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Development of animal breeding research

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Introduction

The Dutch Coordinating Commission for Animal Breeding Research reported on future planning for 1987-1991 in October 1985. The aim of this contribution is to review the development of animal-breeding research in the Netherlands. Partly on the basis of this report, we intend to use cattle-breeding research as an example for other species, in order to demonstrate some main lines of development.

Research on animal breeding

Describing a breeding goal

The goal in breeding of farm animals is to obtain animals that can produce animal products most efficiently under present and expected management conditions on the farms and also under present and expected market conditions (costs and prices of the products). So genetic change so defined is strongly directed to meet the human needs for cheap products of good quality. In the process of adaptation of farm animals, attention must be directed to primary production traits such as milk yield and content of fat and protein in milk for dairy cows and growth rate and body composition, e.g. lean meat, fat and bones for beef cattle, but also the need for our farm animals to produce their high-quality products in a socially respectable way for a longer time. In this way the secondary production traits are also important to lower the costs of production. Genetically we want to maintain a good level or to improve traits like animals health, fertility, ease of milking and strong feet and legs, in order to improve replacement rate based on which the farmer has no choice. The quality of production, thus the conditions of production, is focused more in society. In other words, consumers and producers want to improve the production process for farm animals in a way better adapted biologically for an efficient production.

Goal and facilities in research

Animal breeding research in the Netherlands has increased in amount and improved in quality in the past 20 years. This research is concentrated on two institutions, namely the Animal Breeding Department of the Agricultural University at Wageningen and the Research Institute for Animal Production (IVO) at Zeist. Research is directed to the development of selection criteria and to breeding pro-

grammes for different species and with different production patterns of farm animal populations.

The development and application of population genetics with a main interest for quantitative traits plays a central role. The expected developments in molecular genetics (DNA level) and biotechnology will have an important impact.

In animal breeding research, we use results of different sciences, namely animal physiology, biochemistry, immunology, ethology and more applied sciences, such as economics, statistics and operations research. The development of computer and statistical analysis in large data sets, for example in milk recording, have given us tools to measure genetic and environmental effects on production traits. Estimation of the breeding values for production traits could be extended to the individuals of large population with improved accuracy. These results are included in the development of breeding plans and resulted in intensive selection within a population. In crossbred populations with a combination of breeds or specialized lines, the individual and maternal heterosis could be exploited. A profit heterosis for species with a high reproductive rate could be exploited especially in poultry and pigs.

Research programmes

Research projects in animal breeding frequently last a long time. Selection trials need two or more generations. With a generation interval of one year in pigs and poultry or even longer in cattle and horses, several years are needed to complete a project. New developments are often gradually absorbed into a current programme. We can, however, divide the research projects into several classes that are not self-contained.

Choice of traits and parameter for selection

In this part of research, the basic information about traits with impact on physiological potential of animals and the relation between traits is the objective of research.

Choice of traits. In the first place, we can remark that traits must be measurable before we can decide on the choice for selection in animal breeding. This is not only true for primary production traits such as growth, body composition, or milk production and milk composition. These traits are sometimes only measurable in the females. Sires are then selected on an estimate of the breeding value based on the pedigree and later on a progeny test. Estimation of the breeding value based on its own performance test in the living animal for example growth, feed efficiency, and growth composition, can be a powerful tool for selection.

Research is now directed to a search for underlying traits based on biochemical, physiological, immunological and possibly molecular genetic parameters related to primary and secondary production traits. Of course, the genetic variation and economic importance of the traits must be taken into consideration, and also the costs of the measurement must preferably be low enough to test a large number of breeding animals in a population.

Estimation of genetic parameters. On the basis of related animals in field data the ratio between genetic varation (σ^2_A) and phenotypic variation (σ^2_p) can be estimated as a heritability coefficienct (h^2) for different traits. The selection result per year (R_j) is the product of selection intensity (i), the selection accuracy (r_{AI}), and genetic variation (σ^2_A) divided by generation interval (g). In a population, 4 selection paths, namely sires to breed sons and daughters, and dams to breed sons and daughters, give the final result of selection. The phenotypic correlation (r_p) and genetic correlation (r_g) between traits are also necessary to construct a selection index.

Selection trials in a controlled environment of a experimental farm with a chosen structure of related animals can be necessary to analyse the genetic parameters.

Breeding plans

On the basis of the analysis of choise of traits and parameters, research of breeding plans can be developed and classed as follows.

Experimental results of breeding plans. The efficiency of selection methods can be analysed for different environments, for instance level of feeding on an experimental farm.

Model calculations to analyse breeding plans. Breeding plans can be optimized for a set of traits, production environment and breeding structure. Dependent on the amount, quality and price of the products, and the costs of testing and selection, breeding plans can be constructed for populations of farm animals.

Estimation of breeding values. A systematic estimation of breeding values is necessary to achieve breeding plans. The accuracy of the estimate of breeding values could be improved by the development of new statistical techniques on the computer. Correction for systematic environmental errors has improved also the accuracy. The weighting and inclusion of information for related animals in the pedigree, sibs, their own performance, and progeny, has improved the accuracy of estimates of breeding values.

Research facilities in the Netherlands

Research workers in animal breeding are working in different sectors (October 1985) (Table 1). The Research Institute for Animal Production (IVO) at Zeist has 4 permanent positions and 1 temporary position in this research. The Department of Animal Breeding of the Agricultural University at Wageningen has 11 scientific staff, whose main task is teaching. So only 3.6 structural positions are available for research and 3.1 temporary positions (Ph.D. projects).

The breeding organizations work mainly in the applied sector, for instance to improve accuracy of the estimates of breeding values. The Netherlands Cattle Syndicate (NRS) has 2.5 scientific workers and the Cooperative Pig Improvement Organization (CBV) 0.4. There are also animal breeding research activities of the Veterinary Faculty of Utrecht University, the Poultry Research Institute at Beekbergen and the Department of Animal Husbandry at Wageningen.

TABLE 1. Number of research workers in animal breeding.

Research sectors	Number of research workers		
	structural	temporary	total
Choice of traits, parameters			
– choice of traits	3.5	1.0	4.5
– estimation of genetic parameters	3.2	1.5	4.7
Breeding plans			
– experimental results	3.45	–	3.45
– model calculations	0.4	1.6	2.0
– estimation of breeding values	0.95	1.0	1.95
All sectors	11.5	5.1	16.1

Activities are spread over different species, namely cattle 4.2 + (2.5), pigs 2.35 + (1), poultry 1.95, sheep 2 + (1), horses 0.2 and general 0.8 + (0.6). Since the publication of the report in October, sheep research has diminished by 2 places, but DNA research has taken 1 extra place.

Cattle breeding research

The main lines of development in cattle breeding research demonstrate changes in priorities and kind of activities.

Milk, fat and protein

The primary dairy traits have received most attention. The farmers organizations, namely the Friesian Herdbook Society (FRS) and the cooperative dairies in that province, started a project to study genetic aspects of protein content in milk around 1955. In the Netherlands and especially in Friesland, cheese and condensed milk are important products. Since 1957, the milk from the farmers is paid for by the dairies on the basis of content of fat and protein. With the increasing value of protein, the price ratio of fat to protein changed from 2:1 initially to about 1:1 now. Also there is an increasing cost for manufacture of milk products. Costs are mainly based on the amount of milk (transport, evaporation of water, and manufacture), so there is now a 'negative price' for the amount of water. This price system stimulates breeding for fat and protein yield, but results in a low value attached to production of milk serum and lactose. A selection index based on milk yield, and contents of fat and protein includes the feeding costs of producing serum with lactose (negative value), fat and protein (feeding costs higher for fat than protein). This gives the net milk yield index (I_{net}) expressed in guilders. So it is clear to the farmer what he can earn on milk yield and composition. If feeding costs be so included, the price ratio of fat to protein is about 1:2. In 1984, the milk quota system was introduced in the European Community. Model calculations show that an even higher value can be given for protein content than now. The farmers react by intensive se-

lection for a high I_{net}. This is namely a simple and clear expression of the breeding value of cows and bulls (progeny test) for primary dairy traits.

Estimation of breeding values

Since 1955, systematic estimation of breeding values has been introduced. Progeny testing based on a daughter-dam comparison was started. With the introduction of the computer (75 % of all cows are recorded every 3 weeks or monthly for their milk), more sophisticated methods are being used. Calculation of a sire and cow index is based on the BLUP calculation technique (best linear unbaised predictors). Systematic influences of herd, year and season are corrected for and genetic information on relatives and mates included.

Research is in progress on special problems such as optimization of the use of information part of a lactation (early use of data, influence of selection). Further corrections can be made for selective use of mates, and for how information of second and later lactations can be included. Special problems are being studied such as comparison of bulls used in different populations (bulls are now chosen from all over the world), possible genotype/environment interaction, breeding value based on crossing. Current topics are still further improved in statistical methods to estimate variance and covariance components in an analysis of field data and multitrait estimation of breeding values with effects of heterosis and possibly of genotype-environment interaction.

Trials on breeding of dairy cattle

Since 1970, the experimental farms of IVO at Zeist and the Agricultural University at Wageningen started in the new polder of Flevoland. A catlle-breeding trial at the Minderhoudhoeve of the University with 240 dairy cows started with the comparison of randomly sampled Dutch Friesian calves bought in two main breeding districts (Friesland, North Holland) from low-producing and high-producing farms. A genetic difference of about 10% was demonstrated between the two subpopulations, but no genetic difference between groups of high-producing and low-producing herds within a region. Within this herd, we used the best progeny-tested bulls for yield from the Netherlands, the United States and Britain over three generations. The Dutch Black-Pied population (Dutch Frisian) is now open for genetic improvement with bulls for all over the world.

At the experimental farm of IVO, different breeds are being compared, namely Dutch Friesian, Dutch Red-Pied (Meuse-Rhine-Yssel) and United States Holsteins. Later crosses were made also with Jerseys and recently a breeding programma based on biotechnology (sexing of embryos, embryo transfer).

Biological and economic efficiency of milk and beef production is being based on experimental data. Roughage intake is measured on rations high and low in concentrates. Genotype-environment interaction is being studied and the possibilities to select for roughage intake are being tested at the Minderhoudhoeve.

The breeding experiments in recent years are mainly directed to basic information to study the efficiency of a production system.

Model calculations and breeding plans
Optimization of breeding plans in a cattle population have received a high priority and are being studied with a gene-flow programme. In collaboration with the Department of Agricultural Economics of the Agricultural University the biological and economic efficiency of production systems are being studied. A breeding goal for milk and beef traits, including also secondary production traits, must be stressed for different economic, technical and structural developments. Research on biomodelling is under way.

Secondary production traits
Replacement policy of a dairy herd is being studied in a model research. The proposal is to introduce a parameter into the milk-recording system as a guideline for voluntary culling and insemination of dairy cows.

Dystocia in breeding dairy cattle, with special attention to sire evaluation for categorial traits, has been studied. Any way of preventing calving problems and calf losses is of economic importance.

Reproduction data from artificial insemination can be used for management of the herds, AI centres (fertility of bulls) and insemination results of technicians.

Udder health parameters are being studied in relation to somatic cell counts. These data are being routinely collected during milk recording in a pilot project.

Recording of hoof problems and hoof measurements can give a basis for genetic improvement of hooves.

Thus new techniques to measure secondary production traits are being gradually introduced into breeding plans.

Genetic manipulation and biotechnology
Developments in molecular genetics and biotechnology are receiving high priority in animal breeding research. Research on embryo transfer, multiple ovulation, splitting of eggs, sexing of embryos are giving promising results. Genetic improvement in disease resistance using immunological techniques with the BoLA system of manipulation at DNA level are promising subjects in research. How far genetic manipulation at DNA level can be included in breeding plans is not yet clear. Thus genetic improvement based on efficient selection within and between breeds and crosses will remain important in the future.