Sélection de la race Holstein pour les caractères fonctionnels en France.

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SELECTING THE HOLSTEIN BREED FOR FUNCTIONAL TRAITS IN FRANCE

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Selection for production traits has been demonstrated to be highly efficient. However, this result has been achieved at the expense of the genetic level for functional traits due to numerous unfavourable genetic correlations. Concern is now worldwide about the negative consequences of this situation on the costs of livestock production, animal welfare and public perception. Then, the current trend in dairy cattle selection is to introduce significant changes in selection procedures so that favourable genetic trends for functional traits prevail eventually, while maintaining a high potential of productivity. Research in this area is intense and the quantitative perception of the real value of breeding animals is made increasingly accurate through the use of EBVs (estimated breeding values) more and more appropriate to the different segments of 'functionality'.

The objective of this communication is to present the situation occurring in France with respect to selection for functional traits and the different perspectives.

1. Traits recorded and evaluated.

Specific evaluations for functional traits started relatively recently: *functional longevity* (1997), through a survival analysis after correction for within-herd milk yield [14,15,16, 17,19,20], *somatic cell score* (1997), *female fertility* (1998) *i.e.* probability of success at AI, c*alving difficulties* (2000). The first three evaluations were released to breeders before their first incorporation into the new synthetic EBV (the so-called ISU) updated in 2001. However, the need of further changes is clearly felt by breeders and geneticists.

Due to the high economic impact of clinical mastitis and to its moderate genetic correlation with somatic cell score [2,11,26,27,28,29,30,31], an evaluation for clinical mastitis is planned. Currently, about 50% of cows are recorded for clinical mastitis as a new service from milk recording organisations. Completion is expected to be achieved in a few years and the first official evaluation is planned for 2005.

Fertility rate at each AI is not the only relevant trait for female reproduction [1,3,5]. Due to cost considerations, the use of systems heavily resting on grass consumption is still relevant in our country. Hence, interval between calving is more close to the ideal synthetic reproduction variable and the interval from calving to first AI, influenced by management and by genetics as well, should be evaluated. This need is made all the more urgent as genetic relationships between these two components of female reproduction are not very strong. The implementation of a routine evaluation on such a trait is under investigation.

Reduction of dystocia is desirable because calving disorders induce important economic losses via increased mortality, decreased fertility and higher labour costs. Such a reduction can be achieved through the identification of extreme sires and their proper use in A.I., for example for avoiding risky matings (e.g., with heifers). This has been the motivation for the development of a routine genetic evaluation on dystocia, based on calving ease scores systematically recorded on farms. These are analysed with a statistical approach [8] to produce bull EBVs on birth conditions of the calf and calving conditions of the cow. Together with calving scores, stillbirth information is also available. The inclusion of stillbirth among the list of evaluated traits may be envisioned for the near future.

19 *type traits* are recorded and evaluated in the Holstein breed: 8 for udder, 6 for body capacity, 3 for feet and legs, plus ease of milking and temperament. The new overall EBV for type modified in 2003 is proportional to the combination

0.60 Udder + 0.20 Body Capacity + 0.20 Feet and Legs

where the three variates are themselves appropriate combinations of basic traits. In comparison with the previous EBV, selection for body capacity is less stressed upon whereas feet and legs and aptitude to locomotion are clearly favoured.

Before the settlement of the new ISU in 2001, type traits had been of course intensively selected for, partly because they were thought to be predictors of longevity (demonstrated to be partly true [22,23,24,25], as it has been found worldwide) and partly because they were thought to be related to workability and labour time. As it will be explained later on, both aspects of type traits were used through the new ISU. Over time in the future, type recording may be subject to an evolution of its own, according to national and international needs.

2. The selection objective

The old selection objective considered only dairy and type traits. The dairy traits were summarized by an overall EBV (the so-called INEL). The new selection objective considers INEL, type traits and the three functional traits currently evaluated (functional longevity, somatic cell score and fertility). The formulation chosen is quite simple to keep in mind.

INEL has the same weight as the sum of the four other traits,
each of these has the same weight,
(expressions in genetic standard units).

The exact results obtained from modelling suggest that such a simplification could be carried out without major loss of accuracy [12]. See also Table 1.

The model used considers economical parameters provided by 6 farms monitored within an economical agricultural network. These farms are chosen by the Breed Association (UPRA *Prim'Holstein)* in order to represent the diversity of management conditions of the Holstein breed in the country. In contrast, demographical and longevity parameters are those of the whole breed at the country level. Consequently, these parameters are observed ones and not calculated, for example based on optimisation methods. Therefore, the weights found by the approach (to be detailed later on) certainly reflects current culling practices by French breeders exploiting the Holstein breed, which in turn are partly dictated by Nature, i.e., true genetic relationships.

Constraints

The first constraint introduced is farm overall cost, excluding labour costs. Then, the economical weight of each trait considered is appreciated by its impact on the ratio farm margin / farm cost where margin is the difference between farm income and farm cost. Instead of adopting a quota constraint (as was used for defining the INEL available between 1993 and 2001), investment capacity is felt to be the most relevant limiting factor in dairy farms and relatively insensitive to possibly changing market regulations. Labour cost is not included because in our country, dairy farms are mainly familial. Then, the relevant question is maximizing personal revenues for farmers involved in cattle.

The second constraint concerns the indirect selection response for type traits because they are ignored in the economical model. However, workability is essential for breeders, even though difficult to assess objectively in an economical model. Then, the weight for type traits is empirically determined so that this indirect response be similar to the one induced by the previous overall EBV (where weight for type was about half the weight of INEL). Due to numerous substantial genetic correlations between type traits and functional traits, this can be achieved despite a significant (50%) decrease of the weight given to conformation.

Weight transfers

Usually, in the international literature, functional longevity has been found to have a large economic weight (typically, 50% the one for dairy traits). In this context, other functional traits are weighted for their impacts unrelated with cost of culling. However, the approach used for implementing ISU 2001 follows another idea [10], due to the fact that in our country progeny group sizes are not very large (90 daughters per young bull in the Holstein breed). Then, obtaining very reliable (and even publishable with the official minimum accuracy) EBV for functional longevity is difficult when selection decisions are needed after progeny testing. Then, the economical weight of functional longevity is partly re-allocated into the 'somatic cell count' and 'fertility' components after considering genetic correlations between these three ~~variates~~ traits (|r_g| between functional longevity and the other functional traits are about 0.40) Finally, the remaining weight is the weight of the 'residual functional longevity'. This weight is nevertheless given to the available functional longevity.

Similarly, weight transfer occurs between SCC and clinical mastitis. SCC is given an extra weight corresponding to the expected cost of clinical mastitis, based on the genetic correlation between both variates and the cost of mastitis cases.

Construction of final weights

The weight given to *dairy traits* depends of course on their direct effects on income and cost for milk production. However, an extra weight is added after considering that potential for milk production is statistically related to overall longevity. Culling risks according to production classes provided by the national evaluation for functional longevity allows one to calculate this weight objectively. It should be kept in mind that they highly depend on the desired intensity of selection for milk yield on field, disregarding the possible sub-optimality of such practices.

The weight given to *SCC* depends on its direct effect on milk price (high SCCs are penalized) and on two transfers, the first one from functional longevity and the second one from clinical mastitis, as mentioned previously. The most important component originates from functional longevity.

The weight given to *fertility* depends on its direct effect on AI cost, on its relationship with calving interval and on a transfer from functional longevity (the most important component).

The weight given to *functional longevity* corresponds to the weight to be given in fact to residual longevity, *i.e.,* for culling reasons other than milk yield, fertility and mastitis.

The weight given to *type traits* is *ad hoc* according to desired genetic gains.

Mature cow size is not directly considered (is given a null weight). In fact, the model calculations indicate that the corresponding weight should be slightly positive (see Table 1). Here, the constraint chosen has a major impact. If constraint would have been farm feed cost, then the weight of mature size would have been largely negative (see the international literature). However, it can observed based on the definition of the current overall type, that French Holstein breeders still like tall cows.

EBV for *calving ease* is basically devoted to avoid risky matings for heifers and is not included in the selection objective.

The detailed results

Table1 shows the weights (in %) obtained for each of the six farms.

Table 1 Weights (%) obtained from specific farms for INEL, functional trait and mature size. *Here, weight of type traits is ad hoc and constrained to be 1/8 i.e., 12.5 %.*

Farm	INEL	SCC	Fertility	Func. Long.	Mature size
1	48	11	14	11	4
2	51	10	13	10	3
3	54	9	14	9	2
4	50	10	13	10	4
5	51	10	13	10	3
6	49	11	15	11	1
ISU	50	12.5	12.5	12.5	0

Responses to selection

Breeders demand that responses to selection be illustrated through dummy selection runs on past batches of progeny-tested bulls. Detailed results of Table 2 show the selection differential for functional traits observed on the best 10% of the bulls born between 1991 and 1994, selected based on the old ISU or the new ISU.

Table 2 Selection differentials for functional traits

Trait	Old ISU	New ISU
SCC	-0.17	**0.39**
Fertility	-0.38	**0.01**
Functional . Longevity	0.25	**0.41**
Type	0.44	**0.30**

Using the new ISU improves considerably the situation of functional traits. It induces favourable responses for SCC and functional longevity and almost null responses for fertility in contrast with the very negative responses incurred with the old ISU. However, the situation is not fully satisfactory.

Based on the well-known genetic parameters, responses for clinical mastitis are slightly negative (instead of very negative when using the old ISU): definitely favourable genetic gains should be obtained instead. Responses for fertility were evaluated based on the published EBV for fertility that does not account for genetic relationship with other traits, especially milk yield. ‘Combined’ fertility is used for calculating ISU and is more accurate. If responses are evaluated based on this EBV, then responses for fertility are slightly negative (instead of very negative with the old ISU).

Calculating ISU

Complex multi-trait evaluation procedures [13,21,22] are used for taking account of the indirect information conveyed through genetic correlations. Accuracy of EBV on functional longevity is substantially increased by this way. Resulting EBVs are called ‘combined’ and are the ones published for longevity. ISU is proportional to the weighted sum of these combined EBVs, where the weights are the same as in the selection objective. The procedure is correct because combined EBVs are close to the true multi-trait BLUP and because the best estimate of a linear function of breeding values is the same linear function of BLUPs: weights do not depend at all on the amount of information.

Effective use of ISU

AI data show that the new ISU is effectively used by breeders when choosing sires for regular AI. Since 2001, selection pressures for SCC and fertility have increased dramatically. The new ISU is of course used within the selection programmes especially for choosing bull sires and bull dams.

3. The future role of marker-assisted selection.

Research is very active worldwide for identifying genes controlling traits of economical importance. A preliminary step consists in considering not the genes themselves but the genes or group of genes situated in some chromosomal regions indicated by molecular markers, the so-called QTLs. Corresponding research is less expensive but less accurate because genotypes for the true genes are unknown and because effect of QTLs on performances still have to be estimated, after considering the distribution of familial performances and the effective transmission of markers to individual animals: then, marker-assisted selection is very demanding. Nevertheless, simulation has clearly shown that selection based on QTLs (marker-assisted selection or MAS) would be very beneficial for traits with low heritability [9]. Functional traits belong to this category of traits. Indeed, MAS is able to assess Mendelian Sampling (MS), i.e., the deviation between animal’s true value and average parental value, more accurately than conventional evaluation.

Since 2001, the French AI industry has been testing MAS experimentally on the three major dairy breeds, in cooperation with Research [6]. This step logically follows an initial QTL detection step, largely based on Holstein data [2,7,8] and is conducted at an almost full scale (8000 animals typed for markers each year). The objective is to better identify the young bulls to be further progeny-tested. Currently, the five dairy traits, SCC and fertility are concerned by MAS. 4 QTLs are considered for each of the two traits: SCC and fertility. Percentages of genetic variance controlled by these QTLs are 44 and 42 respectively. MAS is planned for some type traits such as ‘udder depth’ and ‘udder cleft’ where significant QTLs are available.

An essential question is whether MAS will be really effective, given the QTLs detected and the associated parameters. MS estimates have recently been calculated based on the conventional EBVs of males progeny-tested and of females with recorded performances. MS predictions from MAS predictions excluding daughters’ performances for males and own performances for females have been found in good accordance with conventional MS estimates. Then, it is reasonably believed that MAS will work and that the experiment has been successful. Simulation based on real data with real information structure has shown that genetic gains obtained with the best progeny-tested bulls could be maintained even if the number of progeny-tested bulls per year would drop by 10-15%. If AI organizations were able to maintain the size of their selection programmes, then an enhanced genetic gain for functional traits would be expected: this time, genetic trends might be actually favourable.

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