity of cows with the autonomic regulation of sympathicotonia in the process of economic use. The paper analyzes parameters of milk productivity of the experimental group of animals for different periods of time and the significant difference in milk productivity for different years is indicated.

1. Introduction

The study and identification of the adaptive capabilities of the cardiovascular system, the study of the relationship between the functional reserves of the cardiovascular system and the potential of milk production in order to form a highly productive herd is currently one of the priority areas of biological science.

The methods to evaluate functional states are various, but it is necessary to choose the ones making possible to get the maximum amount of information when registering a relatively small number of physiological characteristics. Such methods, in particular, include heart rate analysis. This method is unique, as it allows forecasting milk production. The results of scientific research make it possible to introduce an electrocardiographic examination of the cardiovascular system of first-calf cows and rearing heifers as a test for early prediction of the potential of animal milk production, which will increase the economic efficiency of milk production in enterprises of various ownership.

2. Materials and methods

The method is based on a mathematical analysis of the animal's heart rhythm.

Changing the heart rhythm is a universal reaction of the whole organism in response to any environmental impact. The average heart rate reflects only the final result of numerous influences on the circulatory apparatus, characterizes the features of the already established homeostatic mechanism. An important link in this mechanism provides a balance between the parasympathetic and sympathetic parts of the autonomic nervous system.

Various parts of higher levels of regulation and control of body functions influence the heart rhythm. The basic information about the state of the systems regulating the rhythm of the heart is contained in the "scatter function" of the duration of the cardio intervals. Sinus arrhythmia reflects the



complex processes of interaction of various circuits of the regulation of heart rhythm. The hierarchical structure of function management includes successive levels of humoral, hormonal autonomic and central (cortical) regulation. Certain anatomical and physiological structures correspond to these levels:

- 1) subcortical nerve centers providing autonomic homeostasis;
- 2) higher vegetative centers balancing the humoral-hormonal-vegetative control units of cortical mechanisms;
- 3) central nervous system, coordinating all control processes in the body in accordance with environmental conditions.

When evaluating the state of regulatory systems according to the mathematical analysis of heart rhythm, a number of parameters is distinguished that can be conditionally divided into three groups, corresponding to the levels of the control system.

Parameters M (mode), MA (mode amplitude), SI (stress index) characterize the state and interaction of the autonomic nervous system departments, or the so-called autonomous regulation circuit, where the main importance is given to the analysis of the respiratory component of sinus arrhythmia.

The relationship of milk productivity and the functional state of the cow's body has been studied by many authors.[1,2,3].

It is proved that congenital functional reserves provide the initial power of adaptation mechanisms and they are not the same in different animals. The technique allows mathematical evaluation of the functional reserve of the animal organism and is used for cows of black-motley, Jersey breed. The authors established the parameters of the initial vegetative tone (IVT) by the stress index (SI) and the relationship with the milk productivity of cows of the Jersey breed [4,5,6].

The issue of reducing milk productivity of cows in the process of economic use is urgent. It is necessary to analyze parameters of milk productivity of the experimental group of animals for different periods of time.

The study of the dynamics of milk productivity of cows with different initial vegetative tone (IVT) is an urgent issue, as this makes it possible to establish a correlation relationship between these parameters. Such studies, along with the study of other factors, will make it possible to forecast the milk productivity of cattle in the early stages, which will lead to an increase in the economic efficiency of production. The studies by the authors show that sympathetic vegetative regulation predominates in the first calf cows of the Jersey breed. According to the researchers [1, 2], the number of sympathicotonicity in the animals studied is 48 %. It is established that at the initial stages of economic use, sympathicotonic cows are characterized by the highest milk productivity in comparison with other groups of animals having a different initial vegetative tone according to the stress index (SI). However, the issue of the stability of this pattern is not described in the literature. Therefore, there is a need for research in this direction.

The studies were carried out in the livestock complex of Vakinskoye Agro LLC in 2016 and 2018, on cows of the Jersey breed in the amount of 103 heads.

The tests included a clinical and cardiointervalometric study. A clinical examination was conducted to exclude nosology. Cardiointervalometric study took place for establishing the initial vegetative tone of the studied animals.

A clinical examination and a general study of the cardiovascular system were carried out according to the methods of clinical examination of animals by B.V. Usha. Clinical parameters included: examination and determination of the general condition of the animal by hairline, skin and mucous membranes.[7,8,9].

For cardiointervalometry, the CONAN – 4.5 comprehensive electrophysiological laboratory was used in the frontal lead system according to Roschevsky method 2-3 hours before a meal.

For further studies, animals with an initial autonomic tone of sympathicotonia were selected and an experimental group was formed.

The evaluation of milk productivity took place in 2016 (lactation 2) and in 2018 (lactation 4).

During the period of the study, the animals were in the same conditions of feeding and keeping in accordance with zoohygienic requirements.

Statistical processing of the results was carried out in Statistica 10 program with the calculation of the following parameters: arithmetic mean (M), arithmetic mean error (m), Student's t-test. The differences were considered significant at $p < 0.05$.

3. Results

The milk productivity of cows on the second lactation with the initial vegetative tone of sympathicotonia was compared to the milk productivity of cows with other established levels of vegetative regulation.

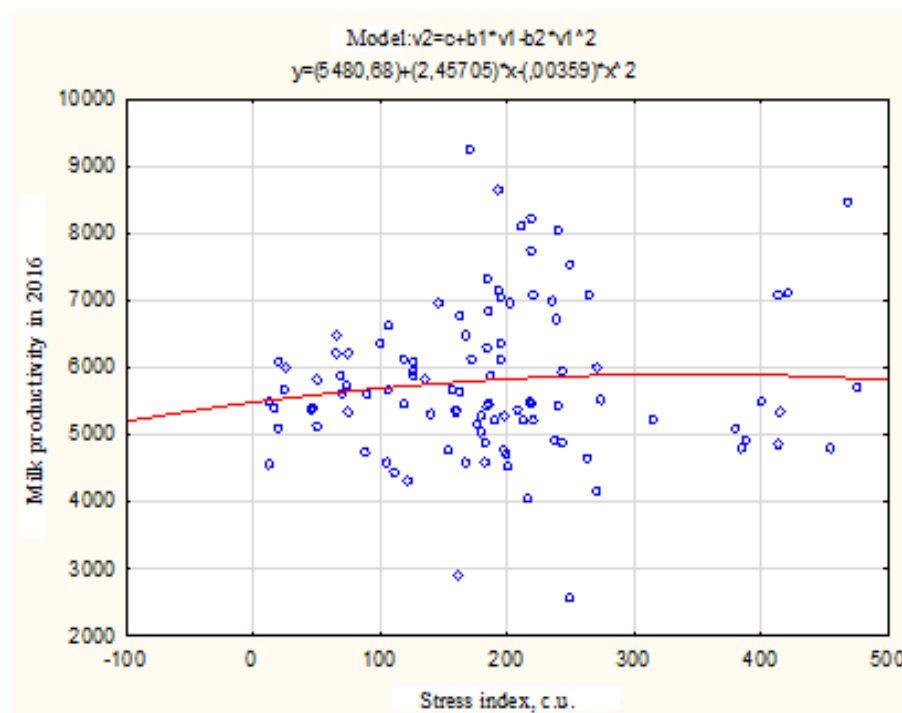


Figure 1.Parabolic dependence of milk productivity of Jersey breed cows with a stress index of the body's regulatory systems for 305 days (2016)

The analysis of Figure 1 shows that with an increase in the stress index, an increase in milk productivity occurs first (the branch of the analyzed parabola rises), and then a gradual decrease (the branch of the analyzed parabola is directed down), this is associated with a decrease in the level of milk productivity for 305 days. The parabolic function is more visual, because it reliably takes into account both hypersympathicotonic and vogotonic influences. The peak of the analyzed parabola is in the range of SI = 151 - 250 c.u. This is explained by the fact that the highest level of milk productivity for 305 days is observed in cows of the Jersey breed and the assumed initial vegetative tone is sympathicotonia. The correlation dependence of milk productivity of Jersey breed cows with a stress index for 305 days in 2016 was $y = 5,480.68 + 2.5x - 0.00359x^2$, the correlation coefficient was 0.55 and the determination coefficient was 30.49 % at $p < 0.05$.

Cows with initial vegetative tone of sympathicotonia were selected for further studies.

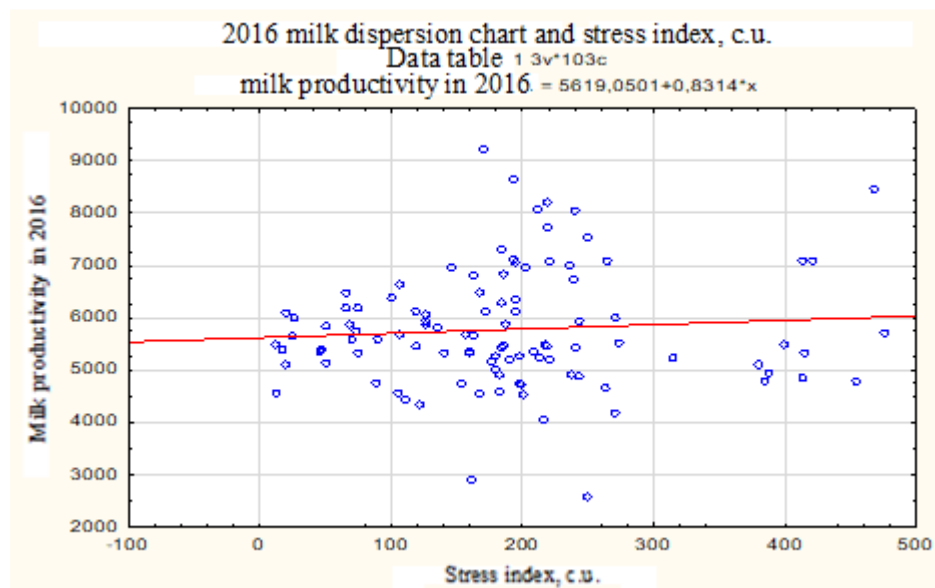


Figure 2. Dairy productivity for 2016

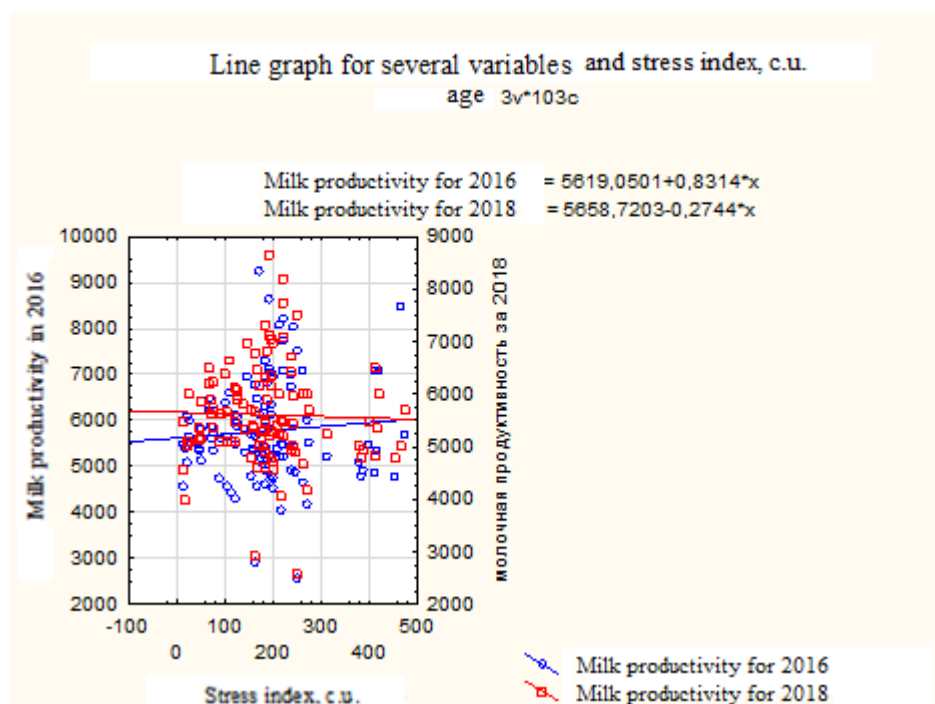


Figure 3. Diagram of dispersion of milk productivity of Jersey breed cows for 305 days for the period 2016 and 2018 with a stress index

In the course of the research, the analysis of the milk productivity of cows with the initial vegetative tone of sympathicotonia was made in dynamics. The initial vegetative tone was established by the stress index. The milk productivity of the study group for 305 days was $5,903 \pm 196$ kg. The analysis of the milk productivity of the experimental animals in the fourth lactation in 2018 was carried out, which revealed that this parameter decreased by 3.26 % and amounted to $5,710 \pm 150$ kg (Table 1).

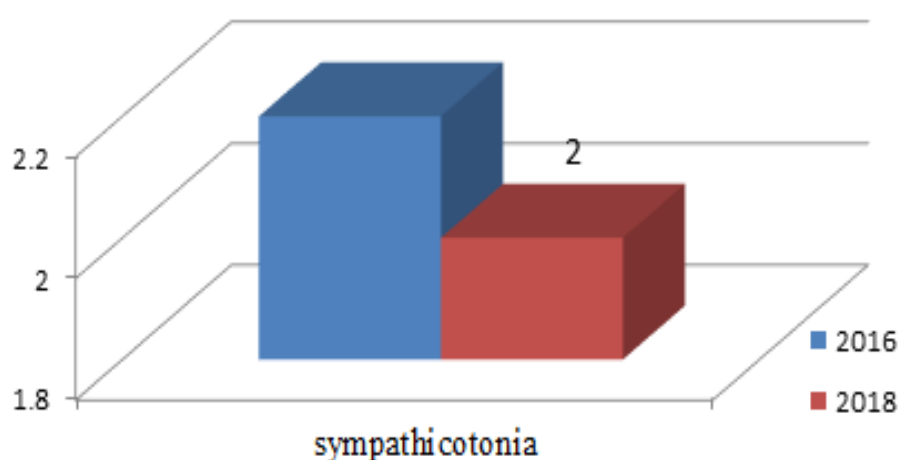
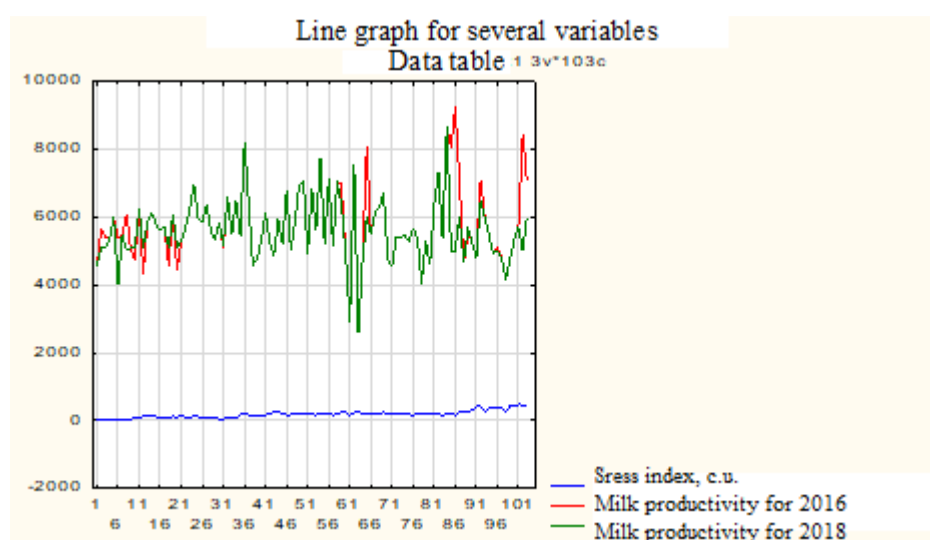
The difference between the parameters was 193 kg.

Table 1. Age-related changes in milk productivity of cows with different IVT, $M \pm m$

SI, c.u.	IVT by SI	Milk productivity for 305 days, kg			
		2016	2018	Difference	%
151-250	sympathicotonia	5,903 \pm 196*	5,710 \pm 150*	-193	326

Note:* indicates a significant difference in milk productivity in 2016 and 2018 relative to the initial vegetative tone (IVT) - $p < 0.05$

The difference in parameters was 193 kg. A clear decrease in milk productivity of cows with age can be seen in Figure 2.

**Figure 4.** Decrease in milk productivity with the age of cows**Figure 5.** Variation in milk productivity by years (2016 and 2018)

Negative dynamics can be explained by the tension of regulatory mechanisms in response to the load provided by the lactation process. The functional reserves of sympathicotonics are quite enough to maintain homeostasis in the initial stages of lactation. However, in the future, the process of

mobilizing strategic reserves is included, which is regulated by the central circuit. It is possible that cows with the initial vegetative tone of sympathicotonia regulation do not have a sufficient pool of congenital functional reserves to ensure the long-term lactation process.

4. Conclusion

Thus, in the course of studies it was found that cows with the initial vegetative tone of sympathicotonia have some negative dynamics in milk productivity, a decrease of 3.26 %.

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