Body Condition Scoring

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Introduction

Live weight change is a poor estimate of tissue mobilization in lactating dairy cows due to gut fill and shifts in body water as fat is mobilized for milk production. Therefore body condition scoring has received considerable attention as a means to estimate tissue mobilization (Domecq et al., 1997b; Flamenbaum et al., 1995).

Systems

There are different scoring scales, 0 to 5 (**$CS_{5.0}$**), 0 to 4 (**$CS_{4.0}$**), 1 to 4 (**$CS_{4.1}$**), and 1 to 9 (**$CS_{9.1}$**), but the most common system in use for dairy cows in the U.S. uses a scale of 1 to 5 (**BCS**) with 1 being emaciated, 2 thin, 3 average, 4 fat, and 5 obese (Wildman et al., 1982; Flamenbaum et al., 1995). It is common to divide the scale into 0.25 point increments (Ferguson et al., 1994; Wildman et al.,1982; Edmonson et al., 1989). To convert between systems, the following formulae may be used:

Repeatability

To examine this issue we had four observers, who had never scored cows together, score 249 cows in three replicates. Observer 4 only was present for the first 80 cows, therefore data for him will not be presented in entirety. Observer 3 walked down the feed alley and scored cows from the front end, while observers 1 and 2 (and 4) scored cows from the rear. Cows were held in lock ups at the feed manager for scoring. Results are presented in Table 1.

These correlations are similar to ones we have obtained within individual scoring the same cows later on the same day or on the following day. However, correlations may be high yet there may be a systematic bias between observers. To examine this we looked at the difference in score between observers (Table 2).

$BCS = ((CS_{9.1}) + 1) / 2;$ $\qquad CS_{9.1} = (BCS*2) - 1;$

$BCS = ((CS_{5.0})*(4/5)) + 1;$ $\qquad CS_{5.0} = (BCS - 1) * (5/4);$

$BCS = (CS_{4.0}) + 1;$ $\qquad CS_{4.0} = BCS - 1;$

$BCS = ((CS_{4.1})*(4/3)) - (1/3);$ $\qquad CS_{4.1} = (BCS + (1/3)) * (3/4);$

Table 1. Mean and correlation between observers scoring cows in replicates.

Item	Observer 1	Observer 2	Observer 3
Mean score (sem)	3.26 (.47)	3.26 (.46)	3.17 (.45)
Correlations			
Observer 1	.	0.93	0.89
Observer 2	.	.	0.89

Table 2. Distribution of differences between observers as a percent.

Difference	Observer 1 - 2	Observer 1 - 3	Observer 2 - 3
-0.75	0.4	.	.
-0.5	1.2	1.7	1.7
-0.25	21.1	16.2	14.5
0	56.2	35.7	38.6
0.25	20.5	37.3	35.3
0.5	1.2	8.3	9.1
0.75	0.4	0.8	0.8

Differences between observer 1 and 2 are normally distributed around 0 with 97% of the observations falling within .25 units. Differences between observer 1 and 3 and 2 and 3 indicate a bias, as more scores are +. 25 units higher for observer 1 and 2 than observer 3. Observer 3 scored cows from the front, which may have imposed a bias of scoring cows in lower BCS, since the tail head and rump were not as visible. Observer 3 was lower in score in 15% of the cows. However, 90% of observations still fall within .25 units. Body condition score is repeatable between individuals. Repeated observation within an individual follows a similar pattern as between different individuals.

Agreement between individuals may occur due to chance. A test statistic called Kappa measures the reliability of the test above chance. The Kappa for body scoring between observer 1 and 2 is .48 which indicates body condition scoring has moderate test value. If we included the .25 *noise* as agreement, then body condition scoring would have a higher value as a diagnostic test.

Using principal components, Ferguson et al. (1994) found that main descriptors of BCS were primarily associated with the appearance of the ischial and ileal tuberosities and coccygeal and sacral ligaments (Table 3). Using this system gave good repeatabilities across and within observers, simplified body scoring, and could separate .25 unit classes between BCS of 2.0 to 4.0, and by .50 units above and below BCS of 4.0 and 2.0 (Ferguson et al., 1994). If the ileal and ischeal tuberosities have no fat pad present then they appear angular in appearance. As fat increases over these prominences, they become more rounded. The coccygeal and sacral ligaments are sharp in appearance when fat covering is low. They become blunted with fat filling and eventually disappear when cows are very fat.

Table 3. Main descriptors which improved repeatability and simplified body condition scoring (Ferguson et al., 1994).

	Tuberosity-appearance/fat pad		Thurl	Ligaments-appearance		Appearance
BCS	Ileal	Ischeal	V	Coccygeal	Sacral	Spinous processes
<2.0	angular-none	angular-none	V	sharp	sharp	angular > 8 cm visible
2.25	angular-none	angular-none	V	sharp	sharp	angular > 8 cm visible
2.50	angular-none	angular-fat pad	V	sharp	sharp	angular 6-8 cm visible
2.75	angular-fat pad	rounded-fat pad	V	sharp	sharp	angular 6-8 cm visible
3.00	rounded-fat pad	rounded-fat pad	V	sharp	sharp	angular 6-8 cm visible
3.25	rounded-fat pad	rounded-fat pad	U	sharp	sharp	angular 4-6 cm visible
3.50	rounded-fat pad	rounded-fat pad	U	blunted	sharp	rounded 4-6 cm visible
3.75	rounded-fat pad	rounded-fat pad	U	not visible	blunted	rounded 0-2 cm visible
4.00	rounded-fat pad	rounded-fat pad	U	not visible	not vis.	rounded 0-2 cm visible
>4.00	rounded-fat pad	rounded-fat pad	flat	not visible	not vis.	rounded 0 cm visible

Table 4. Quantification of body condition score with carcass composition based on Otto et al. (1991).

score	WT, KG	sem	DM	sem	CP	sem	Fat	sem	Energy, Mca	sem
1	416.34	27.41	30.54	2.65	18.74	0.83	11.95	3.44	614.55	144.70
1.5	422.98	38.95	29.53	3.76	19.17	1.19	8.45	4.88	502.39	205.63
1.75	487.96	47.43	30.22	4.58	19.09	1.44	10.95	5.95	729.19	250.38
2	530.31	64.92	34.21	6.27	20.82	1.98	12.15	8.14	941.73	342.71
2.25	619.49	67.55	42.49	6.52	20.30	2.06	22.91	8.47	1381.13	356.58
2.5	508.79	26.97	35.92	2.60	19.61	0.82	15.85	3.38	940.08	142.39
2.75	520.70	40.67	38.30	3.93	21.08	1.24	17.36	5.10	1041.48	214.70
3	564.46	25.93	42.30	2.50	17.98	0.79	23.82	3.25	1315.96	136.87
3.25	587.76	49.80	44.01	4.81	16.27	1.52	27.52	6.24	1448.74	262.88
3.5	588.32	29.38	47.40	2.84	15.71	0.89	31.22	3.68	1643.38	155.10
3.75	596.30	67.55	53.92	6.52	13.46	2.06	40.10	8.47	1909.85	356.58
4	684.69	25.14	53.21	2.43	13.79	0.77	38.88	3.15	2184.46	132.73
4.5	773.58	67.55	56.09	6.52	13.04	2.06	41.70	8.47	2518.75	356.58
5	732.29	35.54	53.86	3.43	12.63	1.08	40.62	4.45	2362.77	187.58

Between scores of 2.25 to 4.00 the ileal and ischeal tuberosities and coccygeal and sacral ligaments provide the primary information concerning BCS. Below 2.25 and above 4.00 the transverse processes of the lumbar vertebrae need to be used. The appearance of the rump or thurl region is a major feature distinguishing cows below 3.25 in BCS and above a 3.0 in BCS. The rump has a “V” appearance in cows with a BCS$\leq$3.00 and “U” appearance in cows with a BCS>3.00. In cows above a 4.00 the thurl region becomes flattened.

Previously we have described that body condition change correlates well with cumulative negative energy balance (Domecq et al., 1997a) and lipid mobilization (Domecq et al., 1997b), and there should be no more than one condition score loss by 30 days in milk for an individual cow (Domecq et al., 1997a). On a herd basis cows should only lose about 0.5 body condition units from calving to 30 days in milk. This is within ranges observed by Ruegg et al. (1992) for 66 cows in a California dairy (Ferguson et al., 1994). If cows are too fat at calving (>3.5) and/or diets are not provided ad libitum or are not well formulated, cows will lose more body condition (Domecq et al., 1997a, b; Ferguson et al., 1994). We have observed that less than 15% of cows in a herd will lose one condition score or more if diets are provided ad libitum to lactating cows (Table 5).

Health Associations

Gearhart et al. (1990) in an extensive survey of BCS at dry off and at calving, observed that overconditioned cows at drying off (BCS$\geq$3.75) were at increased risk for reproductive and lameness problems. Cows dried off in low BCS ($\leq$2.33) were at higher risk of lameness in the subsequent lactation, and cows which lost more condition over the dry period were at increased risk of being culled. However the association of BCS at dry off, or at calving, or loss in early lactation have been associated inconsistently with health and reproductive problems in dairy cows (Table 6).

Table 5. Summary of loss in condition score when cows are provided feed and libitum.

One Body Condition Loss	Item
Tissue Mobilized	54 kgs (40-77 kgs)
Cumulative Negative Energy	-400 Mcal (-300 to -500)
Average Condition Loss - Group	-.5 units
Time to Maximum Loss	30 days post calving
Time to Increase in Condition	50-70 days post calving
Optimum Condition at Calving	3.0 to 3.5

Table 6. Summary of association of health disorder with body condition and body condition loss from various studies.

Study	Body condition calving	Conditions	Risk
Associations with body condition:			
Markusfeld et al. (1997)	One unit lower	RP, Metritis, Anestrus	Increased
	One unit loss dry period	RP	Increased
	One unit higher	Ketosis	Increased
	One unit higher, dry	Ketosis	Increased
Markusfeld (1988)	One unit higher	Metritis	Increased
	One unit higher, dry	Ketosis	Increased
	NS	RP	
Ruegg et al. (1995)	No association with disease		
Gillund et al. (2001)	BCS≥3.5	Ketosis	Increased
Heur et al. (1999)	BCS≥4	Milk Fever	Increased
	No association other diseases		
Waltner et al. (1993)	No association with disease conditions		
Pedron et al. (1993)	No association with disease conditions		
Gearhart et al. (1990)	BCS dry ≤2+	Lameness	Increased
	BCS 30 d≥4+	Metritis	Increased
	BCS dry ≥4+	Cystic ovaries	Increased
		Reproductive disease	Increased
Associations with body condition loss:			
Markusfeld (1997)	One unit loss dry period	RP	Increased
	One unit loss postcalving	Anestrus	
Ruegg et al. (1995)	BC Loss	Disease	Increased
Gearhart et al. (1990)	Loss dry period	Lameness, dystocia	Increased

The main effect across most data sets was the association of higher BCS at calving with a higher risk of ketosis. Retained placenta was associated in a few studies with lower BCS at calving and loss of BCS in the dry period in one study (Markusfeld et al., 1997). Metritis was associated with lower BCS at calving (Markusfeld et al., 1997), higher BCS at calving (Markusfeld, 1988), and higher BCS at 30 days postcalving (Gearhart et al., 1990). The relationship between fat cows at calving and ketosis is consistent with the observation from many studies that fat cows eat less than thin cows, have higher concentrations of nonesterified fatty acids in plasma, and have more negative energy balance postpartum, conditions associated with a higher risk of ketosis.

The fact that some studies found no association may be related to few herds in the study, few fat cows in the study, or management factors which minimized the risk of disease.

Reproduction

Lower reproductive efficiency (increased days open or days to first insemination) and reduced conception rate to first insemination have been associated with low BCS at first insemination (BCS<2.5) and/or increased BCS loss after calving (BCS loss >.75 to 1.0 units).

Table 7. Summary of association of reproductive parameters with body condition score and body condition

score loss from various studies.

Study	Body condition	Condition	Risk
Associations with BCS:			
Markusfeld (1997)	No association	FSTCR	
	One unit lower BCS calving	Days Open	Increased
	One unit lower BCS calving	Culling	Increased
Pryce et al. (2001)	One unit lower BCS week 10	FSTCR	Decrease
	One unit lower BCS week 10	DFS, DFO	Increased
Syriyasathaporn et al. (1998)	BCS at calving <3.0	First insemination	Decreased
	BCS<2 after 45 d	First insemination	Decreased
	BCS<2 after 45 d	Pregnancy	Decreased
Ruegg and Milton (1995)	BCS at calving	DFB, DFH, DO	No Association
Gillund et al. (2001)	BCS at calving	DFB, DO, FSTCR	No Association
Heur et al. (1999)	BCS at calving	DFB, DO, FSTCR	No Association
Waltner et al. (1993)	BCS at calving	DFB, DO, FSTCR	No Association
Pedron et al. (1993)	BCS at calving	DFB, DO	No Association
Domecq et al. (1997a,b)	BCS at calving	FSTCR	No Association
	Lower BCS dry period	FSTCR	Decreased
Associations with BCS loss:			
Markusfeld (1997)	Loss in dry period	Days Open	Increased
Pryce et al. (2001)	Loss first 10 weeks	DFS	Increased
	Loss first 10 weeks	FSTCR	Decreased
Syriyasathaporn et al. (1998)	BCS loss 45 d postcalving	DO	Increased
		DFB	Increased
Ruegg and Milton (1995)	BCS loss (weak association)	Number AI	Increased
Gillund et al. (2001)	BCS loss $\geq$1.25 units	FSTCR	Decreased
	BCS loss $\geq$ 1.25 units	DO	Increased
Heur et al. (1999)	BCS loss	DFS, DO, FSTCR	No Association
Waltner et al. (1993)	BCS loss	DFB, DO, FSTCR	No Association
Pedron et al. (1993)	BCS loss	DFS	Increased
Domecq et al. (1997a,b)	BCS loss 4 weeks postcalving	FSTCR	Decreased
	BCS loss dry period	FSTCR	Decreased

FSTCR = first service conception rate
DFS = Days to first service
DFO = Days to first ovulation
DO = Days open
DFH = Days first heat
BCS week 10 = BCS 10 weeks postcalving
AI = number of artificial inseminations

BCS at calving has not been associated consistently with lower reproductive performance. Possibly this is due to the association of low BCS at calving with increased culling in several studies. Therefore thin cows do not get inseminated. In addition, cows with excessive BCS postcalving have a lower risk of being inseminated, which may contribute to bias in examining associations with BCS and BCS loss and reproductive efficiency. BCS at insemination and BCS loss post calving are associated with lower FSTCR and increased DO, DFS, DFH, and DFO. It may be that the effects of BCS loss are a major factor influencing DFO and thus other reproductive measures. It seems across studies, that reproduction is not a major problem with modest to moderate loss in body condition (<1.0 unit loss). BCS at insemination may not be a problem unless cows are excessively thin (<2.5) or excessively fat (>3.5).

Loss of BCS and low BCS may influence reproduction by delaying first ovulation post calving and by reducing progesterone production in cycling cattle (Koenen and Veerkamp, 1998; Burke et al., 1996). Villa-Gadoy (1990) observed that heifers placed on a diet to induce weight loss produced less progesterone over the next four estrous cycles. The effect was initially mitigated if BCS was high and was not immediately observed but occurred at the 3rd to 4th estrous cycles after the reduced feed intake, whereas thin heifers experienced an immediate decline in progesterone concentrations at the first estrous cycles. However, fat heifers had lower progesterone concentration than thin heifers before initiation of the negative energy balance. Burke et al. (1996) found that FSTCR in cows synchronized for insemination with a GnRH-Prostaglandin protocol were significantly reduced with lower BCS. For every increase in BCS at first AI, conception and pregnancy increased 13 and 16%, respectively (Burke et al., 1996), and progesterone was 2.2 ng/ml higher for every increase in BCS. Thus, loss of BCS or lower BCS may reduce fertility by reducing progesterone production from the corpus luteum. Mechanisms of reduction are beyond the scope of this paper.

Feed Intake and Milk Production

Domecq et al. (1997b) observed that a one point increase in BCS over the dry period was associated with 545.5 kg more milk produced in the first 120 d of lactation. In addition, a one point higher BCS at dry-off was associated with 300 kg less milk in the first 120 d of lactation. A loss of one point in BCS in the first week postcalving was associated with 241 kg more milk produced in the first 120 d of lactation (Domecq et al., 1997b). This herd had average dry-off and calving BCS of 2.77 and 2.66, respectively, which is somewhat thin. Therefore, an increase in BCS across the dry period may have benefited milk production. Higher BCS at dry-off may have been due to lower milk production in the previous lactation. Average BCS loss was .62 units and was maximal by 4 to 8 weeks postcalving for first and greater parity cows.

Ruegg and Milton (1995) observed that higher producing cows lost more BCS postcalving and fat cows lost more condition than thin cows within each production class. Higher producing cows experienced rapid condition loss in the first 30 to 50 days postcalving and modest losses through 75 d postcalving. Lower producing cows lost condition rapidly through 30 to 50 d postcalving and then began to increase in condition. The gain of BCS was similar for all groups of cows over 300 days of lactation (.58 units by 300 days in milk). Waltner et al. (1993) observed that maximal FCM production in the first 90 days postcalving occurred when cows calved with a BCS of 3.5. Production through 90 days was lower for cows with BCS at calving below 3.0 and above 4.0 (Waltner et al., 1993). Maximal 305 d milk production was associated with a loss of BCS of .75 units. Body condition change below and above this value was associated with lower production. Mean condition loss increased with parity, from .3 in first lactation cows to .9 in 4+ parity cows (Waltner et al., 1993). Change in BCS was most related to days in milk and parity and less with milk production in the study (Waltner et al., 1993).

Pedron et al. (1993) observed that an increase in BCS at calving was associated with 422 kg more 305 day milk production when cows ranged in condition from 3.0 to 4.0 at calving. Minimum BCS occurred at weeks 7, 10, and 12 postcalving for cows with BCS at calving of 3.0, 3.5 and 4.0, respectively. Maximal loss was .6, .8, and 1.05 for the respective condition classes. In general, they did not find a strong effect on milk yield.

Across most studies, the effect of BCS on milk production has been minor. A consistent trend has been an increase in loss with cows in higher BCS at calving, suggesting on common diets, feed intake is lower in these animals and more milk is produced from body tissue. Pooling BCS at calving against change in BCS for several studies (Garnsworthy and Topps, 1982; Pedron et al., 1993; and Ruegg and Milton, 1995) results in an intercept of 1.24 (sem, .14) and slope of - .59*BCS at calving (sem, .054) (R^2 = .92). Thus, if cows calve with a BCS of 3.0, condition loss will be -.53 units; if BCS at calving is 3.5, condition loss will be -.82 units, and if BCS at calving is 4.0, condition loss will be -1.1 units.

Typically cows outside a range of 3.0 to 3.75 have comprised less than 10% of the observations. Therefore observational data may not assess effects of BCS on milk production adequately. In addition researchers (Garnsworthy, 1988; Garnsworthy and Jones, 1987; Garnsworthy and Topps, 1982; and Jones, 1989) have observed that BCS at calving and diet interact to effect production and feed intake. Unfortunately, most studies have not characterized diets fed when describing BCS change.

Conclusions

Most studies have identified that BCS is a useful tool to aid in management of dairy cows as a proxy for estimating energy balance and risk factors for disease. The primary disease condition most commonly associated with BCS at calving has been ketosis in fat cows. Fat cows typically have fallen in categories ≥ 3.75 in BCS at calving. Condition loss in the dry period has been associated with dystocia and other health problems and lower production. Excessive condition loss (>1 unit) and thin body condition at insemination (<2.5) have been associated with lower fertility. Interactions of BCS at calving with diet, milk production and feed intake need further elucidation. Genetic associations of BCS, BCS loss, and milk production have been identified and indicate a potential to select cows for improved BCS and higher milk production.

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