Recording and genetic analysis of functional traits in French dairy cattle : a review

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Abstract

In this paper the genetic analyses of type traits, milking ease, dystocia, fertility, and longevity in French dairy cattle are reviewed. The current situation is described, with emphasis on the data recording scheme, the choice of the model of analysis, and the estimates of genetic parameters obtained.

1. Introduction

For a long time, the interest for functional traits informations in dairy breeding programs in France focused only on sire evaluations for type. Some data were collected on some other functional traits but in a nonexhaustive, heterogeneous way, not always suitable for genetic evaluations. However, these data were the basis for important genetic studies, which in turn have generated interest and new recommendations and have led to a more homogeneous and exhaustive data collection. This was a prerequisite for the implementation of several new routine genetic evaluations on functional traits which will be made available to the French dairymen in the near future.

2. Data recording scheme

In the Holstein breed, type traits scores are collected by technicians from the Holstein association for all first (and sometimes second) lactation cows in registered herds and for 20% of the daughters of sampling bulls, as well as by technicians from the AI studs for the remaining 80%. The 15 elementary traits considered are related to udder (8 traits), capacity (2), rump (3), and feet and legs (2) and are scored on a linear scale from 1 to 9. No final score is defined. 4 herdmates are required to be classified at the same time as each young sire's daughter, in order to be able to define a round-herd-classifier contemporary group. This leads to about 200,000 cows scored each year. This system is being generalized to the other breeds. For those breeds, a higher number of traits (25 and 28 in Montbéliarde and Normande breeds, respectively) is collected due to their dual-purpose objectives.

During classification, a milking ease score (1-5) is given to the cow by the dairyman. This survey replaced more precise measures of milking speed used prior to 1990, because it was cheaper and easier to maintain and to generalize to the whole population. Moreover, it was found to be as heritable as the more objective milking time measures, probably because dairyman's opinion is based on repeated milkings.

Two different ways of collecting calving conditions and stillbirth data coexist. The most reliable system (40% cows) is based on a calving list preprinted by the milk recording organization. After each calving, the dairyman records the calving date, the identification and sex of calf, and the calving conditions. In the rest of the population, calving conditions are recorded together with the birth registration. In contrast to the first system, which is exhaustive with one record per cow, the latter information is relative to the calf, and is known only if the calf information is supplied by the dairyman. This information being a prerequesite for pedigree identification, data on virtually all female calves are available, but most records on males and dead calves, *i.e.,* the most informative ones, are missing. This system is not satisfactory and is going to be replaced either by the calving list approach, or by a survey performed by the milk recording technician on the first test-day of any new lactation. Calving ease is scored on a scale from 1 (without help) to 5 (embryotomy). However, because very difficult calvings remain rare in dairy breeds, categories 3 (very difficult), 4 (caesarian), and 5 are usually merged for analysis purposes.

The basic information about fertility is provided by the AI organizations. It includes the date of service and the identification of the cow, of the service bull, and of the technician. All AI (and only AI) are considered, in pure breed or in crossbreeding, for heifers or for lactating cows. The result of each insemination (later on referred to as conception rate, CR) is determined by the subsequent calving date. In absence of subsequent calving, all inseminations but the last within lactation are considered as failures, and the status of the last IA depends on lactation length (Boichard and Manfredi, 1994).

The trait of interest for longevity analysis is the duration of productive life (DPL), *i.e.* the interval between first calving and culling. This trait can be analyzed without any additionnal data collection, using milk recording information. The major problem of DPL is censoring, *i.e.,* only a lower bound of DPL is known for cows still alive at the time of the analysis, or for cows sold for dairy purposes. Cows without recent test day information are considered uncensored. Reasons for culling are not used because this information is not exhaustive and not accurately recorded, and would, in any case, be highly subjective and rarely unique.

3. Choice of the model of analysis

3.1. Statistical model

The linear scale, the symmetry of the distribution and the relatively high number of categories allow to use a standard linear model for type traits and milking ease (Ducrocq, 1993). In contrast, a threshold model, TM (Gianola and Foulley, 1983) has been chosen by Manfredi et al. (1991) for calving conditions and stillbirths. TM explicitly accounts for the functional relationship between mean and variance. Moreover, some interactions on the observed scale, due to incidence differences, are removed on the underlying scale, and one single trait could be considered across parities. For CR, which is a binary trait, Boichard and Manfredi (1994) compared the linear model and TM. Both models provided virtually the same results, except that all variance components (expressed in residual variance unit) were 60% higher with TM, in agreement with theory. The limited interest of TM could be explained by the intermediate incidence (close to 50%) of the trait across levels of fixed effects, resulting in a rather homogeneous residual variance.

Survival was analyzed by Ducrocq (1987, 1994) with a proportional hazards model. Such a model is based on the concept of hazard rate, *i.e.* the probability of being culled at time t, given that the animal is alive immediately prior to t. In a proportional hazards model, the hazard rate is described as the product of a baseline hazard representing the aging process, and a positive function of explanatory variables influencing culling rate. This approach uses the information on censored and uncensored records in a same way and allows for an accurate modelling of changes in culling policies over time. DPL data are found to be influenced by many time-dependent factors, like stage of lactation and herd-year-season effects. Culling policies can drastically change over time in a same herd, for example as the result of changes in herd size or tough quota constraints. Only one contemporary group effect is defined in classical stayability analyses, preventing from a proper description of these changes over time which in turns lead to an improper correction for environmental factors, a lower heritability and potential biases in the analyses. Proportional hazards models can handle time-dependent covariates in a straightforward (although computationaly demanding) way. Ducrocq

(1988) checked the validity of the proportional hazard model and showed that the baseline hazard function could be well approximated by a Weibull distribution. The resulting simpler model can be used for routine sire evaluations.

3.2. Genetic model

The model used for type traits, milking ease and DPL includes only a direct genetic effect. In contrast, both direct and maternal effects are considered for calving condition and stillbirth. Although only the direct effect is of primary interest for mating decisions, including both sire and maternal grand-sire in the model avoids any bias due to assortative matings. A similar model is used for CR. However, the trait of interest is female fertility and the service bull effect is considered as a nuisance parameter.

In the recent years, animal model has become very popular and is commonly used in most evaluations worldwide. It is used in France for type traits and milking ease (Ducrocq, 1993). A sire model is used in DPL analyses. Because of the low heritability of fertility and calving conditions, and because no evaluation is required for females, these traits are evaluated with a sire and maternal grand-sire model.

3.3. Variance structure

Taking advantage of the canonical transformation, a multiple-trait model is applied to 2 groups of type traits (udder, capacity and rump) at a cost comparable to regular univariate analyses. For dystocia and CR, the traits are assumed to be the same, regardless of parity. However, the question of a common genetic determinism of CR for heifers and lactating cows is still open.

3.4. Environmental effects

The contemporary group is a fixed round-herd-classifier group for type and milking ease and a random herd-year effect for the other traits. Other fixed effects are always considered, usually nested within parity, year, and region. These include age at calving and interval between calving and scoring (for type), interval between calving and insemination, month and week day of insemination (for CR), season of calving, age at calving and sex of calf (for dystocia), or stage of lactation and change in herd size (for DPL). A random permanent environmental (PE) effect is included when repeated performances are considered (CR, calving conditions). In the DPL analysis, a baseline hazard function plays the role of a mean. A within-herd production level effect is included to adjust for the voluntary culling due to low production. It is believed to be a better alternative than a multiple trait approach applied to milk production traits and DPL together, because the relationship between production and longevity is not linear at all.

4. Estimation of genetic parameters

4.1. Methods

After a first study by Colleau et al. (1989) with a sire model in the Normande breed, Ducrocq (1993) estimated genetic parameters for type traits and milking ease by REML applied to an animal model on repeated samples and considering all service sires as fixed (Ducrocq, 1993). The REML-type approach was found to be not feasible in the TM analyses, mainly because of the large number of PE and herd-year effects. The tilde-hat method of VanRaden and Jung (1988) was adapted to correlated random effects and to the threshold model by Manfredi et al. (1991) and was used for calving condition and CR (Boichard and Manfredi, 1994). Ducrocq (1987, 1994) estimated the sire variance in the DPL analysis as the mode of the posterior density of the parameters after integrating out the random effects, in a Bayesian framework.

4.2. Results

Type traits in the Holstein breed have moderate to high heritabilities (0.23-0.47) except for feet and legs traits (<0.10). Genetic correlations are positive and high to very high among capacity traits. They are moderate and favourable among udder traits. Genetic correlations are usually stronger than residual correlations, leading to some gain in accuracy when applying a multiple trait evaluation. Direct and maternal effects on dystocia have an heritability close to .10 in the Normande and Holstein breeds. They do not present any antagonism, as the genetic correlation estimates are .15 and -.09 on the underlying scale in both breeds, resulting in a clearly positive correlation between sire and maternal grand-sire effects. The heritability of CR is very low, .02 and .03 with the linear model and TM, respectively. Male fertility and female fertility are different and almost uncorrelated traits. CR presents a clear antagonism with production, with a genetic correlation of -.62 and -.36 with 100-day milk and protein yields.

The heritability of DPL is difficult to define because the phenotypic variance varies according to environmental conditions. However, the genetic variability could be illustrated by the difference in expected number of completed lactations across progeny groups. This difference reaches about one completed lactation between progeny of two sires differing by 2 standard deviations. This large effect could be attributed to the fact that survival analysis extracts more information than the classical stayability analysis.

5. Conclusion

Most of these results have been published several years ago. However, routine genetic evaluations are available so far only for type and milking ease. Elementary type evaluations are combined into semi-composite proofs (udder, capacity, rump, legs) and into a final type proof with a 60% weight on udder. The first proofs for CR, DPL (and somatic cell counts) are expected in 1997, and for dystocia as soon as the recording scheme is improved. The breeding values on these new traits will be added to the existent aggregate genotype index for bulls and cows which already combines production, type and milking ease evaluations. With an average first crop of 60-70 daughters, the reliability of CR and DPL evaluations is sufficient to identify the worst sires. In addition to selection, these evaluations will be used to investigate the genetic relationship with production, to assess the interest of some type traits to predict longevity and to find QTLs for functional traits.

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