Economic values of functional traits in dairy cattle

Ab F. Groen

Department of Animal Breeding, Wageningen Institute of Animal Sciences
P.O. Box 338, 6700 AH Wageningen, The Netherlands

1. Introduction

Integration of functional traits into breeding programmes requires among others knowledge on economic values of these functional traits. The economic value of a trait expresses to what extent economic efficiency of production 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 future expression of a superior genotype originating from the use of a selected individual in a breeding programme (Brascamp, 1978). Multiplication of the economic value by the cumulative discounted expression gives the discounted economic value. Discounted economic values are used (1) to aggregate genotypes for several traits to the 'aggregate genotype', in other words, to weight genotypes in a specific breeding goal (Hazel, 1943), and (2) to value predicted genetic superiorities in a breeding goal in order to calculate economic revenues of this programme. 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), primarily the absolute levels of economic values are important.

The aim of this paper is to discuss methodology in deriving economic values, with special emphasis on functional traits. A summary of literature on estimated economic values for functional traits is included.

2. Methodology

Objective versus non-objective methods

At first, one might distinguish between objective and non-objective methods to derive economic values.

The principal tool used in objective methods to derive economic values is a model. 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, economic results 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, often the terms 'profit function' and 'bio-economic model' are used. There principally is 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 being 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 bio-economic model (e.g., Tess et al, 1983; Groen, 1988). Using simulation models, economic values are derived by studying the behaviour of the system as a reaction to a change in level of an (endogenous) element that represents 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 system 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 reason called upon in practically applying non-objective methods is 'difficulties' to perform an objective calculation; 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 each trait (Kempthorne and Nordskog, 1959; Brascamp, 1984). These methods may be useful in commercial pig and poultry breeding because commercial breeders tend to calculate economic values according to the performance of their stock relative to those of other breeders (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 Yaimada, 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 only perform equally or less efficient. In practice, 'true' efficiency functions are unknown, and breeders applying subjective economic values argue that they have a better 'expert' insight in future development than an objective model.

In conclusion, objective methods are preferred in deriving economic values to define breeding goals. Modelling is not an easy job, requiring multi-disciplinary effort. Some basic choices to be made in modelling when deriving economic values are discussed below.

**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 terms; in the economic definition this is done in terms of money. The major problem arising with the biological definition is that not all costs and revenues can be expressed in terms of energy and/or protein. The economic definition largely deals with this problem. A disadvantage of the economic expression is weakness in stability in time and place of monetary units (Schlote, 1977). Notwithstanding imperfection, money is ‘the standard for measuring value’ (Stonier and Hauge, 1964). Therefore, efficiency of production is usually considered to be economic efficiency, and the contribution of improvement of a trait to improvement of efficiency is called ‘economic value’.

**System level**

A system is considered to be a finite number of elements, together with relationships between elements and their environment (Gaj, 1982). Genetic merit is tied up to the level of an individual animal, not just an organ or tissue. 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 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 level of improvement of traits) are influenced by product and production-factor prices, and level of improvement of a trait will itself influence future prices. Therefore, 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 reduction in the number of cows (reduced costs of housing, feeding, labour and so on), 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 international 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.

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, usually, the strategic planning term is 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 short term efficiency of a single farm (e.g. value of new born calf to be sold for beef production).

The choice of a planning 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 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 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 production-factor 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 1). 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 is 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, 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 cost minus revenues of beef production per unit milk. Theory given is based on a single base of evaluation. Situations with multiple quota systems are dealt with by Gibson (1989).
Table 1  Economic values for different perspectives (base of evaluation and interest of selection) expressed in concepts of economic production theory (From: Groen, 1989c).

<table>
<thead>
<tr>
<th>Base of evaluation</th>
<th>Interest of selection</th>
<th>Cost price</th>
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<tbody>
<tr>
<td>Fixed number of animals</td>
<td>Marginal revenues₁ - marginal costs₂</td>
<td>Average total costs₁ - marginal costs₂</td>
</tr>
<tr>
<td>Fixed input</td>
<td>Marginal revenues₁ - average (revenues - fixed costs per animal)₃</td>
<td>Average total cost₁ - average fixed cost farm₃</td>
</tr>
<tr>
<td>Fixed output</td>
<td>Average variable costs₁ - marginal costs₅</td>
<td>Average variable costs₁ - marginal costs₅</td>
</tr>
</tbody>
</table>

₁: per dy units of product  
₂: per dy units of product, corresponding to δx, units production-factor  
₃: per δx, units of production factor

The essence of improvement of efficiency of a production system is: saving inputs of production-factors per unit product and/or a change towards use of cheaper production-factors. Saved production-factors can either be used in the system where they are saved from (and thus extend product output of this system) or can be 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 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 1) 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 to be 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 Hague, 1964). This is the approach considered by Brascamp et al. (1985) in proposing to set profit to zero. In terms of Table 1, economic values on base of fixed number of animals are equivalent when derived within profit and cost price interests. On 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 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.

Concluding, assuming that all costs are variable and that also the costs of producing the variable production-factor at the farm equals the market price, all perspectives are equivalent. However, in agricultural industries, products and production-factors are commonly heterogeneous and not fully divisible. Heterogeneity 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 from an individual producer's point of view. In defining breeding goals, definition of efficiency function has to correspond to the individual livestock producer's interest of selection; the producer's primary reason to buy a certain stock at a certain price, will be based upon his assessment of how animals will contribute to the efficiency of his
farms (Harris, 1970). These concepts form the theoretical base for a diversification of breeding goals among (groups of) farms (Smith, 1986; Groen, 1990), and impose the question of the usefulness of customised 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 bias the economic advantage of reducing involuntary culling (Dekkers, 1991). Steverink et al. (1994) applied linear programming to derive economic values in dairy cattle in dependence on governmental 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 sizes, number of farms) based on profitability of individual farms. Other studies using mathematical programming are among others 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 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 discontinuously variable) with respect to size of the farm (Horning, 1948). Considering these fixed to be variable per unit product requires an assumption on (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 same size, and that changes in output and input are accomplished by change in number of farms, the condition of fixed cost to be constant per unit of product is arithmetically correct. However, structural developments in industry are detached from improvements in efficiency of production, which is not correct considering long term effects of the implementation of new techniques (Groen, 1989c; Amer and Fox, 1992).

**Functional traits**

After giving these general aspect on the methodology to derive economic values in animal breeding, I will denote some aspect specifically related to functional traits.

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 choosen (low) level, referring to public opinion and consumer attitude. However, I consider this problem in deriving economic values for functional traits as a major challenge for animal breeders in the near future. Constructing models at sector level, including mathematical programming techniques is, therefore, highly relevant in deriving economic values for functional traits.

As denoted in the introduction, weighing factors in the aggregate genotype should be discounted economic values, and not economic values as such. However, often only economic values are considered in deriving practical selection indices. Under the assumption of cumulative discounted expressions to be equal for all genotype traits considered (e.g., correct for only milk production traits), this simplification (economic values in stead of
discounted economic values) will not influence relative emphasis on index traits. However, when considering both production traits and functional traits in the breeding goal, the assumption on equal cumulative discounted expressions will not hold. For example, Groen (1990) gives cumulative discounted expressions for milk production traits, live weight and mature body weight, showing apparent differences. Ignoring cumulative discounted expressions in breeding goals that consider both production and functional traits is incorrect and will lead to bias in relative selection emphasis on traits, and thus to non-optimum genetic responses.

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 lower milk production 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 choice of genetic parameters, economic values and aggregate genotype traits chosen (Kennedy et al., 1993).

Another point raising attention when considering functional traits is 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). 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, this workshop) extensively discusses properties of different methods to select for non-linear profit functions.

Table 2  Functional traits considered as breeding goal traits and examples of possible information index traits (From: Strandberg et al., 1996). Traits in italic are considered in this summary.

<table>
<thead>
<tr>
<th>Functional traits</th>
<th>Possible information index traits for selection</th>
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<tbody>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
</tr>
<tr>
<td>Body weight</td>
<td>Linearly scored type traits, body measurements</td>
</tr>
<tr>
<td>Feed intake capacity</td>
<td></td>
</tr>
<tr>
<td><strong>Fertility</strong></td>
<td></td>
</tr>
<tr>
<td>Showing heat</td>
<td>Interval calving to first heat, interval calving to 1st insemination</td>
</tr>
<tr>
<td>Pregnancy rate</td>
<td>Non-return, interval 1st insemination to pregnancy, number of inseminations per pregnancy</td>
</tr>
<tr>
<td>Calving ease</td>
<td>Rump angle</td>
</tr>
<tr>
<td>Stillbirth</td>
<td></td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td></td>
</tr>
<tr>
<td>Mastitis</td>
<td>Teat placement, suspensory ligament, udder depth, SCC, milking speed, longevity</td>
</tr>
<tr>
<td>Feet and legs</td>
<td>Rear legs set, claw diagonal, longevity</td>
</tr>
<tr>
<td>Other diseases</td>
<td>Longevity</td>
</tr>
<tr>
<td><strong>Milkability</strong></td>
<td></td>
</tr>
<tr>
<td>Milking speed</td>
<td></td>
</tr>
<tr>
<td>Behaviour</td>
<td></td>
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</table>
3. Literature

In this chapter, a summary of literature on estimated economic values for functional traits is given. Functional traits considered are summarized in Table 2. Absolute figures on derived economic values depend strongly on price parameters and methodology and are, for that reason, not presented here. Also relative importance of traits towards production traits is not denoted: 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.

Only original references are included. I know this summary is not complete, and I would like to encourage people having other sources to inform me. 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 is published by Harris and Newman (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). Economic 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 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 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 VanRaden (1988) and Alborn and Dempfie (1992).

Feed intake

Feed intake is a very complex trait, which in fact can not be treated on its own, but should always be considered in relation to milk production and body weight. An important question is whether a reduction or an increase in (residual) feed intake (capacity) should be considered. Increasing (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 lower 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 of 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).

Health

Financial losses from diseases at the farm level can be attributed to one or more of the following factors (Schepers and Dijkstra, 1991): (1) less efficient production and more 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 Dijkstra, 1991), nor do they consider effects of increased disease incidence on public health and consumer behaviour (McInerney, 1992). My personal feeling is that the latter point, consumer behaviour, is the main incentive to consider health (and reproductive) traits in cattle breeding programmes. A lot of work is to be performed in this area.

A critical analysis of estimates of economic losses from mastitis at farm level is given by Schepers and Dijkstra (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 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 Dijkstra et al. (1985).

The economic value of prolonged calving interval or period with days open depends on relative prices for 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 Dijkstra (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 economic 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 the economic 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).

Calving ease

Meijering (1986) presented a model for the derivation of the economic value for dystocia, assuming recording of dystocia as 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). In dependence 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 culling, and the costs of veterinary fee and calf loss in these classes.

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 cost 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 (1950), a longer 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 an increase in size of the milking herd for a given acreage, and (d) by an increase in the culling 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 depends 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). Recently, Dekkers and Lairith (1994) summarized the role of longevity in the breeding goal. Economic values of longevity are recently calculated by Harris and Freeman (1993), Reinsch (1993), Böbner (1994), and Stott (1994).

Concluding remarks

Integration of functional traits in dairy cattle breeding goals, with a correct weighing relative to milk production requires economic values of these functional traits. Derivation of objective economic values of functional traits, including physiological modelling of animal production, farm economic and social aspects (like price development, consumer behaviour) is still a major challenge for animal breeders, requiring a multi-disciplinary effort.

References


Tess, M.W., Bennett, G.L. and Dickerson,


