New Applications of Conformation Trait Data for Dairy Cow Improvement

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Introduction

Recent research efforts have been directed at investigating the potential value of three conformation traits to help improve the functionality and profitability of the Holstein cow. Two new traits, rear teat placement and thurl position are being studied, and a new perspective was taken with dairy form.

Understanding the relationship that dairy form has with health and fertility traits of cows can be aided by a review of its relationship with body condition score (BCS). Lassen *et al.* 2003 mentions that BCS can be used as a management tool to estimate energy balance at specific periods of a lactation or in a breeding program as an indicator of energy balance. They refer to BCS as "a subjective method of assessing the amount of metabolizable energy stored in fat and muscle". They report "when dairy character (DC) and body condition score are recorded as in the present Danish conformation scoring system, observations on DC will add more information as a genetic indicator of disease resistance." The potential value of dairy form as an indicator trait for disease resistance was reported by Rogers *et al.* 1999. He found a genetic correlation of .73 between dairy form measured in the United States and disease other than mastitis measured in Denmark.

Dechow *et al.* 2004c did a follow up study with both Danish and U.S. data and found that dairy form had a stronger correlation with disease incidence than BCS when both traits are measured by U.S. classifiers. In fact, correlations between BCS and disease tended to be non-significant when adjusted for dairy form, whereas genetic correlation estimates between dairy form and disease, except for one exception, were not reduced significantly by adjustment for BCS. They hypothesize that the relationship between both dairy form and BCS with metabolic and digestive diseases is likely due to differences in early lactation negative energy balance.

This study takes a closer look at the reasons behind the value of dairy form as an indirect predictor of the health and fitness of cows, as well as the introduction of two new research traits and their potential economic value.

Methods

Conformation trait information came from the Holstein Association USA, Inc. for the time period of October 1997 through December 2000. The beginning date coincides with the initiation of the collection of body condition score as a routinely collected research trait. The end date was selected, so that cows would have enough time to complete their productive life evaluation. A corresponding data file of production traits (305-day milk, fat and protein yields), somatic cell score (SCS), days open, and days-in-milk was provided by the Animal Improvement Programs Laboratory at USDA.

Results for this paper are a combination of three separate analyses; Tsuruta *et al.* 2005; and Dechow *et al.* 2004a&b. In the first paper, genetic parameters for 25 traits (productive life (PL), milk, fat, protein, SCS, days open, 18 linear type, and final score) were estimated with a multiple-trait sire model via Gibbs sampling. Productive life was defined in three ways (PL_{305}, PL_{500} or PL_{999}) where the maximum number of days-in-milk per lactation was 305, 500 or 999 days.

The second paper used a multiple trait sire model. Analyses among dairy form, BCS and daughter pregnancy rate (DPR) were conducted with and without a covariable for dairy form, BCS and ME milk.

The third paper applied a sire model using ASREML. Random regression model included days-in-milk and lactation number nested within sire using a second order Legendre polynomial and heterogeneous residual variance.

Results

Dairy Form: Dairy form and BCS are two separate visual appraisals of a cow. Genetically, the two traits are similar, genetic correlation of -.66 (Tsuruta *et al.,* 2005*,* Table 1). Dairy form is more related to production, udder traits dealing with the size of the udder (rear udder height & width and udder depth), final score, productive life and most importantly fertility.

Table 1. Genetic correlations between Dairy Form and Body Condition Score with twenty three other traits.

Traits	Dairy Form	Body Condition Score
Milk	0.61	-0.33
Fat	0.53	-0.26
Protein	0.61	-0.30
Somatic Cell Score	0.19	-0.20
Daughter Pregnancy Rate	-0.46	0.26
Productive Life	-0.26	0.05
Stature	0.30	0.19
Strength	-0.04	0.71
Body Depth	0.30	0.43
Rump Angle	-0.04	-0.01
Thurl Width	0.25	0.28
Rear Legs Side View	0.30	-0.35
Rear Legs Rear View	-0.02	0.22
Foot Angle	-0.12	0.34
Fore Udder Attachment	-0.07	0.20
Rear Udder Height	0.29	-0.07
Rear Udder Width	0.46	-0.02
Udder Cleft	0.20	-0.07
Udder Depth	-0.29	0.10
Front Teat Placement	0.18	-0.02
Teat Length	0.02	0.14
Udder Tilt	-0.07	0.22
Body Condition Score	-0.66	0.20
Dairy Form	0.29	-0.66
Final Score	0.40	0.04

BCS has the desirable features that it is positively correlated with DPR, PL and negatively correlated with SCS thus making it appear to be a good trait to include in a selection index. However, selecting against dairy form is the better choice, as it is more strongly associated with fertility and longevity.

The relationship of both dairy form and BCS with PL is dependent upon how the productive period is defined. Varying the amount of time (lactation length) for which a cow receives credit has a direct relationship upon the goal or objective of this trait. When looking at shorter lactations (305 days or less), the trait is essentially a lactation count. The trait PL_{305} is most highly correlated with DPR and has a negative association with production. When the productive period evaluated is less than 305 days, those cows who breed back easily and give up a certain amount of production to accomplish this goal would be selected. As the productive period evaluated is extended (PL_{500} and PL_{999}), productive life becomes more associated with higher yields.

From this study it appears that fertility and production are competing for the same nutritional resources. Both dairy form and BCS are measures of how the cow stores and mobilizes its energy reserves (fat deposits) over a lactation. Short lactations favors fatter (higher BCS) and less dairy looking (lower DF) cows. While, PL utilizing longer lactations, favors higher production, lessens the magnitude of the negative correlation with DF and reverses the association with BCS from a positive to a negative relationship.

Table 2. Genetic correlations of traits that change* with different measures of the productive period.

	PL_{305}	PL_{500}	PL_{999}
DPR	.62	.36	.36
Production **	-.11	.05	.12
Dairy Form	-.25	-.12	-.08
BCS	.05	-.05	-.08

* Change in genetic correlation of at least .10
** Average of milk, fat and protein.

Longer lactations may allow for more recovery time from the stress of higher production, especially in early lactation. When the productive period includes time beyond 305 days, a combination of both better fertility and higher yields is most desirable combination.

These results have important implications regarding selection goals under different environments. If a cow's lactation length is restricted to 305 days or less, such as in a pasturing situation, selection for fertility is most likely the most important trait. Whereas, when longer lactations are permitted, such as in most intensive farming situations, selection for both better fertility and higher production appears to be warranted.

Results comparing Dairy Form and Body Condition Score with DPR are presented in table 3. Dairy Form is more highly correlated with daughter pregnancy rate and productive life than BCS. In the companion study of U.S. data, Dechow *et al.* 2004a also reported that dairy form is more highly correlated with both production and fertility than BCS. Genetic correlation estimates of ME milk with dairy form and BCS were 0.49 and –0.25, respectively. Both the genetic and phenotypic correlations between dairy form and DPR were stronger than between BCS and DPR. After adjusting for ME milk, estimates of genetic correlations between DPR with dairy form and BCS were -0.38 and 0.24, respectively.

Table 3. Genetic correlations of Dairy Form and Body Condition Score with Daughter Pregnancy Rate.

	Dairy Form	Body Condition Score
DPR – *Tsuruta et al. 2005*	-.45	+.25
DPR* - *Dechow et al 2004a*	-.48	+.30
DPR*-Adjusted for milk yield	-.38	+.24
DPR*-Adjusted for milk yield	-.40	
DPR*-Adjusted for milk yield		.00
*Originally reported as days open		

Dairy form is more valuable than BCS when using a selection index to improve DPR. The genetic correlation between dairy form and DPR was 0.40 after adjustment for BCS, whereas the genetic correlation between BCS and DPR was zero after adjusting for dairy form.

The importance of dairy form as an indicator trait of potential changes in energy balance is further illustrated by the fact that it explains important variation in fertility above and beyond its association with production. Dechow et a. 2004a state that "an unfavorable genetic relationship between ME milk and days open exists even after one adjusts for dairy form. The squared genetic correlation between ME milk and days open when not adjusted for dairy form indicates that genetic differences among cows in ME milk explain approximately 14.4% of the genetic difference among cows in days open. The squared genetic correlation between ME milk and days open is only 4.8% after adjustment for dairy form. This indicates that a majority of the unfavorable relationship between ME milk and days open is likely due to higher dairy form for cows with high genetic merit for yield."

A stressful time for cows is during early lactation when a cow has a negative energy balance and must mobilize body reserves. Dechow *et al.* 2004b reported that the phenotypic scores of dairy form and BCS closely follows the cow's lactation curve, albeit in opposite directions. This indicates that both traits are visual measures of fat (energy reserves). Additionally, cows that are genetically inclined to have a high dairy form score (high angularity) at calving are apt to have the most change in dairy form during the first two months of lactation. That is, cows who have a high breeding value for dairy form will appear even more sharper, angular and thinner at the peak of lactation than the other cows.

Table 4. Change in Linear Score over first 70 days-in-milk.		
	Average Change	Additional Change*
1st Lactation	1.9	4.3
2nd Lactation	4.4	3.3
3rd Lactation	5.6	3.4
* High vs.Low BV cows, +3.00 or –3.00 SD		

Changes in linear scores during early lactation was greater for the high genetic merit dairy form cows than for extreme BCS cows. High dairy form, indicating large changes in energy reserves during early lactation, appears to be a good indicator of the health liability of a cow. High producing dairy cows, who are very good at mobilizing body reserves in the early part of lactation, may do so at the detriment of their reproductive ability and health status. The importance of early lactation stress in breeding programs is partially dependent upon the length of the lactation. Greater productive life is associated with higher production if the productive period per lactation is long enough to give higher producing cows enough time to recover from the stress or if the extra production during this extended time period is more than enough to compensate for the decreased fertility of these cows.

Application of these findings have included the inclusion of dairy form with a negative weight into the Holstein Association's TPI formula.

Rear Teat Placement Holstein classifiers have been collecting this new trait since January 2003. Current selection for higher type has moved the rear teats closer together. Rear teat placement is strongly correlated with udder cleft and front teat placement. As we select for a stronger center ligament and closer front teat placement, we've move the rear teats closer together.

Improper teat placement will lead to milking problems. Teats that are not centrally located on the quarter will cause the teat cups to be situated at an awkward angle allowing air to leak into the claw. As air rushes in a squawking noise can be heard. Some problem cows require milkers to hold the claws apart to keep them from squawking.

Economic losses, such as, longer milking time, incomplete milkout and an increase in mastitis, are associated with squawking milkers. A sudden rush of air can push tiny droplets of milk from one claw across to the alternate claw allowing for the potential spread of mastitis from one quarter to another.

Figure 1 shows a non-linear relationship between a sire's PTA for somatic cell score and his STA for rear teat placement. Bulls who sire cows with their rear teats slightly closer (STA= +1.0) have daughters with the lowest SCS. This is a clear example of an intermediary optimum. Transforming the data (fig. 2) shows a simple way of putting the transmitting ability information on an easy to understand basis. Bulls whose STA for RTP is close to +1.0 are desirable while bulls whose STA differ from +1.0 in either direction from this optimum are less desirable. The long term consequences of using such a transformation in a breeding program are not yet clear.

Figure 1. Actual Values

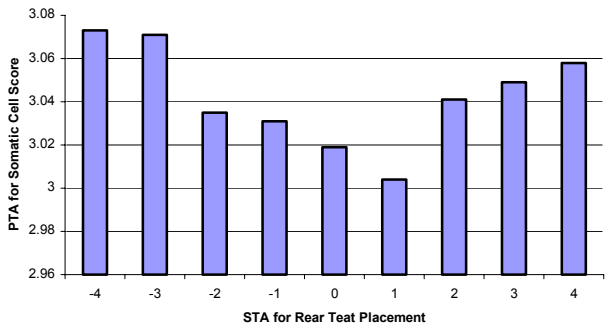
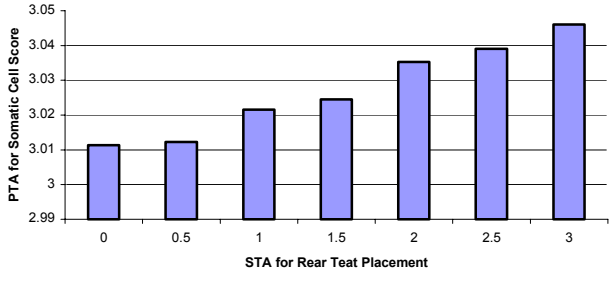
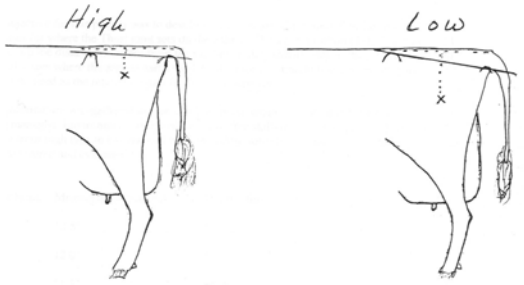


Figure 2. Intermediate Optimum Deviated Expression using Absolute Values |STA RTP -1.0|



Thurl Position: Thurl position (TH) is now being evaluated by measuring the distance in inches from the top line of the animal back to the point of the thurl joint (hip joint). In cases where the animal has a weak back or loin, a straight line, representing a correct back, would be used as the reference point for the measurement. The biological range for most cows is between 7.5" inches from the top line (high thurls, linear score = 1) to 12.5" (low thurls, linear score = 50). It is hypothesized that a lower thurl position will be positively correlated withh easier calving.



Conclusions

Dairy Form is an important indicator of a cow's ability to mobilize energy (fat reserves). Physical characteristics such as openness of the ribs, sharpness of bones, and thinness of the tail and thigh are all indicators of the cow's ability to milk. Classifiers are looking for those characteristics that best predict which cows have the ability to convert high quality feed into high yields. Cows that are more dairy appearing are also better able to metabolize body fat and herein may lie the problem. Under today's conditions, those cows that maintain body fat in early lactation, appear less dairy, and are able to bred back earlier would be more advantageous.

Rear teat placement has a non-linear relationship with somatic cell score. Selecting for a trait with an intermediate optimum provides dairy cattle breeders a challenge over the long term. Identifying and recording new traits, such as thurl position, provide promise that conformation traits will continue to be an important contributor to the improvement of dairy cows in the years ahead.

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