DOI: 10.37000/abbsl.2026.118.16
УДК: 636.083:614.9

Zoia YEMETS,
Ph.D. of Agricultural Sciences, Associate Professor,
Associate Professor at the Department of the Department of Genetics,
Breeding and Feeding of Farm Animals,
ORCID ID: 0009-0007-1507-9734
e-mail: zoyaemets@gmail.com

Igor NIKOLENKO,
Ph.D. of Agricultural Sciences, Associate Professor,
Head of the Department of Genetics,
Breeding and Feeding of Farm Animals,
ORCID ID: 0000-0002-8581-4569
e-mail: igor.nikolenko.87@ukr.nete-mail

Iryna HONCHAROVA,
Ph.D. of Agricultural Sciences, Associate Professor,
Associate Professor of the Department of Genetics,
Breeding and Feeding of Farm Animals,
ORCID ID: 0000-0003-0190-7803
e-mail: irina.i.goncharova@gmail

Oksana SHEVCHENKO,
Ph.D. of Agricultural Sciences, Associate Professor,
Associate Professor of the Department of Genetics, Breeding and
Feeding of Farm Animals,
Odesa State Agrarian University, Odessa, Ukraine
ORCID ID: 0000-0002-6747-5487
e-mail: sksena76@gmail.com

APPLICATION OF MODERN GENETIC SELECTION METHODS IN LIVESTOCK PRODUCTION

Abstract

The article is descriptive and review-based and is devoted to the analysis of the use of modern breeding methods in animal husbandry. The breeding process is highlighted as an important component of the agricultural sector, since it contributes to the improvement of the genetic *characteristics of animals. The most effective breeding methods in animal husbandry and the agricultural sector are also described. It is emphasized that the theoretical basis of breeding is genetics and only a deep knowledge of the laws of variability and inheritance of traits will allow the breeder to competently plan and conduct breeding work. It is indicated that in addition to genetics, the breeder must have thorough knowledge of the biology of the selected object of study, the laws of its reproduction, growth and development of its individuals, their resistance to infectious diseases and other adverse environmental factors. Thus, the article highlights that breeding programs for the creation of new plant varieties and animal breeds, first of all, are firmly based on genetic principles, relying on the laws of genetics. The article also describes how genetic and breeding research on farm animals is key to increasing the productivity and quality of agricultural products. It also considers how modern animal husbandry, using the achievements of basic biological sciences, including DNA technologies, leads to increased economic efficiency in the agro-industrial complex. It is emphasized that quantitative traits in animals are particularly important, including milk production, milk composition, meat and carcass quality, fertility, as well as resistance or susceptibility to infections. It is also described that these traits are mainly polygenic, which is the result of the interaction of several genes. As a result, it is emphasized that the development of economically useful traits is also of crucial importance, and chromosome maps of farm animals are necessary, which increases the likelihood of detecting polygenic quantitative traits and the effectiveness of breeding efforts using genetic markers.*

Keywords: *Keywords: DNA, selection, animal husbandry, variability, inheritance, methods, breeding, farm animals, innovations, genetics, chromosome maps, genetic markers.*

Relevance of the problem. Today, with intensive selection in livestock breeding, the introduction of advanced technologies, and the requirements for the productive qualities of animals have increased significantly. For farm animals, an important and determining criterion is a specialized direction of productivity and its high level, the duration of productive life, stress resistance and resistance.

The selection process is an important component of the agricultural sector, as it contributes to improving the genetic characteristics of animals. It can also affect the quality of products, health and resistance to diseases. There are various progressive selection methods, such as genetic engineering, marker selection and breeding methods, such as artificial insemination and embryo transplantation [1, 2].

Genetic and selection research of farm animals is the key to improving the productivity and quality of agricultural products. Modern livestock breeding using the achievements of fundamental biological sciences, including DNA technologies, results in increasing the economic efficiency of the agricultural industry. Quantitative traits of animals, namely: milk yield, milk composition, meat and carcass quality, fertility, resistance or susceptibility to infections, are mostly polygenic traits that are the result of the interaction of many genes. The development of economically useful traits is based on the identification of polygenic systems for marking and mapping the main genes of breeding traits. The more complete the chromosome maps of farm animals are, the higher the probability of marking polygenic quantitative traits and the higher the efficiency of breeding work using genetic markers [3].

Molecular genetic markers, the polymorphism of which is closely related to the variability of polygenic quantitative traits, allow us to detect the influence of environmental factors that modify the phenotypic value of a given trait, and this significantly simplifies breeding work with it, as well as the forecast of its development. Artificial insemination of livestock on a large scale has created conditions for the targeted transfer to the offspring of gene complexes that underlie the development of economically useful traits. The technology of superovulation and embryo transplantation significantly and dramatically increases the possibility of obtaining numerous offspring from animals with desired productivity characteristics and with certain gene combinations useful for the population.

The persistent work of livestock breeders, breeders, and scientists should be continued, because breeding work requires appropriate training and knowledge, especially in the field of applied genetics, without which their successful and effective application is impossible [4, 5].

Research results. In animal husbandry, genetics methods are used to increase the economically useful traits of animals, namely:

- when creating new lines and breeds of animals that exceed existing ones in productivity, differ in specific marker traits (for example, resistance to diseases, product quality, autosex - sex marking in poultry farming);
- when using the phenomenon of heterosis to obtain hybrid animals and poultry from specialized related forms characterized by high combining ability;
- when using related breeding (inbreeding) in the breed-forming process and establishing inbred lines;
- to assess the genetic potential of animal productivity, which is controlled by the genotype, its preservation in a number of generations;
- to develop methods for assessing the genotype of individual animals and their groups by the quality of offspring;
- to preserve the gene pool of rare species, breeds and reserve lines, herds;
- for the diagnosis and treatment of viral, bacterial and other infections of farm animals (using monoclonal antibodies and enzyme-linked immunosorbent assays);
- in the study of genetic changes in organisms associated with increased radiation pollution;
- in controlling the origin of animals (genetic examination).

In the modern world, doctors fight with hereditary diseases using genetic methods. Genetic methods are used to assess the ecological state, the manifestation of undesirable mutations.

Selection in human production.

The term selection (from the Latin selectio - selection) means - a science that develops the theory and methods of creating new and improving existing forms of plants, animals and microorganisms. Selection as a science consists of the following sections: the study of the species and breed composition of domestic animals; analysis of the patterns of hereditary variability of animals; research into the role of the environment in the development of animal traits and properties; development of artificial selection and selection systems that contribute to the consolidation and strengthening of desired traits and properties of organisms.

The theoretical foundations of selection, which are most closely related to genetics, include: hereditary variability of traits and characteristics of animals during purebred breeding and crossing, methods of selection and selection [6].

The theoretical basis of selection is genetics. Only deep knowledge of the laws of variability and inheritance of traits will allow the breeder to competently plan and conduct selection work. Of course, in addition to genetics, the breeder must have a thorough knowledge of the biology of the selected object of research, the laws of its reproduction, growth and development of its individuals, their resistance to infectious diseases and other adverse environmental factors. However, selection programs for the creation of new varieties of plants and breeds of animals are primarily firmly based on genetic principles, relying on the laws of genetics.

Like any science, selection has its own subject and methods of research. The subject of selection in general is the study of the laws of change, the process of development and transformation of plants, animals and microorganisms in man-made conditions.

In animal husbandry, the subject of selection is breeds, that is, populations of farm animals that are artificially created by man and have certain hereditary characteristics. In a breed, all individuals have similar hereditarily fixed signs and properties: productivity, a complex of physiological and morphological properties, as well as a certain reaction to environmental factors. The methods of selection are genetic methods of induced forms of variability of traits and artificial selection. Actually, the latter is leading in any programs of breeding work.

Agricultural production is the leading branch of the economy of any society. In turn, breeding provides agricultural production with high-yielding varieties of cultivated plants and highly productive breeds of animals. Due to this, labor productivity in agriculture increases. From this point of view, breeding acquires great importance in human production activities [7, 8].

The concept of breed. Already in ancient times, man noticed that due to variability within each population of plant and animal organisms, individuals with different levels of resistance to adverse environmental conditions, with unequal fertility and viability, with various other characteristics are born. Even then, it turned out that the vast majority of descendants of highly fertile individuals inherit the trait of high fertility, and the trait of high viability of parents is inherited by the majority of their descendants, etc. Therefore, already in ancient times, man selected seeds from the best plants and descendants from the best animals for reproduction. These, at first glance, primitive methods of artificial selection, which were used for several millennia, gave good results, a huge number of varieties of cultivated plants and breeds of domestic animals were created. At the same time, it turned out that most of them, combining such features as resistance to diseases and harmful insects, as well as resistance to other adverse environmental conditions, are highly productive and highly productive. Some of these plant varieties and animal breeds turned out to be so perfect that even with the use of modern breeding methods they cannot be significantly improved [1, 2, 9].

Cultivated plants and domestic animals originate from their own wild ancestors. In the process of cultivation and domestication, they all acquired economically valuable features, the formation of which was facilitated by artificial selection. For example, high meat and milk productivity of animals or high 110 protein or high sugar productivity of plants are of no importance in the evolution of a plant or animal organism. But with the help of artificial selection, man formed alternative features in animals and plants in such a way that they would ensure maximum productivity. Therefore, domestic animals and cultivated plants are not adapted to independent existence.

No domestic animal or cultivated plant, left alone with natural environmental conditions, that is, in the wild, will survive.

Based on the phenotypic and genetic properties of animal breeds and plant varieties, these concepts can be defined as follows: a variety or breed is a population of organisms that is created by artificial selection and is characterized by hereditarily fixed signs of high economic productivity. Thus, the best varieties of wheat created by Ukrainian breeders, in combination with modern cultivation methods, allow obtaining yields of 60-80 centners/hectare of grain. Or, for example, in Denmark, annual milk yields from the best Jersey cows are over 7200 kg with a fat content of more than 6-7%, and in England, the best potato varieties provide a harvest of high-quality tubers of 700-800 centners/hectare [2, 10].

The influence of selection, natural or artificial, will be the more effective, the higher the variability of the traits that fall under the action of this selection. It is the variability of the source material that is the fundamental basis necessary for the creation of new animal breeds and plant varieties. In this case, all forms of hereditary variability, including mutational and combinational, play the most important role. As for modifications, since this form of variability is not inherited, it significantly complicates the implementation of artificial selection.

Forms of artificial selection.

The doctrine of artificial selection was developed by C. Darwin. In his works "The Origin of Species..." and "Variability of Animals and Plants under Domestication" (1868), he distinguished three forms of selection that operate in the process of forming new animal breeds and new plant varieties, namely: natural selection, unconscious selection and methodical selection (artificial).

Natural selection. It was under its influence that the characteristics were formed in the populations of various species of animals and plants, by which man isolated the corresponding organisms from the wild and introduced them into culture.

In addition, in the process of domestication of animals and cultivation of plants, as well as in the process of creating new breeds and varieties, natural selection continues to act regardless of the will of man. This is due to the incessant processes of mutational variability. The processes of spontaneous mutagenesis can be strengthened or weakened, but cannot be stopped [11].

Mutational variability under the influence of natural selection is capable of introducing into the genotypes of breeds or varieties modifications of some characteristics, the formation of which was not foreseen by the breeder.

In both wild and domestic animals, natural selection contributes to the destruction of harmful mutant genes and the survival of those most adapted to environmental conditions. It should be noted that natural selection in populations of domestic animals is aimed at the survival of those individuals that are more adapted to the environmental conditions provided by man.

Unconscious selection. This is a form of artificial selection that was carried out by man unconsciously, without any desire to breed a new breed. This form of selection developed spontaneously, because man always left the best animals for the tribe, and for sowing - good seeds, and for food or other needs he was the first to use animals and fruits of plants that were inferior in terms of the development of traits to the best specimens. Unconscious selection has been occurring continuously for many millennia. Therefore, it has led to the creation of populations of animals and plants with traits inherent only to a certain natural and climatic zone or a certain geographical region. Such populations are called local breeds, varieties or populations. Note, however, that over the past two to three centuries, the formation of local breeds or varieties has been influenced by the genotypes of breeds and varieties that are occasionally imported from other areas.

Methodical selection. This is a form of conscious artificial selection. It is used by man in case of desire or necessity to make changes in the formation of the characteristics of a breed or variety towards a certain ideal. Man consciously selects and uses for reproduction only those individuals whose phenotypic characteristics in their manifestation more closely correspond to the expected ideal. Methodical selection over several or many generations allows to achieve the desired results [12].

Thus, artificial selection is carried out by man and is aimed at increasing the frequency of desired genes by allocating the most productive individuals to the tribe by the breeder. And natural selection eliminates those individuals that are not adapted to the environmental conditions. Therefore, often in practice, natural and artificial selection act in opposite directions.

Selection does not create new genes. It is carried out with the aim of increasing the frequency of desirable genes in the population and reducing the frequency of harmful genes.

Suppose that A is desirable, and a is undesirable.

♀ AA χ ♂ aa

F1 Aa (frequency is 0.5)

F2 1 AA, 2Aa, 1 aa (frequency is 0.5)

Therefore, the proportion of gene A in F2 is still 0.5. But if all individuals with the genotype aa are eliminated, then among the individuals that remain there will be 4A and 2a. As a result, the proportion of gene A will be increased to 0.67, and the proportion of gene a will be reduced to 0.33, etc.

If selection is effective, then its genetic consequence is expressed in an increase in the proportion of the gene for which selection is carried out. If the proportion of the desirable gene increases, then the proportion of individuals homozygous (AA) for the desirable gene also increases.

Depending on the breeding program and the biological characteristics of the breeding object, various types of selection are used in practice, determined by the nature of the action of genes: selection for a dominant gene, selection against a dominant gene, selection for a recessive gene, selection against a recessive gene, selection for genes with an epistatic effect, selection for genes with an additive effect, etc.

Selection methods based on Mendel's laws.

With the understanding of the rediscovered Mendel's laws, the concept of the combining ability of genotypes of lines, varieties of breeds and even individual organisms was formed.

Combining ability is the relative level of viability and productivity of offspring from crossing partners belonging to different lines, varieties (breeds) or species. A distinction is made between general combining ability and specific combining ability.

The total combining ability is the average level of heterosis in the offspring from crossing lines, plant varieties or animal breeds with any of the partners under study. In breeding work, diallel, topcross, polycross and free crosses are used to identify the total combining ability.

Diallel or polyallel crosses are understood as crossing individuals of a separate line or a separate family with individuals of other lines or families in all possible direct and reciprocal combinations in order to study their combining ability.

The number of possible combinations between different lines in direct crosses will be ⟦n^2⟧^ – n^2

where n is the number of lines involved in the crosses.

Specific combining ability is the ability of any line or variety (breed) from crossing with its partner to produce offspring with a certain burst of heterosis.

Often, hybrid F2 offspring are split by phenotypic traits into groups in such proportions that there is doubt about the regularities to which this splitting should be subject according to Mendel's law. Then the researcher, relying on the genetic laws of heredity, can put forward a working hypothesis to explain the data obtained. If, using the working hypothesis, the theoretically expected frequencies are calculated and compared with the frequencies obtained in the experiment, the degree of correspondence between the distribution of the actually obtained and theoretically calculated frequencies will show how much these distributions correspond to each other.

In statistics, the working hypothesis is also called the null hypothesis. This means that if the working hypothesis is confirmed, the difference between the experimentally obtained and theoretically calculated distributions is zero. The degree of correspondence of the actual data to the expected is calculated using the correspondence criterion, which is called the χ2 criterion (Chi square).

When comparing the empirical value of the chi-square calculated using this formula with the theoretically expected, that is, with the standard value, two situations may arise. The first situation is x^2 empir >⟦x^2⟧^stand at a certain number of degrees of freedom - γ. This means that the distribution of empirical frequencies is significantly different from the distribution of theoretically expected frequencies. Therefore, we can say that the two frequency distributions being compared - the experimental and theoretically expected - are incompatible. They belong to different populations. Therefore, the working hypothesis is not confirmed.

Assessment of specific combining ability. Animal breeding based on the assessment of specific combining ability means that with a significant effect of non-additive genes, selection can be aimed at using the effect of heterosis. This is achieved, as a rule, by crossing lines or breeds in poultry and pig farming for traits that are poorly inherited and are controlled mainly by non-additive genes [2, 4, 13].

The first stage of such work is the creation of several inbred lines by inbreeding.

The next stage is checking the created lines for compatibility, that is, identifying combinations of cross lines that produce the most productive offspring. Inbred lines, from which the most productive offspring are obtained when crossed with each other, have opposite homozygosity for many pairs of genes, which provides higher heterozygosity of the offspring and the manifestation of the heterosis effect.

An example of such a breeding scheme is reciprocal recurrent selection, aimed at increasing the combining ability of two or more lines or breeds that have been found in previous crosses.

Selection by quantitative factors.

The vast majority of traits in certain organisms differ in the quantitative manifestation of their variability in the process of reproduction. Quantitative variability is referred to as such variability, in which the numerical value of a trait in a set of organisms of the same type forms a continuous series of classes, which make up the variation series. Recall that in Mendel's studies on different varieties of peas, each gene differed from its allelic partner with high discontinuity. It was thanks to this effect that Mendel discovered units of heredity - genes. However, such traits as the mass of the organism, its linear and volumetric dimensions, growth rates, the capacity of certain substances in various components of this organism, and others are characterized by the continuity of the transition from one size of the trait to another.

For example, pea seeds can be smooth or wrinkled in shape, but the protein content in individual pea seeds in different populations can vary from 22 to 34% with continuous transitions in their ranking from seed to seed. Numerous studies have shown that quantitative traits are formed under the influence of many non-allelic genes of unambiguous action. Therefore, unlike qualitative traits, which are inherited alternatively, quantitative traits are inherited polygenically. Hence, polygenic inheritance can be imagined as a function of a whole system of genes, the interaction of which during the formation of the organism determines the quantitative effects of various traits and serves as the genetic basis of quantitative variability. An important feature of polymeric genes is that from the crossing of individuals that differ from each other in a quantitative trait, offspring with an intermediate inheritance of this trait are always reproduced. Therefore, the ability of dominance in this case is not manifested [4, 13].

However, due to the complexity of the genetic systems that determine the development of quantitative traits, selection for these traits in the process of selection work is significantly complicated. Therefore, methods of statistical analysis come to the aid of breeders. The simplest of them is the method of comparing the average values of an economically useful trait that manifests itself in the compared populations (confidence level td).

Determining the level of probability of the difference between the averages of the compared populations does not provide information about the dependence of the nature of the manifestation of a quantitative trait on certain genes. At the same time, in the practice of selection work, it is often necessary to determine what determines the variability of a quantitative trait in a particular population of organisms. After all, it is known that the variability of traits can be caused by both the heterozygous state of the genotype and the modifying influence of environmental conditions. But since the formation of quantitative traits is determined by several (or even many) non-allelic genes of unambiguous action, in order to find out their number for a certain trait in a certain species of organisms, it is necessary to conduct rather laborious studies over dozens of generations.

To avoid the above difficulties, breeders use the heritability coefficient. This coefficient determines the size of the share of the genetic component in the phenotypic variability of a quantitative trait, which is due to the function of the corresponding system of polymeric genes of unambiguous action. Therefore, the heritability coefficient makes it possible to judge only the specific weight of the genotypic variability of a trait in a certain set of organisms.

Selection for one quantitative trait [7, 11].

Quantitative indicators include numerous economically useful traits that have economic value. This is the milk yield from a cow, the content of nutrients in it, the meat yield in pigs, the number of piglets born by a sow, the laying ability of chickens, the shearing of wool in sheep, and the like. These traits are formed under the influence of numerous pairs of genes, each of which has a low, individual phenotypic effect. The formation of such traits occurs under the influence of both additive and non-additive genes.

Unlike qualitative traits, quantitative traits are largely influenced by environmental conditions. The concept of "environment" includes such factors as the body's supply of nutrients, diseases, temperature, air humidity, and others that accompany an individual throughout the entire ontogenesis period.

Phenotypic variability, which has a number of features, is caused by environmental factors. It is not transmitted from parents to offspring, it covers genotypic variability, which makes it difficult to detect. In order to reveal the genetic potential of an individual, appropriate environmental conditions are necessary. By creating optimal environmental conditions, it is possible to achieve a rapid increase in the production of livestock products.

The magnitude of genetic progress per generation (SE) achieved by selection for a quantitative trait depends on the magnitude of the selection differential (Sd) and the heritability coefficient of the trait (h^2^) :

SE = Sd • h^2^

The selection differential is the difference between the average value of the trait in animals selected as the group of parents of the next generation (P), and the average value of the same trait in the herd or population (P):

Sd = (P – P)

For example, if in a herd of cows with an average milk yield of 4000 kg (P) of milk, the breeding nucleus will be selected

That is, over several generations, as a result of targeted selection of cows for milk yield, the average level of herd productivity increases. As already noted, this is a consequence of an increase in the concentration of genes that determine the level of animal productivity.

It is necessary to highlight one of the most important provisions of the theoretical foundations of selection, that the growth of animal productivity as a result of selection will occur under the condition of adequate improvement of environmental conditions, since the realization of the genetic potential of highly productive animals requires a high level of feeding and maintenance. Without the creation of appropriate conditions, a breeding animal with a high level of genetic potential, especially imported specialized breeds, will not meet the standard in terms of its exterior and productivity.

It is also necessary to note the second regularity - the interaction of the genotype of animals with the environment. As an example, we can cite the crossing of dairy breeds of cattle in Ukraine with Holstein breeders. Practice has shown that with an increase in bloodline of the Holstein breed in crossbred animals, the genetic potential for milk yield increased. However, in commercial herds with a low level of feeding and maintenance, the absolute milk yield of crossbred animals did not increase. In such herds, the best genotypes show worse results. The reason for this is that crossbred animals with high bloodline to the Holstein breed are characterized by increased energy metabolism, require a higher level of feeding, react sharply to unbalanced diets and low-quality feed, reduce fatness and live weight, and are more susceptible to diseases in adverse environmental conditions. Since such shortcomings are constantly observed in commercial farms, the duration of productive use of such animals is significantly reduced. The level of their milk productivity and reproductive ability decreases [12, 13].

Selection of animals by a complex of traits.

In breeding activities, animals are selected more often by a complex of economically useful traits that have different economic significance, different degrees of inheritance and genetic correlations between them. Theory and practice demonstrate that increasing the number of selection traits in a breeding program leads to a decrease in the genetic progress of each of them. If the traits are independent of each other and have the same degree of inheritance, then with simultaneous selection of animals for n traits, the genetic progress for each of them will be $\sqrt{n}$. That is, the more traits are included in the breeding program, the lower the effect of selection for each of them.

There are several methods of selecting animals for a complex of traits: the method of sequential (tandem) selection, the method of independent levels of culling and selection indices.

The method of sequential (tandem) selection involves selecting animals for one trait for several generations until the desired improvement is achieved. Subsequently, the selection pressure for this trait decreases, and efforts are directed to improving the second trait, then the third, etc. If there is a positive relationship between the breeding traits, then this selection method is quite effective. However, there is mostly a negative correlation between the main breeding traits, especially between the quantity of production and its quality. In such a case, this selection method will be ineffective. For example, a negative genetic correlation between milk yield and milk fat content will actually nullify the effectiveness of sequential selection, since genetic improvement of one trait will lead to genetic deterioration of the second.

When selecting animals by independent levels, a minimum grade is established for each trait, the requirements of which must be met by breeding animals. If the requirements for one of the traits are not met, the animal is removed from breeding. The disadvantage of this selection is that animals with a high development of traits have to be culled, because they do not meet the standard for one of them. For example, with a selection standard of egg production of chicken lines of 250 eggs, egg weight of 60 g and hatchability of 80%, one laying hen had 270 eggs, an average egg weight of 60 g and hatchability of 88%. Another laying hen had the following indicators: 280 eggs, 65 g and 70%. Despite the fact that the other laying hen has high egg productivity, she will be culled, because her fertility does not meet the standard [11].

However, this method is widely used in breeding practice, for example, in the sequential selection of bulls for breeding associations. It is also used in the creation of specialized homozygous lines in poultry and pig farming, in the selection of animals for exhibitions, auctions, and test stations.

The most effective is the method of breeding indices, since it makes it possible to select highly valuable animals for a breeding group, even if they do not meet the standard for one trait. The measure of the value of an animal is an index or a total value for all breeding traits, compiled taking into account the economic and genetic significance of each trait. If the index is compiled correctly, taking into account all factors (relative economic value of the trait, heritability, genetic correlations, etc.) and taking into account genetic and mathematical methods and computers, then this method allows you to obtain the greatest breeding effect for a certain period of time and per unit of funds spent.

In addition to selection, the effectiveness of selection is based on breeding and selection methods.

The effectiveness of selection depends on breeding methods.

Breeding methods include - a system of selection and selection of farm animals, taking into account their species, breed and line affiliation.

Selection (selection) is a process that determines the relative proportion of descendants of a genetic group (structure) of a population (herd, line, family), which remains for reproduction in subsequent generations.

Selection is a system of measures for mating individuals (males and females) in order to obtain offspring with high productive and breeding qualities from them.

In the system of breeding methods, there is purebred breeding and various forms of crossing.

Purebred breeding is the mating of animals belonging to the same breed. The offspring obtained from such mating is called purebred.

Purebred breeding, especially of dairy breeds of cattle, is the main method. The most highly productive are animals obtained through purebred breeding. The main methods of purebred breeding are outbreeding, inbreeding, and breeding by lines and families [12].

Crossbreeding is the mating of animals belonging to different breeds and species, as well as the mating of crossbreeds with each other. The offspring obtained through crossbreeding are called crossbreeds or hybrids. Most often, hybrids are called offspring obtained through interspecific crossing. When crossing, the heterozygosity of animals increases, which often leads to heterosis. Therefore, crossbreeding, especially in poultry and pig farming, is the main method of obtaining highly productive commercial animals.

The method of outbreeding should be distinguished from crossbreeding. Outbreeding is the mating of individuals of a breed that are not related to each other by kinship, which is used to obtain purebred animals.

The genetic consequences of crossing and outbreeding are directly opposite to inbreeding. While inbreeding promotes homozygosity for most gene pairs, crossing and outbreeding lead to an increase in heterozygosity.

For example, if one breed is homozygous for the dominant gene (AA) and the other is recessive (aa), then all offspring obtained from crossing these breeds in the first generation (F1) will be heterozygous (Aa). In subsequent generations, heterozygosity decreases, since 120 gene splitting occurs. Thus, in F2, the number of heterozygous individuals will be only 50%: 1 AA, 2 Aa, 1 aa. This situation is also true for traits affected by more than one pair of alleles.

Animals obtained from crossing or unrelated mating are less constant than inbred ones. Heterozygous animals transmit different genes to their offspring.

When crossing, in some cases and for some traits, heterosis is manifested in F1. Heterosis or hybrid vigor is an increase in the viability of crossbred offspring compared to the parents of the original breeds, which is manifested in improving reproductive function, growth rate, and increasing productivity.

The phenomenon of heterosis has been known since ancient times. One of its examples is the mule - an F1 hybrid obtained from interspecific crossing of a donkey with a mare. As has long been known, the mule has good adaptability to a hot climate, enduring to hard work. In recent years heterosis is obtained in poultry farming, pig farming, and beef cattle breeding. In poultry farming, by crossing, for example, white Plymouth Rock laying hens with white Cornish roosters, synthetic lines of highly productive broiler crosses have been created based on the breeding of specialized combined inbred lines. Egg-producing crosses are created based on the crossing of inbred lines of the Leghorn breed. The effect of heterosis can be determined by comparing the level of productivity of crossbred and purebred animals. Some breeders believe that the most objective assessment of the effect of heterosis is the excess of the average productivity of the offspring in F1 over the productivity of the best of the parental forms of the original breeds. However from a genetic point of view, a more reasonable method of assessing the effect of heterosis is to compare the average productivity of the offspring F1 with the average productivity of the parents. If the trait is significantly affected by the non-additive effect of genes, then the average F2 does not coincide with the average of the parents, but turns out to be higher or lower than it. In some cases, it may be higher than the highest, or lower than the lowest value in the parents. Heterosis is due to the heterozygosity of genes that exhibit a non-additive effect (dominance, overdominance, epistasis). The influence of dominance on the manifestation of heterosis can be traced on the example of American beef cattle breeding. J. F. Leslie (1982) believes that most of the breeds of animals in the United States were bred on the basis of a relatively small number of animals imported from Western Europe. Therefore, it is likely that they are homozygous for many genes or that the frequency of one allele in some breeds may be higher than in other breeds. Thus, more than half of the American Shorthorn population comes from a single bull. When crossing such breeds with each other, heterosis was obtained in terms of average daily gain [13].

The cause of heterosis can also be overdominance, that is, when several pairs of genes act on the same trait, and the strength of their action is not the same. With this type of gene action, it is impossible to fix the desired combinations of genes in one line, because the gene action depends entirely on heterozygosity. In this case, the only way to take advantage of this type of gene action is to form inbred homozygous lines. Then the lines must be tested in crosses in order to identify those that are well-matched, which show the greatest heterosis in the offspring. This is exactly what is done in poultry farming when creating highly productive crosses. In farm animals, the effect of heterosis is manifested in traits with a low degree of heritability, that is, in traits that are more susceptible to the influence of adverse environmental conditions and inbreeding. Practice has shown that the effect of heterosis depends on the magnitude of the genetic difference between the individuals being crossed. Therefore, a greater effect of heterosis is obtained when crossing breeds with each other, rather than lines within a breed. A higher effect of heterosis is obtained when crossing breeds with a more pronounced genetic difference than when crossing breeds with a similar genetic structure. From a theoretical point of view, this should be understood as meaning that unrelated parents have less chance of being homozygous for the same pair of genes than related ones. In recent years, interbreeding has been widely used to breed new highly productive breeds by mating dams of local breeds with breeds of specialized productivity. In Ukraine, a meat breed of pigs was bred by crossing dams of the Large White breed of pigs and other local breeds with sires of imported meat breeds. The red-and-white dairy breed was created by crossing Simmental cows with Holstein bulls, the Ukrainian beef breed was bred by crossing Simmental cows with sires of imported beef breeds [12, 13].

Inbreeding is a selection system for obtaining offspring from mating related animals.

The genetic consequences of inbreeding are to increase homozygosity in the population for most gene pairs.

Inbreeding, combined with targeted selection and selection, contributes to the consolidation of desired traits in the population. Offspring from related parents often receive the same genes as

a common ancestor. Therefore, there will be a certain similarity between parents and offspring, which will increase with increasing homozygosity. Using special terminology, it can be argued that inbred parents are more prepotent than non-inbred ones. Therefore, in dairy cattle breeding, they try to complete breeding associations with inbred bulls as fertile animals in order to use them on outbred cows, and in poultry farming, they try to breed inbred specialized lines to obtain the effect of heterosis in crosses.

At the same time, in the process of inbreeding, mutant genes pass into a homozygous state, which causes depression (reduction in the viability of organisms or lethal outcome). However, mutations can be those that reduce viability and those that increase it. Therefore, depression does not always occur with inbreeding.

Inbred depression is a decrease in the viability and productivity of animals as a result of inbreeding. Inbreeding depression is most susceptible to traits with a low degree of heritability (hope, egg production, growth rate, reproductive ability, disease resistance, adaptive ability), that is, traits that characterize the viability of individual animals and populations as a whole. In industrial animal husbandry, the breeding system should avoid inbreeding and be based on obtaining heterozygous individuals, which are more viable and therefore more productive. One form of inbreeding is considered to be line breeding, the goal of which is to concentrate the heritability of one representative or one ancestral line in the offspring of several generations.

Line – a breed or interbreed group of farm animals that originate from one or more outstanding sires. In cattle breeding, lines refer to a breed group of animals that originate from one sire. In poultry farming, a line is understood as both a breed and an interbreed group of animals that originate from several sires, specialized in one or more economically useful traits.

The genetic consequences of breeding by lines are the same as inbreeding. Breeding by lines leads to homozygosity of pairs of genes that are in the ancestors in the heterozygous state. The probability that the line offspring will have the same genes as the ancestor of the line also increases. If the ancestor had a large number of desirable genes, this will contribute to the fact that the descendants will also have the same desirable genes. If the ancestor had harmful genes in the heterozygous state, then the offspring may also have them, and in some animals in the homozygous state. That is why it is necessary to carefully choose the ancestor of the line. It should be evaluated by the quality of the offspring not only by economically useful traits, but also by the presence of recessive harmful genes in their genotype.

Breeding by lines is used only in purebred breeding. The use of inbred lines of bulls-sprouting on unrelated cows (outbreeding) has become widespread in dairy cattle breeding, which contributes to the genetic improvement of breeds by economically useful traits. In addition, linear-rotational selection in commercial herds makes it possible to exclude spontaneous related mating of cows during artificial insemination [11, 12, 13].

Lines are divided into:

- genealogical line - a group of animals that have a common ancestor in the direct paternal pedigree, obtained without a specific plan, without directed selection and selection. Genealogical lines make up the structure of the breed and are a means of rotational selection in commercial herds in order to prevent spontaneous inbreeding.

- hybrid line - a group of animals obtained from crossing two or more lines of the same breed or lines of different breeds. This breeding method is used in poultry farming, it is aimed at obtaining heterosis.

- factory line - a group of animals that originate from an outstanding breeder, obtained by targeted selection and selection, differs from other lines in characteristic breeding and productive qualities.

- inbred line - a group of animals that are obtained by close related mating in several generations. They are bred in poultry farming, less often - in pig farming in order to obtain [12].

a heterosis effect when crossing such lines. In inbreeding, it is necessary to cull animals, therefore, in low-fertility livestock (cattle, horse breeding and sheep breeding) inbred lines are not bred.

- combined lines - lines, when crossed, the effect of heterosis is manifested in the offspring. The phenomenon of linear combination (combining ability) is widely used in poultry farming.

Conclusions. The introduction of progressive technologies, selection and breeding methods in livestock farming, the development and implementation of methods for breeding and selection of farm animals that take into account the specifics of all branches of livestock farming are the key to increasing the production of high-quality food products, in particular milk and dairy products, for consumers and raw materials for industry.

References

1. Admina N. G., Admin O. Ye.,T. L. Osypenko, Yemets Z. V. INFLUENCE OF PARATYPIC FACTORS ON THE FERTILITY OF DAIRY COWS AND REPLACEMENT HEIFERS. Scientific and Technical Bulletin of the Institute of Animal Science NAAS of Ukraine / - The Scientific and Technical Bulletin of the Institute of Animal Science NAAS of Ukraine / Kharkiv, No. 131- 2024/8/27 | Journal article DOI: 10.32900/2312-8402-2024-131-4-18 https://doi.org/10.32900/2312-8402-2024-131-4-18
2. Z. Yemets, PROGRESSIVE TECHNOLOGIES, METHODS OF SELECTION AND BREEDING OF AGRICULTURAL ANIMALS: Agrarian Bulletin of the Black Sea Region. Odesa, 2024. Issue 110.- p.149; DOI: https://doi.org/10.37000/abbsl.2024.110.23
3. Barkar E.V. Genetic resources of farm animals: a course of lectures. – Mykolaiv: MNAU, 2016. – 84 p.
4. Pidpala T.V. Breeding of farm animals: a textbook. - Mykolaiv: Publishing Department of MNAU, 2006. – 277 p.

5. State book of breeding animals of cattle of the Ukrainian black-and-white dairy breed / Shablya V.P., Admin O.E., Khramtsova O.M., Osypenko T.L., Yemets Z.V., Trotsenko Z.G., Ivanchenko M.I. - K.: PC “Foliant”, 2008. - 496 p.
6. Yemets Z.V. Dependence between the average fat content for the lifetime milk productivity of cows-mothers and daughters // Scientific and technical bulletin / IT UAAN. – Kharkiv, 2006. No. 93. P. 29-31.
7. Yemets Z.V. Fat content in cow's milk and milk fat yield depending on the breed // Bulletin of the Poltava State Agrarian Academy, 2005. No. 2. P. 127-128.
8. Yemets Z.V. Development of models for the selection assessment of fat content in milk and milk fat yield of cows: author's abstract. dissertation for the degree of candidate of agricultural sciences: 06.02.01 - animal breeding and selection. Kherson, 2009. p. 19.
9. Genetic Fundamentals of Breeding. website. URL: https://osau.edu.ua/wp-content/uploads/2020/05/1.2.4.1.-K_lektsij_Genetychni-osnovy-selektsiyi.pdf.
10. Yemets Z.V.,1 Miroshnikova O.S.2 ECOLOGICAL INNOVATIONS IN ANIMAL BREEDING AND GENETICS. Modern challenges and ways to improve the technology of livestock production: materials of the III International Scientific and Practical Conference of NPP and Young Scientists (Odesa, June 6-7, 2024) / Odessa State Agrarian University. Educational and Scientific Institute of Biotechnology and Aquaculture. Odesa, 2024. P. 17-19
11. Course of lectures on the discipline "Genetics in Veterinary Medicine. website. URL: https://nubip.edu.ua/sites/default/files/u104/%D0%9A%D1%83%D1%80%D1%81_%D0%BB%D0%B5%D0%BA%D1%86%D1%96%D0%B9_%D0%93%D0%B5%D0%BD%D0%B5%D1%82%D0%B8%D0%BA%D0%B0_%D1%83_%D0%B2%D0%B5%D1%82_%D0%BC%D0%B5%D0%B4_2.pdf
12. Genetic foundations of animal breeding. website. URL: https://fileview.ukr.net/?url=https%3A%2F%2Fmail.ukr.net%2Fapi%2Fpublic%2Ffile_view%2Flist%3Ftoken%3DHDjLtW8MvItwynPBFFaxZ6E-oTisxTY8X9e2mrzLx_nALXp6xCEluuM4zSMYbO-Y0LBXKvuDNMY58OzXAATFFfdBFGWbq7tuLb4lyc0%3AmpuLfmE5Zs5D0ZzL%26r%3D1742297337173&default_mode=view&lang=uk&mlid=0#start=0
13. Scientific Bulletin of Veterinary Medicine.website. URL: https://fileview.ukr.net/?url=https%3A%2F%2Fmail.ukr.net%2Fapi%2Fpublic%2Ffile_view%2Flist%3Ftoken%3DHDjLtW8MvItwynPBFFaxZ6E-oTisxTY8X9e2mrzLx _nALXp6xCEluuM4zSMYbO-Y0LBXKvuDNMY58OzXAATFFfdBFGWbq7tuLb4lyc0%3AmpuLfmE5Zs5D0ZzL%26r%3D1742297337173&default_mode=view&lang=uk&mlid=0#start=2

ЗАСТОСУВАННЯ СУЧАСНИХ МЕТОДІВ ГЕНЕТИЧНОЇ СЕЛЕКЦІЇ У ТВАРИННИЦТВІ

Зоя Ємець,
кандидат сільськогосподарських наук, доцент
кафедри генетики, розведення та годівлі тварин,
Одеський державний аграрний університет, Одеса, Україна
ORCID ID: 0009-0007-1507-9734
e-mail: : zoyaemets@gmail.com

Ігор Ніколенко,
кандидат сільськогосподарських наук, доцент
кафедри генетики, розведення та годівлі тварин,
Одеський державний аграрний університет, Одеса, Україна
ORCID ID: 0000-0002-8581-4569
e-mail: igor.nikolenko.87@ukr.nete-mail

Ірина Гончарова,
кандидат сільськогосподарських наук, доцент
кафедри генетики, розведення та годівлі тварин,
Одеський державний аграрний університет, Одеса, Україна
ORCID ID: 0000-0003-0190-7803
e-mail: irina.i.goncharova@gmail

Оксана Шевченко,
кандидат сільськогосподарських наук, доцент,
кафедри генетики, розведення та годівлі тварин,
Одеський державний аграрний університет, Одеса, Україна
ORCID ID: 0000-0002-6747-5487
e-mail: sksena76@gmail.com

Анотація

Стаття має описовий та оглядовий характер і присвячена аналізу використання сучасних методів селекції у тваринництві. Висвітлено процес селекції, як важливої складової аграрного сектору, оскільки він сприяє покращенню генетичних характеристик тварин. Також описано найефективніші методи селекції у тваринництві, аграрному секторі. Наголошено, що теоретичною основою селекції є генетика і тільки глибоке знання законів мінливості та успадкування ознак дозволить селекціонеру грамотно планувати та проводити селекційну роботу. Вказано, що крім генетики, селекціонер повинен мати ґрунтовні знання біології обраного об'єкта дослідження, законів його розмноження, росту та розвитку його особин, їх стійкості до інфекційних захворювань та інших несприятливих факторів навколишнього середовища. Отже висвітлено у статті, що, селекційні програми зі створення нових сортів рослин і порід тварин, перш за все, міцно базуються на генетичних принципах, спираючись на закони генетики. У статті також описано, як генетичні та селекційні дослідження сільськогосподарських тварин є ключовими для підвищення продуктивності та якості сільськогосподарської продукції. Також розглядається, як сучасне тваринництво, використовуючи досягнення фундаментальних біологічних наук, включаючи ДНК-технології, призводить до підвищення економічної ефективності в агропромисловому комплексі. Наголошено, що кількісні ознаки у тварин є особливо важливими, включаючи виробництво молока, склад молока, якість м'яса та туші, плодючість, а також стійкість або сприйнятливість до інфекцій. Також описано ці ознаки, як переважно полігенні, що є результатом взаємодії кількох генів. В результаті наголошено, що розвиток економічно корисних ознак також має вирішальне значення, і хромосомні карти сільськогосподарських тварин є необхідними, що це підвищує ймовірність виявлення полігенних кількісних ознак та ефективність селекційних зусиль за допомогою генетичних маркерів.

***Ключові слова**: ДНК, селекція, тваринництво, мінливість, успадкування, методи, розведення, сільськогосподарські тварини, інновації, генетика, хромосомні карти, генетичні маркери.*

Список використаної літератури

1. Admina N. G., Admin O. Ye.,T. L. Osypenko, Yemets Z. V. INFLUENCE OF PARATYPIC FACTORS ON THE FERTILITY OF DAIRY COWS AND REPLACEMENT HEIFERS. Scientific and Technical Bulletin of the Institute of Animal Science NAAS of Ukraine / - The Scientific and Technical Bulletin of the Institute of Animal Science NAAS of Ukraine / Kharkiv, No. 131- 2024/8/27 | Journal article DOI: 10.32900/2312-8402-2024-131-4-18 https://doi.org/10.32900/2312-8402-2024-131-4-18

2. Z. Yemets, PROGRESSIVE TECHNOLOGIES, METHODS OF SELECTION AND BREEDING OF AGRICULTURAL ANIMALS: Agrarian Bulletin of the Black Sea Region. Odesa, 2024. Issue 110.- p.149; DOI: https://doi.org/10.37000/abbsl.2024.110.23
3. Barkar E.V. Genetic resources of farm animals: a course of lectures. – Mykolaiv: MNAU, 2016. – 84 p.
4. Pidpala T.V. Breeding of farm animals: a textbook. - Mykolaiv: Publishing Department of MNAU, 2006. – 277 p.
5. State book of breeding animals of cattle of the Ukrainian black-and-white dairy breed / Shablya V.P., Admin O.E., Khramtsova O.M., Osypenko T.L., Yemets Z.V., Trotsenko Z.G., Ivanchenko M.I. - K.: PC "Foliant", 2008. - 496 p.
6. Yemets Z.V. Dependence between the average fat content for the lifetime milk productivity of cows-mothers and daughters // Scientific and technical bulletin / IT UAAN. – Kharkiv, 2006. No. 93. P. 29-31.
7. Yemets Z.V. Fat content in cow's milk and milk fat yield depending on the breed // Bulletin of the Poltava State Agrarian Academy, 2005. No. 2. P. 127-128.
8. Yemets Z.V. Development of models for the selection assessment of fat content in milk and milk fat yield of cows: author's abstract. dissertation for the degree of candidate of agricultural sciences: 06.02.01 - animal breeding and selection. Kherson, 2009. p. 19.
9. Genetic Fundamentals of Breeding. website. URL: https://osau.edu.ua/wp-content/uploads/2020/05/1.2.4.1.-K_lektsij_Genetychni-osnovy-selektsiyi.pdf.
10. Yemets Z.V.,1 Miroshnikova O.S.2 ECOLOGICAL INNOVATIONS IN ANIMAL BREEDING AND GENETICS. Modern challenges and ways to improve the technology of livestock production: materials of the III International Scientific and Practical Conference of NPP and Young Scientists (Odesa, June 6-7, 2024) / Odessa State Agrarian University. Educational and Scientific Institute of Biotechnology and Aquaculture. Odesa, 2024. P. 17-19
11. Course of lectures on the discipline "Genetics in Veterinary Medicine. website. URL: https://nubip.edu.ua/sites/default/files/u104/%D0%9A%D1%83%D1%80%D1%81_%D0%BB%D0%B5%D0%BA%D1%86%D1%96%D0%B9_%D0%93%D0%B5%D0%BD%D0%B5%D1%82%D0%B8%D0%BA%D0%B0_%D1%83_%D0%B2%D0%B5%D1%82_%D0%BC%D0%B5%D0%B4_2.pdf

12. Genetic foundations of animal breeding. website. URL: https://fileview.ukr.net/?url=https%3A%2F%2Fmail.ukr.net%2Fapi%2Fpublic%2Ffile_view%2Flist%3Ftoken%3DHDjLtW8MvItwynPBFFaxZ6E-oTisxTY8X9e2mrzLx_nALXp6xCEluuM4zSMYbO-Y0LBXKvuDNMY58OzXAATFFfdBFGWbq7tuLb4lyc0%3AmpuLfmE5Zs5D0ZzL%26r%3D1742297337173&default_mode=view&lang=uk&mlid=0#start=0
13. Scientific Bulletin of Veterinary Medicine.website. URL: https://fileview.ukr.net/?url=https%3A%2F%2Fmail.ukr.net%2Fapi%2Fpublic%2Ffile_view%2Flist%3Ftoken%3DHDjLtW8MvItwynPBFFaxZ6E-oTisxTY8X9e2mrzLx _nALXp6xCEluuM4zSMYbO-Y0LBXKvuDNMY58OzXAATFFfdBFGWbq7tuLb4lyc0%3AmpuLfmE5Zs5D0ZzL%26r%3D1742297337173&default_mode=view&lang=uk&mlid=0#start=2

Стаття надійшла до редакції 20 січня 2026 року
Стаття пройшла рецензування 23 лютого 2026 року
Стаття опублікована 30 березня 2026 року