GENETIC CORRELATIONS AMONG BODY CONDITION SCORES, BODY CONDITION SCORE LOSS, PRODUCTION AND DAYS TO FIRST INSEMINATION

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INTRODUCTION

Dairy cattle selection programs have successfully increased genetic merit for yield. However, cow health and fertility have declined as a correlated response to selection for yield. Negative energy balance during lactation is common in high yielding dairy cows and may be, in part, responsible for reduced cow health and fertility. Body condition score (BCS) is a subjective measure of body fat and energy reserves that can be used to monitor energy balance during lactation. The objectives of this study were to estimate the heritability of BCS and early lactation BCS loss from field data and determine the genetic relationships among BCS, BCS loss, production and reproductive performance.

MATERIALS AND METHODS

Data. Body condition scores, mature equivalent (ME) for milk yields and days to first insemination (DFI) were obtained from the Dairy Records Management Systems in Raleigh, NC. Body condition scores at calving and during the early postpartum period were recorded by producers or herd-consultants using PCDART dairy management software. The number of days in milk (DIM) when postpartum BCS was recorded was not available. Body condition score loss was defined as BCS at calving minus postpartum BCS. Therefore, a higher value for BCS loss indicates that more BCS was lost in early lactation.

Edits applied to the data set included: requirement of a valid identification number and valid Holstein sire registration number, valid calving and birth dates, ME milk of at least 4537 kg, a calving age of 20 to 36 months for first lactation cows and a calving interval of at least 10 months and no more than 24 months for second lactation cows. Days to first insemination records were edited to include cows that had been first inseminated between 25 and 200 days in milk. After edits, records were available for BCS, production or reproductive performance for 51,195 cows from 245 herds. The number of observations and mean of BCS at calving and postpartum, BCS loss, ME milk and DFI are given in Table 1.

Table 1. Number of observations and mean of body condition score (BCS), BCS loss, ME milk (kg) and days to first insemination

Trait	First Lactation		Second Lactation	
	Observations (n)	Mean	Observations (n)	Mean
BCS at calving	17,316	3.18	13,937	3.07
BCS at postpartum	10,728	2.91	8,308	2.82
BCS loss	7,424	0.30	6,092	0.29
ME milk	48,332	10,409	32,796	10,688
DFI	11,319	86.6	10,192	88.4

Analyses. Heritabilities and genetic correlations among BCS, BCS loss, ME milk yield and DFI were analyzed with a series of bi-variate animal models using DFREML (Meyer, 1998). The basic statistical model used in the analyses was :

$$y_{ij} = \beta_1 \text{ age} + \beta_2 \text{ yield} + \text{hys}_i + \text{animal}_j + e_{ij}$$

where y = a vector of BCS or BCS loss and one of the following: BCS, BCS loss, ME milk, or DFI,
β_1 and β_2 are regression coefficients,
age = age at calving,
milk = ME milk yield (for models with DFI only),
hys_i = ith fixed effect for herd-year-season of calving,
animal_j = jth random animal effect and
e_{ij} = a vector of random residuals.

The three seasons-of-calving were defined as January through April, May through August and September through December. In addition, models for all second lactation traits included length of the previous calving interval as a co-variable. Approximate standard errors were calculated according to Falconer and Mackay (1996).

Two approaches were used to determine the genetic relationship between BCS and BCS loss. In the first set of analyses, all observations for BCS loss and BCS were included in a bi-variate animal model. All cows with a BCS loss observation would also have a BCS observation at either calving or postpartum, depending on which BCS trait was being analyzed. In the second set of analyses, those cows with both BCS at calving and postpartum BCS contributed BCS loss observations only. Cows with BCS available at calving, but with no postpartum BCS, contributed the observations for BCS at calving. Likewise, cows with postpartum BCS available, but not BCS at calving, contributed postpartum BCS observations. Genetic correlations would thus be estimated through pedigree linkages between those cows contributing BCS loss observations and those cows contributing BCS observations. The second approach should allow estimation of genetic correlations free of potential part-whole influences that might bias parameter estimates when one trait is a function of a second.

RESULTS AND DISCUSSION

Heritabilities and correlations among BCS, BCS loss, ME milk yield and DFI in first and second lactations are given in Tables 2 and 3, respectively. Heritability estimates for BCS ranged from 0.10 to 0.15, which is lower than other published results (Veerkamp *et al.,* 2001). Body condition scores in this data set were from producer and herd-consultant recorded field data and may not be as consistently recorded across evaluators and herds as BCS would be in experimental settings, or if included in a routine linear type trait appraisal system. In addition, the DIM when postpartum BCS was assigned was not known and thus could not be included in the model.

Table 2. Heritabilities (diagonal), genetic correlations (above diagonal) and phenotypic correlations (below diagonal) among BCS, BCS loss, ME milk and DFI in 1st lactation[1]

Trait	BCS at Calving	BCS at Postpartum	BCS Loss	ME Milk	DFI
BCS at calving	0.10	0.74	-0.15	-0.02	-0.23
BCS at postpartum	0.26	0.15	-0.72	-0.29	-0.57
BCS Loss	0.55	-0.69	0.06	0.50	0.52
ME Milk	0.06	-0.06	0.10	0.29	-
DFI	-0.05	-0.11	0.08	-	0.06

[1]Approximate standard errors for heritability estimates are <0.03. Approximate standard errors for genetic correlations range from 0.06 to 0.17.

Table 3. Heritabilities (diagonal), genetic correlations (above diagonal) and phenotypic correlations (below diagonal) among BCS, BCS loss, ME milk and DFI in 2nd lactation[1]

Trait	BCS at Calving	BCS at Postpartum	BCS Loss	ME Milk	DFI
BCS at calving	0.13	0.87	-0.29	-0.27	-0.68
BCS at postpartum	0.35	0.14	-0.89	-0.31	-0.72
BCS Loss	0.53	-0.64	0.02	0.17	0.29
ME Milk	-0.01	-0.10	0.09	0.17	-
DFI	-0.04	-0.09	0.05	-	0.03

[1]Approximate standard errors for heritability estimates are <0.04. Approximate standard errors for genetic correlations range from 0.03 to 0.49.

Genetic correlations between BCS at calving and postpartum BCS were high (>0.73). Phenotypic correlations between BCS at calving and postpartum BCS were only 0.26 in first lactation and 0.35 in second lactation. There appears to be significant variation in the amount of BCS lost in early lactation, but that variation appears to be predominately under environmental control. Thus, heritabilities for BCS loss were less than half the heritability of BCS.

The genetic correlation estimates between BCS and BCS loss reported above are from the first set of analyses where all observations for both BCS and BCS loss are used. Genetic correlations estimated only through pedigree linkages differed slightly in magnitude, but not in sign. Cows that are genetically inclined toward higher levels of BCS appear to maintain BCS in early lactation and have higher postpartum BCS.

Yield was negatively correlated with BCS and positively correlated with BCS loss. Cows that have high genetic merit for yield lose more BCS in early lactation and are thinner during the postpartum period. Genetic correlation estimates were moderate, however, and selection programs could continue to increase genetic merit for yield while maintaining BCS levels. Cows that mobilize large amounts of BCS to support early lactation yield are likely less efficient than those cows that produce milk directly from food and mobilize smaller amounts of BCS (Garnsworthy and Jones, 1987).

Genetic correlation estimates between BCS and DFI were negative, while genetic correlation estimates between BCS loss and DFI were positive even when yield was included in the model. Cows genetically inclined to lose BCS in early lactation and have low BCS levels in the postpartum period are inseminated for the first time later in lactation. Veerkamp *et al.* (2000) reported a genetic correlation estimate between energy balance and the interval to first luteal activity of –0.49 after adjustment for yield. Cows that are losing condition and in negative energy balance are likely inseminated later in lactation due to delayed onset of ovarian activity.

CONCLUSIONS

Higher genetic merit for yield is correlated with lower levels of BCS. Selection for yield also increases BCS loss and negative energy balance in early lactation by lowering postpartum BCS more than BCS at calving. Lower genetic merit for postpartum BCS and genetic merit for more severe negative energy balance in early lactation increase DFI, likely by causing a delay in ovarian activity. The correlation estimates between BCS, BCS loss and yield are moderate and selection could increase yield and maintain BCS levels. Body condition score loss and postpartum BCS are highly correlated. Postpartum BCS is more highly heritable and would likely result in more efficient selection for improved reproductive performance than direct selection to reduce early lactation BCS loss.

REFERENCES

Falconer, D.S. and Mackay, T.F.C. (1996) Introduction to Quantitative Genetics, 4th Edition. Longman, Inc., New York, NY.

Garnsworthy, P.C. and Jones, G.P. (1987) *Anim.Prod*. **44**:347-353.

Meyer, K. (1998) DFREML: version 3.0β.

Veerkamp, R.F., Koenen, E.P.C. and De Jong, G. (2001) *J. Dairy Sci.* **84**:2327-2335.

Veerkamp, R.F., Oldenbroek, J.K., Van Der Gaast, H.J. and Van Der Werf, J.H.J. (2000) *J. Dairy Sci*. **83**:577-583.