GENETIC AND POPULATION ANALYSIS

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THE ROLE OF MITOCHONDRIA IN THE FORMATION OF THE BIOPHYSICAL POTENTIAL OF THE BODY AND THE MANIFESTATION OF HETEROSIS

Research article

Abstract

A retrospective analysis of the theoretical developments of the causes of the phenomenon of heterosis has been carried out. In connection with new scientific achievements of the fundamental sciences, various hypotheses of heterosis have been revised. A new hypothesis has been proposed, according to which heterosis is explained by the relationship between genetic heterozygosity and the high initial potential of free energy of germ cells, caused by increased work and reproduction of mitochondria. This work of mitochondria is regulated by the hypothalamus in response to signaling by free radicals and humanin of the conditions of interaction between the nuclear and mitochondrial DNA of parental individuals of different breeds (cultivars) caused by environmental factors, for example, stress, a certain force within the limits of the species reaction. As a result of incomplete interaction between nDNA and mtDNA of different breeds, a sharp increase in the work of mitochondria occurs, enriching the hybrid with energy, which is accepted as hybrid strength or heterosis. Various ways of improving the work of mitochondria are considered, which can enhance heterosis and, at the same time, increase the productivity of animals and plants.

Keywords: heterosis, crossing, mitochondria, energy, mtDNA.

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РОЛЬ МИТОХОНДРИЙ В ФОРМИРОВАНИИ БИОФИЗИЧЕСКОГО ПОТЕНЦИАЛА ОРГАНИЗМА И ПРОЯВЛЕНИИ ГЕТЕРОЗИСА

Научная статья

Аннотация

Проведен ретроспективный анализ теоретических разработок причин явления гетерозиса. В связи с новыми научными достижениями фундаментальных наук пересмотрены различные гипотезы гетерозиса. Предложена новая гипотеза, согласно которой гетерозис объясняетс взаимосвязью между генетической гетерозиготностью и высоким начальным потенциалом свободной энергии половых клеток, вызванных усиленно работой и размножением регулируется гипоталамусом в ответ на сигнализацию свободными радикалами и белком гуманином условий взаимодействия между ядерной и митохондриальной ДНК родительских особей разных пород (сортов), вызванных определённой силы в пределах нормы реакции вида. В результате неполного взаимодействия между яДНК и мтДНК разных пород происходит резкое увеличение работы митохондрий, обогащающее гибрид энергией, что и принимается как гибридная сила или гетерозис. Рассмотрены разные способы улучшения работы митохондрий, что может способствовать усилению гетерозиса и вместе с тем – увеличения продуктивности животных и растений.

Ключевые слова: гетерозис, скрещивание, митохондрия, энергия, мтДНК.

1. Introduction

The phenomenon of heterosis or hybrid vigor, which consists in the superiority of first-generation hybrids over the original forms in terms of growth intensity and viability of the organism, is a unique phenomenon that is not fully understood, but is very widely used in the practice of crop and animal husbandry. To explain the causes of heterosis, various hypotheses were put forward, which we described earlier [1], [2]. Some scientists explain heterosis by the heterozygosity of hybrids at many allelic loci, which provide hybrids with a biochemical advantage, others – by the transition of non-allelic recessive genes when crossing into a heterozygous state, others – explain the advantage of hybrids by the heterozygosity of alleles of the same locus (monohybrid heterosis). However, at the same time, cases of excess yield of hybrids of the first generation over the sum of yields of both parental forms, lack of fixation of heterosis in subsequent generations of breeding hybrids "in themselves" and the possibility of separating individuals homozygous for most dominant factors [3] are not explained. Hypotheses of heterozygous balance [4], [5] of biochemical enrichment of hybrids [6], [7] and others also do not provide an answer to all such facts. The practice of animal husbandry also shows that the effect of heterosis appears only in hybrids of the first generation, and then it fades.

In the problem of heterosis, attention is drawn to the fact that in hybrids there is no increased development of any individual traits due to certain genes, as one might expect, according to the hypotheses of dominance or overdominance, but viability generally increases. For example, [8] gives examples showing that heterotic plant hybrids do not differ from the original lines in terms of the number of protein fractions and isoenzymes, while hybrid proteins do not outperform "pure" types in functional terms. It turns out that with heterosis, most systems develop better than in the original forms, all metabolic processes are enhanced. Heterosis is more prone to traits with low heritability, while traits caused by the additive action of genes, characterized by high heritability, are weakly affected by heterosis [9]. A distinctive feature of heterosis is not superiority in some individual traits due to specific genes, that is, their expression, for example, in eye color, hair length and color, etc., but the overall better development of crossbred individuals. Even Shull [10], one of the founders of the theory of heterosis, believes that "this is a more"diffuse"phenomenon that is not amenable to genetic analysis" and this is its main difference. All these hypotheses, despite the presence of a huge amount of factual material on heterosis, inbreeding depression and various aspects of their manifestation, do not reveal the specific mechanisms of allelic and non-allelic interaction of genes, do not explain the causes of all cases of manifestation of heterosis.

In all these hypotheses, the most important factor was not taken into account – the role of energy in the manifestation of heterosis and inbreeding depression. Based on the second law of thermodynamics, the theoretical provisions of E.S. Bauer [11], his principle of stable non-equilibrium of living systems, recognized by many biologists and philosophers as a universal law of biology, from the theory of I.I. Prigogine [12], energy has its own specific laws of transformation in a living organism. E.S. Bauer [11, P. 143] writes: “The continuous neoplasm of germ cells from generation to generation in multicellular organisms occurs as a result of the process of death of body cells due to the structural energy of the latter, just as the reproduction of unicellular occurs due to the structural energy of those parts of the cell, which will inevitably die. To prove the influence of the characteristics of maternal energy exchange organism, the conditions of its existence on the formation of the potential of germ cells, all the more so to clarify the ways of forming their energy potential depending on the genotype, environmental conditions, to find ways to influence it extremely difficult. To do this, you can use the concept of biophysical potential proposed by Voeikov V.L., by which he understands that part of the free energy that living matter has as a result of its non-equilibrium state [13]. On this basis, as well as on the data obtained in various observations and experiments, it is possible to formulate certain theoretical propositions and answer many specific questions.

2. Material and research methods

A retrospective analysis of theoretical developments on the causes of the phenomenon of heterosis has been carried out. In connection with the new scientific achievements of the fundamental sciences, various existing hypotheses of heterosis, the reasons that cause them, are considered. Particular attention is paid to modern developments on mitochondria as energy structures of cells, on the interaction of nuclear (nDNA) and mitochondrial DNA (mtDNA), on free radicals, peptides that transmit signals to the hypothalamus, which regulates most of the life processes in the body and affects its biophysical potential, for the manifestation of heterosis. A general scheme of the manifestation of heterosis (biophysical potential) is presented in different variants of purebred breeding, inbreeding, interbreeding, taking into account the interaction of nDNA and mtDNA.

3. The discussion of the results

We believe that the phenomenon of heterosis is associated not only with genetic information (overdominance, etc.), as is interpreted in most works, but also with the free energy of germ cells of the original forms, that is, with their initial potential [14]. In our opinion, the nature of the manifestation of heterosis is due to the higher energy potential of the tissues of hybrid organisms, placing them on a higher level of non-equilibrium (or stationary) state compared to inbred and outbred organisms.
In our hypothesis [15], [16], we take into account that energy and life are inseparable, that the main thing in the manifestation of heterosis is not only and even not so much genetic information, but the role of energy as a key element in the formation of the initial potential of germ cells, which depends on the work of mitochondria, from the specifics of individual development and aging of the original forms and hybrids.

We believed that the burst of viability occurs as a result of a combination of two processes – a higher level of free energy of germ cells of inbred individuals, or individuals subject to stress due to a narrower reaction rate, on the one hand, and high biochemical enrichment due to the heterozygosity of hybrid individuals possessing low energy demand on the other hand. That is, heterosis is a manifestation of gene-energy resonance during fertilization and development) [1], [15]. This formulation of the formation of the initial potential of germ cells is based on their dependence on the rate of individual development, on the influence of stress on the body. A number of experiments by various scientists are given, in which the germ cell is enriched with energy at the expense of the energy of the whole organism and depending on the conditions of its vital activity. When the organism is subjected to certain stresses (within the limits of the normal reaction rate of the species), the more energy accumulates in the eggs and spermatozoa, the effect of heterosis is more pronounced when the parents are under developmental stress. In individuals exposed to stress, that is, in an excited state of body structures that perceive an external, in a sense, damaging signal, the germ cell acquires the ability to extract energy from the environment and, thereby, increase its biophysical potential [16].

So, in experiments on quails under the influence of a stress factor, males with a better reproductive ability are obtained than males whose parents were in normal environmental conditions [17]. Similar results were obtained in experiments on beetles (Tribolium castaneum), when under stress conditions, i.e., with a lack of essential amino acids in the feed, heterosis in larval weight was significantly higher than under normal feeding conditions [18]. With inbreeding, the reaction rate of animals, as opposed to crossing different breeds and lines, becomes narrower, they are more easily stressed. Inbred individuals more often violate the boundaries of physiological adaptation, they are more susceptible to stress, and their aging proceeds faster [19], [20], [21]. It can be said that in animals subjected to stress, including inbred animals, the level of non-equilibrium of living matter is maintained more intensely, which leads to a higher metabolism, rapid wear and aging. Consequently, in stressed organisms, as well as inbred individuals, due to a decrease in the potential of somatic cells, generative cells turn out to be more enriched with energy substances and have a greater biophysical potential compared to organisms under optimal environmental conditions. That is, the germ cells of inbred individuals have a higher biophysical potential, despite the reduced somatic potential. So, in the studies of Dogadaev A.M., Moiseeva I.G. in inbred hens, in comparison with outbred hens, the most important parts of the eggs (yolk fat, the number of solids and yolk lipids) even increase in quantitative terms [22], [23]. The viability of spermatozoa of inbred sires of cattle is higher than that of outbred cattle, and the closer the inbreeding, the higher the viability [24] and the fertilizing ability of sperm. The activity of the frozen-thawed sperm of such bulls is higher by 0,06-0,15 points, its fertilizing ability is by 1,8-4,4% [25]. In our studies, inbred boars also had an advantage over outbred boars in terms of multiple pregnancies of the queens that happened to them.

It has been established that, in response to stress, mitochondria signal their metabolic state to the nucleus and other cells by releasing free radicals [26], [27], sending signals to the hypothalamus, which controls energy metabolism, cardiac activity, respiration, sleep, body temperature, and hunger. The hypothalamus is a link between the nervous and endocrine systems, affects the sexual and reproductive behavior of the body. It directs energy either towards the growth and development of the body or towards enriching the energy of oocytes, spermatozoa, that is, towards reproduction. In conditions of intensive growth or productivity of animals, in the presence of metabolic syndrome, mitochondria increase their activity, multiply intensively, but at the same time release a large number of free radicals that prevent the movement of spermatozoa, the development of eggs, zygotes and send signals to the hypothalamus to inhibit the reproductive function. In conditions of insufficient life support, the body, on the contrary, seeks to reproduce its own kind as soon as possible, increase life expectancy through generational change, release few free radicals, which is also regulated by the hypothalamus. That is, animals with a high level of metabolism quickly form free radicals and live a short life, while animals with a low level of metabolism form free radicals slowly and live long [28]. In particular, this pattern can be attributed to modern animal husbandry with its problem of high productivity, the presence of metabolic syndrome, but a low duration of economic use, when cows instead of 6-8 calvings are culled after 2-3 calvings for various diseases [29].

However, in this interpretation of the essence of heterosis, in which the stress phenomena of the original forms play a significant role in the phenomenon of heterosis, due to which the energy potential of generative cells increases, affecting the overall viability of the organism, not all of its manifestations can be explained. It was not clear where the additional energy comes from during the manifestation of heterosis during crossing under normal conditions of existence, that is, in the absence of stress and inbreeding, and what signaling pathways contribute to its accumulation.

In our previous hypothesis, we did not attach much importance to the main energy machine of the body – mitochondria, we did not attach much importance to the main energy machine of the in particular, mitochondrial DNA (mtDNA), which is located in the ring chromosome. The successful operation of mitochondria depends on the interaction of proteins encoded by the nuclear and mitochondrial genomes [29]. Mitochondrial functions affect not only the supply of energy to the cell, but also vital processes such as apoptosis, fertility, sex, heat supply, disease, and aging. Relatively recently, it was discovered that mtDNA is inherited only through the maternal line (1974), which, in our opinion, is very important for considering the nature of heterosis. During sexual reproduction, recombination and rearrangement of nuclear genes occurs, that is, maternal and paternal genes mix, but paternal and maternal mitochondrial DNA do not mix. Apparently, the phenomena of heterosis and inbreeding depression are associated with the interaction of these two genomes. Lane Nick [28] believes that the coadaptation of mitochondrial and nuclear genes is of exceptional importance; their mismatch affects the rate and efficiency of respiration. In his opinion, "Any mismatch between the work of proteins encoded in the nucleus and proteins encoded in mitochondria is fraught with disaster." With purebred breeding, hybridization of individuals of different breeds, species, a combination of nuclear (nDNA) with mtDNA occurs, and in different ways. It can be assumed that in a hybrid organism, mitochondrial and nuclear genes do not interact sufficiently coordinated due to their different structure, they need additional energy, so mitochondria release not only free radicals, but also some peptides that send a signal about a lack of energy to the hypothalamus, and it carries out the regulation of the energy potential of germ cells, the result of which is its significant increase, which is accepted as heterosis.

When crossing, as a rule, different genes go into a heterozygous state. These genes are “unfamiliar” with each other, they can interact poorly with each other in terms of molecular bonds, in terms of the energy of these bonds. A kind of stress arises in these heterozygotes – there is not enough energy for their normal interaction. The mismatch between mitochondrial and nuclear genes affects the rate and efficiency of respiration [28]. This leads to the fact that mitochondria are forced to increase their activity or multiply faster in order to deliver additional energy to normalize the interaction between allelic genes. As previously shown [30], GC nucleotides require less energy for RNA and protein formation than AT nucleotides. At the same time, if opposite alleles are found in the same locus in the heterozygote, for example, GC and AT, then more energy will be required for protein synthesis, and the need will be covered only by additional reproduction of mitochondria.

Thus, relatively recently, the works of Nir Barzilai and Pinchas Cohen have appeared, shedding light on this process. Sexual and reproductive behavior has been found to be influenced by an important peptide, humanin, a 24-amino acid peptide encoded in the 16S rRNA gene produced by mitochondria, which is encoded in the mitochondrial genome, circulates throughout the body and is directly associated with the hypothalamus, which is the control center of energy metabolism [31], [32], [33], [34].

It is believed that humanin may be an ancient mitochondrial signaling mechanism that is key to regulating the health and longevity of the body. In many animal species, humanin levels decrease with age. A higher level was observed in long-lived organisms, but they had fewer offspring. That is, there is a relationship between longevity and reproduction, due to the use of energy to produce a large number of offspring or to sustain life. In addition, humanin protects cells from oxidative stress. It is assumed that humanin is the link that provides the "main process" according to Bauer E.S. (1935), which allows a living system to repeatedly "rejuvenate" and re-enter the development phase while maintaining high vitality, to maintain the constant viability of a living system, despite the death of an individual. The constant process of fission and fusion of mitochondria that occurs in the body helps maintain their optimal function, allowing them to adapt to periods of nutrient restriction or excess [36].

The mitochondria get their orders from the cell nucleus, where the vast majority of DNA resides, but there is a feedback loop by which the mitochondria inform the nucleus about their own health and energy metabolism in the cell as a whole. The nucleus responds with changes in transcription based on association with mitochondria. It is assumed that there is a mechanism to control the evolution of the mitochondrial genome, efficiently functioning mitochondria are encouraged to reproduce. The most powerful stimulator of the growth of new mitochondria is exercise [26].

It can be assumed that when using inbreeding (pure breeding), the body is subjected to a certain degree of stress due to low adaptability to the environment, as a result of which the body lacks energy. Its mitochondria scavenge free radicals, which signal this to the mtDNA, which in turn increases mitochondrial production to replenish energy. This is facilitated by a high mutation rate in mitochondria, which is 20 times higher than in the nucleus. However, this is fraught with the fact that the altered genetic composition of mtDNA may not be consistent with the work of nuclear genes, and cells require even more energy. Then the humanin peptide sends a signal to the hypothalamus, which is the regulator of the process of directing energy towards the growth and development of the body or enriching oocytes and spermatozoa with energy. There is an increased work of all systems of the animal's body, an increase in the growth and productivity of farm animals due to the better energy supply of all cells and systems. A phenomenon called heterosis occurs, which is associated not so much with the heterozygosity of genes, but rather with an increased biophysical potential of the organism. We can say that heterosis is an increased vitality – the vitality of the body. Then they find explanations for the difficulty of explaining the essence of the causes and consequences of heterosis, the various hypotheses and theories cited above, for example, about the lack of fixation of heterosis in the second and subsequent generations of crossing.

We give an approximate scheme for the formation of the energy potential of germ cells and the zygote, taking into account the impact on the maternal organism of a physiologically moderate level of stress (Table 1).

In option 1a, animals of breed A are subjected to various types of stress, as a result of which the zygote of the offspring received maternal mtDNA, which may not always be consistent with the work of nuclear DNA, and, despite the absence of heterozygosity in nuclear DNA, the zygote was enriched with energy due to the stress received by the maternal organism, but mismatched with nuclear DNA and the organism exhibits a phenomenon similar to heterosis of small force.

In option 1b, the work of nDNA and mtDNA is coordinated with each other, there is no additional heterozygosity of the offspring genotype, no additional energy is required, and heterosis does not appear, that is, the biophysical potential of the organism does not increase. In variants 2a and 2b, with purebred breeding of breed B, we observe a similar difference between these subgroups.

Table 1 – Influence of nDNA and mtDNA in the offspring genotype under stress, inbreeding, and crossing on the biophysical potential of the zygote

Mating type, breeding options	Variants of genotypes	Male	Female	Generation of offspring	Offspring genotype F1	Biophysical potential of the zygote, + -
Purebred breeding of breed A under stress, inbreeding	1a	AAC	AAC*	F1	AA C*	+
Purebred breeding of breed A, control	1b	AAC	AAC	F1	AA C	-
Purebred breeding of breed B under stress, inbreeding	2a	BB D	BB D*	F1	BB D*	+
Purebred breeding of breed B, control	2b	BB D	BB D	F1	BB D	-
Crossbreeding A and B		AAC*	BB D*	F1	AB D*	+ +
		BB D*	AA C*	F1	BA C*	+ +
		AAC*	BB D	F1	AB D	+
		BB D*	AAC	F1	BA C	+
1st breeding option "in itself", (Paternal and maternal individuals are stressed		AB D*	BA C*	F2	AA C*	+
					AB C*	+ +
					BA C*	+ +
					BB C*	+
2nd breeding option "in itself", (Paternal is stressed)		AB D*	BA C	F2	AA C	-
					AB C	+
					BA C	+
					BB C	-

End of the Table 1 – Influence of nDNA and mtDNA in the offspring genotype under stress, inbreeding, and crossing on the biophysical potential of the zygote

Mating type, breeding options	Variants of genotypes	Male	Female	Generation of offspring	Offspring genotype F1	Biophysical potential of the zygote, + -
3rd breeding option "in itself", (Maternal is stressed)		AB C	BA D*	F2	AA D*	-
					AB D*	+
					BA D*	+
					BB D*	-
4th breeding option "in itself", (Paternal and maternal individuals are not stressed)		AB C	BA D	F2	AA D	-
					AB D	+
					BA D	+
					BB D	-

Note: A, B – animal breeds, plant varieties; AAD, ABD*, BAD*, BBD* – mtDNA of individuals of breed A subjected to stress and their descendants, whose mtDNA was obtained from parents subjected to stress. AAC*, AB C*, BA C*, BB C* – mtDNA of individuals of breed B subjected to stress and their descendants, mtDNA of which was obtained from parents subjected to stress*

When crossing breeds A and B, the genotypes of the descendants of ABD*, BAC* (variants of genotypes 1 and 2) are not only heterozygous, but their mtDNA is enriched with energy due to the increased reproduction of mitochondria caused by the stressful conditions of their mothers, their mtDNA and nDNA are not consistent with each other, since they have not previously met, therefore, the zygotes of these animals are enriched with energy due to a signal from the hypothalamus and exhibit the highest heterosis as a result of crossing parents (++). The ABD and BAC genotypes are heterozygous, but they have not been subjected to stress, they do not have any inconsistency between dna and mtDNA, therefore they exhibit weak heterosis (+) due to genetic heterozygosity or do not have it at all.

When breeding "in-itself" genotypes, 4 variants of hybrids may appear in which they were stressed: paternal and maternal individuals AB D* and BAC*; only paternal AB D* and BAC; only maternal AB D and BAC*; both individuals AB D and BACwere not stressed.

Animals with the genotype AAC, BBC, AAD and BBD are homozygous and have not been subjected to stress, therefore they do not show any heterosis (-).

Genotypes AA C*, BB C* and AAD*, BBD* are enriched with energy due to the stress received by their mothers, but they are homozygous and, therefore, like heterosis have improved growth, productivity (+).

Animals with genotypes: ABC*, BAC*, ABD*, BAD* are heterozygous for nDNA and also have a conflict between nDNA and mtDNA [28], requiring pumping them with energy, as a result of which they are energetically enriched, therefore they exhibit the highest biophysical potential (heterosis) (++).

The above provisions characterizing the exchange of energy in the body lead to a different understanding of the various aspects of animal adaptation to environmental conditions. A promising way to improve the reproduction of animals can be actions leading to the intensification of metabolism and energy, increasing the level of adaptation, including the work of natural hormonal regulators of reproduction during the maturation of germ cells. The use of moderate physiological stresses that do not deplete adaptive capabilities, but create energy conditions for switching on the main process, that is, the formation of the initial potential of free energy of germ cells, is useful for the body. They are also a condition for the manifestation of heterosis during interbreeding.

It should be taken into account that the viability of an organism depends on the level of free energy (mitochondria) obtained by germ cells due to the energy of aging cells of the mother organism, due to apoptosis. In this case, the eggs acquire an initial supply of biophysical energy, which has the potential ability to extract energy from the environment. During the period of oogenesis, the process of rejuvenation of the system takes place, and at all other stages of the life of the organism, the aging process occurs.

The phenomenon of heterosis is used all over the world, both in animal husbandry and in crop production, it brings many billions of dollars in profits. Seeds of various plants with the stamp F1 are widely used, that is, seeds obtained from crossing different breeds of animals, plant varieties. However, the scientific meaning of this F1 effect is understood and used all over the world, paradoxically, incomplete.

With the correct knowledge and interpretation of this phenomenon, undoubtedly, its use will be much more effective, giving new directions and perspectives to the study of it. Considering the above characteristics of the phenomenon of heterosis, we propose the following interpretation of this phenomenon.

3. Conclusion

Heterosis is explained by the relationship between genetic heterozygosity and the high initial potential of free energy of germ cells, caused by increased work and reproduction of mitochondria. This work of mitochondria is regulated by the hypothalamus in response to signaling by free radicals and humanin about the problems of interaction between the nuclear and mitochondrial DNA of parental individuals of different breeds (cultivars) caused by environmental factors, for example, stress, a certain strength within the norm of the reaction of the species.

In the human and animal body, biophysical energy, through the interconnection of mitochondria and the hypothalamus, is redistributed to the energy of growth (productivity), on the one hand, and the energy of reproduction, on the other, depending on the level of metabolic activity and environmental conditions:

- under favorable conditions of nutrition and life, feeding and keeping animals, high metabolic and mitochondrial activity of the body, absence of stress, an increase in the production of reactive oxygen species negatively affects the body. The fertility and duration of the economic use of farm animals is decreasing. At the same time, an increased level of free radicals can be useful as a neutralizer of various viruses and bacteria, especially those with easily oxidized lipid membranes.

- under unfavorable living conditions, under the influence of moderate stress, reduced activity of mitochondria, reduced metabolism, the body is more exposed to infections due to insufficient levels of free radicals that can neutralize infectious agents. The energy of the body switches to the reproductive function, which is carried out through the hypothalamus with the help of free radicals and a special protein - humanin, produced by the mitochondrial genome.

It is proposed empirically to establish the optimal level of antioxidant activity and lipid peroxidation, that is, the antioxidant status of protection of the breeding stock and bring it back to normal by normalizing the stress load on the body, using enzymatic (catalase, glutathione peroxidase) and non-enzymatic (vitamins, thiols, lipoic acid, etc.) factors. This will allow using various feed, technological, pharmacological factors, genetic markers to bring the concentration of free radicals and antioxidant activity, fatty acids, cholesterol to a physiologically balanced level, ensuring high productivity, fertility and viability of animals (cows, sows) and ensure the quality of the resulting livestock products (milk, meat, lard, etc.). The data obtained in various observations and experiments make it possible to formulate certain theoretical premises (hypotheses), stimulate scientific thought and answer many specific questions.

It is proposed to develop a methodology for the integral assessment of the viability of people and animals, similar to the selection index used in animal husbandry. This assessment includes the most important signs of vital activity, such as, for example, the level of antioxidant protection (biophysical potential), age, productivity and viability of ancestors, hereditary diseases, genetic markers, etc., with a determination of significance for each of them. Such an indicator will be the closest to reality integral assessment of the vitality of a living organism, or the productivity of an animal at every moment of life, which can be called the Vitality of an organism. It can be used to determine the strategy for improving the viability, reproductive function, productivity of animals and plants, disease control, the duration of the economic use of farm animals and old age in each case.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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