PREDICTION OF FUNCTIONAL LONGEVITY FOR DAIRY COWS BY USING FOOT QUALITY TRAITS IN GERMAN HOLSTEIN BULLS

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INTRODUCTION

In dairy cow populations traits related to longevity are of great interest, because overall profitability strongly depends on the lifetime performances of the cows (costs of replacement, higher milk yields in later lactations). In the past longevity became a problem, because the selection for increasing milk yield influenced the length of productive life in an undesired way. Changes in the environmental conditions of the cows also enforce this trend. Selection for longevity should become more important, but unfortunately precise information about this complex is only available late in the lifetime of the breeding stock. Therefore other traits which may be genetically related to longevity but are available in early selection stages should be used in a regular breeding schemes. Claw and leg quality of young Fleckvieh bulls was shown to have an important influence on longevity of their daughters (Distl 1999). The performance test of young bulls gives the possibility to record these traits in a standardized environment. The objective of the study was to analyse additive genetic variances of claw measures and scores for claw and leg quality traits and the genetic relationships between claw and leg traits on one side with traits related to longevity on the other side in German Holsteins.

MATERIAL AND METHODS

Data. Data of young bulls were collected at five different test stations since 1996 onwards with 3.055 records of German Holstein bulls in total. The age of the bulls at testing time ranged from 11 to 15 months. The number of bulls tested at each station differed from 213 to 1.014. The traits which are recorded were length of dorsal border (LDB), angle of dorsal wall (ADW), heel height (HH), heel length (HL) and diagonal length (DL). Also measurements of claw hardness were taken at two different points at the dorsal wall, one of them at top of the dorsal wall (HTDW) the other at the middle of the dorsal wall (HMDW). These seven traits were measured at one front and rear leg. Additionally, at two of the test stations also the hardness of the claws at ground surface (HGS) was recorded. Furthermore, scores for claw and leg conformation on a scale from 1 to 9 were taken, the number of them differing between stations. These scores were related either to claw-shape conformation or to leg judgment. Interdigital space (IS), interdigital hyperplasia (IH), angle of side wall (ASW), straightness of the dorsal wall (SDW) and arrangement of the digits (AD) were traits which belong to the first group and while front legs front view (FLFV), rear legs side view (RLSV), rear legs rear view (RLRV) and hock angle at the rear legs (RLHA) belong to the second group. With the exception of AD the remaining four traits of the first group could be observed at the front legs and the rear legs as well. The 29 traits recorded can be grouped into four categories, the first describing claw size (CSIZE), the second claw hardness (CHARD), the third and fourth containing claw and leg conformation traits based on a scoring system (CSCORE, LSCORE).

Statistical analyses. The data were analysed with a mixed linear model in which test station, year and season was included as a combined fixed effect. The age of the bulls expressed in months was also taken as fixed effect into the model. By using pedigree information for each young bull it was possible to include the additive genetic effect of the animals (n=12.443) as random effect into the model. The estimation of the genetic parameters was done by using VCE4 (Groeneveld 1998) or MTGSAM (Van Tassel and Van Vleck 1996). Because of the large number of traits it was not feasible to analyse all traits in one run. Instead the traits were combined into different groups and jointly analysed. The way in which traits were grouped was dependent either on the kind of the traits (measurements or subjective judgments) or either on the location, where the traits were observed (front or rear legs). In VCE4 up to five traits could be analysed without getting problems with no convergence, while MTGSAM was able to analyse more traits at once. The procedure of using subsets of traits resulted in multiple estimates for single genetic parameters. Using the standard errors of the estimates as weighting factors a set of estimates for all traits could be achieved. Breeding values (BV) for all animals in the pedigree were estimated by using MTGSAM with the observed variance-covariance matrix. Among the 12.443 animals in the pedigree were 102 sires, who have also got BV for length of productive life (RZN) and other traits related to longevity in the German national-wide evaluation. The national-wide evaluation is mainly based on the performances of the sires' daughters. Especially for traits related to longevity and under the restriction of a minimum accuracy BV are only available late in life for a given sire. Therefore not every sire of the test bulls had also a breeding value for length of productive life. Using those sires who got BV for the claws and legs traits as well as for length of productive life the correlations between these BV could be calculated. In order to reduce the measuring expenditure in the future it was tried to find the most significant traits out of the 29 available by forming 10 different sets of traits and analysing the overall correlations of the BV within these sets with respect to the BV for length of productive life. The number of traits which belonged to a set differed from 5 to 29, in case the last one the information of all traits was combined to get a prediction of RZN. The other subsets were formed dependent on the kind of traits and their origin (front or rear legs). The overall correlation coefficients were used as parameters to rank the different subsets of traits according to their ability to predict the RZN. Because the observed overall correlation coefficients between the BV were strongly dependent on the accuracies of the BV two analyses were conducted with different thresholds for the BV to be included. First the threshold was fixed at 0.5, then at 0.7. As the minimum accuracy became higher, the number of sires with BV for both fields decreased from 79 to 56.

RESULTS AND DISCUSSION

Heritabilities of the 29 claw and leg conformation traits are shown in table 1. Among the traits describing claw size the length and angle of dorsal wall and the diagonal length had the highest heritabilities. By comparing front and rear legs with respect to these traits the values for front legs exceeded the ones for rear legs, while the results were contrary for heel height and heel length. But all estimates were in the range found by other studies (Baumgartner *et al*. 1990;

Choi and McDaniel 1993; Boelling and Pollot 1998). Among the measurements of claw hardness the highest estimates were observed for the trait HGS. It seemed to be difficult to measure hardness precisely, especially at the dorsal border wall. The estimates of the heritabilities for claw horn hardness decreased as the claw horn hardness increased at this particular location of measurement. Moderate to high heritabilities were found for the claw shape characteristics, especially for IS and IH, while moderate values were obtained for all leg conformation traits. In table 1 the observed correlations between the BV for claw and leg characteristics and the BV for length of productive life, based on the values found for the bulls' sires are given. By looking at the absolute values of the correlations as criteria for the usefulness of single traits it became obvious that among the claw size traits the ones based on front legs were more valuable than the ones based on rear legs, while the claws shape at the rear legs seemed to be a better indicator for length of productive life.

Table 1. Estimates of the heritabilities (h^2) for the analysed traits and the observed correlations (r) between BV in these traits to BV for length of productive life

		h^2		r	
Trait category	Traits	Front legs	Rear legs	Front legs	Rear legs
Claw size (CSIZE)	LDB	0.42	0.27	0.12	0.01
	ADW	0.37	0.29	-0.23	0.08
	HH	0.21	0.24	-0.06	0.02
	HL	0.21	0.25	0.26	0.07
	DL	0.44	0.39	0.50	0.08
Claw hardness (CHARD)	HTDW	0.12	0.17	0.16	-0.03
	HMDW	0.05	0.03	0.23	0.15
	HGS	0.36	0.25	-0.08	0.00
Claw conformation (CSCORE)	IS	0.51	0.39	-0.04	0.14
	IH	0.44	0.68	0.01	0.08
	ASW	0.43	0.24	-0.29	-0.31
	SDW	0.36	0.24	-0.06	-0.23
	AD	0.32	-	0.11	-
Leg conformation (LSCORE)	FLFV	0.27	-	0.16	-
	RLSV	-	0.25	-	0.06
	RLRV	-	0.33	-	0.10
	RLHA	-	0.32	-	0.11

In table 2 the observed overall correlation coefficients between BV for sets of foot and leg quality traits and BV for functional longevity are shown. By including all 29 recorded traits the correlation coefficients between the estimated BV in the claw and leg traits and the RZN-values were 0.62 and 0.69, depending on the lower bounds for the BV to be included in this analysis. According to the coefficients the sets of traits could be ranked in order to predict RZM by the mean of the recorded claw and leg traits in the most efficient way. Most informative traits were the ones which belonged to $CSIZE_{front}$. The traits measured at the rear legs did obviously not contribute very much additional information. When reducing the number of traits it makes more sense to restrict the measurements to the front legs. As the costs and efforts for recording traits belonging to either the CSCORE or LSCORE group are considerably lower than for CSIZE or CHARD traits, these scores should be used along with claw measures in future evaluations.

Table 2. Observed overall correlation coefficients (R) between claw and leg traits and length of productive life, dependent on subsets of traits

Subsets of traits	# of traits in subset	R minimum accuray = 0.50	= 0.70
$CSIZE_{front}$	5	0.28	0.40
$CSIZE_{rear}$	5	0.16	0.19
$CSIZE_{front+rear}$	10	0.33	0.45
$CHARD_{front}$	3	0.27	0.32
$CHARD_{rear}$	3	0.17	0.11
$CSIZE_{front}$ + $CHARD_{front}$	8	0.37	0.46
$CSIZE_{rear}$ + $CHARD_{rear}$	8	0.23	0.21
$CSIZE_{front+rear}$ + $CHARD_{front+rear}$	16	0.45	0.58
$CSIZE_{front}$ + $CHARD_{front}$ + CSCORE + LSCORE	21	0.55	0.62
$CSIZE_{front+rear}$ + $CHARD_{front+rear}$ + CSCORE + LSCORE	29	0.62	0.69

CONCLUSION

Using claw and leg measurements of test bulls during a performance test at station it is possible to construct an index, which is significantly related to the breeding value for length of productive life. This index gives the opportunity to select young bulls for longevity in future daughter generations. Traits measured at front legs seem to be more informative than the ones measured at rear legs. The foot quality index should include traits which describe the claws precisely ($CSIZE_{front}$ and $CHARD_{front}$) and traits which can be recorded quite easily by using a scoring system (e.g. CSCORE and LSCORE).

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