Genetic Parameters of Claw and Foot Disorders Estimated with Logistic Models

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ABSTRACT

The primary aim of this study was to estimate heritabilities for different types of claw and foot disorders and the genetic relationship of disorders with milk yield and selected conformation traits by applying logistic models in Holstein dairy cattle. The study included data from 5634 Holstein cows kept on large-scale dairy farms in Eastern Germany. Dichotomous response variables were the presence or absence of the disorder in 2003. Cows that were present in herds for <6 wk in 2003 were excluded from the analysis. Incidences, disregarding repeated measurements, for digital dermatitis (DD), sole ulceration (SU), wall disorder (WD), and interdigital hyperplasia (IH) in rear legs were 13.2, 16.1, 9.6, and 6.3%, respectively. The herd effect was highly significant for all disorders. Incidences increased with increasing parities for SU and WD, but were highest among heifers for DD. High milk yield at the first 2 test d after calving was associated with a greater risk for claw and foot disorders in the same lactation. Estimates of heritability were 0.073 for DD, 0.086 for SU, 0.104 for WD, and 0.115 for IH. Genetically, health problems appear to occur in clusters (i.e., a cow showing one disease has an increased genetic risk of showing another claw disease). This phenomenon was also observed between claw and foot disorders and the somatic cell score. Genetic correlations between milk yield in early lactation and disorders were 0.240 for DD, 0.057 for SU, 0.270 for WD, and 0.336 for IH, indicating a physiological antagonism. Correlations between breeding values for claw and foot disorders of bulls and official breeding values for functional type traits were mostly favorable. Routine recording of claw data will offer a new chance to improve claw health within the population as was elaborated by different scenarios applying selection index procedures.
(**Key words:** Generalized Linear Mixed model, claw and foot disorder, genetic parameters)

Abbreviation key: DD = digital dermatitis, **IH** = interdigital hyperplasia, **SU** = sole ulceration, **WD** = wall disorder.

INTRODUCTION

As the level of milk production in dairy cattle increases, correlated increases in health problems need to be studied in more detail. Health problems result in higher culling rates, increased veterinary costs, and economic losses caused by lower production and discarded milk. In recent years, research on health traits has focused on fertility and mastitis. In the Nordic countries, for example, clinical mastitis has been included in dairy cattle breeding objectives since the late 1970s. Genetic evaluation is based on defining the trait as a binary response in a linear model (Heringstad et al., 2000). In Germany, inclusion of health traits in selection programs has been limited because of a lack of reliable data on disease events. In addition, the discrete nature of most disease observations makes their statistical analysis and interpretation more difficult (Mäntisaary et al., 1991).

In the last 10 yr, involuntary culling because of feet and leg disorders is of increasing relevance. Results of a survey by the National Animal Health Monitoring System (APHIS, 1996) in the United States reported that 15% of all cullings were directly due to lameness or leg injury. In Germany, cullings because of feet and leg disorders among all cullings were reported to be 3.2% in 1980 and 9.1% in 2000, as shown in annual statistics published by the German Cattle Breeders Federation (ADR, 1980–2000). Enting et al. (1997) concluded that clinical lameness is one of the most costly diseases in dairy cattle. The economical loss attributable to feet and leg disorders in a 100-cow herd in Great Britain was 8000 Euro/yr on average (Kossaibati and Esslemont, 2000). Much of the variability in feet and leg health is associated with environmental effects, but a few studies have revealed a genetic impact on such traits. An overview of published heritability estimates for different types of claw and foot disorders and related traits in different dairy breeds since 1990 is given in

Table 1. Heritability estimates for different types of claw and foot disorders and related traits in dairy cattle.

Reference	Breed	Cows, no.	Model	Trait	h^2
Boettcher et al., 1998	HOL	1342	Linear animal model	Clinical lameness	0.10
			Threshold animal model	Clinical lameness	0.22
Fatehi et al., 2001	HOL	53,736	Linear animal model	Claw uniformity	0.03
Huang and Shanks, 1995	—[2]	1239	Linear animal model	Heel erosion	0.13
				Sole ulcers	0.03
				Interdigital dermatitis	0.07
				Laminitis	0.14
				Corkscrew claw	0.05
				White line separation	0.08
Lyons et al., 1990	HOL	9187	Linear animal model	Trimmed feet	0.08
				Foot problems	0.11
				Crampy	0.11
				Locomotion	0.11
Paget et al., 2004	JER	6590	Linear animal model	Locomotion	0.22
	GUE	3838	Linear animal model	Locomotion	0.17
Sander-Nielsen et al., 1996	DF	163,361	Linear sire model	Feet and leg diseases[3]	0.01
	RD	58,259	Linear sire model	Feet and leg diseases	0.01
	DJ	31,559	Linear sire model	Feet and leg diseases	0.001
Uribe et al., 1995	HOL	5217	Threshold sire model	Culling for leg problems	0.15
Van Dorp et al., 1998	HOL	3190	Linear animal model	Lameness	0.16
Van Dorp et al., 2004	HOL	3298	Linear animal model	Locomotion	0.06

[1]HOL = Holstein-Friesian, JER = Jersey, GUE = Guernsey, DF = Danish Friesian, RD = Red Danish, and DJ = Danish Jersey.

[2]1239 cows of 5 breeds: Ayrshire, Brown Swiss, Guernsey, Holstein, and Jersey.

[3]Feet and leg diseases include heel erosion, interdigital dermatitis, interdigital necrobacillosis, interdigital skin hyperplasia, laminitis, arthritis, sole ulcer, pressure injuries, and tenosynovitis of hooves.

Table 1. Several papers have focused their investigations on locomotion or overall feet and leg problems. Detailed research on different claw and foot disorders, including relatively large data sets comparable with our study, was only done by Huang and Shanks (1995). For selection to be effective, reliable estimates of genetic parameters of claw and foot disorders are needed to determine the amount of genetic variation available. Correlations with other variables of economic importance are also required to allow the development of a combined breeding value for production and functional traits.

The intent of this work was to estimate heritabilities of some clinical claw and foot diseases of Holstein dairy cows kept in large-scale dairy farms in Eastern Germany and to measure genetic and environmental correlations between diseases and production traits. Milk secretion in dairy cows has a high metabolic priority and is clearly maintained at the cost of other reproductive and metabolic processes (Fleischer et al., 2001). To assess the impact of physiological stress, much attention was given to the impact of milk yield at the beginning of lactation on claw and foot disorders in the following stage of lactation. Furthermore, EBV for claw and foot disorders of widely used sires were correlated with the official breeding values of these sires for some type traits. Results revealed to what extent claw and foot disorders are sufficiently covered by the type recording schemes implemented today in Germany.

MATERIALS AND METHODS

Materials

The data set comprised test-day production records and claw and foot disorders recorded in 2003 from 5634 Holstein cows on 9 large-scale dairy farms from one region in Eastern Germany collected by 9 different hoof trimmers. The guideline for classification of individual claw and foot disorders was developed by the German Agricultural Society, and all trimmers were trained for uniform identification of traits. Claw and foot diseases were divided into 4 different categories digital dermatitis (**DD**), sole ulcer (**SU**), wall disorder (**WD**), and interdigital hyperplasia (**IH**) (Figure 1) and were analyzed separately. Interdigital hyperplasia and to a large degree, DD, are foot disorders that do not directly affect the medial or distal claw on each foot, whereas SU and WD belong to classical claw disorders. Wall disorder mainly describes the different types of white-line disease and further lesions along the wall of the claw. A few specific cases of heel erosion were considered together with digital dermatitis, because both disorders are caused by bacteria. Disorders were scored on an all-or-none basis. If a cow had the health problem in one or both rear legs, she was given a score of 1; otherwise, she was given a score of 0. Repeated measurements of same claw and foot diseases were not taken into account; hence, no effects of lactation stage were considered in the model. Cows that were present in