Effects of Bovine Leukemia Virus Infection on Production and Reproduction in Dairy Cattle

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ABSTRACT

The purpose of this study was to determine the effects of bovine leukemia virus (BLV) infection on production, reproduction and longevity in dairy cattle. The study population was a commercial Holstein dairy herd of approximately 400 milking cows. Cattle were tested for antibodies to BLV at least annually for three years and when culled. Four groups of culled cows were compared: seronegative cows (n = 79), seropositive cows without lymphocytosis (n = 176), seropositive cows with lymphocytosis (≥ 9,000 lymphocytes/microliter) (n = 74), and seropositive cows with lymphosarcoma (n = 29). Seropositive groups of cows were bred more times and had longer calving intervals than seronegative cows. The seropositive groups had greater 305-day ME (mature equivalent) FCM (3.5% fat-corrected milk) per lactation and were older when culled than seronegative cows. However, the percent fat per lactation was greater in seronegative cows. In the last complete lactation, differences in 305-day ME FCM, days open and cull age between groups were reduced and none were significant (p >0.05). In the cull lactation, only cows with lymphocytosis had reduced milk production relative to seronegative cows, although this difference was not significant. After adjustment for initial production and reproductive values, only seropositive nonlymphocytotic cows were culled at a significantly older age than seronegative cattle. Lymphocytotic cows were culled four months younger on average than nonlymphocytotic seropositive cows. Hence, BLV infected cows had greater milk production on average than uninfected cows. Adverse effects of BLV infection were primarily limited to lymphocytotic cows which were culled earlier and had reduced milk production in the cull lactation.

RÉSUMÉ

Cette étude avait pour objectif de vérifier les effets du virus de la leucose bovine sur la production, la reproduction et la longévité des bovins laitiers. La population étudiée se composait d'un troupeau commercial de plus ou moins 400 vaches laitières de race Holstein. Les animaux étaient testés pour leur taux d'anticorps au virus de la leucose bovine au moins une fois l'an et lors de leur sortie du troupeau. Quatre groupes de vaches devant être réformées furent comparés: les vaches séronégatives (n = 79), les vaches séropositives mais sans lymphocytose (n = 176), les vaches séropositives avec lymphocytose (≤9000 lymphocytes/microlitre) (n = 74) et les vaches séropositives avec présence de lymphosarcomes (n = 29). Les vaches séropositives ont eu plus de services par conception et ont eu des intervalles de vêlages plus longs que les groupes séronégatifs. Les groupes séropositifs ont donné plus de lait par lactation (lait corrigé à 3,5% M.G.) et furent réformées plus tard que les vaches séronégatives. Toutefois, le taux de gras était supérieur chez les vaches séronégatives. Lors de la dernière lactation complète, les différences quant à la production de lait (corrigée pour la M.G.) sur 305 jours, le nombre de jours ouverts et l'âge de la réforme étaient grandement diminués et non significatifs (p > 0,05). Lors de la dernière lactation, seules les vaches présentant des signes de lymphocytose ont subi une diminution de production laitière par rapport aux vaches séronégatives, bien que cette différence ne fût pas statistiquement significative. Si on tient compte de rajustements qui s'imposent pour les premières lactations et des données reproductrices, seules les vaches séropositives non « lymphocytosées » furent envoyées à l'abattoir à un âge significativement plus avancé que les vaches séronégatives. Les vaches « lymphocytosées » furent réformées quatre mois plus tôt en moyenne que les vaches séropositives non « lymphocytosées ».

Toutefois les vaches infectées par le virus de la leucose ont produit plus de lait en moyenne que les vaches non infectées. Les effets indésirables causés par le virus de la leucose bovine furent principalement limités aux vaches « lymphocytosées » qui furent réformées plus tôt et qui produisirent moins de lait dans leur dernière lactation. (*Traduit par Dr André Cécyre*)

INTRODUCTION

Bovine leukemia virus (BLV), an exogenous C-type retrovirus with worldwide distribution, is the causative agent of enzootic bovine leukosis. Although BLV infection is asymptomatic in most cattle, approximately 30% of infected cattle develop persistent lymphocytosis (PL) while usually

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less than 5% develop lymphosarcoma (1). Cattle with PL are more likely to develop lymphosarcoma but PL is found in only 50–75% of cattle with lymphosarcoma (2,3).

Although the relationship of BLV infection with these specific subclinical and clinical disorders is well established, the effect of BLV infection on production, reproduction and survival is unclear. Several studies have found no substantial differences in various measures of production or reproduction between BLV infected and uninfected dairy cows (4–7). However, one study found that in spite of higher genetic potential for fat production, BLV infected cows had reduced milk fat percentage relative to uninfected cows (8). The goals of the present study were to determine if production, reproduction or longevity in the herd were influenced by BLV infection, especially in cows with lymphocytosis or lymphosarcoma.

MATERIALS AND METHODS

The study population was a commercial Holstein dairy herd located in western Washington state. It was managed as a closed herd during the study period and all breeding was by artificial insemination. Approximately 400 cows were milked twice daily. They were maintained in covered pens and grouped by production levels. Dry cows were maintained on pasture. Cows in late gestation were kept in a common calving pen until parturition. Within 24 hours postpartum, cows entered the hospital string for freshening and then were placed in the appropriate production pen.

All cows and heifers in the herd were initially tested for antibodies to BLV in November 1983. All heifers retained for the milking herd and all cattle that tested negative on previous tests were tested at six month intervals (April and October) until October 1985 and then again in October 1986. Cattle that were positive for BLV antibodies were not retested until they were culled or at the last yearly testing. Management personnel were unaware of the BLV status of individual cattle in the herd. Serum from blood collected by venipuncture was used to determine BLV infection. The serum was incubated in wells of agar-gel immunodiffusion (AGID) plates with BLV antigens gp51 and p24. Plates were examined for antigen-antibody precipitin lines after 48 and 72 hours of incubation (9). The sensitivity and specificity of this test at 72 hours were previously reported as 94.6% and 96.4%, respectively (10).

Information was collected on cows culled from January 1984 through October 1986 for evaluation of production and reproduction. The cull date and reason for culling were provided by the owner. If lymphosarcoma was diagnosed by the veterinarian for the dairy, lymphosarcoma was given as the reason for culling. If a reason was not provided, it was categorized as unknown. At the time of culling, blood was collected in a heparinized tube for a total and differential white blood cell count (WBC). The Dairy Herd Improvement Association (DHIA) record was obtained for each culled cow for the last month in the herd. This record provided information on production for each lactation over the life of the cow, including total pounds of milk produced, pounds of fat produced, 305-day mature equivalent (ME) milk production, 305-day mature equivalent fat production, and number of days milked. The somatic cell count from the last month of lactation was also provided. Milk and fat values were converted to kilograms (kg) and used to calculate 3.5% fat corrected milk (FCM) values. The DHIA record also contained information on reproductive history, including parturition dates, days open and breeding dates.

Complete records of blood tests were available for 374 (84%) of the 446 cows culled during the study period. Of the 374 cows, 11 had no DHIA record and five had discrepancies between DHIA records and blood test records. Therefore, records from 358 (80%) of the eligible cows were utilized. These cows were sired by more than 88 different bulls and only ten bulls sired more than ten cows (maximum 30 cows).

Cows were categorized into four groups by serological and hematological results at time of culling. The seronegative group (n = 79) included cows with negative AGID tests for BLV. Two groups had positive AGID tests for BLV and no clinical signs of lymphosarcoma. The seropositive group (n = 176) had lymphocyte counts less than 9,000/microliter whereas the lymphocytotic group (n = 74) had lymphocyte counts equal to or greater than 9,000/microliter. This cut off was used because the upper 95% normal prediction limit for lymphocytes from dairy cows free of BLV infection was between 8,000 and 9,000/microliter for cows >24 months old (11). Only one cow in the seronegative group had a lymphocyte count greater than 9,000/microliter (9,048/microliter). Cows in the lymphosarcoma group (n = 29), had a clinical diagnosis of lymphosarcoma and a positive AGID test when culled. Unless otherwise specified, only information from complete lactations was used for comparing production and reproduction parameters. Information from both complete and cull lactations was used for comparing age at calving and calving interval.

The *t*-statistic was used to compare the means of production, reproduction and hematological parameters (12, SPSS/PC+, version 3.1). The results are presented as p-values for two-tailed tests. Because multiple comparisons between groups were examined, results were only considered significant if the differences were still significant at the 0.05 level by the least significant difference (LSD) method (13). When significant heterogeneity of variance was present, the variable was transformed to provide variance homogeneity prior to the LSD test. The sample (Pearson) correlation coefficient was used to determine the index of association (r) and the significance of the association (p) between somatic cell counts and blood counts (13).

To account for factors other than BLV infection that may affect cull rate, adjustments of the crude comparisons were required. Production parameters from the last complete lactation or cull lactation were compared between the BLV seropositive groups and the seronegative group using multiple linear regression to adjust for lactation number, birth cohort and initial production and reproduction parameters. The lactation number, production and reproduction parameters were utilized as linear adjustments. The cohort adjustment used dummy variables for cows born in 1980, 1981, 1982 and after 1982, with cows born prior

to 1980 as the base line. Age at culling was also compared between groups with multiple linear regression to adjust for production parameters of the first lactation and birth cohort effects. For a difference between groups to be significant, the group dummy variables had to contribute significantly to the fit of the model ($p < 0.05$ for a partial F test) and the individual group comparison had to be significant (95% confidence interval of beta excluded 0).

RESULTS

Low milk production was the reason for culling in 42% of seronegative cattle compared to 31% and 28% of seropositive and lymphocytotic cattle, respectively (Table I). Reproductive problems was the reason for culling for about 16% in all three groups. Although the expected numbers were small (3.1 and 1.2 cows, respectively), neither structural udder problems nor old age was given as the reason for culling in seronegative cows. Similarly, mammary gland infection was not given as a reason for culling in lymphocytotic cows (3.1 cows expected).

The mean age at culling was significantly greater for the seropositive (58 months), lymphocytosis (52 months) and lymphosarcoma (58 months) groups than the seronegative (43 months) group (Table II). To determine if differences in mean cull ages were due to BLV infection, adjustment was made for factors that were associated with BLV infection and culling. When adjusted for birth cohort, the 305-day ME FCM and days open from first lactation (complete or incomplete), differences in mean cull ages between the groups were greatly reduced. Cows in the seropositive group were culled when 6.0 months (95% CI, 3.5–8.6) older than seronegative cows (Table III). Cows in the lymphocytosis and lymphosarcoma groups were also culled at older ages than seronegative cows, but the differences in mean cull ages were smaller and not significant (95% CI included 0). Compared to seropositive cows, lymphocytotic cows were culled when 3.9 (95% CI, 1.3–6.5) months younger.

The mean white blood cell and lymphocyte counts were significantly greater in the three seropositive groups than in the seronegative group (Table II). The mean neutrophil counts were also higher in the seropositive groups. The mean somatic cell counts from the last month in the milking herd were significantly increased in the three seropositive groups compared to seronegative cattle (Table II). However, there was no correlation between somatic cell count and any of the blood counts (white blood cell, lymphocyte or neutrophil) within each group or all groups combined as all correlation coefficients were < 0.20.

In general, the seropositive groups were older at calving for each lactation and had longer calving intervals than seronegative cattle (Table IV). Seropositive groups had longer open periods and were bred more times per complete lactation than the seronegative group. There were no consistent differences in reproductive parameters between seropositive cows with and without lymphocytosis (Table IV). When adjusted for birth cohort and lactation number, the differences in days open in the last complete lactation between the seropositive groups and the seronegative group were no longer significant (Table III).

The seropositive groups of cows had greater 305-day ME FCM per lactation, actual FCM per lactation, days milked per lactation, FCM per day milked per lactation and lifetime FCM per day milked than seronegative cows (Table V). The percent fat per lactation and percent fat for lifetime production were lower for the seropositive groups than seronegative cows (Table V). Of the seropositive groups, cows with lymphosarcoma had the highest, and the seropositive group of cows had the lowest milk production levels. The only significant difference in production found between seropositive cows with and without lymphocytosis was a lower mean lifetime FCM per day milked for the former group (Table V). Also, the percent fat in milk was lower in later lactations in this group. When adjusted for birth cohort and lactation number, the differences in FCM per day in the last complete lactation between the seropositive groups and the seronegative group were not significant ($p = 0.12$). The 305-day ME FCM for the last complete lactation was significantly greater for the seropositive groups than the seronegative group when adjusted for birth cohort and lactation number. However, with additional adjustment for 305-day ME FCM of the first lactation, the differences were reduced and none were significant (Table III). With similar adjustments, the 305-day ME FCM from the cull lactation was greater for the seropositive and lymphosarcoma groups and lower for the lymphocytosis group compared to the seronegative group but these differences were not significant (Table III).

TABLE I. Measures used for culling cattle at a commercial dairy

Reason culled	Percentage of cows culled			
	Seronegative (79)[b]	Seropositive (176)	Lymphocytosis (74)	Total[a] (329)
Low milk production	41.8	31.3	28.4	33.1
Reproductive problems	15.2	16.5	17.6	16.4
Lameness/Hoof disorders	1.3	2.8	1.4	2.1
Injuries	2.5	2.3	6.8	3.3
Abnormal udder structure	0.0	5.1	5.4	4.0
Mammary gland infection	6.3	5.1	0.0	4.3
Other medical problems	1.3	3.4	1.4	2.4
Old age	0.0	2.3	1.4	1.5
Unknown or missing	31.6	31.3	37.8	32.8

[a]Excludes lymphosarcoma as cattle diagnosed with lymphosarcoma were assigned this reason for culling
[b]Number in group

DISCUSSION

As in this study, low milk produc-

tion and reproductive problems have been the most frequently reported reasons for culling in dairy herds (17). In this study, a higher proportion of uninfected cows were culled, especially at younger ages, for poor production than in the BLV infected groups. When stratified by cull lactation number, the mean 305-day ME FCM from the first lactation was consistently lower for cows that remained uninfected than infected cows (data not shown). Possible explanations for these findings are that BLV infection stimulates milk production or that high production increases the likelihood of acquiring infection. The latter seems more probable due to the nature of spread of BLV and management practices of most modern dairies.

After adjustment for birth cohort and initial production levels, the lymphocytosis and lymphosarcoma groups of cows were about the same mean age at culling as uninfected cows while infected cows without lymphocytosis were six months older. This suggests that seropositive cows without lymphocytosis represent the potential for survival of BLV infected cows and that cows with physiological changes associated with BLV infection have reduced survival. It would not be expected, however, that BLV infected cows remain in the herd longer than uninfected cows with similar initial production. This may indicate inadequate control of confounding by milk production levels or some other confounder in the analysis. When comparing infected groups, lymphocytotic cows were culled four months younger on average than infected cows without lymphocytosis after accounting for birth cohort and initial production. Previous studies reported that infected cows with lymphocytosis were the same age or older, on average, than infected cows without lymphocytosis (8,14,15,16) and that the mean lymphocyte count increased with age in infected cows (15). Therefore, the younger age at culling for lymphocytotic cows is probably not due to the age distributions of lymphocytotic and nonlymphocytotic cows in the herd. The decreased survival for lymphocytotic cows, in spite of similar initial production and last complete lactation production, suggests a more rapid decrease in production in the cull lac-

TABLE II. Comparison of age, lactation, blood and somatic cell counts in bovine leukemia virus seronegative and seropositive groups of dairy cows when culled

Group	Number	Mean	Standard deviation	p-value
Age at culling (Months)				
Seronegative	79	42.8	14.6	
Seropositive	176	58.1	17.9	0.00[a,e]
Lymphocytosis	74	51.7	15.4	0.00[b,e]
Lymphosarcoma	29	57.9	17.9	0.00[c,e]
Seropos vs lymphocytosis				0.01[d,e]
Lactation at culling				
Seronegative	79	1.9	1.1	
Seropositive	176	3.0	1.3	0.00[e]
Lymphocytosis	74	2.6	1.2	0.00[e]
Lymphosarcoma	29	2.9	1.2	0.00[e]
Seropos vs lymphocytosis				0.04[e]
White blood count				
Seronegative	79	7864.1	2619.2	
Seropositive	176	9059.0	3285.5	0.00[e]
Lymphocytosis	74	20044.7	7606.1	0.00[e]
Lymphosarcoma[f]	28	27157.1	32756.0	0.00[e]
Seropos vs lymphocytosis				0.00[e]
Lymphocyte count				
Seronegative	79	4184.6	1605.3	
Seropositive	176	4773.8	2047.0	0.01
Lymphocytosis	74	16287.5	7541.6	0.00[e]
Lymphosarcoma[f]	28	22206.0	32985.1	0.01[e]
Seropos vs lymphocytosis				0.00[e]
Neutrophil count				
Seronegative	79	3679.5	1746.1	
Seropositive	176	4285.2	2701.4	0.03
Lymphocytosis	74	3757.2	2128.4	0.80
Lymphosarcoma[f]	28	4951.1	3396.7	0.07
Seropos vs lymphocytosis				0.10
Somatic cell count				
Seronegative	79	271.0	839.9	
Seropositive	176	619.7	989.8	0.01[e]
Lymphocytosis	74	509.5	1145.5	0.15[e]
Lymphosarcoma	29	957.2	1930.9	0.09[e]
Seropos vs lymphocytosis				0.44

[a] Comparison of seronegative and seropositive groups
[b] Comparison of seronegative and lymphocytosis groups
[c] Comparison of seronegative and lymphosarcoma groups
[d] Comparison of seropositive and lymphocytosis groups
[e] Significant at the 0.05 level by LSD for multiple comparisons (for transformed variable where heterogeneity in variance was present)
[f] One outlier omitted (WBC = 450000)

TABLE III. Adjusted differences in various parameters between bovine leukemia virus seronegative and seropositive groups of dairy cows

	Mean differences and 95% confidence intervals by group		
Variable	Seropositive	Lymphocytosis	Lymphosarcoma
Cull age[a] (Months)	6.0 (3.5 - 8.6)	2.1 (−0.9 - 5.1)	3.7 (−0.3 - 7.8)
Days open[b]	11.6 (−6.0 - 29.2)	12.1 (−8.0 - 32.2)	13.0 (−12.3 - 38.3)
305-day ME FCM Last complete lactation[c] (kg)	463.8 (−28.3 - 955.8)	348.5 (−209.7 - 906.7)	666.8 (−30.9 - 1364.5)
305-day ME FCM Cull lactation[c] (kg)	148.6 (−619.9 - 914.1)	−232.5 (−1101.8 - 636.8)	667.8 (−418.8 - 1754.5)

[a] Adjusted for birth cohort (dummy), 305-day ME FCM (linear) and days open from first lactation (linear)
[b] Adjusted for birth cohort (dummy) and lactation number (linear)
[c] Adjusted for birth cohort (dummy), lactation number (linear) and 305-day ME FCM from the first lactation (linear)

TABLE IV. Parameters of reproductive variables, stratified by lactation, for bovine leukemia virus seronegative and seropositive groups of dairy cows

	Groups of cattle														
	Senonegative			Seropositive			Lymphocytosis				Lymphrosarcoma				
Lact[a]	n	Mean	SD	n	Mean	SD	P[b]	n	Mean	SD	P[c]	n	Mean	SD	P[d]	P[e]
Calving age (Months)															
1	78	24.3	1.7	176	24.6	3.5	0.29	74	23.9	1.7	0.14	29	24.8	1.9	0.21	0.02[f]
2	40	36.1	1.4	154	37.0	3.6	0.02	59	36.8	2.6	0.10	25	37.6	2.6	0.01	0.63
3	22	48.0	1.7	98	49.1	3.0	0.02	36	49.8	3.5	0.02[f]	18	49.9	3.6	0.04[f]	0.24
4	7	60.7	1.6	59	61.4	3.3	0.60	18	61.1	4.2	0.24	9	63.3	4.2	0.12	0.45
5	3	72.3	1.5	34	74.3	4.1	0.43	5	74.0	4.6	0.58	3	73.3	2.3	0.04	0.90
Calving interval (Months)															
2	39	12.1	0.9	154	12.5	1.8	0.04	59	12.8	1.5	0.00[f]	25	12.8	1.8	0.08	0.33
3	22	12.0	1.0	98	12.6	1.7	0.11	36	13.1	2.0	0.00[f]	18	13.1	2.0	0.04[f]	0.10
4	7	12.4	0.8	59	12.7	1.5	0.68	18	12.8	2.1	0.67	9	13.0	1.7	0.42	0.83
5	3	11.7	0.6	34	13.0	1.9	0.25	5	12.8	0.8	0.09	3	13.0	1.7	0.28	0.85
Open (Days)															
1	39	90.6	31.8	154	102.6	54.1	0.08	59	109.4	47.2	0.02	24	112.9	55.2	0.08	0.40
2	22	90.5	28.2	98	104.4	49.4	0.08	36	122.9	57.4	0.01[f]	18	113.4	50.4	0.10	0.07
3	7	92.7	20.9	59	106.7	41.7	0.40	18	107.2	56.4	0.36	9	111.4	42.2	0.30	0.96
4	3	69.0	12.0	34	117.9	56.7	0.15	5	99.0	21.4	0.07	3	116.3	37.3	0.10	0.47
5	1	305.0	0.0	9	135.4	68.2	—	1	92.0	0.0	—	2	117.0	24.0	—	—
Bred (Times)															
1	39	1.6	0.9	154	1.8	1.2	0.17	59	1.9	1.1	0.18	25	1.8	0.9	0.37	0.81
2	22	1.5	0.8	97	1.7	1.2	0.42	36	2.4	1.8	0.01[f]	18	1.7	0.8	0.53	0.04[f]
3	7	1.6	0.6	59	1.8	1.1	0.66	18	2.1	1.4	0.22	9	2.1	1.2	0.28	0.37
4	3	1.0	0.0	34	2.1	1.2	—	5	1.6	0.9	—	3	2.7	0.6	—	0.42
5	1	4.0	0.0	9	2.3	1.9	—	1	2.0	0.0	—	2	4.0	1.4	—	—

[a] Includes complete and cull lactations
[b] Comparison of seronegative and seropositive groups
[c] Comparison of seronegative and lymphocytosis groups
[d] Comparison of seronegative and lymphosarcoma groups
[e] Comparison of seropositive and lymphocytosis groups
[f] Significant at the 0.05 level by LSD for multiple comparisons (for transformed variable where heterogeneity in variance was present)

tation and/or culling due to reasons other than milk production.

Production and reproductive parameters examined in the present study were from culled cattle and are not representative of cattle still in the milking herd. Therefore, the results of the present study are not directly comparable to results of previous studies on production and reproduction (4–8). Comparison of milk production of culled cows in the present study revealed that BLV infected cows were on average higher producers than uninfected cows. This agrees with retrospective (4) and prospective (5) studies that found higher production in BLV infected cows in their first lactation than in uninfected cows. Milk production in subsequent lactations was also higher for the infected groups than the uninfected group in cull cows from this study. Milk production in subsequent lactations was about the same or lower in infected than uninfected cows in previous studies (4,5,7). In cows followed for at least one year, both hematologically normal and lymphocytotic seropositive cows had higher mean milk production in their current lactation than seronegative cows (8). The latter comparison may be biased as no adjustment was made for the older age and, therefore, higher lactation number in infected groups of cows.

The adjusted 305-day ME FCM levels were greater for all seropositive groups of cows in the last complete lactation compared to the seronegative group. Comparison of milk production in the cull lactation revealed that the seropositive and lymphosarcoma groups of cows maintained higher production but lymphocytotic cows had decreased production relative to the seronegative group. These results are consistent with infected cows being higher producers on average than seronegative cows up to the cull lactation. They also provide support that decreased production is responsible for the earlier culling of lymphocytotic cows than seropositive cows. Cows with lymphosarcoma were consistently the highest milk producing group even after adjustment for initial production levels. The high production even in the cull lactation indicates minor effects, if any, on production prior to clinical signs of lymphosarcoma.

The spread of BLV within the milking herd is likely to be highest among high producing cows even if there is no increased susceptibility among high producers. A positive association between transmission and the prevalence of infected cows in pens has been reported (18). Also, the average prevalence was highest in pens with high producing cows (18). The prevalence of BLV infection in high production pens would be expected to be greater because high producers would remain in the herd longer, on average, than lower producing cows and therefore have greater opportunities for infection. In a dairy herd that was BLV seronegative for several years, no variation in susceptibility to infection by age was noted for three years subsequent to a resurgence of BLV infection in the herd (19). Hence, increasing age, by itself, does not appear to

TABLE V. Parameters of production variables, stratified by lactation, for bovine leukemia virus seronegative and seropositive groups of dairy cows

	Groups of cattle														
	Seronegative			Seropositive			Lymphocytosis				Lymphrosarcoma				
Lact	n	Mean	SD	n	Mean	SD	P[a]	n	Mean	SD	P[b]	n	Mean	SD	P[c]	P[d]
305-day ME FCM (kg)															
1	39	10367.0	1695.0	154	10652.2	1618.3	0.33	59	10747.6	1435.7	0.24	25	11519.9	1452.1	0.01[e]	0.69
2	22	10564.0	1692.2	98	11021.7	1821.4	0.28	36	11083.2	1680.4	0.26	18	11626.1	1817.8	0.06	0.86
3	7	9522.5	1088.9	59	10734.8	1566.7	0.05[e]	18	10424.2	1637.6	0.19	9	11166.9	1229.8	0.02[e]	0.47
4	3	9233.0	1862.0	34	10446.5	1270.5	0.13	5	10857.2	1539.7	0.23	3	10896.9	1012.1	0.24	0.51
5	1	13594.7	0.0	9	10271.0	1197.1	—	1	12077.0	0.0	—	2	11125.8	220.0	—	—
Actual FCM (kg)																
1	39	8412.4	1528.2	154	8966.7	2096.7	0.07	59	9090.1	1739.9	0.05	25	9827.7	1755.6	0.00[e]	0.69
2	22	9450.3	1693.3	98	10235.7	2266.6	0.13	36	10382.6	2061.6	0.08	18	10875.7	2206.3	0.03[e]	0.73
3	7	9066.5	1007.6	59	10495.3	1797.1	0.04[e]	18	10270.0	1827.6	0.12	9	11229.5	1664.5	0.01[e]	0.64
4	3	9168.5	1805.8	34	10851.8	1964.7	0.16	5	10865.4	1571.0	0.21	3	10654.2	804.0	0.26	0.99
5	1	17374.3	0.0	9	10907.7	1970.6	—	1	11841.3	0.0	—	2	12003.0	632.3	—	—
Days milked																
1	39	308.6	29.9	154	321.5	53.1	0.05	59	329.4	45.4	0.01[e]	25	331.0	53.8	0.07	0.31
2	22	297.1	30.0	98	319.8	49.7	0.01	36	333.5	55.5	0.00[e]	18	329.1	47.1	0.01	0.34
3	7	304.2	19.4	59	315.5	38.4	0.45	18	313.8	50.5	0.50	9	323.3	45.1	0.32	0.88
4	3	272.6	18.9	34	329.7	54.5	0.08[e]	5	301.6	34.6	0.24	3	313.0	11.2	0.03[e]	0.27
5	1	487.0	0.0	9	338.7	51.7	—	1	312.0	0.0	—	2	365.0	25.4	—	—
FCM per day (kg)																
1	39	27.2	4.0	154	27.8	3.7	0.39	59	27.5	3.6	0.63	25	29.7	3.1	0.01[e]	0.72
2	22	31.7	4.3	97	31.9	4.2	0.87	36	31.1	3.8	0.59	18	33.1	5.1	0.36	0.34
3	7	29.7	2.5	59	33.2	4.2	0.04[e]	18	32.9	5.0	0.14	9	34.8	3.9	0.01[e]	0.76
4	3	33.4	5.0	34	33.0	4.0	0.85	5	36.0	3.4	0.42	3	34.1	3.6	0.87	0.12
5	1	35.6	0.0	9	32.1	2.2	—	1	37.9	0.0	—	2	32.9	0.6	—	—
LT[f]	79	27.1	5.1	176	30.1	4.0	0.00[e]	74	28.8	4.5	0.04[e]	29	32.6	3.0	0.00[e]	0.03[e]
Percent fat																
1	39	3.7	0.4	154	3.6	0.4	0.30	59	3.6	0.5	0.12	25	3.6	0.4	0.29	0.35
2	22	3.6	0.4	97	3.6	0.4	0.71	36	3.5	0.4	0.40	18	3.6	0.5	0.84	0.52
3	7	3.5	0.3	59	3.5	0.4	0.58	18	3.3	0.5	0.59	9	3.5	0.4	0.89	0.09
4	3	3.6	0.3	34	3.5	0.4	0.56	5	3.3	0.5	0.45	3	3.6	0.5	0.94	0.43
5	1	3.7	0.0	9	3.5	0.2	—	1	2.7	0.0	—	2	3.1	0.1	—	—
LT[f]	79	3.7	0.5	176	3.6	0.4	0.44	74	3.6	0.5	0.12	29	3.7	0.5	0.71	0.22

[a] Comparison of seronegative and seropositive groups
[b] Comparison of seronegative and lymphocytosis groups
[c] Comparison of seronegative and lymphosarcoma groups
[d] Comparison of seropositive and lymphocytosis groups
[e] Significant at the 0.05 level by LSD for multiple comparisons (for transformed variable where heterogeneity in variance was present)
[f] Lifetime production

decrease susceptibility to infection. An increase of BLV seroprevalence with age has been reported in many studies (4,5,7,8). Thus, even if cows are not grouped by production levels, BLV infection would be concentrated in cows with high production due to their age distribution.

In summary, by virtue of the distribution of BLV infection in the herd, infected cows had greater milk production than uninfected cows. Among infected cows, cows with lymphocytosis were culled at a younger age and had reduced production in the last lactation relative to other groups.

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