Topic 3: Optimization of mating plans and breeding strategies on the example of cattle
Practical example

Example 1 In a herd of dairy cattle, one production feature is being improved - milk yield during lactation.
Three cows with known breeding values (EBV - estiamted breeding value) were intended for mating.
Let's assume that there is semen available from four bulls with known breeding values and different prices, and each cow will be mated to a different bull.
Assumptions:

1 kg of milk = PLN 2;
For every 1% increase in inbreeding, milk production during lactation decreases on average by 16 kg.

The order in which the actions are performed:
Firstly - the net present value is determined, indicating the amount of profit associated with obtaining offspring from each mating.
Secondly - All possible sets of pairs are created using available individuals (the size of the set is determined by the number of females).
Third - The NPV (net present value) of the offspring of each of the pairs making up the set is added up.
Finally - A cow-bull set is selected to guarantee the highest profit.

Data for example 1
3 cows with known breeding value EBV in kg and 4 bulls with known breeding value and given semen cost.
Data for example 1, i.e. pedigrees of cows and bulls.
A solution, for example 1, to select a cow-bull set that guarantees the highest profit.
We use the following formula to calculate the net present value for calculating the profit of each cow-bull set:
half of the sum of the breeding value of the male and female from the selected set; less the amount of inbreeding depression of the offspring from this set and the cost of purchasing semen from this bull.
In order to calculate the amount of inbreeding depression ($\mathbf{D_{ij}}$), the inbreeding of offspring from a given mating ($\boldsymbol{F_P}$) should be calculated using the presented formula.
Where: n1 is the number of paths from a common ancestor to one parent; n2 is the number of paths from the common ancestor to the second parent of the proband.
F$\boldsymbol{a}$ is the inbreeding of a common ancestor.
The inbreeding coefficient of the offspring from the mating of cow A and bull 1 is 0.
The structural pedigrees of cow A and bull 1 do not have common ancestors.
The structural pedigrees of cow B and bull 1 do not have common ancestors.
Also, the inbreeding coefficient of the offspring of cow C and bull 1 is 0.
The inbreeding coefficient of the offspring of cow A and bull 2 is 0.
The inbreeding coefficient of the offspring of cow B and bull 2 is 0.3125, the pedigrees of the cow and bull have a common ancestor.
The inbreeding coefficient of the offspring of cow C and bull 2 is $\mathbf{0.0625}$.
The inbreeding coefficient of the offspring of cow A from bull 3 is 0.03125.
The inbreeding coefficient of the $\boldsymbol{F_P B3}$ offspring is 0.125.
Also the inbreeding coefficient of the offspring $\boldsymbol{F}$p C3 is 0.125.
to 19.

inbreeding coefficients of the A4; B4; C4 offspring were 0.

The calculated inbreeding coefficients Fp of the offspring of individual pairs are summarized in the table.
The next step is to calculate the net present value (NPV), which indicates the amount of profit associated with obtaining offspring from each mating. These are the calculated NPV values.
Then, all possible sets of pairs are created using the available individuals (the size of the set is determined by the number of females).
The NPV (net present value) of the descendants of each of the pairs that make up the set is summed.
The final element is the selection of cow-bull sets that guarantee the highest profit.
To sum up, the highest profit can be obtained by matching the following cow-bull sets shown on the slide.

Example 2 Please prepare an individual mating plan for a Polish Holstein-Friesian cow of the black and white variety.
Provide suggestions for mating with 3 bulls selected from available bull catalogs, selected companies (using the latest valuations).
Corrective mating, which will aim to improve udder structure (including: posterior udder suspension).
The cow's details and pedigree are visible on the slide.
The cow scored a total of 79 points in the evaluation of type and conformation, which is a fairly good evaluation. For the udder, she scored 77 points.
Detailed information on the breeding value of conformation traits and sub-indices of the Production Functionality selection index are shown here.
Solution to Example 2
The latest catalogs with current bull evaluations should be used.
Such catalogs contain lists and rankings of bulls evaluated conventionally, i.e. on daughters or genomically.
Here is a list of bulls evaluated conventionally of the Polish Holstein-Friesian breed, December 2023 valuation. The bulls are ranked according to the Production Functionality Index value.
The highest values of the Breeding Values for production traits and the highest values of the sub-indices are also marked in colors.
The example suggests creating an individual plan for mating a cow with 3 bulls selected from the catalog. This is to be a corrective mating, which will aim to improve the conformation of the udder (including: rear udder suspension).
To start with, we can use such a list of the best bulls and taking into account the conformation sub-index and in detail the udder sub-index.
Based on the value of the udder sub-index, we can choose bulls from positions 2, 3 and 6.
In order to get acquainted in detail with the breeding value of these individuals, we find the cards of selected bulls in the catalog and analyze the information from the linear diagrams of conformation assessment, especially in terms of the possibility of improving udder characteristics in the offspring of this cow and this bull.
Visible data of the bull Gryfon - position 3.
Here is the bull's data Gavito - position 2.
And the data of the bull Czekan Mlek – position 6.
Therefore, these three bulls presented, after a detailed analysis of the udder conformation, can be selected as fathers of the next generation of the Pietje cow.

Example 3. Please prepare an individual mating plan for the same Polish Holstein-Friesian cow of the black and white variety from Example 2.
Please provide suggestions for mating with 2 bulls selected from publicly available databases:

1) National Research Institute of Animal Production https://wycena.izoo.krakow.pl/ or
2) Genetic Center of the Polish Federation of Cattle Breeders and Dairy Producers https://www.cgen.pl/indeksy/

Corrective mating, which will aim to improve the longevity of the offspring.

Solution to example 3. Using the publicly available database of the Genetic Center of the Polish Federation of Cattle Breeders and Dairy Producers https://www.cgen.pl/indeksy/ we can select bulls evaluated conventionally or genomically in terms of the ranking of the PF selection index value and the longevity subindex. At the same time, checking whether the semen is available and from whom it can be ordered. The slide ranks the bulls in terms of the level of breeding value of longevity, a trait included in the PF index.

Similarly to catalogues, after the initial selection of bulls you can see detailed data regarding the valuation of each bull and compare several selected individuals.

Each bull also has its own card where you can see, among other things, its pedigree. Here you can see the data of the bull Rory.

Pedigree of the bull Altazarek.

Here you can see the pedigrees of the cow and the indicated bulls from the database with the highest breeding value for longevity.

Therefore, the cow and the selected bulls do not have common ancestors and therefore can be selected for mating.