IMPLEMENTATION OF GENETIC EVALUATION

George R. Wiggans
Council on Dairy Cattle Breeding
Bowie, Maryland, USA

Background

Selection is a powerful tool for making a flock of dairy sheep more profitable. With each breeding, an opportunity arises to improve milk production, health, and fitness of the next generation. For selection to result in improvement, accurate information is needed to make selection decisions. Genetic evaluation systems are designed to analyze phenotypic observations on traits related to economic performance. The goal is to develop predictions of the performance of offspring from matings. This requires separating the genetic and environmental factors that affect traits and appropriately crediting animals for the genetic merit of their relatives. Such an analysis enables comparison of animals in different environments and the generation of evaluations for rams, which have no direct information on milk yield. Because of the large numbers of offspring possible from rams through artificial insemination, selection of rams should be the most important breeding decision.

Selection is a continuous process that starts with which ewes to breed followed by which rams to use, which specific matings to make, and then which lambs to raise. Goals besides improving production efficiency may include minimizing inbreeding and correcting faults.

Genetic Improvement

The basic equation to describe an animal's performance is

phenotype = genotype + environment.

Because only the genotype can be passed on to offspring, the purpose of a genetic evaluation program is to estimate the effect of the genotype. The rate of genetic improvement is determined by the generation interval (age of parents at birth of offspring), selection intensity (what portion of the population is being selected), and heritability (the portion of total variation among animals that is due to genetics).

The steps in a genetic improvement program are 1) defining a breeding goal, 2) measuring traits related to that goal, 3) recording pedigree to allow detection of relationships across generations, 4) identifying nongenetic factors to be included in the evaluation model or addressed as preadjustments, and 5) defining an evaluation model. Examples of breeding goals include increased milk, fat, or protein yield; increased longevity; optimal number of lambs born; improved udder conformation; and increased profitability. Nongenetic factors include age, lactation number, season of lambing, litter size, milking frequency, and flock.

Evaluation of Dairy Goats as an Example

The American Dairy Goat Association (ADGA; Spindale, NC; http://adga.org/) currently has a genetic evaluation program for dairy goats. The following description of that program may provide some information on how a program could be established for dairy sheep.

Data flow for dairy goat evaluations. The same Dairy Herd Information milk-recording program (National Dairy Herd Information Association, 2010) is used for dairy cow and dairy goat herds. Many goat owners also register their animals with ADGA. Typically, milk yield data are collected monthly. To minimize the cost of data collection, 3 or 4 herds often collaborate to serve as supervisor for the data collection from each other's herds. Milk samples are sent to laboratories for determination of fat and protein percentages and somatic cell counts. The yields, component percentages, and somatic cell counts are sent to 1 of 4 regional dairy record processing centers (DRPC), where lactation records are calculated and reports returned to the dairies. The DRPC send data to the Council on Dairy Cattle Breeding (CDCB; Bowie, MD; https://www.cdcb.us/), where they are added to the same national database that is used for dairy cattle. Pedigree records are sent to CDCB by ADGA, which also supplies appraisal records on body characteristics of the goats. Twice a year, ADGA manages the calculation of genetic evaluations using data extracted from the CDCB database. Then CDCB posts the evaluations on its web site and distributes them to the DRPC. On January 1, 2016, 589 herds with 17,381 does were in milk-recording programs (Council on Dairy Cattle Breeding, 2016).

Validation. Incoming data are checked against the CDCB database for verification. Birth date is checked against kidding date of the dam. Sire and dam are checked against breeding records and ADGA pedigree. Cross-references are assigned when identification changes. Cross-references are detected based on the animal control number within herd. Abnormal yields are detected and reported to the DRPC. Test dates and testing characteristics are compared with herd data.

Evaluation model. The statistical model used for genetic evaluations is

$$y = hys + hs + pe + a + e,$$

where y = yield of milk, fat, or protein during a lactation, hys = effect of herd-year-season (environmental effects common to lactations in the same season within a herd), hs = effect of herd-sire (effects common to daughters of the same sire within a herd), pe = effect of permanent environment (the nongenetic effect common to all of a doe's lactations), a = animal genetic effect (breeding value), and e = unexplained residual

Selection for more than 1 trait. An index combines evaluations for a group of traits based on their contribution to a selection goal. For goats, yield evaluations are combined into a single value, which is designated as milk-fat-protein dollars (MFP$):

$$\text{MFP\$} = 0.01(\text{PTA}_{\text{milk}}) + 1.15(\text{PTA}_{\text{fat}}) + 2.55(\text{PTA}_{\text{protein}}),$$

where PTA = predicted transmitting ability (an estimate of the genetic value that will be contributed to offspring).

Accuracy of evaluations. Reliability measures the amount of information that contributes to an evaluation. It increases as daughters are added (at a decreasing rate). It also is affected by the number of contemporaries, reliability of parents' evaluations, and heritability. Contemporaries are does that kid in the same environment. More records give a better estimate of the herd-year-season effect. Bucks that have daughters with records in the same herd-year-season can be compared directly, which results in a better ranking of bucks. More lactation records, more daughters, and more completeness of pedigree data add to accuracy.

Defining a base. Evaluations may be expressed as an estimated breeding value or as a predicted transmitting ability, which is half of the estimated breeding value. Genetic evaluations are predictions because the true genetic value is unknown. The predictions rank animals relative to one another using a defined base. The base is the zero- or center-point for evaluations. For goats, the average evaluation of does born in 2010 is forced to be 0, and the base is updated every 5 years.

Requirements for a Dairy Sheep Program

A genetic evaluation program for dairy sheep would be similar to the program for dairy goats. For collection of data, the laboratories that analyze cow and goat milk can be used to ana- lyze sheep milk. The DRPC may be willing to accept sheep data, or computer programs used for on-farm recording may work for sheep. Management software available for commercial flocks could provide a convenient method for recording the data and provide a standard for reporting them to a central site. For calculation of evaluations, utilization of an existing service (such as in Australia or Canada) may give the best results. If the data collection program is able to deliver reliable data, the work of the evaluation center is reduced. A complete program will require over- sight to establish and maintain it. The Dairy Sheep Association of North America may be able to fill this role. The National Sheep Improvement Program is another possibility. Research support also is needed to initially establish trait heritabilities and determine which effects should be in the evaluation model. An ongoing source of research support is critical.

Genomics

Genomics has revolutionized dairy cattle breeding. Genetic markers (single nucleotide poly- morphisms; SNP) can be used to trace inheritance of chromosome segments, which allows evalu- ations to be calculated at birth or as soon as a DNA sample can be taken. These markers also en- able parentage validation and discovery if the parents have been genotyped. The evaluation is based on estimates of the difference in a trait from having 1 allele of a SNP versus the other. The evaluation is based on multiplying the genotype by the SNP effects to get the direct genomic value, the prime component of the genomic evaluation. The estimation of the SNP effects de- pends on a very large reference population that has both traditional evaluations and genotypes.

Genomics does not replace traditional evaluations; it enables the information that they contain to be applied to all genotyped animals.

Conclusions

Traits can be improved through selection. The rate of genetic improvement increases with ac- curacy of evaluations. The use of artificial insemination the enables widespread use of superior rams and facilitates use across herds. Genetic evaluations improve selection accuracy. Accurate evaluations require adequate data and an appropriate model. Evaluations are based on compari- sons. Differences for nongenetic reasons must be removed. Although DNA technology has revo- lutionized selection in dairy cattle, reliable evaluations are still required.

References

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