Constructing the selection objective of the French Holstein population

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Abstract

We describe the approach currently envisioned for defining the future selection objective to be used when selecting the French Holstein breed. The selected traits are dairy traits, female fertility, somatic cell count, functional longevity and body size: reasons of this choice are given. The formal algorithms used for calculating the corresponding weights are given. Very preliminary calculations, to be confirmed based on real farm data, seem to indicate that the weight of each genetic standard deviation for the three 'functional' traits would be similar and in the vicinity of 0.25 – 0.30, after giving the weight 1 to dairy traits. Weight of body size was found to be 0.10.

1. Introduction

The current selection objective for the French Holstein population still refers to the situation where evaluation procedures for non-subjective functional traits did not exist. Then, the synthetic selection index accounts for dairy traits and type traits. The relative weights of yields and milk contents were determined in a quota situation for fat yields (Colleau *et al.*, 1994). The relative weights of type traits vs dairy traits were determined so as to obtain desired proportional genetic gains for some major components of type traits (INTERBULL, 1996).

Since 2 years, information on functional traits has been progressively released and corresponding EBVs have been communicated to the breed association and to the AI organisations: functional longevity (Ducrocq and Solkner, 1998; Ducrocq, 1999), somatic cell count (Boichard and Rupp, 1997), female fertility (Boichard *et al*., 1998). Then, the next step will be to determine the selection objective giving a proper weight to the different information sources. Preliminary studies have been conducted to define a global approach for constructing the selection objective and for obtaining an efficient overall EBV. The present communication gives a short summary of the first part (selection objective) and of the possible avenues still to be debated.

2. Global approach

2.1. Selecting the traits

The selection objective is defined as a linear combination of evaluated traits i.e., traits with direct EBVs. Then, besides dairy traits (considered as an unique block for simplicity), four major items should be considered.

Female fertility

Culling for low reproduction rates is frequent: about 25% of disposal reasons.

Somatic cell counts (SCC) and sensitivity towards mastitis

SCC directly influences milk price and can be considered as an indirect indicator of sensitivity to mastitis, the direct indicator of which is the occurrence of clinical mastitis. If recording of clinical mastitis is lacking, then complications occur (see later). Increased sensitivity to mastitis leads to increased culling and specific treatment costs.

Functional longevity

The aim of this complex trait is to summarise the latent risk of culling for reasons other than low milk yield. It should be kept in mind that it stems from an evaluation procedure where the overall culling risk is 'corrected' for the within-herd phenotypic production level.

Body size

Body size is a trait that can affect the overall economic efficiency through both incomes (from beef production) and costs (from maintenance feed requirements).

It can be observed that appraisals corresponding to type traits, although evaluated, are not incorporated into the selection objective. Then, their role is restricted to indirect prediction of economic traits. However, it should be mentioned that if breeders put a high emphasis *per se* on type traits, then a part of the economic weight of functional longevity corresponds to direct selection on type.

2.2. Calculating the weights

2.2.1 Setting up an economic model

The general approach of the model is akin to that of Visscher *et al.* (1994): the longitudinal profile of an average herd is built with its corresponding cohorts of age, defined by their frequencies and characteristics such as average incomes, costs and surfaces. Furthermore, we use exactly the same constraints as those defined when building up the INEL, i.e., the current synthetic EBV for dairy traits (Colleau *et al*., 1994). Then, the farm modelled is constrained to producing a constant fat yield and to using a constant surface when considering both animal and vegetal production. In this economic model, only the overall culling rate between lactations was considered because it could be calculated without ambiguity. Basically, a decreased culling rate influences the overall economic efficiency by increasing the proportion of adult lactations and by decreasing the impact of replacement cost (heifer rearing cost is higher than salvage value).

Under this circumstance, the economic weight per unit of a given trait of the economic model corresponds to the derivative, with respect to this trait, of the ratio R

(Incomes-costs) / production quota

where costs include fixed costs and the possible costs of replacing animals by crops, if selection leads to decreasing the herd size (see also Gibson, 1989; Groen, 1989; Groen *et al.*, 1997).

2.2.2 Return to the evaluated traits without double counting

Dairy traits are quite explicit in the economic model and then raise no special problem. The latent trait for female fertility is connected to the overall culling rate through an analytic link function (e.g., in a threshold model), which in turn depends on the current culling practices. For now, we consider that cows are culled after 4 unsuccessful inseminations. It is well recognised that calculating the weight of fertility this way can overemphasise fertility in the current economic situation (Van Arendonk, 1985; Boichard, 1990).

If clinical mastitis had been recorded in a large scale in our country, then a direct evaluation could have been implemented. In the current situation, the economic weight of SCC has then to be calculated from its direct effect on milk prices added to its indirect effect on culling for mastitis. Because the genetic correlation between SCC and the latent trait for clinical mastitis is only about 0.7, this procedure corresponds to admitting that a part of the true selection objective, i.e., the economic consequence of clinical mastitis not 'explained' by SCC, is dropped out.

The genetic latent trait for functional longevity can be thought of as a linear combination between the genetic latent trait for the overall culling risk and the breeding value for production. The coefficients of this combination can be indirectly assessed from population studies providing genetic variances and genetic correlation with milk yield for overall and functional longevity. Consequently, the economic value of one genetic standard deviation for functional longevity can be calculated based on the economic values of one genetic standard deviation for milk yield and for the overall culling: these values are given without ambiguity by the economic model. However, functional longevity retains some information about fertility and SCC, as demonstrated by genetic studies on large populations (Larroque *et al.*, 1999) and double counting should be imperatively avoided (Groen *et al.*, 1997). We now describe the approach proposed for disentangling these aspects.

For simplicity, let us summarise dairy traits into a unique trait called 'milk yield' and let us forget body size. Then the breeding values included into the selection objective are:

G_1 milk yield
G_2 female fertility
G_3 somatic cell count
G_4 functional longevity

The selection objective H is equal to

$$a_1 G_1 + (a_{21} + a_{22}) G_2 + (a_{31} + a_{32}) G_3 + a_4 G_4$$

where a_{21} and a_{31} are the weights given to G_2 and G_3 respectively due to connection with culling rate c. Then

$$a_{21} = \delta R/\delta c \;\; \delta c/\delta G_2$$

$$a_{31} = \delta R/\delta c \;\; \delta c/\delta G_3$$

where $\delta R/\delta c$ is obtained from the economic model and $\delta c/\delta G_2$ or $\delta c/\delta G_3$ are obtained through a link function. Then, a_{22} and a_{32} are the economic weights not explained by culling rate and correspond essentially to treatments. They are obtained through an appropriate link function. For instance, Colleau and Le Bihan-Duval (1995) used a threshold model for linking the latent trait for clinical mastitis to both treatment for mastitis and culling for mastitis.

The sub-objective controlled by both yield and culling rate is:

$$H_1 = a_1 G_1 + a_{21} G_2 + a_{31} G_3 + a_4 G_4$$

Here, it should kept in mind that, in reality, G_4 is a composite trait. This sub-objective can alternatively be written as

$$H_1 = a_1 G_1 + a_5 G_5$$

where G_5 is the latent trait for the overall longevity and where

$$a_5 = \delta R/\delta c \;\; \delta c/\delta G_5$$

Finally, a_4 can be derived from a linear equation obtained after letting the variance of the second expression of H_1 to be equal to the covariance between both expressions. Expressions will be more clear if standardised breeding values (G*) are considered.

For simplifying the exposition of the main ideas used for calculating the economic weights, we ignored the complexity originating from the fact that somatic cell count is only an indirect estimator of sensitivity to mastitis (trait G_3*). Then this reality can be accounted for by writing, in the expression of a_{31}, that

$$\delta c/\delta G_3 = \delta c/\delta G_3{}^* \quad \rho_{33}{}^*$$

Here, $\delta c/\delta G_3{}^*$ is directly given by a link function and $\rho_{33}{}^*$ is the genetic correlation between G_3 and G_3 * (assuming that we consider standardised breeding values).

Finally, body size should be re-introduced. No special problem is raised because body size is trait G_6 with weight $a_6 = \delta R/\delta G_6$

2.2.2. Test example

For the present being, no real situation with relevant economic data was investigated. However, in order to test the basic concepts and the basic computing programmes, an imaginary farm was considered with production characteristics corresponding to those of the average recorded herd in Holstein breed. A future set of prices was introduced, anticipating a substantial decrease of market prices i.e., 15 % and 30 % for milk and beef respectively.

Then, after setting a_1 =1, we obtained the values 0.26, -0.24, 0.42, 0.10 for weights a_{21}, a_{31}, a_5, a_6, respectively. Given the genetic correlations available (see Larroque *et al.*, 1999), the value obtained for a_4 was 0.30. This symbolic example should be of course completed by more realistic studies.

3. Conclusion

The present approach provides a selection objective where the major components of adaptive fitness i.e., female fertility, somatic cell counts and functional longevity play a similar role. However, predictions of responses to selection show that the corresponding weights will not be strong enough for definitely turning round the current genetic trends for fertility and resistance to mastitis, that are clearly unfavourable. Then, a future ‘bending’ of the selection objective is probably desirable.

Information is currently gathered from some reference farms so as to provide the relevant parameters corresponding to various degrees of intensive dairy farming. The situations pertaining to the other breeds such as *Montbéliarde* and *Normande* will be helpful for defining separate breed objectives, more appropriate to dual-purpose breeds.

The relevance of the constraints currently envisioned, concerning quotas and surfaces will be re-examined with practitioners, because regulations of the agricultural market are very likely to change in the near future. Then, the inner weights of INEL itself might be re-considered.

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