Topic 3: Optimisation of mating planns and breeding strategies on a cattle exemple
Lecture

The aim of breeding work is to transform the genetic structure of the herd in a direction consistent with human requirements. These requirements focus on improving the animals in terms of performance and direction of use.
In the case of cattle, such a goal may be, for example, increasing milk yield or improving meat quality.
To achieve the previously selected goal, the following actions should be performed: perform an ongoing assessment of the cow herd in terms of selected functional characteristics and breeding value, then select the animals and characteristics that will be improved. The next step is to select a breeder for the female to achieve the intended goal.
Selected traits in cattle can be improved by: selecting heifers or cows in the herd and by assessing and selecting bulls in the population or breed.
Two basic methods of cattle improvement are used in cattle breeding: selection and mating or crossing pairs for reproduction.
The first method of improvement, or selection, is the selection of animals that will become the parents of the next generation. The offspring acquires the genotype at the time of fertilization for the rest of its life. Therefore, appropriate selection of parents may allow for breeding gain.
Some well-known selection methods include: for several features at the same time or selection according to the total value of the so-called features selection index.
In addition to the assumed goal, the breeding program includes the following elements: selection of bull fathers and mothers, then individual pairings of selected individuals, offspring, i.e. young bulls, are subjected to self-assessment, after reaching a certain age, semen is collected from selected bulls and then used in selected herds for testing. The daughters born are assessed for their utility value (milk yield) in order to determine the breeding value of the test bulls.
Genetic gain in cattle takes place along four distinctly different paths.
Father-son path - this is where bull fathers pass on the best genes to their sons. It is carried out with much greater selection stringency, which results from the fact that only 1% of bulls become fathers of sons. These individuals, because there are few of them, have a significant impact on the level of inbreeding in the population in the long run, so care should be taken to ensure that, on the one hand, there are few bull fathers and, on the other hand, that they are not closely related to each other.
Mother-son path – this is the second improvement path on which bull mothers are selected. Traditionally, it was characterized by high severity because there were always relatively many candidates - cows. On this path, not only is it important to look for the best females, but it also matters that they actually leave the expected male offspring.
The **father-daughter** path is traditionally associated by breeders with breeding work in the herd. It is the breeders who decide about it, among other things, by their determination to select males with the highest breeding value.
Therefore, the breeding progress achieved in the herd depends up to 70% on the well-conducted selection of bulls and cows.
The typical life course and productivity of a breeding bull in the conventional method (i.e. assessed on daughters) consists of the following elements: after birth, the bull is reared and, based on its own fattening performance and suitability for reproduction, assessed and then classified into one of 4 classes.
Conventional assessment of the breeding value of a bull takes a long time, even 12 years.
Due to the large role of bulls in genetic progress, a precise assessment of their breeding value is a very important task.

There are the following methods for assessing the breeding value of bulls: pedigree assessment, BLUP method and genomic assessment.
Assessment of breeding value using the BLUP method is expressed in the form of deviations from the average of peers (daughters of other bulls). BLUP can be defined as: best, linear, unbiased prediction.
The best - because the estimated breeding values are characterized by high accuracy.
Linear, because the statistical model used to estimate the breeding value is based on the summing effect of individual factors influencing the level of specific traits.
Unbiased because it means that the obtained breeding values are slightly "distorted" by the influence of non-genetic factors (this distinguishes the BLUP method from the selection index)
Another method of assessing the breeding value of bulls is genomic assessment. Genomic selection in dairy farming allows the identification of the genetically best animals at a very young age, with greater accuracy than an assessment based on the average genetic value of the parents. Genomic evaluation can include large numbers of young animals, allowing for more stringent selection.
The traditional scheme (in assessing conventional breeding value) for bulls requires approximately 6 years from the moment the parents of the next generation are selected for the commercial exploitation of bulls based on the assessment obtained from his daughters. This method is accurate, but expensive and long-lasting. However, genomic assessment allows for the valuation of very young animals. This allows for the shortening of the interpologenesis interval and increasing the severity of selection.
When assessing bulls based on the milk performance of the offspring, the following factors are mainly taken into account: milk yield, fat yield, protein yield, % fat, % protein, conformation, and somatic cell count.
One of the selection methods used in cattle is selection indexes. Here are examples of the construction of such selection indexes used to select bulls in selected countries, combining the values of selected characteristics.
In Canada, the LPI consists of 51% milk production traits, 34% durability (i.e. lifespan and conformation, among others) and 15% health and fertility traits.
In the United States, the TPI selection index consists of 46% production traits, 28% Health and Fertility, and 26% body composition traits.
In contrast, the German selection index is even more detailed and complex.
The formula of the Polish selection index PF is the sum of the sub-indexes: production, conformation, fertility, breeding value of somatic cells and longevity - with their appropriate weight.
The assessment of the breeding value of bulls using the PF Index in Poland is carried out, among others, by the National Research Institute of Animal Production, which publishes a ranking of bulls according to the value of this index on its website twice a year.
The best bull in the assessment of breeding value in Poland in December 2023 was the bull Charon. And these are all the values of individual subindexes from this assessment.
The second method of cattle improvement is the selection of pairs. There are two methods of selecting pairs: mating, i.e. selecting animals within one breed for reproduction, and crossbreeding, i.e. mating animals of different breeds.
In the case of mating pairs, we can talk about matings: random, non-random, kin and free.
In the case of crossbreeding, i.e. mating of animals of different breeds, we distinguish the following: refining crossbreeding, breed-building crossbreeding, displacement crossbreeding, commercial crossbreeding and interspecific crossbreeding.
We will focus on selecting pairs for mating animals. In order for the offspring to meet the breeder's expectations, two mating methods can be used:
- matching the best cows with the best bulls or

- corrective mating, in which cows that are worse in terms of a given production or conformation feature are inseminated with the semen of a bull that significantly improves this feature.

So how do you optimize your mating plans? The most important thing in this respect is the correct choice of a bull, because - depending on the size of the herd - we can obtain from several to several dozen heifers per year. Where to start choosing bulls and what to pay attention to to make the optimal choice? Firstly - Analyze the pedigrees of cows to prevent mating of related animals.

Secondly, choose a bull based on calving ease, especially important when mating heifers and small-sized cows.

An important clue about the bull's value is the selection index. But we should follow the principle that the best bull is the one that "fits" our herd, not the one with the highest index value.

Then, breeding values (so-called advantage) should be taken into account in relation to: daughter milk components (e.g. % protein) and conformation and structure characteristics.

When choosing a bull for mating, functional characteristics should be taken into account: the previously mentioned calving ease and longevity.

One of the possibilities for the optimal selection of pairs for mating is the use of a computer program that has deep pedigrees of cows and bulls and in its analyses, takes into account, among others, genetic defects and estimates the relatedness of future calves.

Computer selection programs make it possible to establish such selection parameters as: improvement of one or two features; bulls that have the appropriate level of breeding values for production and functional traits are initially selected; the breeder selects priority features that will be improved.

The selection of the appropriate number of bulls depends on: the size of the herd, the degree of reliability of the assessment of the breeding value and the level of risk that the breeder is willing to accept. You should not inseminate more than 15-20% of the cows in the herd with the semen of one bull.

So what are the effects of breeding work on the cattle population? These are: change in the breeding value of animals, reduction of genetic variance, spread of genetic defects, increase in homozygosity. Unfortunately, breeding decisions related to the selection of animals for mating result in an increase in inbreeding, and a 1% increase in inbreeding means a decrease in milk yield in a 305-day lactation by an average of 20 kg!!!

Finally, some information to summarize the issue of Optimization of mating plans and breeding strategies on the example of cattle.

Breeding is defined as a breeder's efforts to improve the hereditary characteristics of animals.

In cattle, the main subject of improvement are functional features, such as: milk yield, correct structure, including the structure of the udder and the shape of teats suitable for mechanical milking, functional features and meat performance.

In order to carry out breeding work, i.e. improve cattle, it is necessary to know its utility and breeding value. For this purpose, the utility value of cattle is assessed by collecting information on the milk yield of cows, the chemical composition of milk, etc. On the basis of this information, selection is carried out, i.e. animals with the desired properties are selected and designated for breeding.

Another element of breeding strategies is the selection of pairs for mating. For this purpose, it is necessary to know the value of both the male and the female.

There are two ways of pairing:

matching the best cows with the best bulls and

corrective pairing.

The most important elements taken into account in individual matchmaking are:

degree of relationship (to avoid inbreeding),
breeding goal in the herd (production traits, functional traits).