6. Genetic gain

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Modul no. 3: Animal Breeding
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Animal Husbandry
Genetic gain, also known as genetic progress, is a basic concept in animal and plant breeding, as well as in agriculture and animal production. The amount of genetic progress depends on several factors that I would like to talk about.
Today, the challenge for livestock production is to meet the growing demand for animal products while reducing environmental impact. This means that the performance and resistance of the animals must be increased, as well as the quality of the animal products.
Performance improvement should focus on lifetime productivity, which can be improved not only by increasing production, but also by improving characteristics such as health, reproduction and longevity.

The objectives of animal breeding
The goal of animal breeding is to genetically improve animals in a specific direction.
Notes:
The aim of breeding work is genetic improvement of animals in the designated direction, i.e.:
Milk yield and composition, meat production, egg production and improvement of reproductive characteristics (fertility and prolificacy)
The aim of breeding is to obtain animals with a better genotype in the next generation - for this reason the process of genetic improvement is stretched over time.

Breeding program
This is a detailed diagram of the genetic improvement of the population.
Each species of animals used by humans has its breeding program, which is the basis for improving important functional characteristics - such as those mentioned a moment ago.
The elements of the breeding program are:

- the breeding goal,
- the control of current performance and the collection of this information,
- the selection system for suitable/best individuals from the population and the mating system.
- Finally, an assessment of the transfer of progress in the production population.

Breeding program - structure
Strabel T., 2010
The optimal breeding program is adapted to the specificity of a given species and the characteristics included in the breeding goal.

Breeding program

The breeding program aims at genetic improvement through the selection of individuals for the parents of the next generation.

The breeding goal expresses the combinations of traits that the breeder wants to improve in the selection process. The amount of progress achieved in the breeding goal (and the traits included in it) depends on the accuracy of selection, its intensity and the spacing of generations.

Breeding program for dairy cattle – objectives

The objectives of improvement in the breeding program for dairy cattle are production characteristics, with particular emphasis on the composition and quality of milk, which have a large impact on its price, that is content and yield of fat, protein and lactose in milk, dry matter content.

Functional characteristics that have a significant impact on reducing production costs, such as:

- features of the external structure of the body,
- fertility,
- health of the udder,
- longevity of animals,
- features of milking capacity,
- ease of childbirth.

Breeding program for pigs – objectives

The objectives of the pig breeding program are mainly related to the improvement of reproductive characteristics such as: number of piglets born, number of piglets weaned, number of teats per female and age of her first calving.
In addition to reproductive performance, an important element in pig breeding are meat performance characteristics - fattening and slaughter, such as: daily weight gain, meat content in the carcass, area of the "eye" of the loin, intramuscular fat content, water absorption, active acidity, color and texture of meat.

The assessment of breeding value

The basis for obtaining offspring with better characteristics than the parents is to know the value, milk yield, carcass value or laying value of the parents.
Then, preparing such a ranking, ranking in terms of the feature selected for improvement.
Selection as a process that changes the frequency of genes and genotypes in the selected population, allows for the achievement of the objectives of the breeding program, which most often focuses on improving the breeding value of a selected group of traits in order to maximize profit.

Selection

In assessing the effects of the selection of quantitative (measurable) traits, it is helpful to compare the average phenotypic and breeding values of the improved traits.
Selection is effective if the offspring is clearly genetically superior to the parent.

Distribution of breeding value of offspring from mating parents with known values

Knowledge of the laws of inheritance makes it possible to predict the value of offspring from mating parents with known breeding values.
Unfortunately, the same laws regarding the randomness of gene transmission mean that the expected effect may not be achieved at all.
In practice, the breeder can obtain both higher and lower value animals.
The measure of successful selection is the appropriate response of the population to the breeding methods used, which means that the offspring of the selected parents will be much better than the parents' generation.
Genetic gain is the difference between the average breeding values of individuals from successive generations.
Genetic gain is the product of heritability and selection difference.
Genetic gain, therefore, is the difference between the genetic value of a given trait in the offspring and the value of that trait in the parent herd, obtained as a result of selection that resulted in a favorable change in gene frequency in the progeny compared to the parents.

Notes:
Genetic gain is the measure of the magnitude of the population's response to selection.
It is defined as the difference between the average breeding values of the progeny and the parent generation.
I mentioned at the beginning that the value of genetic progress depends on several factors. These are:
• accuracy of the assessment of the genetic value of individuals subjected to selection,
• selection intensity,
• genetic variability of the selected trait,
• heritability of the selected trait.
I'll start with the first factor: the accuracy of the assessment of the genetic value of individuals subjected to selection, which is reflected in the correlation between the phenotypic and genetic value of individuals.
The assessment of the breeding value is preceded by the determination of the value of phenotypic traits, i.e. the assessment of performance. These are continuous processes. A number of methods are used to assess the breeding value. Methods of evaluating breeding value are subject to modifications due to emerging modern techniques, e.g. related to the development of molecular genetics (genomic evaluation), as well as resulting from breeding reasons (increase in the level of performance characteristics of animals, inclusion of new breeding goals, modifications of breeding programs, etc.).
An important feature of modern breeding value assessment methods is that they allow to separate the influence of environmental factors, such as year of birth, season, season, microclimatic conditions, nutrition, region of the country and others, on the level of production characteristics. Thus, the obtained ratings characterize the potential production possibilities encoded in the animal's genes.Appropriate size of the so-called active population, i.e. the proportion of animals subject to control and evaluation of breeding value in relation to the entire population of a given species, breed, line.
Using in the assessment not only the phenotype the evaluated animal, but also information on the performance of its ancestors, collateral relatives and offspring contributes to increasing the accuracy of animal assessment.

Selection, i.e. the selection of individuals for the parents of the next generation, is the basic tool of the breeder, thanks to which he can pursue the set breeding goal. In the case of selection, we care about choosing the best animals, i.e. those with the highest breeding values.
In most cases, the selection criterion is assumed to have a normal distribution.
The term selection of the best animals is imprecise.
The figure shows the distribution of most traits of great economic importance in animal husbandry.
Depending on the breeder's determination, fewer individuals can be selected for the selection herd, and then the selection intensity will be high.
You can select more individuals, e.g. about 30%, and then the selection intensity will be lower.

The value of genetic gain depends on:
the intensity of selection is greater in males

Species	**% female**	**% males**
Cattle	50-60	0,5-1
Pigs	5-10	0,2
Horses	30-40	0,5-2

The intensity of selection is greater in males than in females.
Among the males, only about 0.5 to 2% of the best individuals are mated with females.
The value of genetic gain also depends on: genetic variation of the selected trait.
Genetic variability consists in the diversity of the genetic endowment of individuals in a population and arises under certain environmental conditions as a result of the action of many factors.
The value of genetic gain also depends on the heritability of the selected trait.
Heritability expresses the extent to which a trait is passed from parents to offspring.
When heritability is high (>0.4), we observe greater phenotypic similarity between closely related individuals.
The process of genetic improvement of animals must go hand in hand with providing them with optimal housing conditions and a high level of welfare, because the effective implementation of the breeding goal depends on the interaction of two basic factors: genotype and environmental conditions.
For example, a sow with the best possible genotype will not produce large numbers of piglets if veterinary care is neglected or if her ration is deficient in nutrients.
Finally, I wanted to give two examples of visible genetic gain.
In dairy cattle, it is an increase in milk yield in subsequent years of the breeding program.

Genetic gain in pigs
In pigs, It is an increase in the meat content in the carcass of paternal and maternal breeds and crosses of the progeny generation.

Years	1	2	3	4	5	6
Father breeds	57,4		58,6		59,8	
Mother breeds	56,2		56,2		57,4	
Maternal breed gilts and F1 crosses		56,2		56,8		57,4
Pork production			58,3		57,4	

Genetic gain - summary

In conclusion genetic gain is:
- improvement of a selected trait or multiple traits in a population over generations,
- is a process that consists in identifying individuals with outstanding genetic characteristics and using them as parents for the next generation. By selecting and breeding these individuals, their valuable genetic material is passed on to the offspring, which leads to an increase in the frequency of desired traits in the population,
- genetic gain depends on several factors, including the heritability of the traits of interest, the intensity of selection, the genetic variation in the population, and the time needed to complete one breeding cycle.

Thank you for your attention!

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