INTEGRATION OF FUNCTIONAL TRAITS IN BREEDING PROGRAMMES : SIMULATION RESULTS

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1. Introduction

The current french breeding schemes on dairy breeds are primarily devoted to selection on dairy and type traits. The latter can be considered as tools for indirect selection on longevity, size and even muscularity (for dual-purpose breeds). This situation does not satisfy geneticists and breeding organizations for the long term because biological and economical meaning of type is rather unclear, while functional traits such as longevity, reproduction capacity and resistance to diseases are of economical importance and are unfavourably correlated with dairy traits. Consequently, informations already available on longevity, female reproduction and leucocyte counts will be exploited and processed into corresponding Estimated Breeding Values, from 1997 onwards (Boichard and Ducrocq, 1996).

Operational and theoretical issues raised by the integration of functional traits into breeding schemes are very numerous. The most important one might lie about the relevance of combining many EBVs for separate traits, with possibly specific statistics and underlying models (Boichard, 1990 ; Colleau and Duval, 1995), instead of evaluating for an overall trait such as longevity, if corresponding economic weight and statistics can be handled properly. A deep knowledge of the genetic situation for each basic trait would be then needed to answer to this question.

If longevity is considered to be a major candidate to replace type traits in the genuine economic selection objective, one can wonder whether introducing such a trait would lead to increased generation intervals, contrarily to the present observed trend, especially when implementing MOET schemes. Furthermore, the consequences of a possible non linear influence of latent variates of interest should be investigated, to examine whether linear approximations are reasonable.

The present paper shows tentative answers to these two questions, given by simulation of fast breeding schemes using MOETs and proposed to french breeding units (Colleau and Phocas, 1994)

2. Material and methods

2.1. Modelling longevity

Ducrocq *et al* (1988) modelled longevity according to Cox's proportional hazards, using a Weibull parametric curve. Predicting response to selection according to relevant EBVs is not an easy task. Furthermore, obtaining correct genetic parameters for longevity parameters concerning involuntary selection raises specific issues (Dekkers, 1993 ; Dekkers and Jairath, 1994). Positive or negative biases on the estimated genetic correlation with milk yield are incurred depending on the magnitude of direct selection on yields. This is true for all the indicators of longevity (herd life length, stayability, survival within lactation and functional longevity corrected for milk yield).

For simulation purposes, functional longevity has been thought to be represented by probability of involuntary culling (1-survival) at each lactation, the heritability of which lies between 0.03 (Visscher et al, 1995) and 0.05 (Dekkers and Jairath, 1994). This probability has been assumed to be linked to latent variate through a threshold model. Furthermore, it has been thought that genetic correlation between milk yield and functional longevity might be negative and around -0.3 i.e., the value found for major components of longevity (female reproduction, resistance to mastitis). Results obtained by Visscher et al (1994) indicated that the economic value of one genetic standard deviation for functional longevity (w) relative to its counterpart for yield might lie between 0.25 and 0.50, depending on the selling value of culled animals.

2.2. Breeding schemes for longevity

The characteristics of the simulated breeding schemes are shown at Table 1. They use the potential from progeny-testing males and from reducing generation intervals for bull dams either with or without embryo transfer (Colleau, 1985, 1989). Informations dealt wich concerned first lactation data (first lactation yield and survival between first and second lactation).

3. Results

3.1. Linear selection objective

Results shown at Table 2 present predicted annual asymptotic genetic gains, accounting for selection, and favour the idea that fast breeding schemes, at least for female paths, are able to generate substantial gains on yields without deteriorating longevity, because information on candidate s'sibs in the commercial population can be used without increasing generation interval.

3.2. Non linear selection objective

From considerations involving Taylor expansions, it can be shown that the expected value for a non linear selection objective at time t depends on the variability of responses to selection at that time for variates exhibiting a non linear weight (Colleau and Phocas, 1995). With this approach, the expected overall responses were examined after 20 years of steady state in our longevity schemes. Results are shown at Table 3. It turns out that predictions of Table 2, corresponding to a linearized breeding objective underestimated a little bit the benefits from introducing longevity into breeding schemes, basically because selection on yield deteriorated longevity and therefore increased its economic weight. The effect of variability of the response was negligible, which allows one to use simple approximations.

Furthermore, the fact that the economic weight of longevity is not constant over time, due to selection, should be accounted for. Analytical methods for optimizing long term response for a non linear objective were proposed (Pasternak and Weller, 1993 ; Groen et al, 1994). For the present complex breeding scheme, a Quasi-Newton procedure was used to optimize selection responses after 20 years. This led to virtually no changes with the economic weights considered (w = 0.25 or 0.50). For higher weights of longevity (w = 1), this optimization was found to increase the overall merit by 2 % and 5 % according to the value of heritability of longevity (0.03 and 0.05 respectively).

4. Discussion and conclusion

The present results apparently show that there is no need to increase generation interval for preventing functional longevity from deteriorating, because of a major economic weight put on dairy traits. Furthermore, non linearity of selection objectives did not turn out to be a major concern for correct predictions.

Future simulations should account for the fact that functional survivals are possibly not the same trait expressed across lactations, due to different impacts of reproduction and diseases (Visscher *et al*, 1995). This could lead to the conclusion that obtaining a positive or at least a zero genetic trend for functional longevity, requires the additional help of early heritable indicator traits such a type traits and (or) of Marker Assisted Selection. Corresponding analytical researches are planned in our country (Boichard and Ducrocq, 1996) with a corresponding evaluation of economic weight of functional longevity.

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Table 1 - Characteristics of the simulated breeding scheme

Male population

100 bulls progeny-tested per year
3 bull sires
13 sires of commercial cows (100 daughters per young bull)

Female population

400 000 cows
50% recorded and inseminated

- subdivision at birth in the recorded population

Section A : 200 females born from bull sires and elite cows
Section B : 2000 females born from bull sires and immediately inferior cows
Section C : 48 000 females born from other sires and other cows

- reproduction method

In mixed MOETs, females A are superovulated at 18 months (10 embryos per female from two collections) and inseminated with bull sires. Females B are inseminated with bull sires during lactation 1. Accelerated conventional breeding schemes corresponds to merging section A and B.

- selection method

Multivariate BLUP with a sire and maternal grand-sire model.

Gene flow between female sections (mixed MOET 100 daughters per bull, selection on yield)

	maternal population (%)		
Progeny	A	B	C
Young bull	78	22	0
female A	29	25	46
B	11	18	71
C	1	4	95

Table 2 - Asymptotic genetic gains when selecting on longevity (S) for a mixed MOET (100d/bull)

w= economic weight of the genetic standard deviation for longevity vs its counterpart for yield
h^2=heritability of longevity

SITUATION AND SELECTION METHOD	MILK YIELD (Y)	LONGEVITY (S)	SELECTION OBJECTIVE
w=0.25 h^2=0.05			
Y	0.32 s_{go}(1)	-0.095 s_{go}	0.31 s_{go}
YS	97.8 (2)	34.5	103.0
YS_o	94.8	0	102.4
w=0.50 h^2=0.05			
Y	0.32 s_{go}	-0.095 s_{go}	0.28 s_{go}
YS	90.8	-31.1	112.3
YS_o	94.8	0	111.5

(1) initial genetic standard deviation
(2) % of the genetic gain obtained with selection method Y

Table 3 - Additional results about the breeding schemes on longevity

w= economic weight of a genetic standard deviation for longevity vs its counterpart for yield
h^2= heritability of longevity

SITUATION AND SELECTION METHOD	CUMULATED RESPONSES (20 YEARS)	
	Standard deviation of the response on longevity (1)	Non linear objective (2)
w=0.25 h^2=0.05		
Y	0.25	100
YS	0.16	104.4
YS_o	0.12	101.9
w=0.50 h^2=0.05		
Y	0.25	100
YS	0.15	115.6
YS_o	0.10	112.9

(1) In initial genetic standard unit
(2) Reference 100 is within situation