GENETIC EVALUATION FOR HEALTH AND REPRODUCTIVE TRAITS IN DAIRY CATTLE USING AN INDEX OF FITNESS COSTS

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SUMMARY

In the present study an approach for the evaluation of cows and sires based on the calculation of costs due to reduced fitness was developed and the usability of that 'fitness costs' for breeding purposes investigated. The study is based on data for 4319 German Friesian cows from 137 Rhenish herdbook farms. The most important components of the fitness costs were the veterinary costs in case of diseases, prolonged calving interval, reduced milk performance in case of diseases and the costs for the replacement of a cow. The results of our study suggest, that breeding activities based on the approach of calculating fitness costs can be efficient. For the fitness costs relatively high genetic variances were found. Further a genetic antagonism between the fitness and the milk performance was estimated. Between the fitness and the overall profitability a remarkable genetic correlation was found.

INTRODUCTION

Fitness traits are of great importance for the profitability of dairy cows; in addition, ethical aspects, aspects of animal welfare and consumer interests have to be considered in this context. There are complex interrelationships between the traits in the fields of calving performance, fertility, disease, culling and milk performance. The situation is further complicated by the fact that fitness traits very often are categorical traits with reduced informational value in comparison with continuous traits. Furthermore the knowledge about the genetic parameters for a whole series of fitness traits is limited. All these reasons induced us to develop an approach for the evaluation of cows and sires which is based on the calculation of costs due to reduced fitness and to investigate the usability of those 'fitness costs' for breeding purposes.

MATERIAL

The study is based on data collected from 4319 German Friesian cows (3461 Black and White and 858 Red and White cows) with first calvings during two years (Oct. 1982 to Dec. 1984) in 137 Rhenish herdbook farms. Enumerators acquired monthly the following items about fitness criteria, until the end of the fourth lactation or the culling of the cow, respectively:

- Calving: date of calving, calving performance, condition of the calf at birth, development of the calf.
- Disease: kind of disease, number of veterinary treatments.
- Fertility: Date of mating or insemination, service sire, heat intensity.
- Culling: date of culling, reasons for culling, profit for carcass.

The date were collected during the period October 1982 until May 1989. In addition, the Rhenish milk recording organisation provided the monthly records of all cows in the participating herds. Further the data of the AI-organisations were matched. The data acquisition is described in detail in Schwenger et al. (1988).

METHODS

Calculation of the fitness costs

Results from the literature about the economic losses caused by reduced fitness were used to compute fitness costs per production day for each cow. The fitness costs in the narrow sense (FIT_1) covered:

- Veterinary costs at calving.
- Veterinary costs due to diseases.
- Costs due to prolonged calving intervals.
- Reduced milk performance due to diseases (mastitis, claw disorders).
- Cost component due to postnatal calf losses.

Further the costs of replacement (FIT_2) considering the following items were calculated:

- Place in the cowshed not used.
- Difference between profit for carcass and heifer costs.
- Reduced milk performance per production day.
- Number of calves (per production day).

These fitness costs were compared with the income from milk production (FCM). Further a profitability index per production day (PROFIT) was calculated as the difference between the income from milk production and the (slightly modified) fitness costs. All pecuniary specifications are made in US$.

Statistical analysis

The statistical model used to describe the fitness criteria, the fitness costs, the milk performance and the profitability index included the fixed effects breed, herd within breed, year-season of first calving, the random effect of the sire within the breed (independently and identically distributed) and the linear and quadratic regression of the dependent variable on age at first calving.
For the estimation of the (co)variance components the method I-MINQUE was chosen. The estimation of the covariance components was based on two-trait-models, analogous to the model presented above. The approximative approach of Swiger et al. (1964) was used for the calculation of the standard errors of the heritability estimators. The computations were conducted with self-written programs.

RESULTS

The initial number of 4319 cows decreased in the following calvings to 74 percent (2nd calving), 55 percent (3rd calving) and 40 percent (4th calving). Table 1 represents further descriptive statistics of the fitness criteria in dependence upon the lactation number.

Table 1. Descriptive statistics of the fitness criteria in dependence upon the lactation number

Criteria	1. Lact.	2. Lact.	3. Lact.	4. Lact.
No. of calvings	4319 (100%)	3182 (74%)	2364 (55%)	1737 (40%)
Calving				
- vet. assistance	2.6%	1.3%	1.2%	1.4%
- operation	-	.1%	.1%	.3%
Diseases				
- retained placenta	7.3%	6.9%	6.7%	8.5%
- metritis/endometr.	7.4%	3.9%	3.8%	4.8%
- cysts	2.8%	2.8%	4.0%	4.3%
- anestrus/acyclia	1.9%	1.4%	2.1%	2.3%
- mastitis	2.9%	3.3%	5.3%	8.5%
- claw disorders	1.0%	.9%	1.5%	4.2%
- milk fever	.1%	.9%	1.8%	4.9%
- ketosis	.2%	.3%	.6%	.8%
Calving interval (d)	378	379	381	-
Postnatal calf losses	1.6%	.9%	1.2%	1.0%

In 2.6 percent of the first calvings a veterinary assistance was registered. With further calvings this value reduced to 1.2 to 1.4 percent. The frequency of veterinary operations was about 0.1 percent. The most important diseases were reproductive diseases - retained placenta, metritis/endometritis, cysts and anestrus/acyclia. Further diseases of greater importance were mastitis and claw disorders. With increasing lactation number the frequency of the diseases mastitis,

milk fever and ketosis also significantly increased. The average calving interval ranged from 378 days to 381 days. The postnatal losses after first calvings amounted to 1.6 percent. With later calvings the losses ranged from 0.9 to 1.2 percent.

Table 2 shows descriptive statistics of the fitness costs (FIT_1, FIT_2) and the economically weighted milk performance (FCM). With reference to the means there is a clear gradation in the order milk performance (FCM), replacement costs (FIT_2) and fitness costs in the narrow sense (FIT_1). Regarding the variation of the traits the clearly greatest value was ascertained for replacement costs (FIT_2), followed by milk performance (FCM) and the fitness costs in the narrow sense (FIT_1). Additionally, table 2 contains descriptive statistics of the profitability index (PROFIT).
The most important components of the fitness costs in the narrow sense (FIT_1) were the veterinary costs due to diseases, costs by prolonged calving intervals and reduced milk performance due to diseases.

Table 2. Descriptive statistics of the fitness costs (FIT_1, FIT_2), the economically weighted milk performance (FCM) and the profitability index (PROFIT) - in US$

Criteria	Mean	Stand. Dev.	Minimum	Maximum
FIT_1	.10	.20	.00	5.11
- vet. costs calving	.01	.02	.00	.54
- vet. costs diseases	.04	.14	.00	4.91
- prol. calv. interval	.03	.05	.00	.26
- reduced milk perform.	.03	.07	.00	.59
- postnatal calf losses	.01	.10	.00	5.11
FIT_2	.97	4.78	-1.23	72.53
FCM	2.80	.75	.67	7.10
PROFIT	2.12	2.69	-42.61	7.18

In table 3 the estimated genetic parameters (phenotypic standard deviation, genetic s.d., heritability) of the fitness costs (FIT_1, FIT_2), the components of FIT_1, the milk performance (FCM) and the profitability index (PROFIT) are shown. For the fitness costs relatively high genetic variances and heritabilities were estimated. The highest genetic variance was found for the replacement costs (FIT_2); this is surely partly due to the skew distribution of the trait (Mayer and Simon, 1993). The estimates of the heritability of the fitness costs were in the range from 4.6 to 14.7 percent. The estimated heritability of the profitability index was 8.7 percent.

In table 4 the phenotypic and genetic correlations between the fitness costs (FIT_1, FIT_2), the milk performance (FCM) and the profitability index (PROFIT) are represented.

DISCUSSION

Because of the low heritabilities of the fitness criteria, which are presently available from field data, the possibility for a genetic alteration on fitness traits and especially on disease frequencies is often assumed to be very limited (see e.g. Schwenger et al., 1989). In accordance with the results in the literature also in the present study the heritability estimates for the single fitness criteria were very low (Schwenger et al., 1989). But based on our approach of calculating the costs due to reduced fitness relatively high genetic variances and heritabilities for these fitness costs were estimated. The estimated genetic standard deviation of the fitness costs in the narrow sense (FIT_1) was about 27 per cent of the genetic standard deviation of the milk performance (FCM).
Evaluating the merit of selection for fitness criteria one has further to take into account that for the relationship between the fitness costs in a narrow sense (FIT_1) and the milk performance (FCM) a genetic antagonism of 0.34 was estimated. Further, between the fitness costs in the narrow sense and the profitabilty index a genetic correlation of -0.22 was found.

Table 3. Estimated genetic parameters of the fitness costs (FIT_1, FIT_2), the components of FIT_1, FCM and PROFIT (s_a: genetic s.d., s_p: phenotypic s.d., h^2: heritability, s_h2: s.e. heritability estimate)

Criteria	s_a	s_p	h^2	s_h2
FIT_1	.050	.195	.064	.020
- vet. costs calving	.004	.019	.050	.019
- vet. costs diseases	.033	.138	.056	.019
- prol. calv. interval	.011	.042	.066	.020
- reduced milk perform.	.009	.063	.019	.015
- postnatal calf losses	.038	.099	.147	.030
FIT_2	1.010	4.707	.046	.018
FCM	.181	.654	.077	.022
PROFIT	.786	2.664	.087	.023

Table 4. Estimated phenotypic and genetic correlations between FIT_1, FIT_2, FCM and PROFIT

	estimated correlation phenotypic	estimated correlation genetic
FIT_1 - FIT_2	.17	.22
FIT_1 - FCM	-.00	.34
FIT_2 - FCM	-.04	-.35
FIT_1 - PROFIT	-.20	-.22
FIT_2 - PROFIT	-.97	-.98
FCM - PROFIT	.28	.54

Although the estimates for the genetic variance and the heritabilty of the fitness in the narrow sense (FIT_1) and the replacement costs (FIT_2) increased slightly with increasing data collection period the presented concept of calculating fitness costs can also be based on a shorter data collection period than four lactations with the consequence of slightly reduced efficiency for the fitness traits (Mayer and Simon, 1993).

The results of our study suggest that breeding activities based on the approach of calculating fitness costs can be efficient. But this requires a thorough and reliable recording system for fitness traits, especially for the disease traits. In most of the countries first of all the establishment of such a system would be necessary; this will surely imply the serious will for the incorporation of fitness traits in breeding programs.

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