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Genetic parameters – heritability, repeatability and genetic correlations

Modul no. 3: Animal Breeding
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GENETIC PARAMETERS OF THE POPULATION - HERITABILITY, REPEATABILITY AND CORRELATIONS

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The genetic parameters of the population include:

- heritability,
- repeatability,
- genetic, phenotypic and environmental correlations.

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Traits that are important in animal husbandry are traits
- related to the performance of animals (e.g. milk production),
- animal reproduction,
- health.

Generally, the features can be classified into two groups:
- quality features,
- quantitative characteristics.

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CHARACTERISTICS OF THE FEATURES

The main factors differentiating these two groups of features is the number of pairs of alleles (genes) affecting their shape 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) affecting their formation is limited and ranges within quite narrow limits from 1 to a maximum of 2-4.

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

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QUANTITATIVE CHARACTERISTICS

- 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 as well as it makes it extremely difficult to identify genotypes based on phenotype.

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- 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 (population) and to estimate the heritability of the traits of interest on this basis.

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HERITABILITY OF CHARACTERISTICS – 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 breeding progress
- The heritability of traits is measured by the heritability coefficient - h2. It is the ratio of genetic variation to phenotypic variation.

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HERITABILITY

- the ratio of genetic variability to the overall phenotypic variability,
- 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).

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THE IMPORTANCE OF HERITABILITY

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

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HERITABILITY

- h2 → symbol derived from the analysis of variance, refers to the mean square of deviations of some of its components,
- h2 → correlation between genotype and phenotype.

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HERITABILITY OF FEATURES - 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 variability,
- δ^2_E – environmental variability.

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HERITABILITY OF FEATURES - METHODS OF ESTIMATION

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

- half-sibling groups: cattle, sheep
- full sibling groups: poultry, pigs.

We calculate on the basis of intraclass correlation coefficients

Analysis of full sibling groups

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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%.

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REPEATABILITY OF FEATURES (r', R)

The repetition of traits is one of the genetic parameters of a population. The repeatability of features can be estimated for features that are cyclically repeated in animals, e.g.: number of young in successive litters, body weight of successive litters, 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): $P = H + E_{ES} + E_{EN}$ or $\sigma^2_p = \sigma^2_g + \sigma^2_{Es} + \sigma^2_{En}$

σ^2_p - phenotypic variation, σ^2_g – genetic variation, σ^2_{Es} – constant environmental variability, σ^2_{En} – environmental variability variable.

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ESTIMATING THE REPEATABILITY INDEX (r', R):

- $r' = (\sigma^2_g + \sigma^2_{Es})/(\sigma^2_g + \sigma^2_{Es} + \sigma^2_{En})$

- Regression method of later performances to earlier performances,
- Variance analysis method.
- Selected values of estimated repeatability indicators 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 – 0.15, repeatability of milk yield in cattle 0.25 - 0.35.

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CORRELATIONS BETWEEN INDIVIDUAL 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

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CORRELATIONS - THEIR MUTUAL RELATIONS

1. With low heritability of traits, the value of the phenotypic correlation is close to the environmental correlation.
2. With high heritability, the phenotypic correlation will be close to the genetic correlation.
3. With heritability of medium-sized traits, or when one trait has a high and the other a low r_{gxp}, the genetic correlation may be positive and the phenotypic correlation negative.

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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 muscle about 0.178.

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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 muscle about 0.740,

litter weight 3 weeks approx. 0.080,

litter size at birth about 0.10.

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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,

fleece weight - 0.40,

wool height - 0.52,

milk yield - 0.18,

fleece weight of the second shearer - 0.32.

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VALUES OF SOME PARAMETERS IN HERDS OF ANIMALS - 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.

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VALUES OF SOME PARAMETERS IN LIVESTOCK 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
torso 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 - the thickness of the fat on the back	-0,10	-0,20
Length of body - thickness of fat on the back	-0,30	-0,40

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