

# Comparison of milk yield in dairy cows with different degrees of lameness

Jorge A. Hernandez, DVM, MPVM, PhD; Eduardo J. Garbarino, DVM, MS; Jan K. Shearer, DVM, MS; Carlos A. Risco, DVM; William W. Thatcher, PhD

**Objective**—To compare milk yield among cows classified as nonlame, moderately lame, and lame and to examine the relationship between severity of lameness and milk yield in cows classified as lame during the first 100 days after parturition.

**Design**—Longitudinal study.

**Animals**—465 Holstein cows.

**Procedure**—Cows were examined weekly during the first 100 days after parturition and assigned a lameness score by use of a 6-point locomotion scoring system (ie, 0 to 5). Milk yield was compared among cows classified as nonlame, moderately lame, and lame. Among cows classified as lame (locomotion score  $\geq 4$ ), milk yield was compared for cows with low, medium, and high cumulative locomotion scores. Cows classified as lame were further examined on a tilt table for diagnosis and treatment of lameness.

**Results**—84 (18%), 212 (46%), and 169 (36%) cows were classified as nonlame, moderately lame, and lame, respectively. Among cows in their second or later lactations, milk yield in lame cows was significantly lower than that in moderately lame and nonlame cows. In addition, among cows classified as lame, milk yield was significantly lower in cows with high locomotion scores during the first 100 days after parturition, compared with cows with low scores. Most (58%) cows classified as lame had laminitis.

**Conclusions and Clinical Relevance**—Results indicate a linear relationship between increasing degree of lameness and decreasing milk yield among cows in their second or later lactations. The locomotion scoring system used in this study may be a useful management tool that veterinarians and dairy farmers could adopt for early detection of lameness in dairy cows. (*J Am Vet Med Assoc* 2005;227:1292–1296)

The relationship between lameness and milk yield in US dairy herds has been studied. In a study<sup>1</sup> conducted in California, lameness was more common in high-producing cows. In another study conducted in

New York,<sup>2</sup> lame cows produced less milk than nonlame cows and the decrease in milk yield was more substantial in lame cows in their second or later lactations. More recently, in a study<sup>3</sup> conducted in Florida, lame cows with interdigital phlegmon produced less milk, compared with nonlame cows.

The effect of severity of lameness on milk yield has not been investigated by means of objective research methods. Results of recent studies reveal a linear relationship between increasing severity of lameness during the early postpartum period and risk of delayed resumption of estrous cycling<sup>4</sup> and conception failure<sup>5</sup> in Holstein cows. Because lame cows spend less time eating<sup>6</sup> and have more severe loss of body condition than healthy postpartum cows, we hypothesized that an increasing degree of lameness would have a greater impact on milk yield. The objectives of the study reported here were to compare milk yield among cows classified as nonlame, moderately lame, and lame and to examine the relationship between severity of lameness and milk yield in cows classified as lame during the first 100 days after calving.

## Materials and Methods

**Cows and herd management**—Cows were from a high-producing dairy herd (rolling herd average milk production, approx 11,818 kg [26,000 lb]/y) of approximately 600 Holstein cows in Florida. Beginning 60 to 70 days after calving, 500 mg of bovine somatotropin<sup>a</sup> was administered to all cows every 2 weeks.

**Study design**—The study was designed as a longitudinal study. Five hundred sixty-three Holstein cows that calved from June 1, 2002 through May 31, 2003 were considered for inclusion; 465 cows with complete records were used in the study. Cows were classified into 1 of 3 categories of lameness during the first 100 days postpartum by use of a 6-point locomotion scoring system.<sup>4,5</sup> Milk yield was compared among cows classified as nonlame, moderately lame, and lame. In addition, milk yield was compared among cows classified as lame with low (22 to 42), medium (43 to 47), and high (48 to 63) cumulative sums of weekly locomotion scores. The interval of 100 days after calving was chosen as the interval of interest because the incidence of lameness was highest (79%) during that period (Figure 1) and because we expected that the impact of lameness on milk yield would be highest during that period.

**Data collection**—The following data were collected from farm records for each cow: lactation number, calving date, calving season (winter months, January to April and October to December; summer months, May to September), dystocia (yes or no), retained placenta (yes or no), metritis (yes or no), mastitis (yes or no), ketosis (yes or no), days in lactation, and 305-day mature equivalent (ME) milk yield.

**Diagnosis of lameness**—During the first 100 days postpartum, cows were examined for lameness and scored weekly (on Tuesdays) according to a 6-point locomotion scoring

From the Department of Large Animal Clinical Sciences, College of Veterinary Medicine (Hernandez, Garbarino, Shearer, Risco), and Department of Animal Sciences, Institute of Food and Agricultural Sciences (Thatcher), University of Florida, Gainesville, FL 32610-0136.

Supported in part by the National Research Initiative of the USDA Cooperative State Research, Education and Extension Service (grant No. 2002-35204-12308); the Florida Dairy Check-Off Program; and the University of Florida College of Veterinary Medicine.

The authors thank Shawn Ward, Marie-Joelle Thatcher, Megan Elliott, Manon Schuppers, Brooke Bloomberg, and Emily Piercefield for technical assistance.

Address correspondence to Dr. Hernandez.

system (ie, 0 to 5).<sup>4,5</sup> Cows were observed and scored by the same veterinarian as they walked out of the washing pen to the holding area before milking. Cows were classified into 1 of 3 categories of lameness: nonlame, moderately lame, or lame.<sup>5</sup> Cows classified as lame (locomotion score  $\geq 4$ ) were examined on a tilt table for diagnosis and treatment of lameness, and lesions observed and date of occurrence were recorded. Cows classified as lame were further designated as having a low, medium, or high cumulative sum of weekly locomotion scores on the basis of the frequency of distribution (ie, in the low, middle, or high 33rd percentiles).

**Outcome**—The outcome of interest was milk yield; the 305-day ME was used as a summary measure of cows' milk

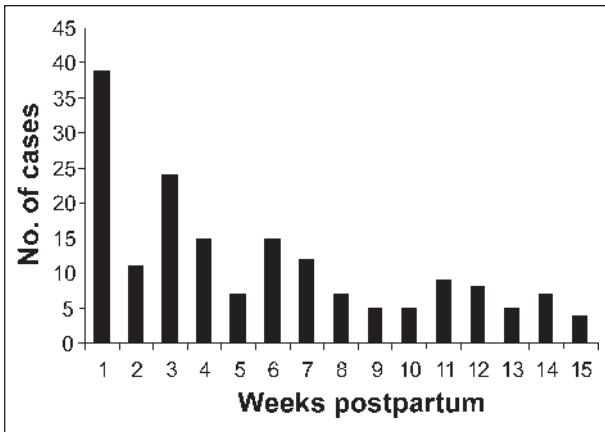


Figure 1—New cases of cows classified as lame during the first 15 weeks (100 days) after parturition.

yield. Milk yield data were collected from farm records on the basis of the level of production at the time of dry-off (cessation of lactation) or culling.<sup>b</sup>

**Statistical analyses**—The hypotheses that lame or moderately lame cows produce less milk than nonlame cows and that milk yield is lower in lame cows with a high or medium cumulative sum of weekly locomotion scores than in cows with low scores were tested by use of ANOVA and regression analysis for the dependent variable of 305-day ME milk yield. Additional variables (ie, lactation number, calving season, dystocia, retained placenta, metritis, ketosis, and mastitis) were assessed to evaluate possible confounding effects that these factors might have had on milk yield. A 1-sided value of  $P \leq 0.05$  was interpreted to indicate that mean milk yield values differed among lame, moderately lame, and nonlame cows. The distribution of cows by lactation number, calving season, dystocia, retained placenta, metritis, ketosis, mastitis, and number of cows culled during the current lactation was compared among lame, moderately lame, and nonlame cows as well as among lame cows with low, medium, and high cumulative locomotion scores by use of a  $\chi^2$  test; a 2-sided value of  $P \leq 0.05$  was considered significant. We did not compare 10-day-average milk weights because examination of electronic herd records revealed that  $> 50\%$  of the cows had  $\geq 3$  missing milk weight values. We used the projected 305-day ME milk yield instead of the actual 305-day milk yield because 94 (20%) cows were culled within 101 to 305 days postpartum.

In the analysis, nonlame cows were those with scores  $\leq 2$  or a score of 3 for only 1 week's duration. The rationale for classifying cows with scores  $\leq 2$  as nonlame in the statistical analysis was that their gait was normal. To decrease the risk of misclassification, moderately lame cows were those with a score of 3 for 2 consecutive weeks. Lame cows were those classified at least once with a locomotion score  $\geq 4$ . To test the sec-

Table 1—Distribution (No. [%]) of milk-yield-related variables in cows classified as nonlame ( $n = 84$ ), moderately lame (212), or lame (169) during the first 100 days after parturition.

Variable	Nonlame	Moderately lame	Lame	P value
Lactation				$< 0.01$
1	11 (13)	74 (35)	82 (49)	
$\geq 2$	73 (87)	138 (65)	87 (51)	
Calving season				0.26
Winter	51 (61)	141 (67)	99 (59)	
Summer	33 (39)	71 (33)	70 (41)	
Dystocia				0.06
No	81 (96)	186 (88)	154 (91)	
Yes	3 (4)	26 (12)	15 (9)	
Retained placenta				0.26
No	77 (92)	179 (84)	146 (86)	
Yes	7 (8)	33 (16)	23 (14)	
Metritis				0.05
No	73 (87)	158 (75)	126 (75)	
Yes	11 (13)	54 (25)	43 (25)	
Ketosis				0.02
No	63 (75)	122 (58)	105 (62)	
Yes	21 (25)	90 (42)	64 (38)	
Displaced abomasum				0.51
No	83 (99)	207 (98)	163 (96)	
Yes	1 (1)	5 (2)	6 (4)	
Mastitis				0.92
No	58 (69)	145 (68)	113 (67)	
Yes	26 (31)	67 (32)	56 (33)	
Culled cows during current lactation				0.78
No	54 (64)	136 (64)	103 (61)	
Yes	30 (36)	76 (36)	66 (39)	
Days in lactation*	336 $\pm$ 9	347 $\pm$ 6	346 $\pm$ 7	0.64
Milk yield (lb)*	26,103 $\pm$ 426 <sup>ab</sup>	26,556 $\pm$ 246 <sup>a</sup>	25,398 $\pm$ 342 <sup>b</sup>	$\leq 0.05$

\*Values are reported as mean  $\pm$  SE.  
<sup>a,b</sup>Groups with different superscripts were significantly ( $P < 0.05$ ) different in univariate analysis.

ond hypothesis (severity of lameness), the lame cows were further classified into 1 of 3 groups: cows with low (22 to 42 points), medium (43 to 47), or high (48 to 63) cumulative sums of weekly locomotion scores on the basis of the frequency of distribution (low, middle, and high 33rd percentiles). For all comparisons, a value  $P \leq 0.05$  was considered significant.

## Results

**Lameness**—Eighty-four (18%), 212 (46%), and 169 (36%) of 465 cows were classified as nonlame, moderately lame, and lame, respectively (Table 1). Proportions of cows during the first or later lactations and cows with metritis or ketosis were significantly different among groups. Most (58%) cows classified as lame had laminitis.

**Milk yield in cows classified as nonlame, moderately lame, or lame**—In the univariate analysis, milk yield in lame cows (mean, 11,545 kg [25,398 lb]) was significantly lower than milk yield in moderately lame cows (12,071 kg [26,556 lb]) but was not significantly different from that in nonlame cows (11,865 kg [26,103 lb]; Table 1).

In the multivariate analysis, terms for mastitis and metritis were retained (Table 2). Negative coefficients indicated production losses associated with the study variable, relative to the reference class. There was no significant difference in milk yield among nonlame cows (mean, 11,663 kg [25,658 lb]), moderately lame cows (11,892 kg [26,163 lb]), and lame cows (11,380 kg [25,036 lb];  $P = 0.12$ ). However, among cows in the second or later lactations, milk weights of 87 lame cows (10,801 kg [23,762 lb]) were significantly ( $P = 0.01$ ) less than those of 138 moderately lame cows (11,744 kg [25,837 lb]) and 73 nonlame cows (11,675 kg [25,685 lb]); variables included in the model explained 9% of the variation in milk yield ( $R^2 = 0.09$ ).

**Severity of lameness**—The number of weeks cows were lame was significantly higher in cows classified as lame and with high cumulative locomotion scores (7 weeks), compared with those with low (1 week) or medium scores (2 weeks; Table 3). The number of weeks lame was higher ( $P = 0.01$ ) in lame cows with claw lesions or disorders (5 weeks), compared with the number of weeks in lame cows with laminitis (3 weeks).

**Milk yield in lame cows with different degrees (severity) of lameness**—In the univariate analysis, milk

yield in lame cows with high locomotion scores (mean, 11,291 kg [24,841 lb]) was lower, compared with cows with medium locomotion scores (11,570 kg [25,453 lb]) and cows with low locomotion scores (12,026 kg [26,457 lb];  $P = 0.06$ ; Table 3).

In the multivariate analysis, the term for mastitis was retained (Table 4). We observed a dose-response effect between severity of lameness and milk yield, but

Table 3—Distribution (No. [%]) of milk-yield-related variables in 169 cows classified as lame and with a low ( $n = 49$ ), medium (66), or high (54) cumulative locomotion scores.

Variable	Low	Medium	High	<i>P</i>
Lactation				0.31
1	28 (57)	31 (47)	23 (43)	
$\geq 2$	21 (43)	35 (53)	31 (57)	
Calving season				< 0.01
Winter	20 (41)	45 (68)	34 (63)	
Summer	29 (59)	21 (32)	20 (37)	
Dystocia				0.58
No	44 (90)	62 (94)	48 (89)	
Yes	5 (10)	4 (6)	6 (11)	
Retained placenta				0.98
No	42 (86)	57 (86)	47 (87)	
Yes	7 (14)	9 (14)	7 (13)	
Metritis				0.82
No	38 (76)	49 (74)	39 (72)	
Yes	11 (14)	17 (26)	15 (28)	
Ketosis				0.35
No	34 (69)	41 (62)	30 (56)	
Yes	15 (31)	25 (38)	24 (44)	
Displaced abomasum				0.26
No	49 (100)	63 (91)	51 (94)	
Yes	0 (0)	3 (9)	3 (6)	
Mastitis				0.92
No	33 (67)	43 (65)	37 (69)	
Yes	16 (33)	23 (35)	17 (31)	
Culled cows during current lactation				0.35
No	33 (67)	41 (62)	29 (54)	
Yes	16 (33)	25 (38)	25 (46)	
Weeks lame*	1.4 $\pm$ 0.1 <sup>a</sup>	2.1 $\pm$ 0.1 <sup>a</sup>	7.6 $\pm$ 0.4 <sup>b</sup>	$\leq 0.05$
Days in lactation*	347 $\pm$ 13	348 $\pm$ 11	344 $\pm$ 15	0.97
Milk yield (lb)*	26,457 $\pm$ 536	25,453 $\pm$ 525	24,841 $\pm$ 526	0.06

\*Values are reported as mean  $\pm$  SE.  
<sup>a,b</sup>Groups with different superscripts are significantly ( $P \leq 0.05$ ) different.

Table 2—Milk yield in cows classified as nonlame, moderately lame, or lame in the first 100 days after parturition. Values are adjusted for the effects of mastitis and metritis.

Variable	Mean milk yield (lb)	Coefficient	SE	<i>P</i> value
All cows				
Nonlame ( $n = 84$ )	25,658	NA	NA	NA
Moderately lame (212)	26,163	504.4	506.9	0.16
Lame (169)	25,036	-622.1	524.1	0.12
Cows in first lactation				
Nonlame (11)	26,120	NA	NA	NA
Moderately lame (74)	27,125	1,004.8	1,064.2	0.17
Lame (82)	26,656	536.3	1,058.1	0.30
Cows in second or later lactation				
Nonlame (73)	25,685	NA	NA	NA
Moderately lame (138)	25,837	151.6	608.7	0.80
Lame (87)	23,762	-1,922.7	663.1	< 0.01

NA = Not applicable.

Table 4—Milk yield in the same lame cows as in Table 3. Values are adjusted for effects of mastitis.

Lameness score	Mean milk yield (lb)	Regression coefficient	SE	P value
Low (n = 49)	26,044.5	NA	NA	NA
Medium (66)	25,068.3	-976.2	725.2	0.09
High (54)	24,400.8	-1,643.7	756.2	0.01

the relationship was not significant. Among cows classified as lame, cows with high cumulative locomotion scores produced less milk than cows with medium scores and cows with medium scores produced less milk than cows with low scores. Cows with high scores produced 304 kg (668 lb) less milk than cows with medium scores, but this difference was not significant ( $P = 0.17$ ). Cows with medium scores produced 444 kg (976 lb) less milk than cows with low scores, but this difference was not significant ( $P = 0.09$ ). Cows with high scores produced 747 kg (1,643 lb) less milk than cows with low scores ( $P = 0.01$ ). Variables included in the model explained 10% of the variation in milk yield ( $R^2 = 0.10$ ).

## Discussion

Previous knowledge regarding the relationship between lameness and milk yield in US dairy herds is limited to 3 studies conducted in California,<sup>1</sup> New York,<sup>2</sup> and Florida.<sup>3</sup> The studies from California and Florida were retrospective in nature, the study animals were limited to cows with or without a history of lameness as determined by examination of herd records, and the severity of lameness was not investigated. The study from California revealed a positive association between lameness and milk yield on a 500-cow commercial dairy. Cows that developed lameness within 49 days had higher milk yield up to 21 days and 49 to 119 days postpartum; lameness was mostly caused by sole ulcers and white line lesions. During diagnosis and treatment of lameness, milk yield was reduced but increased thereafter. The positive association between lameness and milk yield during early lactation suggested that high production was a risk factor for lameness.<sup>1</sup> The study<sup>3</sup> in Florida revealed a negative effect of lameness on milk yield on a 500-cow university dairy. Lame cows with interdigital phlegmon had a decrease in mean milk yield of approximately 857 kg (1,885 lb; 10%), compared with nonlame cows. Chronic interdigital phlegmon is characterized by frequent involvement of tendon and bone tissues, long-standing infection, and failure to respond to antimicrobial treatment.<sup>7</sup> In the Florida study, most lame cows with interdigital phlegmon were affected during the early part of lactation, when cows reach peak yields. These findings suggested that cows sufficiently affected with lameness from interdigital phlegmon during early lactation may adversely affect milk yield during that lactation. In the New York study,<sup>2</sup> a negative effect of lameness on milk yield was reported on 2 commercial dairies with 1,800 and 700 cows. Milk yield of lame cows was 0.5 to 1.5 kg/d (1.1 to 3.3 lb/d) lower for 2 or more weeks after lameness was diagnosed, despite treatment. The decrease in milk yield was more substantial in cows in their second or later lactations or in cows with more

severe lameness. In that study, the severity of lameness (ie, mild, moderate, or severe) was evaluated by farm employees but objective definitions of the degrees of lameness were not used. Lack of a systematic method for diagnosis of an increasing or decreasing degree of lameness (eg, by use of a locomotion scoring system or determining the number of weeks lame) makes interpretation of the effect of severity of lameness on milk yield difficult because different farm employees may have used different criteria for designating severity of lameness, which could have led to bias that resulted in misclassification.

We used 305-day ME as a measure of milk yield in cows. This approach has limitations, particularly in the detection of changes in milk yield when the period of decreased milk yield is short. For example, it is possible that lame cows may have had a decrease in milk yield for only a few days, but the changes were not large enough to have an impact on milk yield as measured in our study. In addition, because cows were observed and scored for lameness weekly and lame cows (locomotion score  $\geq 4$ ) with claw lesions were treated immediately after diagnosis, we believe that the detrimental effect of lameness on milk yield may have been mitigated by early diagnosis and treatment.

In the study reported here, the effect of lameness on milk yield was more substantial in cows in their second or later lactations; cows classified as lame in that group produced a mean of 874 kg (1,922 lb) less milk than nonlame cows, representing a decrease in milk yield of 7%. The observed decrease in milk yield observed in such cows was in agreement with results of a previous study<sup>2</sup> in which the maximum changes in milk yield were  $-0.86$  kg/cow/d (1.9 lb/cow/d) in cows in the second or later lactations, compared with  $-0.68$  kg/cow/d (1.5 lb/cow/d) in all lame cows. This more substantial decrease in production that has been observed in older cows may result in part because older cows have higher milk yield; therefore, larger decreases in milk yield are possible.<sup>2</sup>

Lame cows with high cumulative weekly locomotion scores produced less milk than cows with low scores, although the difference was not significant. Among cows classified as lame, cows with high scores produced a mean of 747 kg (1,643 lb) less milk than cows with low scores. The duration and cause of lameness may explain the lower milk yield observed in cows with high scores. The mean number of weeks lame was significantly higher in cows with high scores (7 weeks), compared with cows with low scores (1 week). Also, most cows with high scores had problems involving the claw, including thin soles, white line disease, abscesses, or sole ulcers. Cows with claw lesions were lame for a mean of 5 weeks, despite immediate initiation of treatment after diagnosis. In contrast, most cows with low scores had laminitis and remained lame for a mean of 3 weeks. Cows with laminitis were monitored weekly and were not treated unless claw lesions developed at some point after the diagnosis of laminitis.

Our results indicated a relationship between increasing degree of lameness and decreasing milk yield among cows in their second or later lactation. Among

cows in their second or later lactation, nonlame and moderately lame cows produced more milk than lame cows. In addition, among cows classified as lame, cows with low locomotion scores during the first 100 days postpartum produced more milk than cows with high scores, although the difference was not significant. These results underscore the importance of early detection of lameness and, if necessary, use of adequate treatment strategies including corrective foot trimming<sup>8</sup> in cows with claw lesions or disorders. The locomotion scoring system used in our study may be a useful management tool that veterinarians and dairy farmers could adopt for early detection of lameness in dairy cows. Early diagnosis and intervention may mitigate the effects of lameness and improve milk yield in affected cows.

- 
- a. Posilac, Monsanto Co, St Louis, Mo.  
 b. PCDART, Dairy Records Management Systems, Raleigh, NC.
- 

## References

1. Deluyker HA, Gay JM, Weaver LD, et al. Change of milk yield with clinical diseases for a high producing dairy herd. *J Dairy Sci* 1991;74:436–445.
2. Warnick LD, Jansen D, Guard CL, et al. The effect of lameness on milk production in dairy cows. *J Dairy Sci* 2001;84:1988–1997.
3. Hernandez JA, Shearer JK, Webb DW. Effect of lameness on milk yield in dairy cows. *J Am Vet Med Assoc* 2002;220:640–644.
4. Garbarino EJ, Hernandez JA, Shearer JK, et al. Effect of lameness on ovarian activity in postpartum Holstein cows. *J Dairy Sci* 2004;87:4123–4131.
5. Hernandez JA, Garbarino EJ, Shearer JK, et al. Comparison of the calving-to-conception interval in dairy cows with different degrees of lameness during the prebreeding postpartum period. *J Am Vet Med Assoc* 2005;227:1284–1291.
6. Hassall SA, Ward WR, Murray RD. Effects of lameness on the behaviour of cows during the summer. *Vet Rec* 1993;132:578–580.
7. Fajt VR, Apley MD. Antimicrobial issues in bovine lameness. *Vet Clin North Am Large Anim Pract* 2001;17:159–173.
8. Shearer JK, van Amstel SR. Functional and corrective claw trimming. *Vet Clin North Am Large Anim Pract* 2001;17:53–72.