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Cull Rates of Dairy Cattle with Antibodies to Bovine Leukemia Virus[1]

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ABSTRACT

The relationship of cull rate to age was investigated retrospectively in dairy cows with and without antibodies to bovine leukemia virus (BLV). Banked sera from eight annual herd tests on one 200-cow herd were tested for presence of BLV antibodies by agar-gel immunodiffusion using the M_r 51,000 glycoprotein antigen of BLV. Age-specific cull rates were computed for BLV-antibody-positive and antibody-negative cows yearly from 2 to 7 years of age. Cull rates, transformed by the Arc-sin square root, were analyzed by weighted regression. Transformed cull rates increased significantly as BLV-antibody-positive cows aged (one-tailed $P = 0.023$) but not as antibody-negative cows aged (one-tailed $P = 0.59$). A Mantel-Byar survival analysis showed significantly longer survival beyond 3.5 years of age among antibody-negative cows than among antibody-positive cows ($P = 0.008$).

INTRODUCTION

BLV[5] has been shown to be the etiologic agent of enzootic bovine leukosis, a lymphoproliferative disease of cattle (13). Infection with the virus ordinarily is spread following close physical contact (14, 20) and is more likely to occur as an animal ages (3–5, 20). Other than the rare occurrence of clinical lymphoma in old cattle (19), effects of BLV *per se* on the host have been disputed. Trainin *et al.* found evidence for acquired immune deficiency related to low IgM production in leukotic cattle (21), but other studies failed to demonstrate such an association (12, 16).

In support of the latter studies, analyses of production variables of antibody-positive and negative cows found no evidence for a detrimental effect of infection on productivity (9, 10). Reports of prevalence rates of seropositive cattle, however, have consistently shown a decline or plateau from 4 to 8 years of age (3–5, 8). Possible explanations for this pattern include: (*a*) a low-prevalence cohort in the 4- to 8-year age group, as suggested by Huber et al. (8); (*b*) a decrease in incidence of seroconversion during this age range, which could explain a plateau but not a decline; or (*c*) higher culling pressure in seropositive cattle during this period.

While decreased incidence could cause a leveling-off of prevalence, it cannot, by itself, cause a decline in prevalence. The purpose of this study was to investigate the relationship of cull rates to age in antibody-positive and antibody-negative cows that were grouped into birth cohorts to control for possible cohort effects.

MATERIALS AND METHODS

Banked sera from 320 cattle bled in August of 1975 to 1982 in a closed Florida dairy herd (20) were tested for BLV M_r 51,000 glycoprotein antibodies by agar-gel immunodiffusion, as described previously (4). Approximately 200 cows were milked in this herd, which had a 70% prevalence rate to BLV antibodies in adult cattle (4). Decisions to cull cows were based on criteria in standard use by dairy managers in North America. Cows were removed most commonly because their milk production was below a mean for the herd. Another common reason for culling was infertility; infertile cows were those that failed to conceive or that aborted repeatedly. Cows were removed also for various diseases and conditions that adversely affected milk production, such as mastitis, lameness, chronic pneumonia, or physical injury. Herdsmen had no knowledge of BLV-antibody status of cows. Prevalence, incidence, and cull rates of seropositive cattle were computed for each annual bleeding of 5 birth cohorts and for all cohorts pooled. Prevalence rates were calculated as the number of seropositive cattle divided by the number of cattle tested. Incidence rates during a year were calculated as the number of new seropositive cattle divided by the quantity: number of seronegative cattle beginning the year minus one-half of the seronegative cattle culled plus one-half of the seronegative cattle entering during the year. The data from which pooled rates were computed is presented in Table 1. Birth cohorts consisted of cows born between the 12 months from August 1 through July 31. Cull rates were transformed by Arc-sin $\sqrt{\text{cull rate}}$, where Arc-sin was expressed in radians and cull rate was the number culled during the year divided by the number present at the beginning of the year, and were analyzed by weighted regression analyses (18). Transformation was performed to linearize the relationship between probability of culling and age and to remove inequalities in variance of cull rates (18). Inequalities of variance arising from differing numbers of animals present at the beginning of each year were removed by assigning weights to proportions culled. These weights were the number at risk at the beginning of each test period. The data at age 6.5 in Table 1 were not used in the regression analyses because of the small number of negative cows at risk at this age. Full and reduced model *F*-tests were performed separately for seropositive and seronegative cows to determine whether the Arc-sin $\sqrt{\text{cull rate}}$-to-age relationship differed among cohorts (18).

Regression analysis was used to test for differences between slopes of transformed cull rates for seropositive and for seronegative cows. Differing slopes, as measured by an *F*-test (18), was interpreted to indicate that differences in the hazard of being culled varied with age. Rates intersected at the age when seropositive and seronegative cows were equally likely to be culled.

Validity of the regression analysis depends on a parametric assumption. A second, nonparametric survival analysis was performed to check for lack of sensitivity of results due to possible violations of that assumption. The Mantel-Byar method (11) was chosen because it adjusts numbers at risk at the beginning of each year to reflect the fact that cows seroconverted during the study period.

RESULTS

Prevalence rates for pooled cohorts (Chart 1) and individual

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[5] The abbreviation used is: BLV, bovine leukemia virus.

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Table 1

Cull rates for dairy cows seropositive and seronegative to bovine leukemia virus

Mean age at time of test (yr)	No. of seropositive cows						No. of seronegative cows					
	Tested	Culled[a]	Seroconverted	Added to herd	Censored[b]	Cull rate (%)	Tested	Culled	Seroconverted	Added to herd	Censored	Cull rate (%)
2.5	194	32	61	17	0	16	126	36	61	4	0	29
3.5	240	82	12	1	0	34	33	7	12	0	0	21
4.5	171	63	2	0	15	37	14	2	2	0	1	14
5.5	95	57	2	0	9	60	9	4	2	0	1	44
6.5	31	20	1	0	12	65	2	0	1	0	1	0

[a] Number of cows culled, seroconverted, added to the herd, and censored in the subsequent year.
[b] Censored cows were those present at the termination of the study in August 1982.

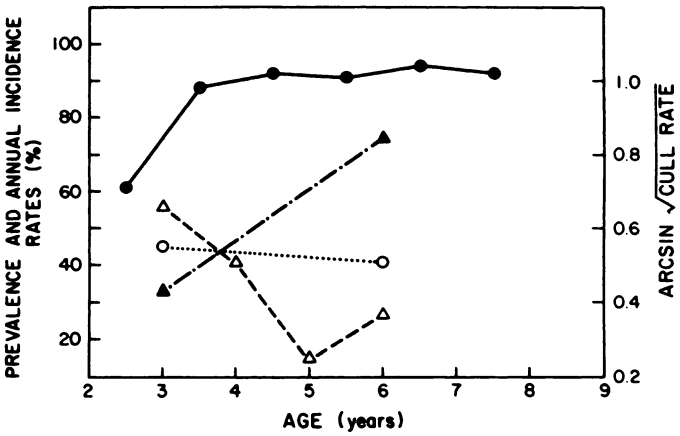

Chart 1. Prevalence (●), annual incidence (△), and regressed transformed cull rates of BLV antibody-positive (▲) and antibody-negative (○) dairy cattle.

cohorts (Chart 2) dipped or plateaued at 4 years of age, except for the 1974–1975 cohort, in which rates declined from 3 years of age. For pooled cohorts, the subsequent increase in prevalence coincided with an increased incidence rate; the trend could not be verified beyond 6 years of age, due to a lack of incidence data.

Results of *F*-tests revealed no significant differences in cull rates between cohorts, thus permitting analysis of pooled cohort cull rates. Results of those analyses indicated a significant increase in transformed cull rates as seropositive cows aged (one-tailed $P = 0.023$) but not as seronegative cows aged (one-tailed $P = 0.59$). Regression equations of transformed cull rates for seropositive and seronegative cows were Arc-sin $\sqrt{\text{cull rate}} = 0.013 + 0.140$ age and Arc-sin $\sqrt{\text{cull rate}} = 0.597 - 0.015$ age, respectively. The rate at which these rates increased with age was significantly greater in seropositive than in seronegative cows (one-tailed $P = 0.049$). The age at which these lines intersected was 3.77 years and, from that age on, estimated cull rates in positive cows were higher than those in negative cows. The Mantel-Byar survival analysis, using the data in Table 1 from 3.5 years on, showed significantly longer survival among seronegative cows than among seropositive cows ($P = 0.008$), indicating greater culling pressure in BLV seropositive cows.

DISCUSSION

This interesting finding of increasing cull rates with age in BLV-seropositive compared with seronegative cows contrasts with results of Huber *et al.* (8), who found annual proportions of seronegative and seropositive cattle retained in a herd to be similar. Design of that study, however, included large numbers of young cattle, which may have caused a dilution of a BLV effect on culling older cows and which could account for the discrepancy. Moreover, differences in yearly age-specific rates were not examined for cows over 5 years of age; one rate only was computed for all cows over 60 months of age.

Prevalence rate patterns found here are similar to those reported in the other longitudinal and one-time cross-sectional studies cited above. Cohort data presented by Huber *et al.* (8) also suggested, subtly, the same within-cohort pattern. In our study, however, cohort effects can be ruled out as an explanation for the dip or plateau in rates.

One interpretation of results of this study is that presence of BLV infection may increase the probability of culling through an effect on productivity, perhaps from impairment of physiological processes by the presence of subclinical amounts of neoplastic tissue. Tumor progression could result in low milk yield and, thus, the subsequent culling of the affected cow during the lactation period, a process which might cause relatively high rates of culling in BLV antibody-positive cattle. As a consequence, effects of BLV would be manifest during the subsequent lactation period, and cows with productivity affected by BLV would be absent at the anticipated completion of a lactation period. Indeed, studies which found no association between presence of BLV antibodies and productivity (9, 10) considered only cows which had completed a lactation.

This interpretation is supported by results of Bloom *et al.* (2), who found a reduction in B-lymphocytes and subsequent progression to tumorous state in lymphocytotic cows given glucocorticoids. A heightened adrenocorticoid response is easily conceivable in dairy cows during the stressful postparturient period.

A second interpretation of our results is that BLV infection in cows may cause an acquired immune deficiency, such as reduced IgM (21), which may lead to reduced productivity and subsequent culling. This is an intriguing possibility, in view of recent evidence for an association of human T-cell leukemia virus with acquired immune deficiency syndrome (1, 17) and a weak antigenic cross-reactivity between human T-cell leukemia virus and BLV core proteins (15). Furthermore, another retrovirus, feline leukemia virus, has been shown to cause immunosuppression in cats (22). Should an acquired immune deficiency explain all or part of the increased cull rates in BLV-infected cows, other infectious diseases would be expected to be more prevalent in BLV-infected cows. Results of studies which found no evidence for a relationship between BLV infection and mastitis, however, provide no support for this view (7, 9, 10).

A third possible explanation is that BLV infection has an effect on reproductive efficiency, similar to that for feline leukemia virus in the feline fetus (6). There are no reports substantiating this view; indeed, Van Der Maaten *et al.* found no effect of BLV infection *per se* on bovine fetuses (23), and Huber *et al.* (9) and

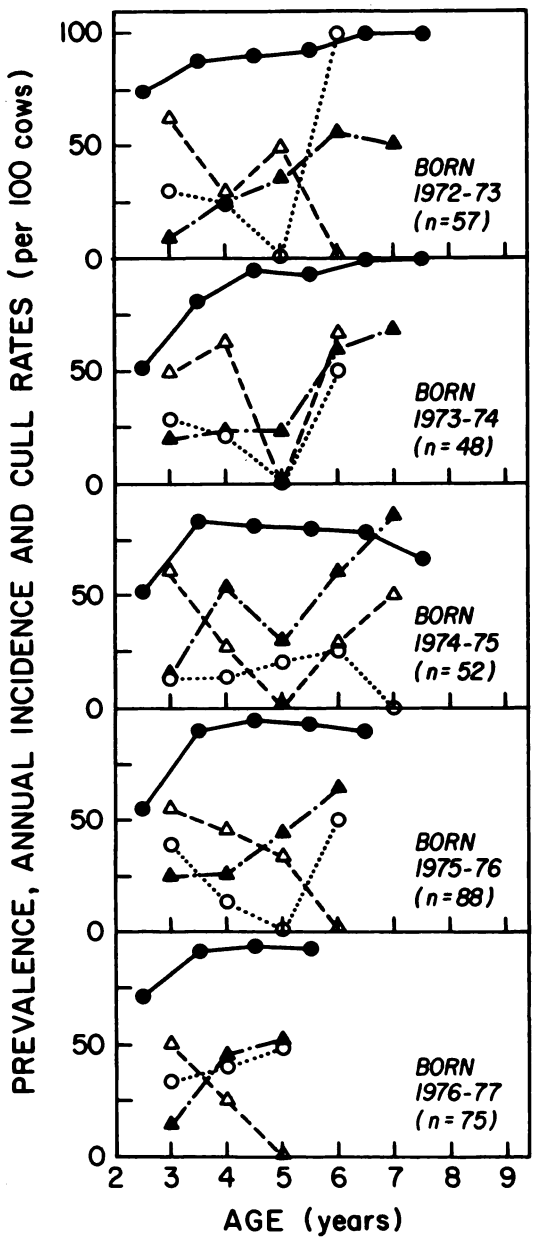

Chart 2. Prevalence (●), annual incidence (△), and regressed transformed cull rates of BLV antibody-positive (▲) and antibody negative (○) dairy cattle for each of 5 birth cohorts. Largest number in a cohort = *n*.

Langston *et al.* (10) found no differences in reproduction indices between seropositive and seronegative cows.

Finally, it cannot be determined by this retrospective study that culling is not related only in an independent way to BLV infection through a shared factor which itself predisposes to culling and BLV infection.

Our results reveal a manifestation of BLV with a likely economic impact on the dairy industry. We speculate that the most convincing means by which BLV may affect productivity is through development of neoplastic tissue in postparturient cows. The recently heightened interest in associations between leukemia-causing viruses and immune deficiency diseases, particularly AIDS, suggests that further research with BLV in the bovine model may be fruitful. Long-term prospective studies of survival of BLV-infected cattle will be needed before cause-and-effect questions regarding morbidity and mortality can be appropriately addressed.

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