12. Methodological procedures for the development and management of breeding programmes

The lecture "Methodological procedures for the development and management of breeding programmes" offers the basic knowledge for the establishment of a breeding programme in animal breeding and also explains the possibilities and principles for the development of a breeding programme. Modern approaches to breeding programme design will be discussed in more detail.

A breeding programme is a planned breeding of a group of animals that takes several generations. The breeding programme is based on knowledge of the basic genetic principles of each economically important trait or characteristic of the animal. Any breeding programme must take into account the country's agricultural and trade policies. The specific objectives and targets shall be adapted to the particular breeding conditions and environmental influences in which the breeding programme is implemented. For this reason, each breed or group of livestock has its own breeding programme, which is a set of interrelated breeding, technical and organizational measures. The achievement of the breeding objectives represents a genetic improvement of animal traits while preserving biodiversity and it also depends on the broad participation of farmers and management in this process.

Each breeding programme accepts the agricultural and commercial policy of the country, based on their conditions and on the specific production system. It is important to know the characteristics of the animal population, their breeding standard and also the infrastructure of the farms in its development.

Individual strategies must be defined in each programme. First of all, a breeding objective must be established, which is drawn up for each breed and approved by the Breeding Commission of each breeders' association. The breeding strategy must take into account if the breed is purebred or cross-bred. In this process, it is very important to establish the conditions for selecting animals for breeding on the basis of the traits and characteristics for which they are bred and to draw up mating plans. Appropriate reproduction methods can ensure an increase in genetic gain in a shorter period of time.

In order to achieve the objectives of breeding, means such as the process of performance control and data collection carried out by the Slovak Breeding Services, genetic analysis and estimation of breeding values for individual traits, and finally monitoring and estimation of genetic gain are used.

The breeding programme includes biological, technical and economic parts.

In the biological part, the estimation of genetic parameters of selected traits and characteristics is carried out in order to determine the effect of the genotype on the improvement of the trait. Many traits have a low coefficient of heritability, which means a small contribution of the genotype to the phenotypic expression of these traits. In this case, it is necessary to focus on environmental factors that influence the traits of interest to a significant extent. Environmental factors include not only climate and weather, but also the whole management system, e.g. feeding, creep feed forage quality and quantity, and health programmes.

The biological part of the breeding programme also includes the estimation of breeding values for individual traits, which are carried out in order to compare the animals against the population average and to rank the best animals that will be selected for reproduction.

In the development of the breeding programme, emphasis is also placed on the technical part, which includes computer equipment, various testing devices, and the entire system of performance control from sampling to testing and the creation of an output database.

Currently, the economic part of the breeding programme is probably the most important part, even if it is listed in 3rd place in the ranking. The economic component represents the actual financial costs associated with the implementation of the breeding programme, which should be covered by the returns from increased or improved animal production. Many times it is not consistent with the biological component, resulting in disruption or even untimely termination of the breeding program.

The breeding programmes consist of 2 groups: classic or traditional and modern.

In classic programmes, phenotypically superior animals are selected for the production of offspring in subsequent generations. The most appropriate breeding methods are proposed. These programmes emphasise extensive progeny testing, which is very time-consuming. In this way, only a gradual cumulative improvement of traits is achieved.

The figure shows a simple breeding program that represents the direct selection of offspring to replace the culled males and females of the parental generation.

In a two-stage breeding programme, there is a delay in genetic improvement of the traits because the initial breeding is done only in the nucleus and then the progeny are included in commercial breeding. In this case, there is a time delay in the improvement of the traits.

Three-stage breeding program traditional pyramid breeding program of livestock breeding, which is most widely used in pig breeding and other livestock species with shorter generation interval. Again, genetic improvement is carried out only in the nucleus. In the case of pigs, the nucleus is generally made up of maternal breeds which are important in terms of reproduction and fattening and paternal breeds important in terms of carcass yield characteristics. From the nucleus, the best individuals are selected for reproduction breeding and from there for commercial breeding. Even if the genetic delay in improving the trait is doubled, the three-stage breeding programme is used quite successfully in these animals.

The best animals in terms of selected traits can be concentrated in one central nucleus, from where the offspring are transferred to reproductive breeding, but also in a nucleus scattered over several locations.

The nucleus consists of bulls selected on the basis of their pedigree. The best bulls are selected according to their genetic superiority and used to produce the best animals. The direction of the gene flow in classic system is always one-sided, that means from the nucleus, to the reproductive and then to the commercial breeding. There is no possibility of animals from other levels entering back into the nucleus. This system is known as closed nucleus breeding system.

Generally superior breeding females – daughters born to sires of nucleus in the reproductive or commercial breeding are selected based on their genetic merit and breeding values and in turn transferred to the nucleus for breeding as replacer such that the nucleus is opened for the

external source of superior genes. The system is called open nucleus breeding system. The gene flow occurs in both directions – from the nucleus to commercial group of animals via reproductive group of animals and back to the nucleus. The major disadvantage of this system is the disease control that have a major influence. For these reasons, breeders prefer to keep their units in a closed breeding system where strict quarantine and biosecurity measures apply.

Modern breeding programmes use the latest biotechnological knowledge and methods of livestock reproduction to shorten the generation interval and achieve genetic gain more quickly. An important part of these programs is marker-assisted selection (MAS), which is based on establishing a linkage between a molecular marker and the chromosomal location of the gene(s) controlling a particular trait or characteristic.

The rate of genetic improvement achieved by MAS may be substantially greater than improvement achieved by selection based on offspring testing (EPD values) especially for traits that are lowly heritable or determined postmortem. The application of MAS in breeding programs depends on the availability of variable marker information, different effects on multiple traits, and genotypic information that helps in improving commercial breeding activities.

The use of MAS in breeding results in increased genetic gain compared to traditional breeding programmes and reduced costs of progeny testing through early selection of potential young bulls. It also facilitates the use of existing genetic diversity in breeding populations and contributes to the improvement of traits in livestock.

Several authors have reported the effect of MAS to increase genetic gain by 5 to 64% in breeding animal populations depending on selected trait and marker and QTL information.

Large-scale genotyping methods and infrastructure, which enable the generation of hundreds or thousands of molecular data at a reasonable cost, will be necessary for making MAS effective in a large breeding population.

MAS is suitable method for highly heritable traits with a genes with large genetic effect. MAS is applied together with Multiple Ovulation Embryo Transfer (MOET) technology and also progeny testing methods in commercial breeding.

MOET increases number of required male or female offspring at rate much higher that is possible through normal reproduction.

Genetic engineering, also called genetic modification or genetic manipulation, is the modification and manipulation of an organism's genes using technology. It is a set of technologies used to change the genetic makeup of cells, including the transfer of genes within and across species boundaries to produce improved or novel organisms.

Genomics is an interdisciplinary field of biology focusing on the structure, function, evolution, mapping, and editing of genomes. A genome is an organism's complete set of DNA, including all of its genes as well as its hierarchical, three-dimensional structural configuration.

In the organic farming system, breeding programs are created, which take into account the methods and conditions of this type of farming.

MOET

Embryo biotechnology makes efficient use of the oocytes producing ability of animals.

Ovaries of a healthy cow can produce around 150,000 eggs during her lifespan, but under natural conditions, a typical cow produces only one calf per gestation. This implies that only one egg or oocyte is utilized to produce a calf. However, it is possible to stimulate the development and release of multiple oocytes and release them from follicles. The released oocytes can be fertilized in vivo or in vitro to generate embryos and to produce live offspring. Multiple Ovulation Embryo Transfer offers a splendid procedure to maximize the use of high-yielding animals.

Efficient use of MOET requires the selection of the genetically best females and the use of MAS technology. In these females, estrus synchronization is performed using medications. Treated females are observed for onset of estrus. Care has to be taken in case of animals with silent estrus. This is followed by insemination of donor females using fresh or frozen semen. Natural mating could be also an option. Use of sexed sperm will yield embryos and offspring of desired sex.

Embryos are collected after 7 days of insemination or mating. Pregnancy should be terminated in superovulated females.

Then embryos are evaluated under microscope. Healthy embryos can be spilt or bisect to develop two embryos from one. This technique has been used in cattle and buffaloes.

Freshly developed embryos are transferred to estrus-synchronized females. In addition, embryos can be cryopreserved for commercial.

In terms of the next modern approach use to animal breeding, an important role is played by the so-called juvenile system, which allows the selection of animals for embryo production according to pedigree value at the age of 13 months. The advantage of this system is the short generation interval. Insemination and embryo transfer are carried out at 15 months. At 22 months, embryo transfer progeny are already produced, and at 24 months own progeny are produced. Lactation is completed at 34 months.

In the adult system, selection of both sexes for embryo production is carried out at 35 months, after the end of lactation, which represents a generation interval of 3.7 years.

The implementation of different forms of MOET, in combination with genomic selection and artificial insemination or natural mating, is the most effective way to increase genetic gain and increase the reproductive efficiency of the animals.

The implementation of a breeding programme consists of evaluating the population in terms of crucial, economically important traits and characteristics. The breeding objective and the selection of quantitative and qualitative traits are determined on this basis. The breeding programme includes selection and mating, and an important part of programme is the control of the population, its size, inbreeding and, the most of all, monitoring of the genetic gain. The evaluation of the characteristics of the progeny is carried out from a biological but also from an economic point of view. On the basis of these analyses, the breeding programme is corrected or new traits are selected. The results of the progeny evaluation are used as a basis for breeding recommendations for the following period.

Optimisation is achieved by selecting animals for the traits, setting new limits for each trait, transferring genes to the next generations and evaluating the economic efficiency of the breeding programme.

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