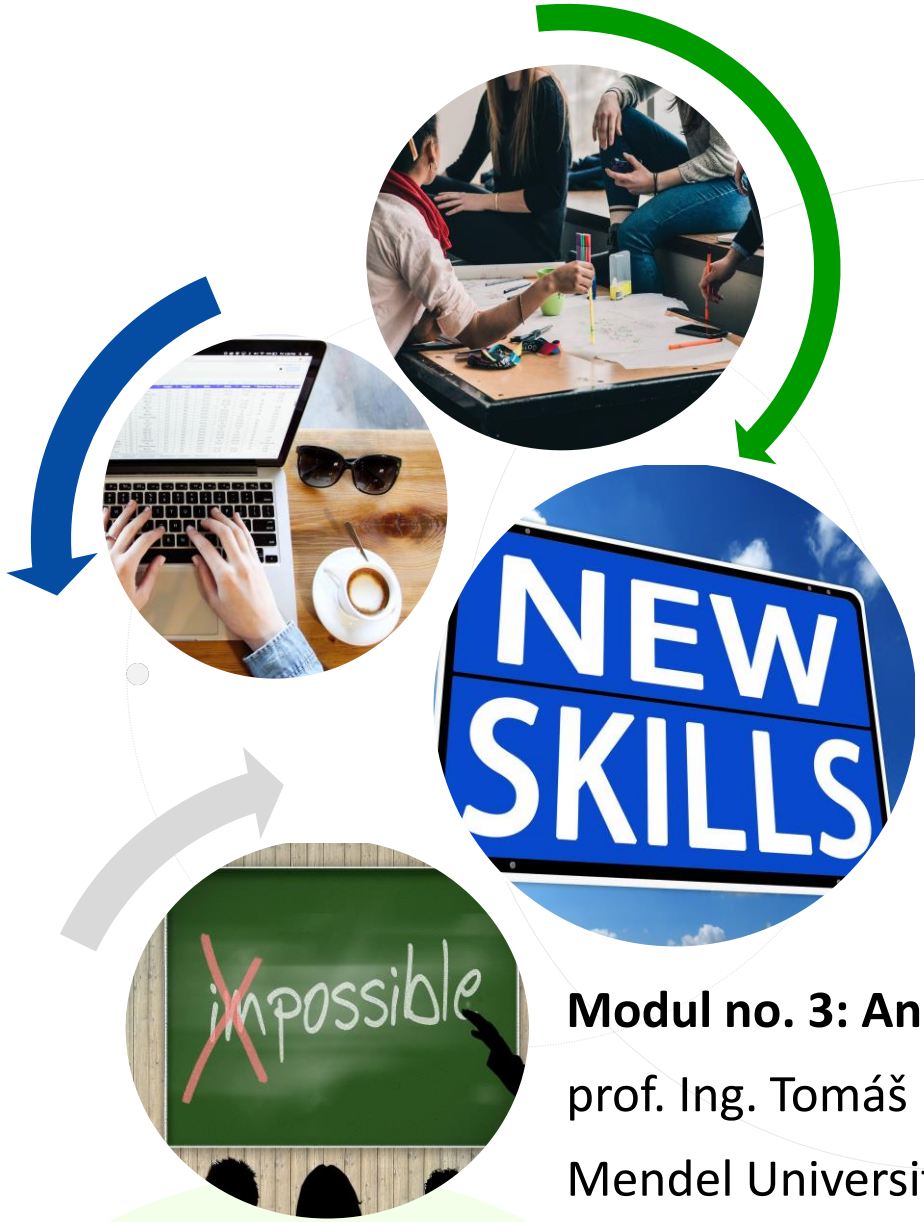

Genetics principles in breeding

Modul no. 3: Animal Breeding

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Domestication - Evolution - Breeding

- Weakening of the action of many natural selection factors (but they still act)
- Targeted selection on the desired trait and its value
- Selection for related traits
- Control of movement, breeding, feeding

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Breeding - human as an agent of selection (evolution)

- Definition of breeding objectives: the best animals are selected
- Typical objectives for breeding are combinations of the above values of different traits that are important for production
- The mean of a trait in a population can be varied in the desired direction
- Most production traits -> complex, quantitative character **(P = G + E)**
- -> **based on the genetic structure of the bred population and environmental conditions**

- **Basic decomposition of phenotypic variability : $V_P = V_G + V_E$**
- **Genetic variability in a population is characterized by the coefficient of heritability : $h^2 = V_G / (V_G + V_E)$**

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Animal breeding is based on the following hypotheses:

- The object of evolution/breeding is not the individual, but the population.
- Most production traits are determined by polygenes - quantitative traits.
- It is not genotypes that are passed from generation to generation, but genes (alleles) via gametes, which combine to produce new genotypes in the offspring generation.
- The phenotype of quantitative characteristics of an individual is modified by environmental influences: **P = G + E**
- The amount of genetic improvement values (ΔG) and its reflection in economic efficiency (profit €) depends on:
  - Genetic basis of the trait and its variation in the population
  - Estimation of the breeding value of individuals and populations (genotypic value)
  - Accuracy in defining the breeding objective
  - Optimal use of animals with high PH

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What information is needed in breeding

- **Phenotypic data** – Performance
- **Genetic (genotype/genomic) data**
  - Relationships data
  - Genotypes of genetic markers
- **Statistical methods** -> data integration -> finding the genetically superior individual (best alleles -> offspring, for a given environment)

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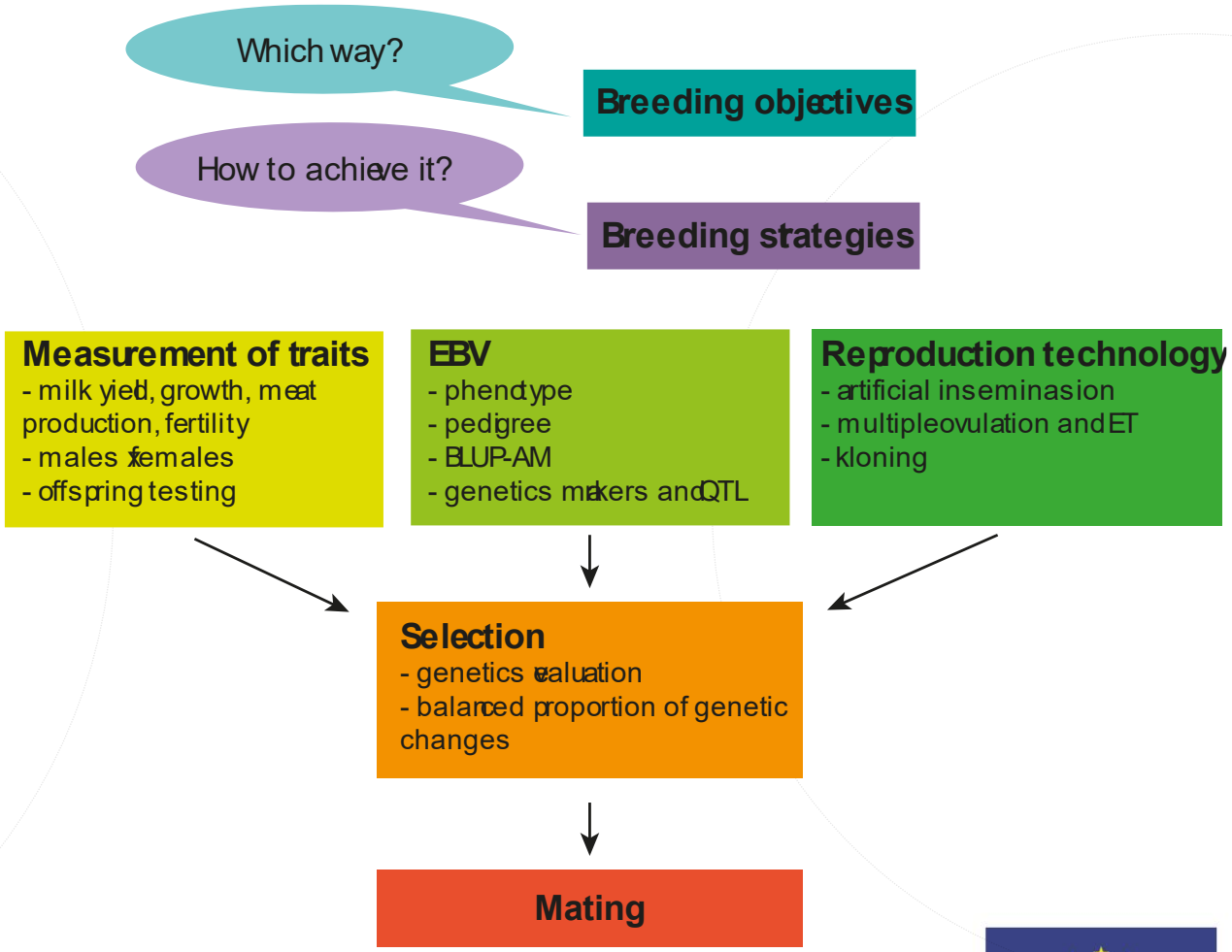
Crucial problems in breeding

- What is the purpose of breeding?: Which traits do we want to improve and how important are the different traits in relation to each other?
- How and whom will we measure? Which traits, which animals?
- Do we need to use reproductive technologies (artificial insemination, embryo transfer, sexing of sperm or embryos, cloning, ...)?
- How many and which animals do we need to select as parents for the next generation?
- How will we mate the selected males and females?



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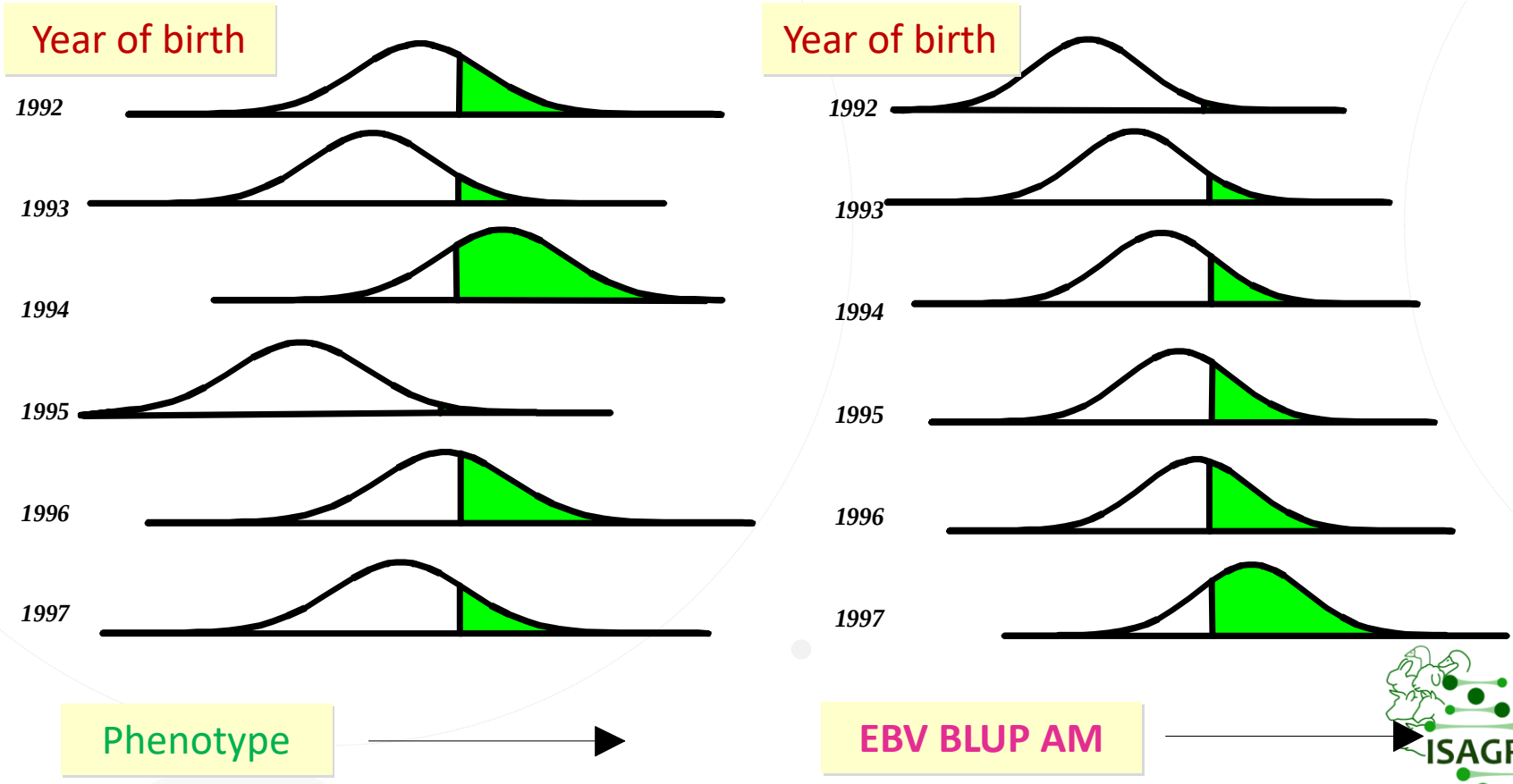
The genetic evaluation system helps in the design of breeding programmes

Selection based on phenotype

From the beginning of domestication to the early 20th century

Selection by EBV (~ genotype)

Since the 1950s



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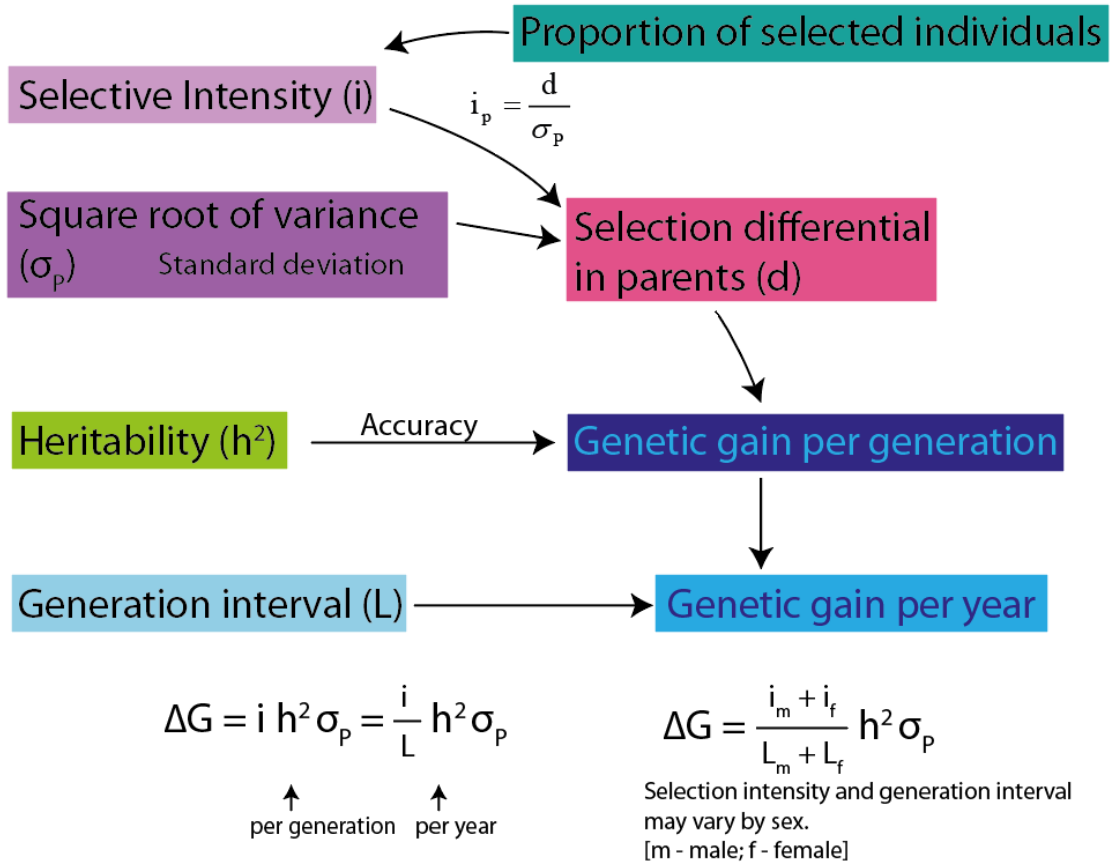
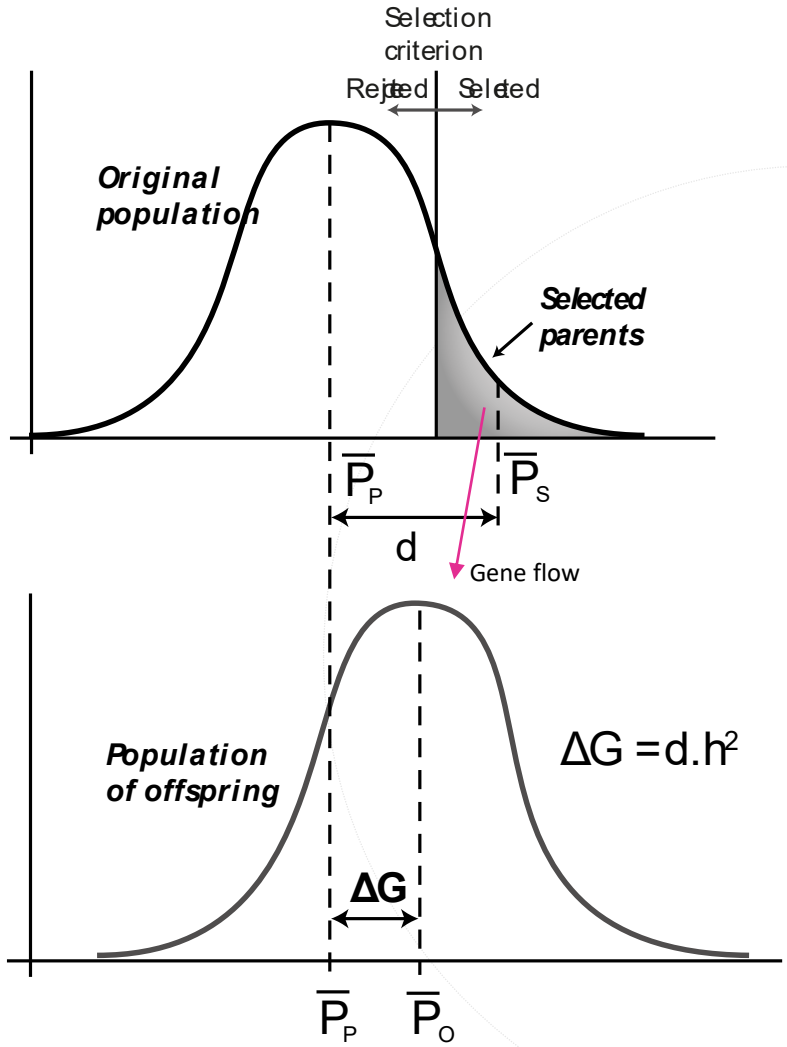
Principles of genetic improvement through selection





- Breeding equation:

$$\Delta G = i_p r_a \sigma_A \qquad \Delta G_{rok} = \frac{i_p r_a \sigma_A}{L}$$

r – Accuracy of EBV
L – generation interval

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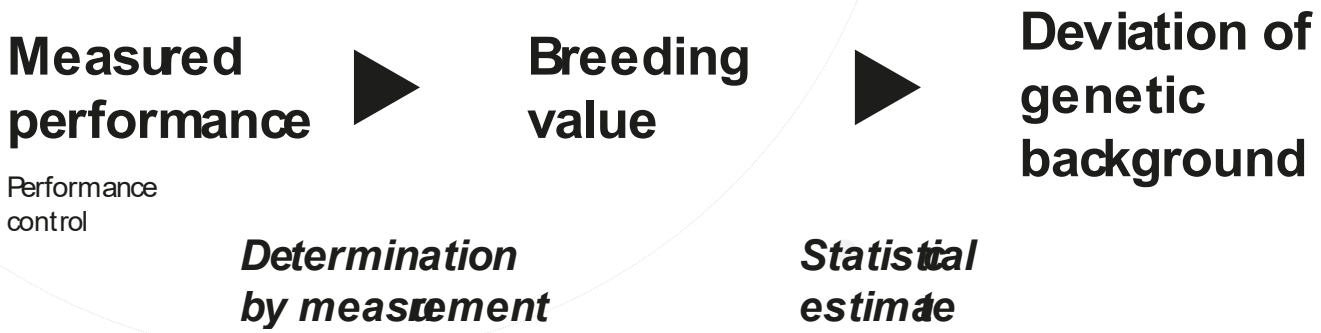
Breeding value (PH) and genetic basis

- It is impossible to directly determine the genetic value of an individual!
- **Genetic differences** (BV) between performance caused by different genotypes can be detected. These differences are **estimable**!!!
- BV - an estimate of the genetic foundation of an individual (its unique genotype) expressed by the **genetic deviation in performance trait from the average of its contemporary group**



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- Genetic variability > individuals with different genotypes > different individuals have different genetic value

BUT

- Gamete = 1 allele >>> BV depends on the effects of the individual allele, not the effects of the allelic pair at the locus

-> EBV is the value of the effects of alleles passed from parents to offspring

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Process of estimation of breeding value (EBV)

- **is the mathematical and statistical process of removing genetic influences on performance from factors of a non-genetic nature (environment) and "removing" everything else from the influence**
- Based on the dependent variable of performance I want to estimate the "genetic background of the individual" (the effect of the parent's alleles in the offspring population) -> animal testing and their mathematical evaluation
- **EBV - estimation of genetic variation.**
  - EBV based on own performance
  - Including the value of the heritability coefficient
  - $\mathrm{EBV} = \mathrm{h}^2(\mathrm{y} - \overline{y})$
  - **estimation of deviation of genetic background**

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Ex. Estimation of BV by own performance

The bull had a significantly better (350 kg) weight at 1 year than the population average (300 kg).

- His phenotype as a deviation is +50 kg.
- But is this phenotypic deviation only due to genetic differences?
- A bull could be good because of his genes, but also because he developed in better conditions.

- The question is, **how much of the phenotypic deviations are due to genetic**, i.e. breeding value?

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Comparison of OPH animals with different peer groups

Animal	Weight at 1 year	Peer average	Phenotypic deviation	**EBV**
Karel	330	300	+30	**+12**
Rudolf	300	260	+40	**+16**

In estimating the BV based on the own performance, the b = h^2

$$h^2 = 0.40$$

$$\text{OPH} = b \cdot D$$

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Conclusion

- The main method of breeding and evolution in general is selection
- The aim is to identify genetically superior individuals > EBV
- It is based on population variability and heritability estimate (h2) for a given trait
- Select the most suitable alleles for a given condition as parents
- Intentional reproduction to carry their alleles into the next generation
- Expect a shift in the average value of the trait being bred in the offspring (genetic gain)
- Breeding must generate economic profit

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Partneři:

Slovak University of Agriculture Nitra

Mendel University in Brno

Siedlce University of Natural Sciences and Humanities

Czech University of Life Sciences Prague

And thank you for your attention!

Táto prezentácia bola podporená grantom Erasmus+ KA2 Partnerstvá pre spoluprácu č. ***2021-1-SK01-KA220-HED-000032068 "Inovácia štruktúry a obsahu študijných programov v oblasti manažmentu živočíšnych genetických a potravinových zdrojov s využitím digitalizácie - Inovácia obsahu a štruktúry študijných programov v oblasti manažmentu živočíšnych genetických a potravinových zdrojov s využitím digitalizácie".*** *Podpora Európskej komisie na prípravu tejto prezentácie nepredstavuje schválenie jej obsahu, ktorý vyjadruje len názory autorov, a Komisia nenesie zodpovednosť za akékoľvek použitie informácií v nej obsiahnutých.*

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