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ECONOMIC VALUES IN DAIRY CATTLE BREEDING, WITH SPECIAL REFERENCE TO FUNCTIONAL TRAITS

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Abstract

A genetically and socio-economically balanced selection on production (milk and beef) and functional traits (health, fertility, efficiency of feed utilisation and milkability) in dairy cattle requires correct economic values. Correct relative levels of economic values of traits give optimum levels of genetic improvement according to future production circumstances; correct absolute levels are important for an accurate calculation of economic revenues of breeding programmes. The derivation of economic values requires a good theoretical basis, proper methodology in terms of models including physiological modelling of animal production, farm economics and social aspects, and appropriate assumptions on future production circumstances. The field of breeding goal definition is of ongoing interest, especially because knowledge on modelling is improving and on uncertain future production circumstances are continuously changing. Moreover, although research has been undertaken for a long period, the practical integration of functional traits in dairy cattle breeding goals is still a major challenge for animal breeders. The aims of this working group report are: a. to present the definition of a set of breeding goal traits, b. to discuss the methodology in deriving economic values, c. to present a summary of literature on economic values of functional traits, d. to discuss a possible justification of differences in breeding goal definition for countries, regions, and/or individual farms, and e. to discuss possible future trends potentially influencing breeding goals by changing economic values.

Keywords: Economic values; Functional traits; Dairy cattle; Breeding goal

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Introduction

Animal breeding is part of the strategic (long-term) planning of production. Breeding is aimed at changing the genetic merit of animals in coming generations such that they will produce the desired products more efficiently (relative to the present generations) under future economic, natural and social circumstances. The definition of "efficiency" is relative to an overall objective or breeding goal. This breeding goal may include only (traditional) economic variables, but can be extended to accommodate also aspects like ethics of production and biodiversity. Selection index theory (Hazel, 1943) provides the framework for a concrete definition on the breeding goal in terms of an aggregate genotype selected for through a correlated information index. The aggregate genotype is used to represent the genetic merit of an animal: i.e. the weighted sum of its genotypic values for several traits. To optimize relative levels of improvement of aggregate genotype traits, traits are weighted by their predicted contribution to the improvement of the breeding goal. This contribution is determined by (Brascamp, 1978) time and frequency of future expression of genetic superiority for the trait (cumulative discounted expression), and benefit at the moment of expression of genetic superiority for the trait (economic values).

In dairy cattle, traits influencing the efficiency of production are roughly characterized as production traits (milk and beef) and functional traits. The term functional traits is used to summarize those characters of an animal which increase efficiency not by higher output of products but by reduced costs of input. Major groups of breeding goal traits belonging to this category are health, fertility, calving ease, efficiency of feed utilisation, and milkability.

There is growing consumer concern for the suffering of animals from diseases and disorders, and the use of antibiotics for treatment, including their effects on both animals, products and humans. Modern cattle production systems are characterized by high levels of product output per animal. Single-minded increase of production per animal will lead to a deterioration of animal health and reproductive performance, and therefore, to increased metabolic stress and reduced longevity. Therefore, thechnological development should be aimed at a balanced improvement of production and functional traits in order to avoid deterioration and possibly improve functional traits, which will support the consumer acceptance of dairy and beef products.

Animal breeding involves three major steps. First, breeding goal definition: seeting up the aggregate genotypa and deriving cumulative discounted expressions and economic values. The second step is breeding value estimation: deciding what traits to be included in the information index, derivation of regression coefficients to be used in the information index, estimation of the information index value, i.e. estimated breeding value for each trait and for each potential breeding animal. The final third step is 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. Now, a balanced integration of functional traits in dairy cattle breeding goals with a correct weighting relative to milk production requires economic values of these funtional traits. Relative levels of discounted economic values of traits are important for an accurate definition of the breeding goal, giving optimum levels of genetic improvement according to future production circumstances (Groen, 1990). To obtain an accurate calculation of economic revenues of breeding programmes (in order to optimize the structure of breeding programmes) the absolute economic values are needed.

The aims of this working group report are:

a. to present the definition of a set of breeding goal traits,
b. to discuss the methodology in deriving economic values,
c. to present a summary of recent literature on economic values,
d. to discuss the possible justification of differences in breeding goal definition of countries, regions, and/or individual farms, and
e. to discuss future trends potentially influencing breeding goals by changing economic values.

Economic values in selection index theory

The choice of an aggregate genotype is the starting point in setting up breeding programmes. The aggregate genotype is used to represent the genetic merit of an animal: 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 (Hazel, 1943). This contribution is determined by the so called cumulative discounted expressions and economic values. The economic value of a trait expresses to what extent the economic efficiency of productin is improved at the moment of expression of one unit of genetic superiority for that trait (Groen, 1989c). The cumulative discounted expression 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 (Brascamp, 1978). Multiplying the economic value by the cumulative discounted expression gives the discounted econimic value. The following equations illustrate the principles used (assuming a dairy cow as the animal of interest, and for instance Dfl as the currency unit):

$$H_{kl} = a_{kl'}\, g \quad (1)$$
$$a_{kl} = c_l\, v_k \quad (2)$$

where,

- H_{kl} : aggregate genotype of an animal in situation k and selection path l (Dfl.cow^{-1}),
- a_{kl} : m*1 vector with discounted economic values of m genotype traits in situation k and selection path l (Dfl.(cow.unit)$^{-1}$),
- g : m*1 vector with genetic superiorities of m genotype traits (unit; e.g.kg),
- c_l : m*m diagonal matrix with cumulative discounted expression of m genotype traits in selection path l (cow.year.cow^{-1}),
- v_k : m*1 vector with economic values of m genotype traits in situation k (Dfl.(cow.year.unit)$^{-1}$).

Selection for improved genetic merit is practiced by selecting for a predictive information index, based on the phenotypic performance of the animal itself and/or of related animals. The calculation of regression coefficients for phenotypic performance traits in the information index maximizes the response to selection by maximizing the correlation between aggregate genotype and information index (Hazel, 1943), considering the number of phenotypic observations for the information index traits, the relationship between the animal being evaluated and the source of the information, the genetic and phenotypic (co)variances among aggregate genotype and information index traits, and the cumulative discounted expressions and economic values of the aggregate genotype traits.

$$I_{kl} = b_{kl'}\, x \quad (3)$$
$$b_{kl} = P^{-1}\, G\, a_{kl} \quad (4)$$

where,

- I_{kl} : information index value of an animal in situation k and selection path l (Dfl.cow^{-1}),
- b_{kl} : n*1 vector with regression coefficients of n index traits in situation k and selection path l (Dfl.(cow.unit)$^{-1}$),
- x : n*1 vector with phenotypic performance for n index traits (unit),
- P : n*n matrix with covariances between n index traits,
- G : m*n matrix with covariances between m genotype traits and n index traits.

After one round of selection, the genetic superiority (GS) of selected animals for each genotype trait m equals (Cunningham, 1969):

$$GS_{klm} = (i_l/\sigma_{Ikl}) * b'_{kl} \text{ (column m of G)} \tag{5}$$

where, σ_{Ikl} is the standard deviation of the information index in situation k and selection path 1 (= $\sqrt{(b_{kl'}\ G\ a_{kl})}$; Cunningham, 1969), and i_l is the intensity of selection in path 1.

b is subscripted to denote that economic values may depend on differering situations or production circumnstances. A breeding programme is defined for a reference (predicted) future situation k_p and corresponding discounted economic values. Obtained economic revenues are the sum of genetic superiorities for all genotype traits (m) due to selection in all paths (1), weighter by 'actual' discounted economic values. The actual situation (k_a) is the real situation at the moment and the place of expression of genetic superiority. When predicted production circumstances equal actual circumstances, optimum levels of improvement per trait and maximum economic revenues (MER) of the breeding programme will be obtained (Cunningham, 1969):

$$MER = \Sigma_l\ [i_l * \sigma_{Ikl}]\ (\text{Dfl.cow}^{-1}) \tag{6}$$

The theory on real obtained versus maximum economic response as presented by Groen (1990) can be used to quantify losses from the incorrect definition of goals, i.e. incorrect economic values due to heterogeneity of production circumstances or uncertainty about future production circumstances (see also paragraph 6).

Note, that equation (6) is equivalent to the formula of Rendel and Robertson (1950a) when cumulative discounted expression in all selection paths equal 1 over the sum of generation intervals for all selection paths.

This will hold when cumulative discounted expressions are derived for an ongoing breeding programme, evaluated over an infinite time horizon, and are not discounted.

A set of breeding goal traits

The first aim of this working group report is present a set of breeding goal traits is dairy cattle breeding. This set can be used as a starting basis for the development of (national) breeding goals, and the priority setting for (national and international) breeding value estimation. The set given in Table 1 is the result of discussions within the working group and at a workshop on genetic improvement of functional traits (Groen *et al.*, 1996).

In dairy cattle, traits influencing the efficiency of production are roughly characterized as production traits (milk and beef) and functional traits. The term functional traits is used to summarize those characters of an animal which increase efficiency not by higher output of products but by reduced costs of input. Major groups of breeding goal traits belonging to this category are health, fertility, calving ease, efficiency of feed utilisation, and milkability.

In this report, specific attention is paid to functional traits. A general characteristic of functional traits is that they are genetically unfavourably correlated to milk production (see e.g., Simianer *et al.,* 1991). This means that selection for production level will only result in a deterioration of functional traits. The need for avoiding deterioration and possibily improving functional traits is not only economic but also social. The consumer concern may turn into a decreased consumption, unless the industry shows an interest in improving functional traits.

Secondly, surveys on national breeding value estimation procedures (Banos, 1996; Brandsma & Banos, 1996) show that rather few countries have incorporated the most important functional traits into their selection schemes (except for among others the scandinavian countries). Cattle breeding nowadays is an international business. Bull semen is currently being widely spread over the world without adequate information for functional traits. Therefore, the recording and the incorporation of functional traits into national breeding programmes should be a high priority goal for the inter-national cattle breeding industry.

Thirdly, compared with milk production many of the functional traits are difficult to describe adequately and to record. Due to the nature of the data recorded (non-Gaussian scale), categorical data (healthy or sick), subjectie scoring (easy/difficult calving), expressed lately during life or involving censored data (a cow alive at 4 years has a life length of at least 4 years)), the recording systems and the statistical procedures for genetic evaluation are not straightforward and the approaches used for genetic evaluation in different countries differe more widely than for milk production. This leads to difficulties in comparing results from different countries.

A clear distinction is being made between breeding goal traits to be weighted in the aggregate genotype and potential information index traits used for indirect selection. Since the common thought about conformation traits is that they are predictors of health, calving ease or efficiency, the rational conclusion is that these traits are only index traits, not breeding goal traits.

Reasoning o a long-term basis, it should be stressed that maintaining selection on conformation *per se* in a situation where functional traits of interest are recorded is a waste of selection pressure. This could cancel the small overall economic progress to be obtained from including functional traits in breeding schemes. In the present situation exchanges of genetic material are carried out based on yield and conformation traits. A reasonable and sound long term objective is that conformation traits would be replaced by functional traits and used only as predictors. The man in the street would better understand cattle being selected on health traits and not on fancy traits and finally, bussiness could be as alive as ever but on a sounder basis.

The proposed role of longevity is, as is the case with conformation traits, to serve as an information index trait. Longevity is a measure of the success of a cow to survive both voluntary and involuntary culling. Therefore, longevity might be considered an 'overall, summarizing' trait for the profitability of a cow, or her ability to please her owner. A major drawback of this approach is, however, that considering longevity a breeding goal trait thus gives equal weight to all underlying traits, irrespective of their potential for genetic improvement, and their relative (economic) importance in culling decisions. For this reason, the second approach, i.e., including longevity in the information index to (indirectly) select for traits that are difficult to measure or that are not recorded routinely, is to be strongly preferred. Currently, genetic evaluations for longevity should be considered an intermediate step towards the development of selection strategies based on genetic evaluations for.

Table 1. - BREEDING GOAL TRAITS AND POTENTIAL INFORMATION INDEX TRAITS FOR INDIRECT SELECTION

Breeding goal traits		Potential information index traits for indirect selection
Production traits		
Milk	Carrier, fat, protein	
	Milk quality	
Beef	Carcass weight/growth	
	Lean meat yield	
	Meat quality	
Functional traits		
Health	Mastitis	SCC, udder depth, fore udder attachment, teat placement/lenght, milking speed
	Feet and legs	Rear legs set, claw diagonal, mobility score
	Other diseases/	
	General resistance	Longevity, persistency
Fertility	Showing heat	Interval calving to first eat, interval calving to 1st insemination
	Pregnancy rate	Non-return, interval 1st insemination to pregnancy, no. of inseminations per pregnancy
Calving ease	Direct effects	
	Maternal effects	Rump angle
	Stillbirth	
Efficiency	Body Weight	Type traits, body measurements
	Feed intake capacity	
	Persistency	
Milkability	Milking speed	
	Behaviour	

health and fertility (Dekkers and Jairath, 1994). Finally, if a full decomposition of functional traits in the breeding goal is not possible, a 'residual longevity' traits could be used as a measure of the general resistance for unrecorded diseases, provided that a proper evaluation with failure time analysis (Strandberg and Sölkner, 1996) is carried out.

Methodology

It is not possible to come up with a "best" methodology in deriving economic values – what is best, will depend on traits and production circumstances considered. Moreover, the better metod from a theoretical point of view is not necessarily the method that is most practical to implement. It is, however, very important the people deriving economic values would be aware that genetic improvement can be compared to a technological development, and would be aware of aspects that are involved in deriving socio-economic benefits of technological developments. Awareness of these aspects might help making appropriate choices when choosing a method to derive economic values.

Objective versus non-objective methods

At first, one might distinguish between objective and non-objective methods.

The principal tool used in objective methods to derive economic values is modelling. A model is an equation or a set of equations that represents the behaviour of a system (France and Thornley, 1984). Modelling is also referred to as 'systems analysis'. Two approaches of systems analysis can be distinguished: positive approach or data evaluation and normative approach or data simulation (James and Ellis, 1979). When applying data evaluation, observed economic and technical data are used to derive economic importance of animal traits. A major drawback of economic data evaluation is that it uses historical prices, while breeding is future oriented. For data simulation models, the terms 'profit function' and 'bioeconomic model' are often used. There is basically no difference between profit functions and bio-economic modelling. A profit function is a single-equation model (e.g., Miller and Pearson, 1979). Regarding the strict definition of profit as output minus input, probably the more general term 'efficiency function' better represents this type of modelling. A multi-equation simulation model is referred to as a bioeconomic model (e.g., Tess *et al.,* 1983; Groen, 1988). Using simulated systems, economic values are derived by studying their reaction to a change of the endogeneous element representing the genetic merit of the animal for a specific trait, without changing other traits. With efficiency functions, this is performed by partial differentiation. With data simulations, possibilities of applying different prices, levels and sizes of the production systems are numerous.

Non-objective methods, as opposed to objective methods, do not derive economic values by direct calculation of influences of improvement of a trait on the increase in efficiency of the production system. A major justification is an insufficient knowledge to model (all) relevant aspects involved. Specific non-objective methods are desired or restricted gain indices. These methods assign economic values in order to achieve a desired or restricted amount of genetic gain for some traits (Kempthorne and Nordskog, 1959; Brascamp, 1984). The methods may be useful in commercial pig and poultry breeding because commercial breeders tent to calculate economic values according to the performance of their stock relative to those of competitors (Schultz, 1986). Gibson and Kennedy (1990) illustrated the in-efficiency of desired gains indices relative to objective indices, and argued that multi-disciplinary scientific effort is needed to derive reliable objective efficiency functions rather than to rely on desired gains (see also notes by Yamada, 1995). Groen *et al.*, (1994) compared linear, quadratic and desired gains indices for multiple generation selection response in a non-linear profit function, and concluded that desired gains indices allow stabilization of base population averages only at the expense of considerable losses in economic selection response. A good example of a multi-disciplinary effort to objectively assign economic values is the method for incorporating competitive market position in economic values, as presented by De Vries (1989). Ollivier *et al.*, (1990) considered the method of De Vries (1989) together with the desired gains index. The competitive index appeared to have better properties than the desired gains index, not only with respect to saleability but also in economic terms. Of course, an important aspect of comparisons performed by Gibson and Kennedy (1990), Ollivier *et al.* (1990) and Groen *et al.* (1994), is that they define a 'true' efficiency function and an appropriate (optimal) objective index. In that situation, any subjective index can not be superior. In practice, 'true' efficiency functions are unknown, and breeders argue that they have a better 'expert' insight into the future than people developing an objective model.

In deriving economic values of functional traits, especially reproductive and health traits related to animal welfare, it is important to consider public opinion and consumer attitude towards animal production. A basic model for the economic appraisal of diseases including these aspects is given by McInerney (1992). Constructing such a model requires knowledge on (agricultural) economics and marketing principles as well as actual values on required parameters that reflect the elasticity of the demand and supply curves for agricultural products (see Amer and Fox, 1992). Avoiding such a multi-disciplinary objective modelling, one might restrict genetic gain in health traits to zero or any other arbitrarily chosen (low) level, referring to public opinion and consumer attitude. However, constraints have to be introduced very carefully, because they can substantially decrease the overall benefits from introducing new traits or even turn them into losses (Colleau and Le Bihan-Duval, 1995; Colleau and Phocas, 1995). The working group considers that considering social aspects in deriving economic values for functional traits will be a major challenge for animal breeders in the near future. Constructing models at sector level is, therefore, highly relevant in deriving economic values for functional traits.

Biological versus economic definition

Efficiency of production is a function of costs and revenues of the production system. Costs can be defined as the total value of production-factors required for production within the system; revenues as the total value of products resulting from production within the system. In calculating costs and revenues of a production system, two aspects are important:

- the physical amounts (and qualities) of each production-factor required and product produced,
- the values per unit of production-factor and per unit of product.

Differences between biological and economic efficiency are restricted to differences in the way of defining costs and revenues. In the biological definition, costs and revenues are expressed in energy and/or protein. The economic definition largely deals with this problem. A disadvantege of the economic expression is weakness in stability in time and place of monetary units (Schlote, 1977). Notwitihstanding imperfectness, money is 'the standard for measuring value' (Stoiner and Hague, 1964). Therefore, efficiency of production is usually considered to be economic efficiency, and the contribution of improvement of a trait to the improvement of efficiency is called 'economic value'.

System level

A system is considered a finite number of elements together with relationships between elements and their environment (Gal, 1982). Genetic merit is tied up with the level of an individual animal. Therefore, the animal level is the lowest system level considered in deriving economic values, but higher levels (farm, sector, or inter-national) may be considered as well.

Improvement of genetic merit of animals increases the efficiency of production. Long run effects of greater efficiency will be lower market prices (Cochrane, 1958). Yet, a cyclic interaction is observed. Economic values (and hence the level of improvement of traits) are influenced by product and production-factor prices, and the level of improvement of a trait will itself influence future prices. Therefore, the derivation of economic values ideally requires knowledge of future levels of improvement of genetic merit and their price effects (Niebel, 1986). The theoretically appropriate level to be used in deriving economic values in animal breeding is the one for which limited resources and prices of products and production-factors are influenced by an improvement of a trait (Fewson, 1982). A good example is given in a dairy industry with a milk quota system limiting the amount of product at farm level. Improvement of genetic merit for milk production per cow will result in a reduction in the number of cows at a farm. To include the effects of a reductin in the number of cows (reduced costs of housing, feeding, labour and so on), the derivation of economic values should be performed at farm level. Another example is the effect of genetic improvement on product market prices. Amer and Fox (1992) denote, within the framework of neoclassical production theory, how to assess the distribution of benefits from genetic improvement between producers and consumers. This distribution of benefits will depend on the elasticity of demand curves for products.

Although theoretically appropriate, national or inter-national levels or sector level are rarely chosen because of methodological problems. Most calculations of economic values are restricted to the animal, herd or farm level (Groen and Ruyter, 1990). The potential bias as a result of simplifications made can be tested by a sensitivity analysis for market prices and production levels. A method of deriving selection index weights which incorporates eror distribution of economic values is presented by Amer and Hofer (1994).

Planning term

The choice of a planning term should be included in deriving economic values regarding (1) the choice of (exogeneous) price parameters, and (2) the distinction between variable and fixed costs. In dairy cattle breeding, the strategic planning term is usually chosen, because future expression of genetic superiority originating from a selected animal will mainly be more than five years after the moment of selection of this animal. Two comments on this choice are to be made. First, it is problematic to distinguish between a strategic and tactical term in estimating future price parameters. Secondly, selection sometimes has major influence on the short term efficiency of a single farm (e.g. value of new born calf to be sold for beef production).

The choice of a planing term is related to the choice of production level; an improvement of a trait will only at the longer term influence limited resources and prices of products and production-factors at sector level.

Perspective

Three different interests of selection can be distinguished (Harris, 1970): (1) to maximize profit (=revenues – costs), (2) to minimize costs per unit of product, and (3) to maximize revenues/costs. In animal breeding, mainly the first and second interest are considered (Groen and Ruyter, 1990). The base of evaluation establishes the size of the system considered in deriving economic values, according to social and economic production circumstances. The three possibilities are (Groen, 1989c): (a) a fixed number of animals within the system, (b) a fixed amount of input of a productionfactor into the system, and (c) a fixed amount of output of a product out of the system. Groen (1989c) presented the concepts of economic production theory regarding different perspectives (combinations of interests of selection and bases of evaluation) in deriving economic values (Table 2). Concepts are derived for a situation with one product and one variable production-factor per animal. However, concepts can easily be extended to situations with more products and more variable production-factors. The costs of other production-factors with a variable input are always to be considered in average variable or average total costs. When the inputs of other variable production-factors are influenced by the level of genetic merit, the marginal costs of production will contain more terms. Analogously, the revenues of other products are always to be considered in average revenues. When the output level of other products in influenced by the level of genetic merit, marginal revenues will contain more terms. When the output level of other products is not influenced, within the profit interest average variable costs are extended. In the latter case, the revenues of other products are 'negative costs' components. For the cost price interest, the consideration of the revenues of other products to be negative costs is optional. For example, in dairy cattle production the gross or net cost price of milk can be calculated. The net cost price considers all costs minus revenues of beef production per unit of milk. Theory given is based on a single base of evaluation. Situations with multiple quota systems are dealt with by Gibson (1989a).

The essence of improving the efficiency of a production system is: saving inputs of production-factors per unit of product and/or a change towards the use of cheaper production-factors. Saved production-factors can either be used in the system where they are saved from (and thus extend the product output of this system) or transferred to another system (via the market) (Willer, 1967). Likewise, additionally required production-factors are either to be drawn from the market or from an alternative use in the system. Obtained differences in concepts of production theory originate directly from differences in the assumed use of saved production-factors. Example given, for the 'profit, fixed number' perspective, saved production-factors are sold at the market. In other words, differences in concepts between perspectives (Table 2) will only lead to differences in economic values when the values of (saved) production-factors differ between alternative uses. Assuming (1) markets of products and production-factors being purely competitive markets and (2) industry and all individual firms to be in equilibrium, market prices will equal average total costs of production (Stonier and Hugue, 1964). This is the approach considered by Brascamp *et al.* (1985) in proposing to set profit equal to zero. In terms of Table 2, economic values on base of fixed number of animals are equivalent when derived within profit and cost price interests. On the base of fixed output, economic values within a profit interest are equivalent to economic values on base of fixed number of animals are equivalent when derived within profit and cost price interests. On the base of fixed output, economic values within a profit interest are equivalent to economic values within a cost price interest. These economic values will also be equivalent to economic value 'fixed number, cost price' when (3) all costs of the farm are considered to be variable per unit of product. This equivalence was pointed out by Smith *et al.*, (1986), who proposed to express fixed costs per animal or per farm, like variable costs, per unit of output.

Table 2 - ECONOMIC VALUES FOR DIFFERENT PERSPECTIVES (BASE OF EVALUATION AND INTEREST OF SELECTION) EXPRESSED IN CONCEPTS OF ECONOMIC PRODUCTION THEORY (FROM: GROEN, 1989c)

Base of evaluation	Interest of selection	
	Profit maximization	Cost price reduction
Fixed number of animals	Marginal revenues[i] – marginal costs[ii]	Average total costs[i] – marginal costs[ii]
Fixed input	Marginal revenues[i] – average (revenues – fixed costs per animal)[iii]	Average total cost[i] – average fixed cost farm[iii]
Fixed output	Average variable costs[i] – marginal costs[ii]	Average variable costs[i] – marginal costs[ii]

[i] per δy units of product

[ii] per δy unist of product, corresponding to δx_v units production-factor

[iii] per δx_v units of production factor

Concluding, assuming that all costs are variable and that also the costs of producing the variable production-factor at the farm equal the market price, all perspectives are equivalent. However, in agricultural industries, products and production-factors are commonly heterogeneous and not fully divisible. Heterogenity of products and production-factors leads to division of markets

(Dahl and Hammond, 1977) and cause the average costs of production to be different for individual firms. Given (equilibrium) market prices, some firms will have a lot of profit; other firms will be just efficient enough to continue production (Stonier and Hague, 1964). As an important result, the equivalence of perspective may hold under certain conditions for the sector as a whole but will not be valid form an individual producer's point of view. In defining breeding goals, the definition of efficiency function has to correspond to the individual livestock producer's interest of selection; the producer's primary reason for buying a certain stock at a certain price, will be base upon his assessment of how animals will contribute to the efficiency of his firm (Harris, 1970). These concepts form the theoretical base for a diversification of breeding goals among (groups of) farms (Smith, 1985; Groen, 1990) and the usefulness of customized indices for (individual) farms (Bowman *et al.*, 1996).

Optimum management

Bio-economic modelling allows for the implementation of mathematical programming techniques to optimize management variables in dependence on genetic levels. Van Arendonk (1985) applied a dynamic programming model to determine the optimum replacement policy of dairy cows. Reducing involuntary (reproductive failure, health problems) disposal rates increased optimum voluntary disposal. Ignoring these changes in (optimum) management variables would underestimate the economic advantage of reducing involuntary culling (Dekkers, 1991). Steverink *et al.* (1994) applied linear programming to derive economic values in dairy cattle according to gevernmental environmental policies. As future governmental policies are yet unknown, different alternatives were studied, and linear programming allowed for the definition of optimum farm management for each of these alternatives, given multiple restrictions. Steverink *et al.* (1994) denoted that linear programming allowed for the best (given farm characteristics, like kg milk quota per ha) use of saved production-factors, in others words, the appropriate choice of (marginal) prices for (marginal) feed requirements. Zeddies *et al.* (1981) used linear programming in a sector model in order to define structural developments (farm size, number of farms) based on profitability of individual farms. Other studies using mathematical programming are Adelhelm *et al.* (1972) and Harris and Freeman (1993).

The question of optimizing farm management given farm structure should not be confused with optimizing farm structure. Animal breeding is part of the strategic (long-term) planning of production. Therefore, it is appropriate to consider all costs to be variable in time, in deriving economic values. However, costs may be fixed (constant or discontinously variable) with respect to the size of the farm (Horring, 1948). Considering these fixed costs to be varibale per unit of product requires an assumption on the (continuously optimum) size of the farm. Smith *et al.* (1996) proposed to express all fixed costs per animal or per farm per unit of output, thereby assuming a given optimum farm structure or size, with efficient use of resources. Assuming all farms to have the same size and that changes in output and input are accomplished by a change in the number of farms, the condition of fixed cost to be constant per unit of product is arithematically correct. However, structural developments in industry are detached from improvemnts in the efficiency of production, which is not correct considering long term effects of the implementation of new techniques (Zeddies *et al.*, 1981; Groen, 1989c; Amer and Fox, 1992).

Cumulative discounted expression

Cumulative discounted expression may differ between (groups of) traits. In many studies, only economic values are considered in deriving practical selection indices. Assuming cumulative discounted expressions to be equal for all genotype traits considered (e.g., correct for only milk production traits), this simplification (economic values instead of discounted economic values) will not influence relative emphasis on index traits, and thus not genetic superiorities obtained (eqn (5)). However, when considering both production traits and functional traits in the breeding goal, the assumption of equal cumulative discounted expressions will not hold. For example, Groen (1990) gives cumulative discounted expression for milk production traits, live weight and mature body weight, showing marked differences. Ignoring cumulative discounted expressions in breeeding goals that consider both production and functional traits is incorrect and will lead to bias in relative selection emphasis on traits and to non-optimum genetic responses.

Double counting

Functional traits are phenotypically 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, in this situation reduced milk production as a result of mastitis incidence should not be accounted for in the economic value of mastitis. Specifically in situations with composite traits like residual feed intake capacity, it is important to adequately attune the choice of genetic parameters, economic values and aggregate genotype traits chosen (Kennedy *et al.*, 1993):

Non-linear economic values

Another point raising attention when considering functional traits is the non-linearity of economic values. The economic value of a trait may depend on the level of the trait itself, or on the level of other traits. The theoretical basis for the application of non-linear (linear and quadratic component) indices was given by Wilton *et al.* (1968). Evaluation of non-linearity of economic values can be performed by deriving economic values at different starting values for genetic merit of the animals. A specific method to derive economic values of traits with an intermediate optimum is presented by Hovenier *et al.* (1993). Relative efficiency of non-linear indices versus regularly updating economic values according to new population averages was recently studied by Groen *et al.* (1994) and Dekkers *et al.* (1995), using examples in dairy cattle (days open) and poultry (egg weight), respectively. Weller *et al.* (1996) extensively discussed properties of different methods to select for non-linear profit functions. Weller *et al.* (1996) concluded that for non-linear profit functions there is no uniformly "best" solution. Maximum genetic progress will always be achieved by a linear index, but for a non-linear profit function, the index that results in maximum genetic gain in the future will be a function of the selection intensity. For traits which are non-linear in the objective function, it should be possible to increase the mean value of the objective function in the progeny by planned matings. The advantage of planned matings will be greatest for traits with a high heritability and a population mean close to the economic optimum (Weller *et al.* 1996).

Literature summary on economic values of funtional traits in dairy cattle

In this paragraph, a summary of literature on estimated economic values for functional traits (see Table 1) is given. Only original references are included. A review on economic values of milk production traits is given by Groen and Ruyter (1990). Recently, a broad review on breeding for profit in livestock was published by Harris and Newman (1994).

Absolute figures on derived economic values depend strongly on price parameters and methodology and are for that reason not presented. Relative importance of traits versus production traits is not denoted either: only index weighing factors fully account for differences in heritability and genetic variance, genetic correlations, differences in discounted economic values, and the amount of information recorded in the breeding programme.

For anyone involved in animal breeding and intending to propose breeding goals to practitioners, a mere compilation of corresponding literature on economic values could be misleading. A correct breeding goal should include economic values calculated when considering all traits to be constant except the for trait of interest (Hazel, 1943). Authors in literature often consider a subset of traits and allocate to them values derived after integrating out other traits. For instance, Colleau and Le Bihan-Duval (1995) considered an objective involving milk yield, resistance to mastitis and somatic cell scores: only 48% of the value given to mastitis is relevant because the rest corresponds to longevity losses statistically linked with mastitis. Conversely, the value given by Biochard (1990) for female reproduction traits might be underestimated: he accounts for modifications of yield involved by different reproduction status. However, these modifications are partly genetic because reproduction is heritable and correlated with milk yield. Likewise, milking speed and calving ease should be given the value they deserve, excluding any consideration about relationships between milking speed and resistance to mastitis or between calving ease and yield losses or even female reproduction.

Health

Financial losses from diseases at farm level can be attributed to one or more of the following factors (Schepers and Dijkhuizen, 1991): (1) less efficient production and higher veterinary costs before disposal (decreased milk yield, changed milk composition, decreased milk quality, discarded milk, decreased feed intake, drug costs, veterinary fee, labour costs), (2) reduced slaughter value and idle production-factors at disposal, and (3) lost future income when replacing animals before reaching there optimal economic age for culling (loss is difference between (a) income that a particular animal could earn during her remaining expected life and (b) expected average income from replacement animals. These losses do not include costs of (national) disease control programs (Schepers and Dijkhuizen, 1991), nor do they consider effects of increased disease incidence on public health and consumer behaviour (McInerney, 1992).

A critical analysis of estimates of economic losses form mastitis at farm level is given by Schepers and Dijkhuizen (1991).

Fertility

Variables used to denote the fertility of a dairy cow are calving interval or days open, and conception or non-return rates, or number of inseminations to obtain pregnancy. It is obvious that these variables are strongly related and directly depend on the insemination and replacement policy of the farmer. The consequences of a decrease in fertility include (Boichard, 1990): additional insemination and veterinary costs, increased length and persistency of the current lactation, increased culling rate, and modifications to subsequent lactations. A basic study quantifying these aspects is described by Dijkhuizen *et al.* (1985).

The economic value of prolonged calving interval or period with days open depends on relative prices of milk and beef. Thereby, the persistency of lactation is an important factor in determining relative production level at the end of lactation (with prolonged days in milk) versus production level at the beginning of (next) lactation. The economic value of days open was recently calculated by Groen *et al.* (1994). A literature review, summarizing cost components included in modelling economic losses of prolonged calving interval, is given by De Boer (1990).

Van Arendonk and Dijkhuizen (1985) used dynamic programming techniques to optimize replacement policies when quantifying the effects of changes in probabilities of conception. Boichard (1990) used a similar model to derive the eonomic value of conception rate in dairy cattle. Amer *et al.* (1995) introduced an alternative approach to derive economic values of reproductive traits, combining partial budgeting of costs of a barren cow with a model of the herd calving distribution which is driven by assumed levels of reproductive parameters. Specificity of the model is that it accounts for non-normal distributions of e.g. days open. Economic values of conception rate are also given by Dekkers (1991) and Pedersen and Jansen (1996).

Calving ease

Meijering (1986) presented a model for the derivation of the economic value for calving ease, assuming recording of dystocia a categorical trait. Meijering (1986) included veterinary fee, farmer labour, calf losses, reduced milk yield, reduced fertility and increased culling as cost components. This model was also applied by Bekman and Van Arendonk (1993), Dekkers (1994), and Groen *et al.* (1995). Depending on other breeding goal traits considered, these authors applied different sets of cost components. The economic value of calving ease is mainly determined by the frequency of animals in classes like veterinary help, caesarian, and foetotomy, and the costs of veterinary fee and calf loss in these classes. Economic values for direct and maternal calving ease are equal, but their respective cumulative discounted expressions differ. When considering calving ease to be a different trait for subsequent parties of the dam (Philipsson, 1996), economic values will differ per parity according to frequency and calf revenue (Dekkers, 1994).

Body weight

Mature body weight of dairy cattle has a negative economic value; marginal costs associated with increased energy requirements for raising female stock and increased maintenance requirements for lactating cows exceed marginal revenues from increased body weight of disposed young female stock and lactating cows (Groen, 1989a). Econoic values for body weight are usually derived without considering changes in body composition. The economic value of mature body weight is mainly dependent on assumed feed prices and beef prices (Groen, 1989a).

Given their impact on marginal feed cost, farming intensity (kg milk quota per ha) and environmental legislation will also influence the economic value of mature body weight (Steverink *et al.*, 1994). The economic value of mature body weight for pasture based dairy production systems in Australia, restricting the input of roughage at farm level, was derived by Visscher *et al.* (1994). When restricting roughage input, the economic value of mature body weight tends to decrease, as the average revenues over fixed costs per unit of roughage in practical situations exceed marginal costs of roughage production (Groen, 1989b, see Table 1). Ignoring the rearing period only slightly influences the economic value of mature body weight (Morris and Wilton, 1977; Groen, 1989a). Economic values for (mature) body weight are also presented by Van Raden (1988) and Ahlborn and Dempfle (1992).

Feed intake

Feed intake is a very complex trait, which in fact can not be treated seperately but should always be considered in relation to milk production and body weight. An important question is whether a reducton or an increase in (residual) feed intake (capacity) should be considered. Decreasing (residual) feed intake at constant production levels and body weight would allow for a more efficient production; less nutrients required per unit of product. An increase in feed intake capacity would allow for more (and cheaper) fibrous feed intake and probably a less negative energy balance in early lactation.

Groen and Korver (1989) derived the economic value of feed intake capacity assuming that nutrient intake is determined by nutrient requirements: an increase in feed intake capacity allowed for a cheaper composition on nutrient intake and their model allowed for a change in genetic value of feed intake capacity without changing levels of body weight and milk production. Increasing feed intake capacity as defined might be a change in body composition and/or an increased rumen outflow rate of particles (Orskov *et al.*, 1988). The economic value of feed intake capacity was found to be highly sensitive to feed and animal factors influencing the feed intake of dairy cows, and to the difference between concentrate and roughage price. This sensitivity corresponds to results by Zeddies (1985).

Persistency

Dekkers *et al.* (1996) derived the economic value of persistency under optimized insemination and culling strategy, evaluating the impact of persistency on feed costs and milk revenues. Persistency was defined as the differential yield between day 60 and 280 of lactation, compared to a lactation curve with an average shape, keeping 305-day yield constant. When evaluated over a 305-day lactation, the economic value of persistency was only due to changes in feed requirements. When evaluated over lactation periods with longer length, the econoic value of persistency picks up benefits from differentials in average daily milk yield over the extended (beyond 305-days) periods.

Milking speed

Dekkers (1993) and Stegink (1994) derived the economic value of milking speed, including the following cost components: labour, electricity, and milking parlour (interest and depreciation). Labour cost were about 90-95% of total costs. Therefore, the level of labour costs per hour and the number of milking machines per person were the most important parameters determining the economic value of milking speed.

Longevity

According to Rendel and Robertson (1950b), an extended productive life in dairy cattle increases profit at farm level in four ways: (a) by reducing the annual cost of replacements per cow in the herd, (b) by increasing the average herd-yield through an increase in the proportion of cows in the higher producing age-groups, (c) by reducing the replacements which have to be reared and therefore allowing and increase in the size of the milking herd for a given acreage, and (d) by an increase in the culling rate possible. Including all these components requires extensive models using mathematical programming techniques to optimize replacement policies, like the model by Van Arendonk (1985). The optimum replacement policy and the economic importance of longevity strongly depend on the relative magnitude of costs of growing (or buying) a replacement heifer versus the salvage value of a cow (Van Arendonk, 1985).

There are two main approaches considered in deriving the economic importance of longevity: calculate either the economic value of increased productive life (Van Arendonk, 1991; Allaire and Gibson, 1992) or the economic value of reducing involuntary culling rates (Van Arendonk, 1985; Rogers *et al.* 1988). Economic values of longevity were recently calculated by Harris and Freeman (1993), Reinsch (1993), Böbner (1994), and Stott (1994).

Differences in breeding goal definition

The set of breeding goal traits in Table 1 intends to be a basis for priority setting of (inter)national breeding goal definition and breeding value estimation. Uniform data recording, evaluation and presentation will facilitate (international) exchange of semen, for the benefit of the individual dairy farmers. It is not the intent of this report to propagandize a uniform set of (international) economic values to be given to these traits. The opposite is true; the working troup recognizes that there are several reasons justifying differences in breeding goals on a national, regional, and farm scale. Economic values are sensitive to production cirsumstances that may differ between nations (e.g. legislation on environmental issues, animal welfare of milk quota, or pricing levels), or regions and farms (e.g. intensity of farming system) (Gibson (1989b); Groen (1989a, b), Pedersen *et al.* (1993a), Visscher *et al.* (1994); Steverink *et al.* (1994)). In general, the definition of one common goal gives opportunities of obtaining large genetic improvement (high selection intensities). However, the definition of one common goal, based on predicted average future production circumstances of individual farmers, may lead to losses in revenues because of the heterogeneity of circumstances among farms (individually, per region or per nation), or of uncertainty about future circumstances (Groen, 1990). Final conslusions concerning the need for diversification of cattle breeding goals should be based on additional revenues and additional costs calculations (Smith, 1985). In doing so, it is important to distinguish between diversification at the level of the breeding organization (i.e. the choice of bull isres and bull dams), and diversification at the level of the individual farmer (i.e. the choice of proven bulls to breed the next generation of commercial cows). Diversification at the level of a breeding organization will not readily be advantageour (Groen, 1990). However, given the one uniform, overall breeding goal at the level of the breeding organization, the forthcoming list of bulls with estimated breedign values will show substantial differences. Not only can a differentiation between good proven bulls ranking highest for production traits versus poor bulls be made but also within the top proven bulls for production, substantial differences in estimated breeding values for functional traits occur. Making available only the top proven bulls for production to farmers will guarantee strong genetic progress; allowing farmers a personal choice within the top will surely benefit (Bowman *et al.* 1996), not only economically but also from a social point of view. Development of software to support customized selection and mating decisions for individual farmers is an important aspect of market oriented genetic improvement.

The importance of maintaining differences in breeding goals between production circumstances for the conservation of breed resources was discussed by Hammond and Leitch (1995). The use of strictly economic models for different breeds and production circumstances seem to give breeding goals that will reduce differences between breeds (Pedersen *et al.* 1993b). On the other hand, competition between breeds might in some situations lead to larger differences between breeding goals than justified by the economic and biological parameters. Competition could cause one breed to put extra emphasis on a poor trait as discussed by De Vries (1989) but there are also examples of breeds that put extra weight on a superior trait for marketing purposes, e.g. protein yield in Red Danish (Pedersen *et al.*, 1993a), kappa-casein type B.

Hammond and Leitch (1995) especially emphasized the global aspects and the problems of the developing countries. For example, cattle breeding in Central and East European countries is strongly influenced by the political changes which produce changes in the ownership of farms and industries, changes in the infrastructure of national economy, and the market possibilities as well. Generally, during the last 6 years the size of cattle population drastically gone down and average production per cow has stagnated at its previous level. The selection indexes with economic values were developed (Pribyl, 1994; Wolvofa *et al.*, 1994; Pribyl *et al.*, 1995) but were generally not used by breeding organizations. In particular in less developed regions cattle production systems keep relatively lower production levels per animal. Breeding programmes balancing the improvement of production and functional traits will allow the development of production systems in these regions that is better acceptable than one-sided development towards higher production levels.

Prospectives about the future

New traits may become part of the breeding goal in future cattle breeding and either increase the total number of traits or replace old ones. The set of information traits in the index may be subject to changes too. The aim of this chapter is to mention some developments, which will possibly generate such changes or at least some modifications in the relative economic weights attached to the breeding goal traits.

New technological developments both in production and performance testing will soon reach a mature state. When robot milking is introduced for wideaspread application, udder shape and teat placement will probably have to fulfil more rigid minimum requirements. New automated techniques for determining individual cow's milking rates and milk flow patterns under field conditions will soon help generate a big bulk of data. Duda (1996) presented a list of 15 different traits related to milkability and electrical conductivity which are measured and recorded by a new designed milkmeter. Parameters like average or peak milk flow, duration of maximum flow rate and time of main milking period will become available for all cows under milk recording. Thus, the milkability part of the breeding goal and information index is a candidate for redefinition or reweighing after experiences with all these parameters and results from genetic analyses have been accumulated. Other examples are e.g. automated monitoring of body weight or automated feeding systems for roughage, which may create new information sources for breeding purposes.

Possible consequences of the application of molecular genetics were discusses by the working group. Breeding organizations may tend to put more weight on traits with at least one known QTL (either closely marked or directly characterized on DNA level). This is not justified, since economic weights are fully determined by cost prices, product prices and production circumstances there is no justification for changes in the breeding goal as a reaction to the establishemen of positive QTL results, i.e. all economic values remain constant and unaffected by results of this type.

A tendency towards more rigid restrictions from environmental and animal welfare legislation may have some impact at least on performance recording and even on the breeding goal itself. This is illustrated by Swedish regulations, which make a missing progeny test for dystocia prohibitive for the heavy use of a bull in the AI population. Regulations like these are reflecting consumer demands for animal health and welfare, safe products and environmental protection. The future impact of these attitudes may create pressure for certain changes in animal production systems. One likely such change is decreased application of antibiotics in order to reduce the danger of bacterrial resistances and antibiotic residuals. As a consequence, direct disease recording in combination with indirect traits may become more attractive to breeders. Quotas for manure will increase the economic importance of body weight (Steverink *et al.* 1994) and the same would happen to feed intake capacity if the number of cows per hectare would be severely restricted.

The relative economic importance of aspects of milk quality like protein content and somatic cell count has been subject to severe changes during the last two decades. Changes have been small with respect to meat and carcass quality. The EUROP grading scheme seems to be a very rough measure for carcass quality and parameters like water binding capacity, protein content or pH measurements may become more frequently used parameters to describe beef quality with respect to processing properties. A general conclusion with regard to quality traits is, that the relative importance of volume or the amount of product seems to decrease during the course of time when compared to product quality.

Concluding remarks

Direct versus indirect selection

In the absence of nationwide recording systems for health, breeding value estimation will be based on indirect information indices. In this situation currently practiced in many countries the need for clarifying relationships between conformation traits and the breeding goal traits is urgent (see for instance Rogers, 1996; De Jong and Lansbergen, 1996). A good example concerns the evaluation of resistance to mastitis when there is no data available to be linked to events involving mastitis without doubt or discussion. This situation corresponds with the recording of somatic cell counts, without any information on clinical mastitis or reasons of disposal. Quality of evaluation depends on the assumed relationships with the trait of interest included in the selection objective. In this case, a short term solution is to verify from time to time, e.g. by sampling daughters of extreme bulls whether assumed relationships still hold considering for instance clinical mastitis. In the long term, data collection systems itself could be changed.

The joint statistical distribution of performances of interest is not normal, some traits are not always recorded nor expressed and finally, the number of traits involved is high: these are reasons why a full BLUP multi-variate evaluation is not possible (especially when considering an animal model). Hence, there is a need to resort to evaluations considering only one trait or a group of traits. These partial evaluations can be combined afterwards to give an approximate overall EBV, less precise than the true one. However, weights to give to these evaluations are no longer those existing in the selection objective, and bias may occur especially with low accuraccies per partial evaluation (Kulak *et al.*, 1996).

Non-linearity of relations

Functional non-linearity might occur within the selection objective if some variates included are latent values expressed through a generalized linear model (Colleau and Phocas, 1995), if variates expressed in the observed scale show a genuine curvilinearity (Boichard, 1990) or if the economic function refers to rations such as productivity per unit of product (kg milk, for instance).

Statistical relationships between some components of the breeding goal and information index traits might be non-linear (e.g., relationships between milking speed and resistance to mastitis). Updated linearized regression formulae could be used to predict BLUPs of components of selection objectives. Trying to keep close to an "optimum" value of information index traits is highly questionable if this concept is not included and justified in the breeding goal itself. Here is the most wasteful source of efficiency losses due to curvilinearity, and such considerations should not be encouraged.

Breeding programmes

In conventional schemes, records observed in the commercial population provide quite naturally the information for calculating EBVs. This is true too for more advanced schemes, such as hybrid MOETs, where bulls are progeny-tested in the commercial population and where the nucleus of dams is permanently dispersed and open to this population. In this context, MOETs can keep their shorter generation interval and generate favourable genetic trends for secondary traits or at least prevent them from deteriorating too much (Bevenhuis *et al.*, 1989; Colleau and Phocas, 1995). The essential reason is that information on half-sibs by bull sires provides an early prediction on young bulls and dams.

Closed nuclei using ET were recommended (Nicholas and Smith, 1983). Research works demonstrated they would be unable to select efficiently for functional traits unless using information provided by test herds sired by nucleus bulls (Bovenhuis *et al.* 1989; Teepker and Smith, 1990). Indeed, this suggests that nuclei could be open to commercial females. However, this type of nucleus have more potential to efficiently use future research advances on hormonal profiles, anatomical measurements and marker typing (Meuwissen and Woolliams, 1993).

When the selection objective involves only dairy traits, the optimum generation interval is generally very short. Reasons for moving from this situation towards older selected cows could be relatively high heritabilities and economic values for functional traits late in the cow's life. Generally speaking, these reasons are not likely to occur: heritabilities are generally lower than for production traits and most functional traits are expressed as early as first lactation. Consequently, no substantial progress is to be expected from delaying bull or cow selection.

The most important question concerns the number of sampling bulls and corresponding progeny sizes. Simulation (Christensen, 1995; Bovenhuis *et al.*, 1989) shows that both should be increased very substantially or that progeny sizes should be increased at the expense of the number of bulls if the proportion of cows served by young bulls is a constant. These works do not consider that bulls can be evaluated for functional traits not only from progeny but also from pedigree, which might temper the impact of introducing new traits on the ideal structure of young bull population. Furthermore, they are based on long-term considerations, especially including asymptotic genetic gain.

In conclusion

A genetically and socio-economically balanced selection on production (milk and beef) and functional traits (health, fertility, efficiency of feed utilisation and milkability) in dairy cattle requires correct economic values. Correct relative levels of economic values of traits should give optimum levels of genetic improvement according to future production circumstances; correct absolute levels are important for an accurate calculation of economic revenues of breeding programmes. Derivation of economic values requires a good theoretical basis, proper methodology in terms of models including physiological modelling of animal production, farm economics and social aspects, and appropriate assumption on future production circumstances. The field of breeding goal definition is of ongoing interest, especially because the knowledge on modelling is improving, and (uncertain predictions on) future production circumstances are continuously changing. Moreover, although research have been undertaken for a long period, integration of functional traits in dairy cattle breeding goals is still a major challenge for animal breeders.

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EKONOMSKA VRIJEDNOST UZGOJA MLIJEČNOG GOVEDA S POSEBNIM OSVRTOM NA FUNKCIONALNE OSOBINE

Sažetak

Genetski i socio-ekonomski ujednačena selekcija proizvodnih (mlijeko i govedina) i finkcionalnih osobina (zdravlje, plodnost, djelotvornost iskorištavanja hrane i mliječnost) u mliječnog goveda traži ispravne ekonomske vrijednosti. Ispravne relativne razine ekonomskih vrijednosti osobina daju optimalne razine genetskog poboljšanja u skladu s budućim uvjetima proizvodnje; ispravne apsolutne razine važne su za točno izračunavanje ekonomske dobiti uzgojnih programa. Izvođenje ekonomske vrijednosti zahtijeva dobru ekonomsku osnovu, pravilnu metodologiju u odnosu na modele, uključujući fiziološko oblikovanje proizvodnje životinja, ekonomičnosti farme i socijanih aspekata i odgovarajuće pretpostavke uvjeta buduće proizvodnje. Područje definicije cilja uzgoja zanimljivo je osobito zbog toga što se znanje o oblikovanju poboljšava a nesigurni uvjeti buduće proizvodnje neprestano mijenjaju. Osim toga, iako se istraživanja provode već dugo vremena praktična integracija funkcionalnih osobina u ciljevima uzgoja mliječnog goveda još uvijek je veliki izazov za uzgajače životinja. Ciljevi izvještaja ove radne grupe su:

a) predstaviti definiciju skupine osobina uzgojnih ciljeva,

b) raspraviti o metodologiji izvođenja ekonomskih vrijednosti,

c) dati sažetak literature o ekonomskim vrijednostima funkcionalnih osobina,

d) raspraviti o mogućem opravdanju razlike u definiciji uzgojnih ciljeva nekih zemalja, područja i/ili individualnih farma, i

e) raspraviti o mogućim budućim tendencijama što bi mogle utjecati na uzgojne ciljeve promjenom ekonomskih vrijednosti.

Ključne riječi: ekonomske vrijednosti, funkcionalne osobine, mliječno govedo, uzgojni cilj

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