The Health and Production Consequences of Poor Body Condition Score: The Untold Story about BCS

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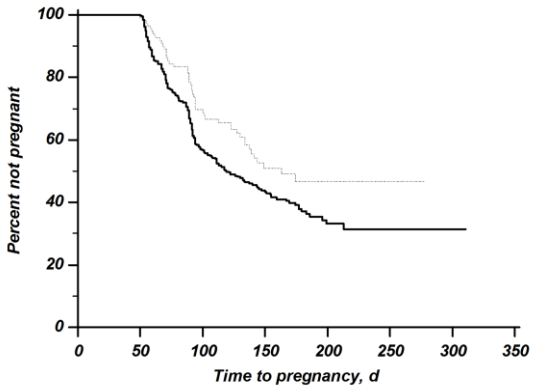
Animal welfare is a growing concern in the dairy industry; both public opinion and farm economics are driving forces in improving the well-being of dairy cows. In North America, lameness is the most important cause of bovine welfare issues (Vermunt, 2007); it also has a negative association with milk production and reproductive performance and leads to increased risk of culling or death (Rajala-Schultz and Gröhn, 1999a; Warnick et al., 2001; Bicalho et al., 2008).

Similar to lameness, poor body condition has economic and welfare implications (Roche et al., 2009). Over- or under-conditioned cows produce less milk and have inferior reproductive performance than their *normally* conditioned counterparts (Waltner et al., 1993; Domecq et al., 1997a; Hoedemaker et al., 2009). Additionally, low body condition score (**BCS**) has been repeatedly associated with lameness (Gearhart et al., 1990; Hassall et al., 1993; Hoedemaker et al., 2009). Previous research by our group has shown that there is a significant association between under-conditioned cows and the size of their digital cushions; and that cows with thinner digital cushions were at a significantly higher risk of being diagnosed with claw horn disruption lesions (**CHDL**), including sole ulcers and white line disease (Bicalho et al., 2009). The objective of this study was to evaluate the effects of CHDL and BCS at dry-off on survivability, milk production, and reproductive performance during the subsequent lactation. Our research hypothesis was that the presence of CHDL and low BCS at dry-off would have a negative impact on future milk yield and reproductive performance and increase the risk of culling or death.

THE EFFECT OF CHDL AND BCS ON REPRODUCTION

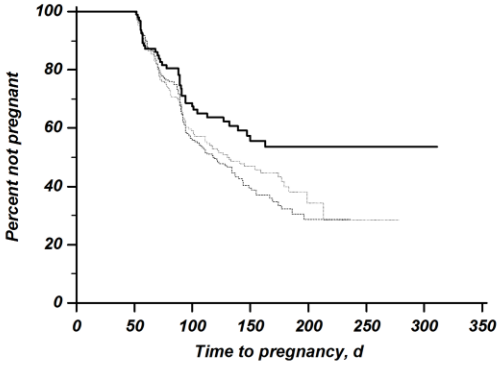
The median calving-to-conception interval for cows without lesions was 119 d and for the cows with CHDL was 163 d (Logrank test, $P = 0.02$). By 200 days in milk (**DIM**), the percentage of cows pregnant was significantly lower for cows with CHDL at dry off; 50 and 70 % of cows with and without CHDL at dry-off, respectively (Figure 1). Additionally, a multivariable Cox's proportional hazard model was performed and the only variables retained in this model were age in days (**AGED**) and the variable CHDL; cows without lesions were 1.4 times more likely to conceive when compared to cows diagnosed with a CHDL at dry-off (hazard ratio = 1.4, $P = 0.02$).

Figure 1. Cows diagnosed with CHDL (interrupted line) had a median calving-to-conception interval of 163-d compared to 119-d for non-lesion cows (solid line).



Cows were assigned to BCS group (**BSCG**) based on BCS, with BCSG 1 having BCS < 3, BCSG 2 having BCS = 3, and BCSG 3 having BCS > 3. By 200 DIM, 70 % of cows in BCSG 2 and BCSG 3 were pregnant, and only 45 % of cows in BCSG 1 were pregnant (Figure 2). The multivariable Cox's proportional hazard model indicated that cows in the BCSG 2 were 1.35 and 1.02 times more likely to conceive than cows in BCSG 1 and 3 respectively ($P = 0.04$).

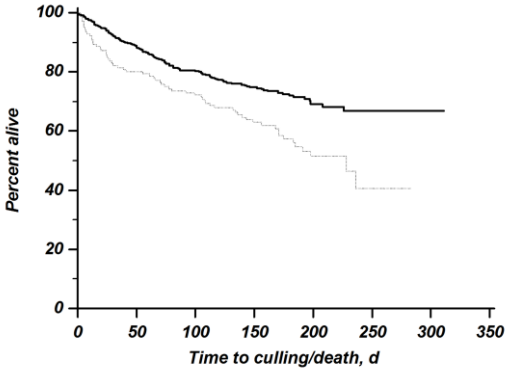
Figure 2. The median calving-to-conception interval for BCSG 2 (inner interrupted line) and 3 (middle interrupted line) was 119 and 132 respectively (*P*-value = 0.02).



THE EFFECT OF CHDL AND BCS ON SURVIVAL

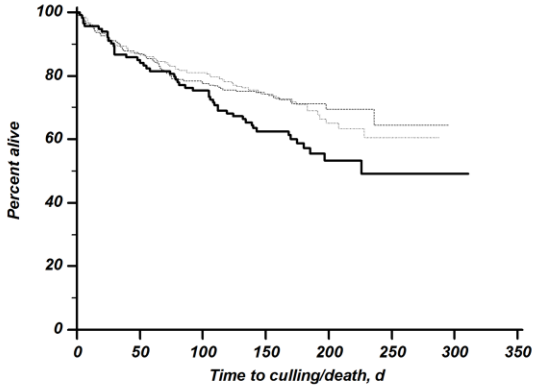
Cox's proportional hazards analysis showed that the hazard of death or culling was significantly greater in cows with CHDL at dry-off, with CHDL cows 1.7 times more likely to die or be culled than cows without CHDL at dry-off ($P < 0.01$). Kaplan-Meier survival analysis showed the median time until death or culling for cows with CHDL was significantly greater than those without CHDL (Figure 3). At 250 DIM, 70 % of the non-lesion cows remained in the herd, while only 40 % of the cows with CHDL at dry-off were still in the herd.

Figure 3. Kaplan-Meier survival analysis of probability of death/culling for cows diagnosed with (n = 140) or without (n = 433) claw horn disruption lesions (CHDL). Median time until death or culling for cows with CDHL (interrupted line) was 228 and was significantly greater than those without CHDL ($P < 0.01$).



Cox's proportional hazards analysis of BCSG showed that the hazard of death or culling was significantly greater in BCSG 1 cows, with BCSG 1 cows 1.55 and 1.47 times more likely to die or be culled than cows in BCSG 2 or 3, respectively ($P < 0.01$). Kaplan-Meier survival analysis showed the median time until death or culling for cows in BCSG 1 was significantly greater than those in BCSG 2 or BCSG 3 (Figure 4). At 250 DIM, approximately 45 % of cows in BCSG 1, 60 % of cows in BCSG 2, and 65 % of cows in BCSG 3 remained in the herd.

Figure 4. Median time until culling/death for the BCSG 1 (solid line) was 226-d and was significantly different from BCSG 2 (outer interrupted line) or BCSG 3 (middle interrupted line) ($P = 0.04$).



THE EFFECT OF CHDL AND BCS ON MILK YIELD

Least square means for average daily milk yield based on BCSG was calculated by group as well as for categorical fixed effects used in the model; lactation number and stage of lactation (Table 1). Milk yield differed significantly based on BCSG as well as for the effects of lactation number and time, with BCSG 1, 2, and 3 cows producing an average of 41.5 kg/d, 44.6 kg/d and 43.6 kg/d, respectively ($P = 0.02$). Average daily milk yield in BCSG 1 cows was significantly lower than in BCSG 2 and 3 cows (Figure 5).

Table 1: Least square means (LSM) of daily milk yield for categorical fixed effects used in the model (lactation number and month of lactation) based on body condition score group (BCSG) at dry-off with BCSG 1 cows having BCS < 3 (n = 113), BCSG 2 cows having BCS = 3 (n = 254), and BCSG 3 cows having BCS > 3 (n = 206).

Variable		LSM (kg/day)	95% C. I.	*P*-value
BCSG	1	41.5	39.8 - 43.3	0.02
	2	44.6	43.4 – 45.8	
	3	43.6	42.4 – 44.9	
Lactation Number	2	44.3	43.2 – 45.5	< 0.01
	≥3	42.2	41.1 – 43.3	
Month of Lactation	1	34.1	33.1 – 35.0	< 0.01
	2	46.1	45.1 – 47.1	
	3	46.6	45.6 – 47.6	
	4	45.8	44.7 – 46.8	
	5	44.5	43.3 – 45.6	
	6	42.5	41.1 – 43.9	

Figure 5: Lactation curve showing milk production in Kg by month of lactation, and by body condition score group (BCSG) at dry-off, with BCSG 1 cows having BCS < 3 (n = 113), BCSG 2 cows having BCS = 3 (n = 254), and BCSG 3 cows having BCS > 3 (n = 206).

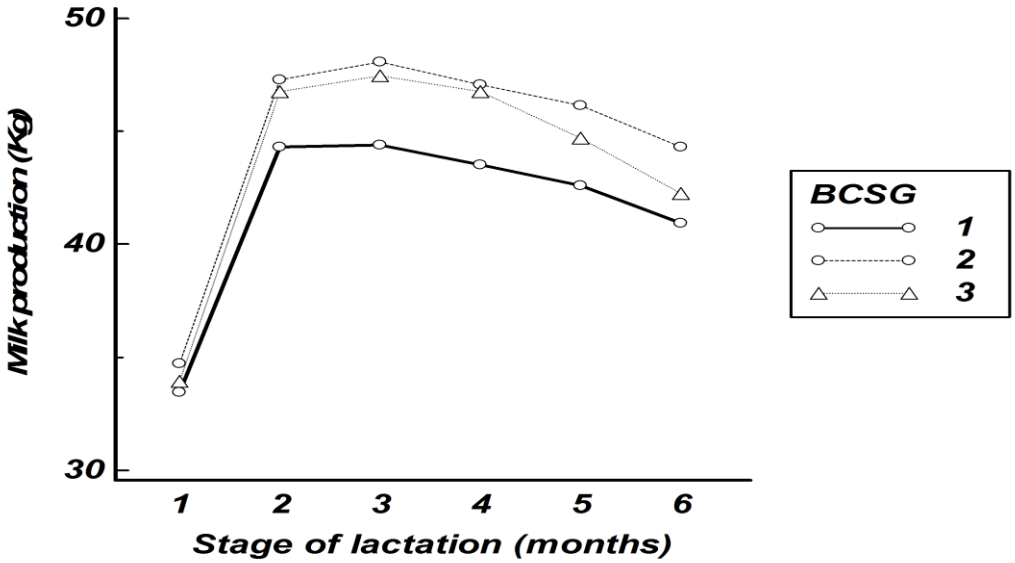


Table 2. Least square means (LSM) of daily milk yield for categorical fixed effects used in the model (lactation number and month of lactation) based on presence (n = 140) or absence (n = 433) of claw horn disruption lesions (CHDL) at dry-off.

Variable		LSM	95% C. I.	*P*-value
CHDL	present	43.5	42.6 - 44.4	0.58
	absent	44.1	42.4 - 45.8	
Lactation Number	2	45.1	43.8 - 46.4	< 0.01
	≥3	42.5	41.4 - 43.6	
Month of Lactation	1	34.2	33.1 - 35.3	< 0.01
	2	46.7	45.5 - 47.8	
	3	47.3	46.2 - 48.5	
	4	46.6	45.4 - 47.8	
	5	45.0	43.7 - 46.3	
	6	43.1	41.5 - 44.6	

Least square means for average daily milk yield were also calculated based on presence of CHDL at dry-off, as well as for categorical fixed effects used in the model (Table 2). Cows diagnosed with CHDL at dry-off had a similar average daily milk yield compared to cows without CHDL at dry-off at 43.5 and 44.1 kg/d, respectively (P = 0.58, Table 2).

LOGISTIC REGRESSION MODEL

A multivariable logistic regression was performed to assess the effect of previous days open (**PDOPN**), lactation number, and previous mature equivalent 305-d milk production (**PME305**) on the odds of low BCS (BCS < 3) at dry off. A total of 237 cows (41 % of enrolled cows) had PDOPN ≤ 91 d; a total of 278 cows (49 % of enrolled cows) had a PME305 > 14,054 kg/305d. Cows with PDOPN ≤ 91 had a 1.6 times higher odds to be classified into the group of under-conditioned cows (BCS < 3) at dry-off. Additionally, cows with PME305 > 14,054 were also at a 1.6 times increased odds of being under-conditioned at dry-off. Cows in lactation ≥ 4 had 2.8 times higher odds and cows in lactation 3 had 1.7 times higher odds of being classified as under-conditioned (BCS < 3) than cows in lactation 2 (Table 3).

DISCUSSION

This study evaluated the effects of CHDL (sole ulcers and white line disease) and BCS at dry-off on survivability, milk production, and reproductive performance during the subsequent lactation. The results indicated that BCSG and CHDL at dry-off were significantly associated with reproductive performance and survivability during the subsequent lactation. Additionally, BCSG was significantly associated with milk production in the subsequent lactation, with under-conditioned cows (BCS < 3)

Table 3. Logistic regression model showing the effect of previous lactation days open (PDOPN), lactation number, and previous lactation mature equivalent 305-d milk (PME305) on the odds of low body condition score (BCS < 3) at dry-off.

Variables	Adjusted odds ratio	*P-value*
PDOPN > 91	*baseline*	0.04
PDOPN ≤ 91	1.6	
Lactation Number = 2	*baseline*	< 0.001
Lactation Number = 3	1.7	
Lactation Number ≥ 4	2.8	
PME305 ≤ 14,054	*baseline*	0.03
PME305 > 14,054	1.6	

producing an average of 3.1 kg/d less milk than cows with BCS = 3.

Multiple studies have found similar association of BCS and future milk production. Roche et al. (2007) found that BCS at calving, BCS nadir, and BCS loss from calving to nadir had significant effects on milk production, and additional studies have reported that BCS at calving was significantly associated with milk yield (Waltner et al., 1993; Berry et al., 2007). Domecq et al. (1997b) reported that a one-point increase in BCS between dry-off and parturition was associated with an additional 545.5 kg of milk in the first 120 d of lactation. However, a study conducted by Pedron et al. (1993) found no association between BCS at calving and subsequent milk production. The present study differs from the published literature concerning the time of body condition scoring; data in this study were collected at dry-off while many previous studies have assessed BCS at parturition or during early lactation (Berry et al., 2007; Roche et al., 2007; Pedron et al., 1993).

The biological justification for the effect of BCS on performance during the subsequent lactation can be explained by the negative energy balance (**NEB**) period experienced by cows from parturition until 40 to 100 DIM (Roche et al., 2007; Coffey et al., 2002). Due to NEB after calving and changes in body reserves, under-conditioned cows have fewer energy resources that can be mobilized for milk production. However, under conditioned cows are at increased risk of several health conditions known to affect milk production, such as lameness and retained placenta (Hoedemaker et al., 2009). In addition under-conditioned cows (BCS < 3) were less likely to conceive than their better conditioned counterparts (BCS ≥ 3). Cows in NEB divert energy from reproduction, resulting in prolonged postpartum anestrous and poorer reproductive performance (Chagas et al., 2007; Peter et al., 2009). Domecq et al. (1997a) reported that cows with BCS loss during the first month of lactation were less likely to conceive than cows that did not lose BCS. Hoedemaker et al. (2009) reported that cows with BCS < 3 at calving had a higher risk of dystocia and retained placenta, and cows with BCS < 3 during early lactation were at a higher risk of developing endometritis and had a lower risk of becoming pregnant when compared to cows with BCS ≥ 3. Hence, the compromised reproductive performance observed in under-conditioned cows.

Data from this study showed that under-conditioned cows (BCSG 1) were at an increased risk of death or culling than cows in BCSG 2 or 3. The relationship between low BCS and decreased reproductive performance may explain the negative effect of BCS on culling, as poor reproductive performance is associated with increased culling (Rajala-Schultz and Gröhn, 1999a). Additionally, as shown in this study, thinner cows tend to produce less milk which can influence survivability because milk yield has a significant effect on culling decisions (Rajala-Schultz and Gröhn, 1999b). Another explanation for the relationship between low BCS and increased culling relates low BCS to lameness. Bicalho et al. (2009) reported that BCS was positively associated with digital cushion thickness, and that thinner digital cushions were associated with a higher prevalence of sole ulcers and white line disease. In this study, cows with CHDL at dry-off were more likely to be culled than cows diagnosed without CHDL, and presumably cows with low BCS had a thin digital cushion and were at increased risk of having a CHDL and therefore culling. In the present study, cows affected with CHDL at dry-off received appropriate therapeutic hoof trimming immediately after the diagnosis. Consequently, it is possible that the negative effect of CHDL and BCSG encountered in this study were conservative estimates had the cows not been appropriately treated. From this study, a BCS of 3 at dry-off optimized subsequent lactation milk yield, reproductive performance, and longevity.

Cows affected with CHDL at dry off were less likely to conceive and more likely to die or be culled when compared to cows with no CHDL at dry-off. The effect of lameness on reproductive performance and survivability has been extensively reported in the literature (Rajala-Schultz et al., 1999; Warnick et al., 2001). Furthermore, the effect of CHDL on subsequent lactation milk production was not significant. Several studies have attempted to estimate the effect of lameness on milk production and the published literature presents conflicting results. Hernandez et al. (2002) reported a non-significant difference in milk production with lame cows producing less milk than their non-lame counterparts. Sogstad et al. (2007) did not find an association between lameness and milk production, but reported an increase in milk yield in cows after hoof trimming. Other studies have found a significant negative effect of lameness on milk yield (Rajala-Schultz et al., 1999; Warnick, 2001; Bicalho, 2008). In the present study, CHDL was evaluated at dry off in contrast with others (Rajala-Schultz et al., 1999; Warnick, 2001; Bicalho, 2008) who evaluated

the effect of lameness events throughout lactation on milk production.

This study also found a positive relationship between PDOPN and BCS at dry-off and a negative association between PME305 and BCS at dry-off. As a consequence of NEB, cows typically lose body condition from parturition up until 60 DIM and once the NEB is resolved (40 – 100 DIM) cows will gradually recover BCS until the end of lactation (Coffey et al., 2002; Chagas et al., 2007; Roche et al., 2007). Thus, it is logical to conclude that cows conceiving earlier in lactation (PDOPN ≤ 91) had less time to recover BCS, as the time from the cessation of NEB until the end of lactation would be significantly shorter compared to cows that conceived later in lactation (PDOPN > 91). The economic consequences of strategically extending the lactation of high producing cows have been evaluated before (Arbel et al., 2001). The results of the present study suggests that extending the lactation of certain high producing cows by extending the voluntary waiting period can lead to higher median BCS at dry off and potentially improve health and production in the subsequent lactation.

CONCLUSIONS

Cows diagnosed with CHDL at dry-off were more likely to die or be culled and less likely to become pregnant in the next lactation than cows without CHDL. Cows under-conditioned (BCSG 1) at dry-off were more likely to be culled, produced less milk, and had inferior reproductive performance on the subsequent lactation compared to their better conditioned herdmates (BCSG > 1). Additionally, cows scored as over-conditioned at dry-off (BCSG 3) consistently underperformed cows in the BCS = 3 at dry-off, which was considered an optimal body condition in this study. Moreover, cows that had PDOPN ≤ 91 and cows with PME305 > 14,054 were more likely to be classified into the group of under-conditioned (BCS < 3) cows at dry-off. Further studies are needed to evaluate strategies to mitigate the prevalence, incidence, and consequences of under-conditioned and lame cows.

REFERENCES

Arbel, R., Y. Bigun, E. Ezra, H. Sturman, and D. Hojman. 2001. The effect of extended calving intervals in high-yielding lactating cows on milk production and profitability. J. Dairy Sci. 84:600-608.

Berry, D. P., F. Buckley, and P. Dillon. 2007. Body condition score and live-weight effects on milk production in Irish Holstein-Friesian dairy cows. Animal 1:1351-1359.

Bicalho, R. C., V. S. Machado, and L. S. Caixeta. 2009. Lameness in dairy cattle: A debilitating disease or a disease of debilitated cattle? A cross-sectional study of lameness prevalence and thickness of the digital cushion. J. Dairy Sci. 92:3175-3184.

Bicalho, R. C., L. D. Warnick, and C. L. Guard. 2008. Strategies to analyze milk losses caused by diseases with potential incidence throughout the lactation: A lameness example. J. Dairy Sci. 91:2653-2661.

Chagas, L. M., J. J. Bass, D. Blache, C. R. Burke, J. K. Kay, D. R. Lindsay, M. C. Lucy, G. B. Martin, S. Meier, F. M. Rhodes, J. R. Roche, W. W. Thatcher, and R. Webb. 2007. Invited review: New perspectives on the roles of nutrition and metabolic priorities in the subfertility of high-producing dairy cows. J. Dairy Sci. 90:4022-4032.

Coffey, M. P., G. Simm, and S. Brotherstone. 2002. Energy balance profiles for the first three lactations of dairy cows estimated using random regression. J. Dairy Sci. 85:2669-2678.

Domecq, J. J., A. L. Skidmore, J. W. Lloyd, and J. B. Kaneene. 1997a. Relationship between body condition scores and conception at first artificial insemination in a large dairy herd of high yielding Holstein cows. J. Dairy Sci. 80:113-120.

Domecq, J. J., A. L. Skidmore, J. W. Lloyd, and J. B. Kaneene. 1997b. Relationship between body condition scores and milk yield in a large dairy herd of high yielding Holstein cows. J. Dairy Sci. 80:101-112.

Gearhart, M. A., C. R. Curtis, H. N. Erb, R. D. Smith, C. J. Sniffen, L. E. Chase, and M. D. Cooper. 1990. Relationship of changes in condition score to cow health in Holsteins. J. Dairy Sci. 73:3132-3140.

Hassall, S. A., W. R. Ward, and R. D. Murray. 1993. Effects of lameness on the behavior of cows during the summer. Vet. Rec. 132:578-580.

Hernandez, J., J. K. Shearer, and D. W. Webb. 2002. Effect of lameness on milk yield in dairy cows. J. Am. Vet. Med. Assoc. 220:640-644.

Hoedemaker, M., D. Prange, and Y. Gundelach. 2009. Body condition change ante- and postpartum, health and reproductive performance in German Holstein cows. Reprod. Domest. Anim. 44:167-173.

Pedron, O., F. Cheli, E. Senatore, D. Baroli, and R. Rizzi. 1993. Effect of body condition score at calving on performance, some blood parameters, and milk fatty acid composition in dairy cows. J. Dairy Sci. 76:2528-2535.

Peter, A. T., P. L. Vos, and D. J. Ambrose. 2009. Postpartum anestrous in dairy cattle. Theriogenology 71:1333-1342.

Rajala-Schultz, P. J., and Y. T. Gröhn. 1999a. Culling of dairy cows. Part II. Effects of diseases and reproductive performance on culling in Finnish Ayrshire cows. Prev. Vet. Med. 41:279-294.

Rajala-Schultz, P. J., and Y. T. Gröhn. 1999b. Culling of dairy cows. Part III. Effects of diseases, pregnancy status and milk yield on culling in Finnish Ayrshire cows. Prev. Vet. Med. 41:295-309.

Rajala-Schultz, P. J., Y. T. Gröhn, and C. E. McCulloch. 1999. Effects of milk fever, ketosis, and lameness on milk yield in dairy cows. J. Dairy Sci. 82:288-294.

Roche, J. R., D. P. Berry, J. M. Lee, K. A. Macdonald, and R. C. Boston. 2007. Describing the body condition score change between successive calvings: A novel strategy generalizable to diverse cohorts. J. Dairy Sci. 90:4378-4396.

Roche, J. R., N. C. Friggens, J. K. Kay, M. W. Fisher, K. J. Stafford, and D. P. Berry. 2009. Invited review: Body condition score and its association with dairy cow productivity, health, and welfare. J. Dairy Sci. 92:5769-5801.

Sogstad, A. M., O. Osteras, T. Fjeldaas, and A. O. Refsdal. 2007. Bovine claw and limb disorders at claw trimming related to milk yield. J. Dairy Sci. 90:749-759.

Vermunt, J. J. 2007. One step closer to unravelling the pathophysiology of claw horn disruption: For the sake of the cows' welfare. Vet. J. 174:219-220.

Waltner, S. S., J. P. McNamara, and J. K. Hillers. 1993. Relationships of body condition score to production variables in high producing Holstein dairy cattle. J. Dairy Sci. 76:3410-3419.

Warnick, L. D., D. Janssen, C. L. Guard, and Y. T. Gröhn. 2001. The effect of lameness on milk production in dairy cows. J. Dairy Sci. 84:1988-1997.

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