4. Genetic parameters – repeatability, genetic correlations

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This lecture will be concerning Genetic parameters - repeatability, genetic correlations

GENETIC PARAMETERS POPULATIONS - INHERITABILITY OF TRAITS, REPEATABILITY AND CORRELATIONS
The genetic parameters of the population include:
heritability of features
repeatability of features
correlations - including genetic, phenotypic and environmental correlations.

Characteristics important in animal husbandry include:

- performance of animals (for example, milk yield)
- animal reproduction
- health

Generally, the features can be classified into two groups:

- quality features
- quantitative characteristics

CHARACTERISTICS OF FEATURES
The main factor differentiating these two groups of traits is the number of pairs of alleles (genes) affecting their formation and the number of classes of differentiated phenotypes.

In the case of qualitative traits, the number of pairs of genes (or a series of alleles) influencing their formation is limited, ranging from 1 to a maximum of 2-4.

This in turn affects a limited number of genotypes (hereditary assumptions of individuals) and, consequently, individuals with specific phenotypes (total characteristics of the organism).

QUANTITATIVE FEATURES
In the case of features defined as quantitative, the situation is much more complex.

Firstly, the number of genes (polygens) affecting their shape is very numerous, sometimes difficult to determine.

Then, in addition to genetic assumptions, environmental factors have a significant impact on their formation.

This type of inheritance significantly increases the diversity of individuals in the herd and makes it extremely difficult to identify genotypes based on phenotype.

With the multiplicity of factors influencing traits, it is impossible to determine the contribution of a single gene to the formation of a quantitative trait.

Only statistical methods allow to determine the influence of genotype and environment on the variability of the trait in the herd and to estimate the heritability of the traits of interest on this basis.

HERITABILITY OF TRAITS - DEFINITION

Heritability (h2) informs us (in a very general sense) about what part of the general phenotypic variation of a given trait in the population is genetic variation (diversity caused by the action of genes)

Heritability also determines how much of the selection difference will be "transferred" to the offspring in the form of breeding progress.

The heritability of traits is measured by the heritability coefficient - h2. It is the ratio of genetic variation to phenotypic variation. We can express
this with the formula:

HERITABILITY OF TRAITS - FORMULA

We can express this with the formula:

$h^2 = \delta^2_G / \delta^2_P$,

Where:

$\delta^2_P = \delta^2_G + \delta^2_E$

δ^2_P – phenotypic variability (total variability of a given trait in a herd-population),

δ^2_G - genetic variation,

δ^2_E – environmental variability

HERITABILITY

- ratio of genetic variation to overall phenotypic variation,

- the degree of influence of the variability of the hereditary assumptions of a given trait on the manifestation of variability in the phenotype,

- the regression coefficient of the breeding value against the phenotypic value of the same individual (refers to the population).

THE IMPORTANCE OF HERITABILITY

- It makes it possible to determine to what extent the observed phenotypic variability results from genetic variability,
- determines the regression of G against P → allows to predict (estimate) the breeding value,
- allows you to predict the effectiveness of selection.

HERITABILITY

h^2 → the symbol derived from the analysis of variance refers to the mean square of deviations of some of its components,

h^2 → correlation between genotype and phenotype.

HERITABILITY OF TRAITS – ESTIMATION METHODS

Analysis of variance,

We estimate the mean and variance for:

A. for the whole population,
B. for all groups of half-siblings,
C. for all sibling groups.

We rely on analysis of
- half-sibling groups: cattle, sheep
- full sibling groups: poultry, pigs

We calculate on the basis of intraclass correlation coefficients
Analysis of full sibling groups

h^2 → population parameter

A. varied depending on the characteristics,
B. varied depending on time (in the same populations),
C. varied depending on the population (for the same features)

h^2 → from 0 to 1 or from 0 to 100.00%.

REPEATABILITY OF TRAITS (r', R)
The repetition of traits is one of the genetic parameters of a population. The repeatability of traits can be estimated for traits that are cyclically repeated in animals, for example.: the number of young in successive litters, body weight of successive litters, the amount of milk obtained from cows and other mammals in successive lactations. When estimating the repeatability index, we assume that the genotype of animals does not change over the course of their lives, and the differences that arise in subsequent years of use result from environmental influences. They can also result from the somatic development of animals.

Estimating the repeatability index
(r', R): $P = H + EES + EEN$ OR $\sigma^2_p = \sigma^2_g + \sigma^2_{Es} + \sigma^2_{En}$
σ^2_p - phenotypic variability, $\sigma^2 g$ – genetic variability, σ^2_{Es} – constant environmental variability, σ^2_{En} – variable environmental variability

Regression method of posterior performances
Regression method of later performances to earlier performances:

Estimating the repeatability index (r', R):

$P = H + EES + EEN$ OR $\sigma^2_p = \sigma^2_g + \sigma^2_{Es} + \sigma^2_{En}$
σ^2_p - phenotypic variability, σ^2_g – genetic variability, σ^2_{Es} – constant environmental variability, $\sigma 2_{En}$ – variable environmental variability.
$r' = (\sigma^2_g + \sigma^2_{Es})/(\sigma^2_g + \sigma^2_{Es} + \sigma^2_{En})$

The method of regression of later performances to earlier performances,
Variance analysis method.
Selected values of estimated repeatability ratios
number of piglets in pigs 0.1 - 0.15, number of young in rabbits 0.09 - 0.12, number of young in chinchillas 0.12 - 15, repeatability of milk yield in cattle 0.25 - 0.35.

CORRELATIONS BETWEEN SPECIFIC FEATURES
Correlations result from:

Linkage of genes - conditioning individual traits are on the same chromosomes,

Selection of two features in the same direction - which in turn leads to the occurrence of interdependence,
Pleiotropic influence of individual genes on various traits

CORRELATIONS - THEIR MUTUAL RELATIONS
With low heritability of traits, the value of the phenotypic correlation is close to the environmental correlation.
With high heritability, the phenotypic correlation will be close to the genetic correlation.
In the case of medium-sized heritability, or when one trait has a high and the other a lowrgxp, the genetic correlation may be positive and the phenotypic correlation negative.

VALUES OF SOME PARAMETERS IN ANIMAL HERDS - HERITABILITY

Cattle:
milk yield: 0.31- 0.39,
fat content in milk: 0.56 - 0.68,
milk protein content: about 0.57,
body weight at birth: about 0.40, body weight at the age of 120 days about 0.50,
daily gain of about 0.40, slaughter efficiency of about 0.60,
height at the withers about 0.542, carcass length about 0.754,
area of the "eye" of the tenderloin about 0.178.

VALUES OF SOME PARAMETERS IN ANIMAL HERDS - HERITABILITY
Pigs:
Daily gain: 0.30,
average daily gain 40-90 kg 0.264,
fat thickness on the back about 0.50, length of the carcass about 0.50,
amount of meat in basic cuts about 0.520,
area of the "eye" of the tenderloin about 0.740,
litter weight 3 weeks approx. 0.080,
litter size at birth is about 0.10.

VALUES OF SOME PARAMETERS IN ANIMAL HERDS - HERITABILITY Sheep:
body weight at birth - 0.30,
body weight after weaning - 0.30,
body weight 10 months - 0.28,
shearing pure fiber efficiency - 0.28,
wool thickness - 0.40,
human mass – 0.40,000.
wool height - 0.52,
milk yield - 0.18,
fleece weight of the second shearer - 0.32.

VALUES OF SOME PARAMETERS IN ANIMAL HERDS - HERITABILITY
Poultry:
Egg size - 0.45,
egg weight - 0.30,
laying capacity - 0.20,
shell color - 0.70,
Fertility - 0.10,

feed efficiency - 0.60,
body weight 8 weeks - 0.10 - 0.30
stroke length - 0.10 - 0.30.

VALUES OF SOME PARAMETERS IN ANIMAL HERDS- CORRELATIONS
Cattle :

	Correlations	
	phenotypic	genetic
milk yield - fat content in milk	-041	0,43
fat content - protein content in milk	0,57	0,60
weight at birth – at the age of 1 year	0,34	0,40
trunk length – body weight	0,70	0,83
Poultry: body weight - egg weight	0,30	0,25
body weight – breast angle	0,38	0,68
body weight – stroke length	0,41-0,74	0,83-0,89
Pigs:		
Daily gain - back fat thickness	-0.10	-0.20
Body length - back fat thickness	-0.30	-0,40