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Full Length Research Paper

Genetic parameters and correlations among linear type traits in the first lactation of Holstein Dairy cows

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The main objective of this study was to estimate the genetic parameters and relationships of 10 linear type traits in the first lactation of Holstein dairy cows. 3274 records for type traits was used (Ag, angularity; Sta, stature; Bdp, body depth; Rw, rump width; Rs, rear leg side view; Fa, foot angle; Fu, fore udder attachment; Ruh, rear udder height; Sl, suspensory ligament and Ud, udder depth) for the first lactation of Iranian Holstein cows collected during 1980 to 2004 at Animal Breeding Center of Iran. Estimations were performed using restricted maximum likelihood method under an animal model and estimated variance components from single-trait analysis using MATVEC software and covariance components from four-trait analysis using DF-REML software was obtained. Heritability estimates for type traits were low to moderate, from 0.075 for rear leg side (Rs) to 0.376 for rump width (Rw). Genetic correlations between type traits ranged from 0.72 for udder depth (Ud) and fore udder attachment (Fu) to 0.75 for foot angle (Fa) and rump width (Rw). The results of this study showed favorable and high genetic correlation among the mammary system traits such as Ud, Fu, Ruh and Sl. Body conformation traits such as Ag and Bdp were unfavorable and negative for the genetic correlation with mammary system traits including Fu, Ruh and Ud.

Key words: Genetic parameter, type traits, Iranian Holsteins.

INTRODUCTION

The concept of linear analysis of type traits was introduced in 1976 and the first programs for linear type trait evaluation were implemented and tested by 1979 (Lucas et al., 1984; Vinson et al., 1982). Today, all breed associations and virtually all artificial insemination (AI) organizations use some form of linear evaluation for conformation analysis of dairy cattle. Early analyses of these programs involved mainly parameter estimation because of the limited number of records available (Foster et al., 1988).

The Holstein Association (HA) began routinely scoring cows with a linear system as part of its herd appraisal program on January 1, 1983. Linear type traits are scored from one biological extreme to another using a continuous scale from 1 to 50 points (Funk and Hansen, 1991). All dairy breed associations and many AI organizations in the US have implemented linear type trait programs that are similar to the program described by Wilson (1979). The relationships of these traits to herd life and profitability, survival and workability, udder health and somatic cell score, and genetic defects have been investigated (Gengler et al., 1997). Dairy farmers, economists and geneticists recognize the importance of herdlife and lifetime performance. Herdlife and lifetime performance are primary factors influencing a cow's profitability.

Direct selection to reduce involuntary culling is of limited value due to increased generation intervals and possibly low heritabilities; therefore, selection on correlated traits that can be measured in first lactation may be warranted. Many researchers have hypothesized that a relationship exists between type or physical characteristics and length of herdlife or lifetime performance (Rogers et al., 1988). Information about conformation traits can also be used as a relatively early predictor of herd life. Some conformation traits are associated with longevity and are recorded early in life. Several countries are now using conformation scores of daughters to help predict the transmitting abilities of the sires for herd life (Boettcher et al., 1997). The breeding goal in dairy cattle is to increase lifetime profit per animal and unit of time. Profit is a function of production and the time that a cow remains in herd. Thus, profit can only be recorded when a cow is culled, and the selection of more profitable

Table 1. Summary of data structure, mean±SD and coefficient of variance for type traits.

Parameter	Sta	Bdp	Ag	Fu	Ruh	Fa	Ud	Rs	Rw	Sl
Number of records	3274	3274	3245	3274	3274	3274	3274	3274	3274	3274
Number of total animals in pedigree	6210	6210	6162	6210	6210	6210	6210	6210	6210	6210
Number of sires	284	284	282	284	284	284	284	284	284	284
Number of RYS[2] subclasses	69	69	NS[3]	69	NS[3]	NS[3]	69	69	69	69
Mean ± SD	139.1±3.5*	5.2±1.2**	6.6±1.1**	6.8±1.4**	25.9±5.6*	5.3±1.3**	5.6±1.1**	5.4±1.1**	19.3±1.6*	5.3±1.7**
Coefficient of variance (%)	2.55	22.04	19.87	20.25	21.44	24.24	20.58	19.81	8.28	32.28

[1] Sta = Stature, Bdp = body depth, Ag = angularity, Fu = fore udder attachment, Ruh = rear udder height, Ud = udder depth, Rw = rump width, Fa = foot angle, Rs = rear leg side view, Sl = suspensory ligament; [2] RYS = fixed effect of region by year and season of evaluation; [3] NS, effect of RYS was statistically non significant (P > 0.05); * = units in centimeter; ** = units in a score from 1 to 9.

animals should be able to be predicted by indexes from measurements at an early age of the cow (Perez-Cabal and Alenda, 2002). The purpose of this study was to estimate genetic parameters and genetic correlations between some selected type traits in the first lactation of Iranian Holstein cows.

MATERIALS AND METHODS

In this study, the data used were Iranian Holstein type traits that were collected from Animal Breeding Center of Iran from 1980 to 2004. The studied type traits were angularity (Ag), stature (Sta), body depth (Bdp), rump width (Rw), rear leg side view (Rs), foot angle (Fa), fore udder attachment (Fu), rear udder height (Ruh), suspensory ligament (Sl) and udder depth (Ud). The classification scores of Bd, Fu, Ud and Ag have scales from 1 to 9, as in the Iranian classification system. Structure of edited data sets and descriptive statistics for type traits are presented in Table 1.

Models were developed based on data availability, literature evidence and available computing facilities. The model for analyzing type traits was:

$$Y = RYS + H(RYS) + \alpha\ DIM + \beta\ AFF + \gamma\ AEV + \delta\ BLD + TEC + A + E$$

Where, Y was the record of particular type trait, RYS was a fixed effect of region by year and season of evaluation, H was a fixed effect of herd, α, β, γ and δ were the linear regression coefficients of Y on days in milk (DIM), age at first freshening (AFF), age at evaluation (AEV) and percent of Holstein heredity (BLD), respectively. The fixed effect of technician was denoted by TEC, the random effect of animal additive genetic effect and residual effects were shown by A and E, respectively.

Each of the fixed effects was investigated via SAS software (proc Generalized Linear Model). In this study, some of these fixed effects such as DIM, AFF and AEV were statistically non-significant (P > 0.05). The other fixed effects were significant (P > 0.05) but each of the type traits was significant for some of these fixed effects (Table 2). Variance and covariance components were estimated by restricted maximum likelihood method using MATVEC program and DFREML program, respectively. Multiple trait analyses were perfor-med to obtain estimates for genetic and environmental correlation between type traits. Convergence criterion was defined as the error sum of squares between successive iterations and was set to 6 -10.

RESULTS AND DISCUSSION

The estimated variance components and heritabilities for type traits are shown in Table 3. The estimated heritability for type traits were low to moderate, from 0.075 for rear leg side view (RS) to 0.376 for rump width (RW). In accordance with other studies (VanRaden and Jensen, 1990; Harris and Freema, 1992), the highest heritabilities were for rump width and body conformation traits, followed by angularity and udder traits, while rear udder height and rear leg side view traits obtained the lowest values. Moderate heritability was obtained for udder traits, ranging from 0.10 for rear udder height to 0.25 for udder depth. Similar heritability for udder depth was reported by Rogers (1993) but the heritability of this trait which was reported by Harris and Freeman (1992) was slightly higher (0.26) than that in this study. Foot angle and rear leg side view had the lowest heritabilities (0.13 and 0.07, respectively). According to the previous studies, the foot angle that was reported by Rogers (1993) and Harris and Freeman (1992) was slightly lower than that of this study (0.10 and 0.09, respectively). The rump width had the highest heritability (0.38), slightly higher than that reported by Boldman et al. (1992) and Misztal et al. (1992) but less than the result obtained by Kadarmideen and Wegmann, (2003).

Genetic and environmental correlations calculated among the conformation traits are shown in Table 4. Genetic correlations ranged from -0.75 between foot angle and rear leg side view to 0.72 between fore udder attachment and udder depth.

Table 2. Significance of fixed effects for each of the type traits studied. Fixed effects of type traits that were statistically significant (P > 0.05) are indicated by ●.

Type trait	Fixed effect			
	RYS	H (RYS)	BLD	TEC
Angularity (Ag)		●	●	
Body depth (Bdp)	●	●	●	
Foot angle (Fa)		●	●	
Fore udder attachment (Fu)	●	●	●	
Rear leg side view (Rs)	●	●	●	●
Rear udder height (Ruh)		●		
Suspensory ligament (Sl)	●	●	●	
Stature (Sta)	●	●	●	
Udder depth (Ud)	●	●		●
Rump width (Rw)	●	●		

RYS, fixed effect of region by year and season of evaluation; BLD, percent of Holstein heredity fixed; TEC, effect of technician.

Table 3. Estimates of variance components and heritability for type traits.

Type trait	Additive genetic variance	Residual variance	Heritability (±SE)
Stature (Sta)	2.57	8.00	0.24±0.116
Body depth (Bdp)	0.37	0.73	0.34±0.033
Angularity (Ag)	0.22	0.77	0.23±0.031
Fore udder attachment (Fu)	0.31	1.28	0.20±0.047
Rear udder height (Ruh)	2.55	25.45	0.10±0.025
Udder depth (Ud)	0.27	0.83	0.25±0.033
Rump width (Rw)	0.88	1.45	0.38±0.040
Foot angle (Fa)	0.19	1.27	0.13± 0.04
Rear leg side view (Rs)	0.068	0.845	0.075± 0.026
Suspensory ligament (Sl)	0.26	2.04	0.114±0.06

Additional pairs of traits with high genetic correlations were angularity with body depth (0.41), body depth with rump width (0.56), body depth with stature (0.50), rump width with stature (0.56) and suspensory ligament with stature (0.42). Positive genetic correlations indicate that selection for increased scores in one trait will be accompanied by increased scores in the correlated trait, regardless of the direction of the score that improves the trait. The genetic correlation between fore udder attachment and rear leg side view, suspensory ligament and stature was almost null (0.07, 0.06 and -0.004, respectively). Additional pairs of traits with null genetic correlations were angularity with suspensory ligament (0.02), body depth with rear udder height (-0.06), rump width with rear udder height (0.02), rear udder height with stature (0.06) and stature with udder depth (0.07).

Body conformation traits such as Ag and Bdp were unfavorably correlated with udder traits including Fu, Ruh and Ud, which means that bigger and thinner cows will have a strong ligament in the fore udder attachment and the udder will have a proper distance from the hock and this means that proper distance should be above the hock. Consequently, mastitis suffering probability could be low for these cows.

Conclusion

Genetic parameters, especially correlations, should be estimated for every breed and country to avoid biasing genetic evaluations because of inappropriate (co) variance components. In this study, heritability estimates for type traits were low to moderate. Genetic correlations between type traits showed favorable and high genetic correlation between mammary system traits. The magnitude of heritability for linear traits, combined with genetic correlations between traits, gives an indication of the rate of change expected in scores when selection is performed on these traits. Information provided in this study could be used to create specific selection indices that

Table 4. Genetic correlations (above diagonal) and environmental correlations (below diagonal) among conformation traits.

Parameter	Ag	Bdp	Fa	Fu	Rw	Ruh	Rs	Sl	Sta	Ud
Angularity (Ag)		0.41	0.27	-0.15	0.18	-0.24	0.31	0.02	0.24	-0.54
Body depth (Bdp)	0.25		0.15	-0.10	0.56	-0.06	0.30	0.37	0.50	-0.44
Foot angle (Fa)	0.03	0.01		-0.14	0.15	-0.23	-0.75	0.28	0.21	-0.20
Fore udder attachment (Fu)	0.02	0.002	0.11		-0.21	0.26	0.07	0.06	-0.004	0.72
Rump width (Rw)	0.03	-0.02	-0.02	-0.006		0.02	-0.11	0.18	0.56	-0.32
Rear udder height (Ruh)	-0.08	0.02	0.06	-0.12	0.10		0.19	0.30	0.06	0.41
Rear leg side view (Rs)	0.01	0.10	-0.19	-0.11	0.02	-0.02		-0.65	-0.12	-0.59
Suspensory ligament (Sl)	0.08	-0.03	-0.07	0.13	-0.05	-0.10	0.06		0.42	0.18
Stature (Sta)	0.12	0.03	-0.02	-0.06	0.21	0.20	-0.05	-0.05		0.07
Udder depth (Ud)	-0.24	-0.24	0.12	0.26	0.05	-0.14	-0.13	0.17	-0.04	

would reflect the optimal conformation of dairy cows in each region in terms of functional longevity. Although these estimates should be useful in multiple- trait animal evaluation and in studying selection responses in multiple traits, further investigation is required to improve the functionality and the longevity of the animal for dairy production. Investigation of genetic and phenotypic associations between type traits and longevity is required.

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