Efficacy of vaccination against *Fusobacterium necrophorum* infection for control of liver abscesses and footrot in feedlot cattle in western Canada

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Abstract — A randomized and blinded field trial was carried out to evaluate the efficacy of a *Fusobacterium necrophorum* bacterin for control of liver abscesses and footrot under commercial feedlot conditions in western Canada. Half of the vaccinated and half of the unvaccinated control animals had ad libitum access to a forage-based (ALF) growing diet. The other half of each group was limit-fed a grain-based (LFG) growing diet. The overall prevalence of A and A+ liver abscesses in this trial was 16.7%. A strong association was found between diet group and presence of A or A+ liver abscessation at slaughter. Diet group modified the effect of vaccination on the prevalence of liver abscesses at slaughter, and on the incidence of footrot during the feeding period. The odds that a vaccinated animal in the ALF group would have an A or A+ liver abscess at slaughter were less than 1/3 the odds that an unvaccinated animal in the same diet group would have an A or A+ liver abscess at slaughter (OR = 0.27, [95% CI: 0.07 to 1.02], $P = 0.05$). The overall incidence of footrot in this trial was 6.5%. The odds that a vaccinated animal in the ALF group would be treated for footrot were less than 1/5 the odds that an unvaccinated animal in the same group would be treated for footrot (OR = 0.18, [95% CI: 0.04 to 0.82], $P = 0.03$). Within the LFG group there were no differences between vaccinated and unvaccinated animals in the odds of an animal being treated for footrot, or in the odds of having an A or A+ liver abscess score at slaughter. This trial suggests that vaccination against *F. necrophorum* infection may have applications to decrease the prevalence of severe liver abscesses at slaughter and decrease footrot treatments in certain diet situations.

Résumé — Efficacité de la vaccination contre l'infection à *Fusobacterium necrophorum* dans la lutte contre les abcès hépatiques et la pourriture du sabot chez des bovins en parc d'engraissement dans l'Ouest du Canada. Un essai sur le terrain effectué au hasard et à l'aveugle a été mené pour évaluer l'efficacité d'une bactérine de *Fusobacterium necrophorum* pour lutter contre les abcès hépatiques et la pourriture du sabot dans les conditions commerciales d'un parc d'engraissement de l'Ouest du Canada. La moitié des animaux témoins vaccinés et la moitié des animaux témoins non vaccinés ont eut accès à volonté à un régime de croissance à base de fourrage (AVF). L'autre moitié de chaque groupe recevait une diète de croissance à base de grains servie avec restriction (GR). La prévalence globale des abcès hépatiques A et A+ dans cet essai était de 16,7 %. On a trouvé une forte association entre les régimes alimentaires et la présence d'abcès A ou A+ à l'abattoir. Les régimes alimentaires ont modifié l'effet de la vaccination sur la prévalence des abcès hépatiques à l'abattoir et sur l'incidence de la pourriture du sabot pendant les périodes d'alimentation. Les probabilités qu'un animal vacciné du groupe AVF soit atteint d'abcès hépatique A ou A+ à l'abattage étaient moins du tiers de celles d'un animal non vacciné du même régime alimentaire (RC = 0,27, [95 % 1C : 0,07 à 1,02],) $P = 0,05$). L'incidence globale de la pourriture du sabot dans cet essai était de 6,5 %. Les probabilités qu'un animal vacciné du groupe AVF soit traité pour la pourriture du sabot étaient moins de 1/5 de celles d'un animal non vacciné (RC = 0,18, [95 % 1C : 0,04 à 0,82], $P = 0,03$). Dans le groupe GR, il n'y avait pas de différences entre les animaux vaccinés et non vaccinés au niveau des probabilités qu'un animal soit traité pour la pourriture du sabot ou dans les probabilités qu'il soit atteint d'abcès hépatiques de cote A ou A+ à l'abattoir. Cet essai laisse entrevoir que la vaccination contre *F. necrophorum* pourrait avoir des effets sur la diminution de la prévalence de grave abcès hépatiques à l'abattage et sur la diminution des traitements contre la pourriture des sabots chez les animaux soumis à certains régimes alimentaires.

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Introduction

The control of liver abscesses is an important economic concern in feedlot cattle. Beef quality audits in Canada have evaluated economic losses due to various quality defects, including liver condemnation, downgrades at slaughter, and other quality parameters that, in 1995, cost the industry approximately $5.31 CDN per head, not including losses of production and feed efficiency (1). Extensive educational programs for producers were instigated to decrease losses to the beef industry. In 1998/1999, losses across the entire Canadian industry due to liver quality defects were estimated at $2.66 CDN per head (2).

Antibiotics in the feed are effective at reducing the prevalence of liver abscesses at slaughter (3,4). Most trials evaluating the efficacy of vaccination against *F. necrophorum* infection on decreasing the prevalence of liver abscesses at slaughter either have been performed in combination with prophylactic feed antibiotics or have evaluated leukotoxin-based *F. necrophorum* vaccines under experimental conditions (5–7). The feeding of antibiotics in the livestock industry has been blamed for increases in antimicrobial resistance in humans (8,9). The use of prophylactic feed antibiotics is banned in some European countries and is currently under scrutiny in Canada (10,11). If prophylactic feed antibiotics were no longer available to prevent liver abscesses, a vaccine that would decrease the prevalence of liver abscesses would be highly desirable. In addition, if vaccination against *F. necrophorum* infection also decreased the prevalence of footrot in the feedlot, labor and treatment costs associated with footrot, along with costs of lost productivity due to severe liver abscesses, would be decreased (3,4).

The objectives of this trial were to evaluate the effectiveness of a *F. necrophorum* vaccine (Fusogard; Novartis Animal Health Canada, Mississauga, Ontario) for the prevention, first, of liver abscesses and, second, of footrot in feedlot cattle not treated with a prophylactic feed antibiotic by comparing the prevalence of these conditions in the vaccinated cattle and the unvaccinated (control) cattle.

Materials and methods

Trial facilities

Backgrounding was carried out in 12 pens at the University of Saskatchewan Research Feedlot with 8 pens of 37 animals and 4 pens of 38 animals. The cattle were moved later to a large commercial feedlot with a capacity of approximately 30 000 head for the finishing period, where they were housed in 2 pens of about 222 animals. Both feedlots are typical of those found in western Canada with open air pens, dirt floors, a central alley, and 20% porosity fencing. The design of the research feedlot is a small scale representation of larger regional feedlots. Both feedlots maintained individual animal records.

Animals

The University Committee on Animal Care and Supply approved this trial and the guidelines of the Canadian Council on Animal Care were followed. In the fall of 2001, 447 auction market-derived steer calves arrived at the University of Saskatchewan feedlot. The steers were crossbred beef calves with an average weight of 249 kg (s = 17 kg). Routine processing was carried out at arrival; this included ear tagging for individual animal identification, weighing, vaccination against infectious bovine rhinotracheitis (IBR), parainfluenza-3 (PI_3), bovine viral diarrhea (BVD), *Hemophilus somnus* (*Histophilus somni*), and *Mannheimia hemolytica* (Starvac 3 Plus/Somnu-Star Ph; Novartis Animal Health Canada) and vaccination against clostridial diseases (Tasvax 8; Schering-Plough Animal Health, Division of Schering Canada, Pointe-Claire, Quebec). The animals also received topical parasiticidal treatment (Dectomax Pour-On Solution; Pfizer Canada Animal Health Group, Kirkland, Quebec), 1 mL/10 kg body weight (BW), and a hormonal implant (Ralgro; Schering-Plough Animal Health). A metaphylactic injection of antibiotic was given to each animal, based on body temperature at processing; each animal with a body temperature greater than 41°C received tilmicosin (Micotil; Provel, Division Eli Lilly Canada, Guelph, Ontario), 1 mL/30 kg BW, SC, while the rest of the animals received long-acting oxytetracycline (Liquamycin LA-200; Pfizer Canada Animal Health Group), 1 mL/10 kg BW, SC. Animals received a 2nd hormonal implant (Component TE-S; Elanco Animal Health, Division Eli Lilly Canada, Guelph, Ontario) and a booster vaccination against IBR and PI3 (StarVac 2; Novartis Animal Health Canada) before moving to the finishing feedyard at 112 d on feed (DOF). All of the above animal health products were used according to label instructions. These steers remained in their respective study groups during finishing, until slaughter. Steers were individually weighed at the feedlot within 24 h before slaughter. Animals were slaughtered between 245 and 260 DOF.

Experimental design

The sample size used in this trial was based on 2 of the major outcomes. The trial had the power to show a decrease in liver abscesses of 40% or more from approximately 27% (the expected level of liver abscessation in controls), with 80% power and a 95% level of confidence. The trial also had the power to see a change of 0.09 kg or more in average daily gain (ADG) across the entire feeding period from a base value of approximately 1.5 kg/d with 80% power and a 95% level of confidence.

Outcomes measured to assess the effect of the vaccine on liver abscessation were liver scores at slaughter and the ADG. Liver scoring at slaughter followed the Elanco system where scores are as follows: 0 (no abscesses), A- (1 or 2 small abscesses or abscess scars), A (2 to 4 well organized abscesses less than 2.5 cm in diameter), or A+ (1 or more large active abscesses with inflammation of surrounding liver tissue) (1,3,12). Outcomes measured for assessment of the vaccination for prevention of footrot were treatment rates for all lameness, and specifically for footrot. The feedlot staff and researchers who scored livers were blinded as to the allocation of the treatment and the specific objectives of the trial.

The 447 steers were randomly allocated by blocks into 12 feedlot pens at processing. The allocation was random within weight blocks to create approximately equal pen

weights. Two milliliters of *F. necrophorum* vaccine was given, SC, in the neck to one half of the calves chosen by random number table from each pen. A placebo injection of saline was given by the same method to all animals not receiving the vaccine. The trial was set up to analyze associations at the individual animal level; therefore, unvaccinated calves intermingled with the vaccinated calves at equal proportions within each pen. No antibiotics for liver abscess prophylaxis were given in the feed during this trial so that comparisons could be made with a negative control group. Decoquinate (Deccox 6% Premix; Alpharma Canada, Mississauga, Ontario) was given to all trial animals. A 2nd vaccination of 2 mL was given, SC, at 94 DOF, 18 d before the steers moved to the finishing feedyard (112 DOF). The on-label recommendations for the vaccine are that the 2nd vaccination should be given 21 d after the 1st injection for footrot, and 60 d after the 1st vaccination for liver abscesses. The timing of this procedure differed from the on-label recommendation of a 2nd vaccination at 60 DOF, because the timing was synchronized with the processing time when the cattle received their 2nd hormonal implant. This meets the withdrawal period of 60 d stated by the manufacturer.

Two feeding programs were used at the University feedlot during the backgrounding period to produce a gain of 1.15 to 1.25 kg/d. The diet and the feeding method were different between the 2 groups. One half of the animals had ad libitum access to a forage-based growing diet consisting of 23.6% barley silage, 27% grass hay, and 49.25% barley based concentrate/supplement on a dry matter (DM) basis. This group will be called the Ad Libitum Forage (ALF) group. The other group was limit-fed a grain based growing diet consisting of 8.5% barley silage, 92.5% barley based concentrate/supplement. This group will be called the Limit-Fed Grain (LFG) group. Calcium, phosphorus, and crude protein were adjusted, so that animals on either diet would have equal intakes. The feeding programs overlapped the vaccination groups in a balanced design to prevent bias. Therefore, a quarter of the animals were in each of the following treatment groups: vaccinated and LFG, vaccinated and ALF, unvaccinated and LFG, and unvaccinated and ALF. The animals remained with their original diet groups throughout the 2nd part of the feeding period, but all animals were fed a high grain diet ad libitum. The diet of the LFG group now consisted of 89.8% barley based concentrate/supplement and 10.2% forage (DM basis). The ALF group was now fed a ration consisting of 90.3% barley based concentrate/supplement and 9.7% forage (DM basis).

The case definition used for footrot was a calf with sudden onset, single-leg lameness, with no other obvious cause for the lameness; for example, no joint involvement or evidence of trauma. Feedlot workers followed a treatment protocol and completed a questionnaire for each animal treated for any lameness during the trial. The questionnaires for footrot included a lameness scale and questions meant to rule out other common causes of lameness (13). Questions were asked about which foot was affected, fever, swelling of the foot, swollen joints, pus at the coronary band, response to treatment, and any other obvious cause of lameness. It was decided to leave all single leg lameness cases in the analysis, as long as no other obvious cause of the lameness could be identified. All lame animals were treated with ceftiofur sodium (Excenel Sterile Powder; Pharmacia Animal Health, Division of Pharmacia & Upjohn, Orangeville, Ontario) at the label dose for 2 to 3 injections, depending on response to treatment.

Missing data

Four animals were lost from the trial due to injury, polyarthritis, myocarditis, or chronic bloat. Eleven other animals had tags missing at the end of the trial, so liver scores could not be matched with the appropriate animal. The feed groups were slaughtered on different days, therefore it is known which feed group these animals with missing tags came from but not which vaccination group. However, treatment data were available for these 11 animals. The liver abscess and ADG analyses included 432 animals. The footrot analysis included 443 animals.

Statistical analysis

Logistic regression (SPSS, version 11.0.1 for Windows; SPSS, Chicago, Illinois, USA) was used to analyze the association between *F. necrophorum* vaccination and the presence at slaughter of liver abscesses grading A or A+, while adjusting for the effect of diet. A similar method was used to analyze the association between *F. necrophorum* vaccine and the number of footrot cases treated for the 1st time during the feeding period. Attributable rates and attributable fractions were calculated for the significant outcomes (14). The linear outcome of ADG was compared between the 2 vaccine groups, while blocking for diet effect with a factorial ANOVA using the Type III sum-of-squares method. Four percent shrink was calculated on the animal weights on arrival and at slaughter for ADG calculations. The assumptions of all statistical tests were met.

Results

Liver scores

The overall prevalence of liver abscess in this trial was 20%. This included all A-, A, and A+ livers. Overall, there were 3% A- livers, 1% A livers, and 16% A+ livers. Liver codes were dichotomized, combining liver abscess categories 0 and A- into the referent category and combining liver abscess categories A and A+ into the other category. Prevalences of liver abscesses in this categorization are shown in Table 1. This method of categorization was chosen a priori to evaluate the effect of the *F. necrophorum* vaccine on decreasing the number of A and A+ livers, as recommended in the 1997 Canadian Beef Quality Audit (1).

Initial exploration of the data revealed that diet was a strong predictor of the presence of A or A+ liver abscesses at slaughter, as would be expected. The odds of an animal in the LFG group having an A or A+ liver abscess score at slaughter were 5.71 times higher than the odds of an animal in the ALF group having an A or A+ liver abscess score at slaughter ([95% CI: 3.02 to 10.77], $P < 0.0001$). The crude association of vaccine group with the presence of A or A+ liver abscesses at slaughter was not statistically or clini-

Table 1. Liver scores stratified by vaccination and diet groups, in a study examining the effect of vaccination against *Fusobacterium necrophorum* infection on the prevalence, at slaughter, of A and A+ liver scores, while adjusting for diet during the feeding period

Diet	Treatment	Liver scores		Total animals	Prevalence (%) (of A or A+)
		0 or A-	A or A+		
LFG	Vaccinated	84	27	111	24.3
	Not vaccinated	75	32	107	30.0
ALF	Vaccinated	105	3	108	2.8
	Not vaccinated	95	10	105	9.5
Totals		359	72	431	16.7

LFG — Limit fed grain (limit-fed a grain based growing diet consisting of 8.5% barley silage, 92.5% barley based concentrate/supplement); ALF — Ad libitum forage (ad libitum access to a forage-based growing diet consisting of 23.6% barley silage, 27% grass hay, and 49.25% barley based concentrate/supplement on a dry matter (DM) basis)

Table 2. Footrot treatments stratified by vaccination and diet groups, in a study examining the effect of vaccination against *Fusobacterium necrophorum* infection on the frequency of footrot treatments in feedlot cattle, while adjusting for diet during the feeding period

Diet	Treatment	Footrot cases (number treated)	Total animals	Incidence (% treatments)
LFG	Vaccinated	8	112	7.1
	Not vaccinated	8	109	7.4
ALF	Vaccinated	3	114	2.6
	Not vaccinated	10	108	9.3
Totals		29	443	6.5

LFG — Limit fed grain (limit-fed a grain based growing diet consisting of 8.5% barley silage, 92.5% barley based concentrate/supplement); ALF — Ad libitum forage (ad libitum access to a forage-based growing diet consisting of 23.6% barley silage, 27% grass hay, and 49.25% barley based concentrate/supplement on a dry matter (DM) basis)

cally significant when both diet groups were considered together.

When the association between vaccination with *F. necrophorum* vaccine and presence of A or A+ liver abscesses at slaughter was adjusted for diet, effect modification of a large magnitude was apparent. This effect modification has clinical and biological significance; therefore, vaccine efficacy was presented separately for each feed group. The odds that a vaccinated animal in the ALF group would develop an A or A+ liver abscess were less than 1/3 the odds that an unvaccinated animal in the ALF group would develop an A or A+ liver abscess (OR = 0.27, [95% CI: 0.07 to 1.02], $P = 0.05$). Within the LFG group, there was no difference in the odds of having an A or A+ liver abscess score at slaughter between vaccinated and unvaccinated animals (OR = 0.75, [95% CI = 0.41 to 1.37], $P = 0.35$).

In the ALF group in this trial, the presence of A and A+ liver abscesses in unvaccinated animals that may be attributed to not vaccinating against *F. necrophorum* is 7 cases per 100 animals. Seventy-one percent of A and A+ liver abscesses in unvaccinated animals in the ALF group can be attributed to not vaccinating against *F. necrophorum*.

Footrot

The overall incidence of footrot in this trial was 6.5%. The distribution and incidence of 1st footrot treatments are presented in Table 2. Thirty individual cases of lameness were reported. One of these cases had a leg laceration, did not fit the case definition, and was not included in the footrot analysis. All other cases were single leg lameness where no other cause for lameness could be determined. One animal from the LFG unvaccinated group relapsed 18 d after initial treatment: the footrot relapse rate for the trial was 3.4%. Two animals (1 from the LFG vaccinated group and 1 from the ALF unvaccinated group) were treated initially with antibiotics for longer than 3 d (5 d each), due to the slow response to treatment.

The crude association of vaccine group with treatment for footrot suggests a preventive vaccine effect where the odds of a vaccinated animal are about one-half the odds that an unvaccinated animal will be treated for footrot (OR = 0.48 [95% CI: 0.22 to 1.06], $P = 0.07$). The effect of diet in the association between vaccination against *F. necrophorum* and treatment for footrot was also investigated. Diet alone was not a strong predictor of footrot treatment. When the analysis for vaccine group and footrot treatment was adjusted for diet, effect modification was again apparent. Therefore, vaccine efficacy will be presented separately for each feed group. The odds that a vaccinated animal in the ALF group would be treated for footrot were less than one-fifth the odds that an unvaccinated animal in the ALF group would be treated for footrot (OR = 0.18 [95% CI: 0.04 to 0.82],

Table 3. Analysis of variance table presenting the results of a study examining the effect of vaccination against *Fusobacterium necrophorum* infection, on average daily gain (adjusted for 4% shrink) in feedlot cattle, while also adjusting for diet during the feeding period. The 2 diets used in this trial were a limit-fed grain-based diet and an ad libitum forage-based diet.

Source	Type III sum of squares	Degrees of freedom	Mean square	F	*P*
Corrected model	0.055(a)	3	0.018	0.766	0.514
Intercept	1040.905	1	1040.905	43694.067	0.000
Diet	0.050	1	0.050	2.103	0.148
Vaccine	0.002	1	0.002	0.102	0.749
Diet * Vaccine	0.002	1	0.002	0.074	0.786
Error	10.172	427	0.024	—	—
Total	1051.830	431	—	—	—
Corrected total	10.227	430	—	—	—

F — the test statistic for the F distribution; *P* — statistical significance of each factor on the dependent variable: average daily gain

P = 0.03). Within the LFG group, there was no difference in the odds of an animal being treated for footrot between vaccinated and unvaccinated animals (OR = 0.86 [95% CI: 0.32 to 2.30], *P* = 0.76).

In this trial, the rate of footrot treatments in unvaccinated animals in the ALF group that may be attributed to not vaccinating against *F. necrophorum* is 7 cases per 100 animals. Seventy-two percent of footrot treatments in unvaccinated animals in the ALF group can be attributed to not vaccinating against *F. necrophorum*.

Average daily gain

Average daily gain over the entire feeding period did not differ significantly between the 2 vaccination groups, even when adjusted for diet group, as presented in Table 3.

Discussion

High grain diets are associated with higher numbers and increasing severity of liver abscesses (3,4,12,15). Limit feeding this type of diet under western Canadian environmental conditions has not yet been evaluated extensively (16). In this trial, the association of diet in the LFG with the presence of an A or A+ liver abscess score at slaughter was strong. It appears that a challenge of limit feeding in western Canada may be managing subclinical acidosis. No strong protective effect of vaccination can be seen across the whole trial for either outcome. When the effect of vaccination was adjusted for diet group, an effect modification of vaccine by diet became apparent. Because of this effect modification, the effect of vaccination on liver abscesses and footrot was reported separately for each diet group. The protective effect of vaccination against development of severe (A or A+) liver abscesses or in decreasing footrot treatments can be seen in the ALF group.

This trial has demonstrated a different effect of the *F. necrophorum* vaccine in animals on different diets. This is a significant finding in itself and has not previously been reported. If the 2 diet groups had not been present, the effect of diet in the LFG group might have led to the erroneous conclusion that the vaccine has no effect. Similarly the use of only the ALF group might have led to the erroneous conclusion that the vaccine does work in the feedlot with no qualifications. The effect modification of diet on the association between the disease outcomes and vaccination is difficult to interpret, because several variables differed between the feed groups. The main difference between the 2 groups was in diet composition and feeding method during the backgrounding period (0 to 112 DOF). The LFG group had a higher grain diet and was limit fed during the growing phase. The ALF group was fed a higher forage diet ad libitum during the growing phase. Both groups were fed similar high grain finishing rations.

The power of this trial was effectively halved by the interaction between vaccine and diet. The effect of the vaccine on severe liver abscess scores at slaughter or footrot treatments can be seen only in the ALF group, which consisted of half of the animals in the trial. Sample size was limiting when looking at the association in half of the group; however, borderline significance for the liver abscess outcome and significance for the footrot outcome were still seen. A priori power calculations suggested that 177 animals per group would be needed to show a significant difference in severe liver abscess prevalence at slaughter. This trial has 105 to 108 animals per vaccine group within the ALF group and analysis still showed borderline significance. There may also have been a herd immunity effect, especially with respect to footrot, as vaccinated and unvaccinated animals were mixed in the same pens, making it more difficult to detect a difference between the 2 vaccination groups.

The lack of a protective effect of the vaccine in the LFG group on the presence of liver abscess at slaughter may be due to the strong acidotic challenge of this high-grain diet. The possible acidosis associated with this diet would lead to more liver abscesses (15,17,18). Limit feeding cattle has also been associated with increased liver abscesses and increased acidosis (19,20). The effect of the LFG diet may simply overwhelm any vaccine effect. Another theory is that other bacteria or a different strain of *F. necrophorum* may become involved in the pathogenesis of liver abscesses in the LFG group (21). The concentration of *F. necrophorum* in the rumen has been shown to increase with lactic acidosis (22,23). The late revaccination with the vaccine may also have

decreased the protective effect of the vaccine, as good immunoglobulin G levels would not be expected until after the 2nd vaccine (24). This might have limited the vaccine's ability to protect against liver abscesses in the LFG group in the face of the strong diet challenge that occurred early on in the backgrounding period.

All of the footrot cases used were identified by the feedlot personnel as footrot. Bias might have resulted if a certain type of case had been excluded post hoc. Several hypotheses exist for why the vaccine did not protect against footrot in the LFG group. The strain of *F. necrophorum* might change in the groups with the high grain diet. Other bacteria like *Prevotella* spp. and *Porphyromonus* spp. might be causative agents of footrot in some animals or some situations (25). The lameness seen in animals on this type of diet might not be due to *F. necrophorum*. It is possible that the LFG diet induces an acidosis-associated chronic laminitis that manifests itself in a way that cannot be differentiated easily from footrot in the feedlot.

Since, in this trial, feed bunks were managed to maintain a specific ADG on the different diets during the backgrounding period, there was no difference in ADG between the vaccinated and unvaccinated animals even when corrected for diet group.

Results from this trial suggest that vaccination against *F. necrophorum* might have application in decreasing the prevalence of severe liver abscesses at slaughter and decreasing footrot treatments in certain diet situations. Applications for the vaccine would include feedlot animals on backgrounding diets fed ad libitum with higher forage levels. In reality, most animals in western Canada are fed in this way, so this is an important finding. The protective effect of this vaccine appeared to be overwhelmed by the challenge of a limit-fed high grain diet. This vaccine may also be of use to prevent footrot in the cow-calf operation. A management strategy to decrease the prevalence of liver abscesses in the feedlot without prophylactic feed antibiotics might include vaccination and diet management during the backgrounding period.

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