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Development of breeding objectives for dairy cattle: Determination of economic value

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Abstract

The purpose of this article was to review the development of breeding objective in dairy cattle and the derivation of economic values. Breeding objective is described by a profit function that takes genetic values as input and produces profit as outcome. This profit may be a bio-economic model of the farm. The modeling methods to derive economic weights can be divided into simulation and profit functions. Cumulative discounted expressions should be multiplied by the economic value to give the discounted economic value.

Key words: Dairy cattle, breeding objective, economic value.

Introduction

Animal breeding is part of the strategic planning of production [10] and aimed at changing the genetic merit of animals in coming generations, so that they can produce the desired products economic and more efficiently (relative to the present generation) under future economic, natural and social circumstances [2].

Animal breeding involves three major steps. First is the breeding goal definition. The second step is the breeding value estimation. The final third step is the breeding programme optimization: optimizing the organization to routinely gather information on potential breeding animals and/or their relatives, and to select and mate breeding animals to breed the next generation.

In economically oriented breeding programmes, the aim is to increase the aggregate genotype which is a function of additive genetic values of traits of interest weighted with economic values. The main aim of any selection program should be the improvement of traits of economic importance. When these traits are easily measured, progress is largely dependent on the effective utilization of the additive genetic variance.

Definition of the breeding objective is generally regarded as the primary step in the development of structured breeding programs [4, 16].The breeding objective involves calculation of economic values for all biological traits that have an impact upon profitability [5]. The breeding objective should be developed by:

• *Specifying breeding production and market system:* defining the role of the breed in the production system. The role of the breed influences the amount of gene present in the various segments of the production system.

Specification of the production and marketing involves the description of how animals are fed and managed, the age composition of the herd, the replacement policy and ages of animals at marketing and slaughter [6].

Defining herd composition aids in identifying age and numerical distribution of the herd, the number of replacements required each year, the number of animal of all classes available for marketing each year, is required in the calculation of the economic value.

• *Identifying sources of income and expense in the systems* enables the development of a profit equation. Income depends on the sale of milk or weaning, surplus heifers and cull cows as well as the value per animal sold. Expenses depend on food intake, the value of the food per kg, husbandry cost, marketing cost as well as fixed costs. Fixed costs are those costs incurred by the producer independent of the level of herd production. All other costs are variable costs and vary with the level of production [4].

• *Determining biological traits influencing income and expense*: During this phase the profit equation is expressed as a function of biological traits that impact on income, expense or both [7]. Choosing selection criteria and organising logically based performance recording is difficult unless the traits that have to be improved have been identified and their relative economic importance has been established [4].

• *Deriving appropriate economic values of each trait utilized in the breeding objective*: The net genetic improvement which can be brought about by selection among a group of animal is the sum of the genetic gains made for the several traits which have economic importance [8]. It is, therefore, logical to weight the gain made for each trait by the relative economic importance of that trait. Economic theory suggests that optimization objectives at farm level would cause adjustments in levels of variable inputs and output in response to a genetic trait change [1].

The breeding objective or goal towards which breeders are progressing is a particular combination of weighing factors (economic weights) and genetic information (estimated breeding value, EBV) of all the characters to be improved [9].

Change in breeding objective requires time; therefore, breeding objectives should be defined according to future market values rather than from historical data.

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Double Counting

Functional traits are phenotypic and genetically related to production traits. For example, incidences of mastitis are more frequent with high genetic potential for milk production in early lactation, but will result in milk production losses during the remaining part of lactation. If both milk production and mastitis are included in the aggregate genotype index calculations using an appropriate correlation structure account for these aspects. To avoid double counting reduced milk production as a result of mastitis incidence, should not be accounted for in the economic value of mastitis [11].

Economic Value

The economic value of a trait is defined as the increase in profit resulting from a unit genetic improvement in that trait, while all other traits in the breeding objective are kept constant [8].

Economic weights can be derived as marginal economic values estimated as marginal returns minus marginal costs obtained by increasing the level of a trait by one unit. Economic returns can be predicted using bio-economic models, which are functions of phenotypic traits and management variables contributing to revenue and cost [12]. Such models aim to effectively describe complex livestock production systems, taking into account genetic, nutritional, management and economic factors.

Estimates for the economic value depend on the definition of the production system, the goals to be optimized and particular production circumstances [10].

A production system can be defined at different level, e.g. animal, farm or sector level [10]. Production systems can be optimized to different goals, e.g. maximum profit, minimal costs of product or maximum return on investment [16].

Traditionally, economic values in the breeding goal are derived using profit equations [13, 14]. When deriving economic values, the primary goal is to maximize farmer profit of the dairy cattle production system, which is based solely on the market economy[15].

Economic value for categorical trait: The calculation of economic value for these optimum categorical traits requires the definition of quality classes (truncation points between classes) for each trait. Furthermore, it was assumed, for these categorical traits, that there is an unobserved underlying normal distribution of the sum of genetic and environmental values, and the phenotypic category is defined by threshold values on this distribution [17].

Two different procedures for calculating economic weights for ordered categorical traits in cattle can be found in the literature [18]. The first approach is that an increase in the frequency in one class is connected with exactly the same decrease in frequency of one of the adjacent classes. In calculating the economic weight only changes in the frequencies of these two classes were considered. The second approach assumed an underlying normal distribution and the economic weight for the transformed (liability) trait were calculated.

Economic value without risk: Risk can be incorporated into derivation of economic values. Risk can make a large difference in economic values, but may have a smaller effect on ratios of economic weights and on the magnitude and direction of genetic change. Higher risk aversion and variances of prices result in increased differences between traditional and risk-rated economic values. Overestimation of profit and economic value, even for small differences between traditional and risk-rated economic value, given the magnitude of costs and benefits from breeding schemes, should demand consideration of risk because of systematic distortion of the value of benefits from not considering risk.

Profit Functions and Bio-economic Models

Methods for deriving economic weights can be divided into positive (data analysis) and normative (bio-economic modeling) methods.

For data simulation models, the terms profit function and bio-economic model are used. There is no basic difference between profit functions and bio-economic modeling.

A profit function is a single equation model. When bio-economic models are used, a large number of factors and their complex production systems are considered simultaneously using such models, costs and revenues are obtained on the basis of real phenotypic performance, which not only depends on genetic potential performance, but on availability of feed resources and feed intake capacity. Using bio-economic simulation models, the effects of genetic change on profit or production efficiency have been examined and economic value of traits in dairy cattle production systems derived [3, 15].

Cumulative Discounted Genetic Expression

Hazel [8] defined the aggregate genotype, H, for a given individual as the sum of its genotypes for several traits (assuming a distinct genotype for each economic trait), each genotype being weighted by their predicted contribution to the increase in the overall objective. This contribution is determined by so-called cumulative discounted expressions and economic value.

The cumulative discounted expressions of a trait reflects time and frequency of the future expression of a superior genotype originating from the use of a selected individual in a breeding programme [13]. Multiplying the economic value by the cumulative discounted expression gives the discounted economic value.

Effect of Errors in Economic Value

Vandepitte and Hazel[19] investigated the effects of errors in economic values on the efficiency of index selection. They used a selection index for multiple trait selection in a pig population as an example (traits considered were daily gain, feed efficiency, carcass back fat, dressing percentage). They found that errors in a single economic value larger than 50% could result in considerable error of the estimated genetic gain per generation.

Conclusions

Breeding goal definition is of ongoing interest, because knowledge on modeling is improving and future production circumstances are continuously changing. Although research has been undertaken for a long period, integration of functional traits in dairy cattle breeding goals is still a major challenge for animal breeders.

Derivation of economic values requires a sound theoretical basis, proper methodology in terms of models including physiological modeling of production, farm economics and social aspects and appropriate assumptions on future production circumstances.

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