Effects of Lasalocid in Milk Replacer or Calf Starter on Health and Performance of Calves Challenged with *Eimeria* Species

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ABSTRACT

Holstein bull calves (n = 48) were purchased from local sale barns at 3 to 7 d of age and were assigned randomly to a 2 × 2 factorial arrangement of lasalocid in milk replacer (0 or 80 mg/kg) and in calf starter (3 or 44 mg/kg of dry matter). On d 10 after arrival, calves were orally dosed with 100,000 *Eimeria* oocysts. Intakes of calf starter and milk replacer, body weight (BW), BW gain, excretion of fecal oocysts, and fecal scores were determined. Calves fed lasalocid in milk replacer consumed more calf starter, had greater BW gain, shed fewer oocysts in feces, and scoured less frequently and less severely than did calves fed no lasalocid or those fed lasalocid in calf starter alone. The combination of lasalocid in milk replacer and in calf starter did not improve performance above that of calves fed lasalocid in milk replacer alone. Low intake of calf starter prior to weaning may provide an insufficient amount of lasalocid to control effectively the effects of coccidiosis when calves are infected with *Eimeria* at an early age. Use of coccidiostats in milk replacers may reduce the effects of coccidiosis in young calves that are infected with *Eimeria* at an early age.
(**Key words**: coccidia, lasalocid, milk replacer, calf starter)

Abbreviation key: **CS** = calf starter, **LAS** = lasalocid, **MR** = milk replacer.

INTRODUCTION

Coccidiosis is a disease that causes significant economic losses on many dairy operations. Intestinal coccidiosis, caused by protozoan parasites of the genus *Eimeria*, cause morbidity and mortality, primarily in calves that are ≤1 yr of age. Calves may be infected by ingestion of sporulated oocysts in contaminated water, feed, or pastures and by hair licking.

Coccidiostats have been used successfully in calf starters (**CS**) to reduce the incidence and severity of coccidial infections (2, 3, 4, 5, 6, 9, 10, 11). Inclusion of a coccidiostat in CS assumes that a minimal intake of CS will provide a sufficient amount of drug to control parasites. Calves that are ≤4 wk of age may also be widely infected (6, 9). Calves do not often consume significant amounts of CS prior to 4 wk of age; therefore, inclusion of a coccidiostat in milk replacers (**MR**) may reduce the incidence and severity of coccidiosis. Intestinal damage occurs prior to expression of clinical signs of the disease (diarrhea), so it is important to treat calves prior to the occurrence of scours. McMeniman and Elliott (8) reported reduced fecal shedding of oocysts when calves were fed lasalocid (**LAS**) in MR at 1 mg/kg of BW and were orally inoculated with coccidia (primarily *Eimeria zuernii*). However, LAS was ineffective in reducing excretion of fecal oocysts when included at 52.5 mg/kg of DM in CS. Hay was also fed during that study (8), which might have reduced the intake of CS.

The objective of our study was to determine the effects of LAS in MR and CS on intake, BW gain, feed efficiency, and excretion of fecal oocysts in calves challenged with coccidial oocysts composed primarily of *Eimeria bovis*.

MATERIALS AND METHODS

Calves and Feed Management

Holstein bull calves (n = 48) were purchased from local sale barns and transported to the experimental facility. On arrival, calves were assigned to a 2 × 2 factorial arrangement of LAS (Hoffman-La Roche, Inc., Paramus, NJ) in MR (0 or 80 mg/kg) and CS [3 or 44 mg/kg of CS (DM basis)]. Calves were 3 to 7 d of age, although dates of birth were not determined. Calves were housed in individual fiberglass hutches

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bedded with straw for the duration of the 42-d experiment. A blood sample was collected from each calf by jugular puncture for determination of serum IgG (VMRD, Inc., Pullman, WA) at approximately 24 h after arrival.

On d 10 after arrival, at the a.m. feeding, calves were orally dosed with 100,000 *Eimeria* oocysts (approximately 80% *E. bovis*, 15% *E. zuernii*, and 5% other *Eimeria* spp.). Electrolyte therapy (2 L of electrolytes at approximately 1100 h) was initiated when calves developed a fecal score >2 [four-point scale where 1 = normal consistency to 4 = severe scours (7)] and continued until signs of dehydration abated. Feeding of MR was not discontinued.

Commercially prepared CS (Tennessee Farmers Cooperative, LaVergne) containing 3 or 44 mg of LAS/kg of DM was offered from d 1 to 42. The CS was originally formulated to contain 0 and 50 mg of LAS/kg; however, errors in formulation and a small amount of carry-over from batches was measured on the assay of LAS in CS. Amounts of CS fed and refused were recorded daily. Commercial MR (Land O' Lakes, Inc., Ft. Dodge, IA) was fed from d 2 to 42. The MR contained all milk proteins and was reconstituted to 12.5% DM and fed at 10% of BW daily. Lasalocid was diluted in a small amount of MR, which was added at each feeding. A similar amount of MR was added for calves that did not receive LAS in MR. Milk replacer was fed at approximately 0800 and 1630 h. The amount of MR that was refused was recorded daily. Water was available at all times, and no hay was fed.

Sampling and Data Collection

Calves were weighed upon arrival and once weekly to d 42. Weekly BW were used to adjust the amount of MR fed. Fecal consistency (to estimate incidence and severity of scours) was subjectively scored at the a.m. feeding using the method of Larson et al. (7). Rectal temperatures and fecal grab samples were taken once daily after the a.m. feeding from d 10 after inoculation to d 42. Fecal samples were refrigerated (3°C) until the number of coccidial oocysts was determined by flotation in a solution of $NaNO_3$ and was counted using the modified McMaster technique (12). Feeds were analyzed for DM, CP (1), and LAS.

Data were analyzed by ANOVA using a completely randomized design. Covariants evaluated in the models included BW at arrival and serum IgG concentration, but neither was significant for any variable except BW at 42 d. Therefore, unadjusted means are reported. Orthogonal contrasts were used to determine effects caused by LAS in CS and MR and their interaction. Weekly intakes of MR, CS, and LAS; BW; and fecal scores were analyzed by repeated measures ANOVA; week of study was the repeated measure. Significance was determined at $P < 0.05$ unless otherwise noted.

RESULTS AND DISCUSSION

Mortality and Morbidity

Forty-eight calves were purchased from local sale barns; 11 died during the trial. Mortality occurred at a mean 6.5 d after arrival and was caused primarily by pneumonia and enteritis. Mean serum IgG concentration at 24 h after arrival was 15.3 g/L; concentration of IgG was ≤10 g/L in 19 of 48 calves (40%). Serum IgG was ≤10 g/L in 46% of calves that died, indicating the effect of the failure of passive transfer of immunity on survival of calves. All data from calves that died were deleted from the data file prior to analysis; therefore, least squares means are presented.

Mean fecal scores, number of days scouring, and excretion of fecal *Eimeria* oocysts were reduced when LAS was included in MR but not when LAS was included in CS (Table 1). Excretion of fecal oocysts by calves fed LAS in MR was markedly reduced from d 31 (Figure 1) compared with the excretion of fecal oocysts in calves in other groups, although the shedding of oocysts was not eliminated for any group of calves. Calves excreted large numbers of coccidial oocysts from d 31 of the study (21 d after inoculation); the extremely high count on d 33 ($>1 \times 10^6$/g of feces) was due to 1 calf that excreted $>5 \times 10^6$ oocysts/g of feces. Calves excreted significant numbers of oocysts from 22 d (12 d after inoculation). The prepatent period of *E. bovis* and *E. zuernii* is 17 to 19 d (4); therefore, excretion of oocysts might have been due to exposure to coccidia prior to arrival on the farm or exposure prior to oral challenge. Calves were 3 to 7 d of age upon arrival at the experimental facility and had been transported through sale barns prior to arrival.

Intake, BW Gain, and Efficiency

Chemical composition of CS did not vary by treatment; mean DM was 88.3% (SE = 0.4%), and mean CP was 18.2% (SE = 0.2%). The DM of MR was 93.0%, and CP was 21.4%. Fat in MR was not determined; a label guarantee indicated that the MR contained a minimum of 20% fat.

Total DMI and DMI of CS were increased when LAS was fed in MR, and intake of MR tended ($P < 0.12$) to be increased when LAS was fed in MR (Table 1). Increased DMI of CS was probably due to improved health of calves fed LAS, which was manifested by increased BW at d 42 ($P < 0.01$) and throughout the study ($P < 0.01$). A trend ($P < 0.10$) for an interaction of LAS in MR and LAS in CS on consumption of CS suggested that calves fed LAS in CS and in MR tended to consume less CS than did calves fed LAS in MR only. However, compared with calves fed no LAS, intake of CS was increased by 26% when calves were fed LAS in CS and by 34% when calves were fed LAS in MR and in CS.

Intake of LAS from CS did not reach an effective dose of the compound (1 mg/kg of BW) throughout the study for calves fed LAS in CS only (Figure 2). In this study, inclusion of LAS at 98 mg/kg of DM would have been required to provide 1 mg of LAS/kg of BW at 4 wk. Calves often do not consume large amount of CS prior to 4 wk of age; therefore, if calves are infected with *Eimeria* spp. prior to 4 wk, the amount of coccidiostat consumed may be insufficient to prevent infection. Typical rates of inclusion are 40 mg of LAS/kg of CS (9) and approximately 50 mg of LAS/kg of CS (2, 8). Stromberg et al. (10) suggested that 0.75 mg of LAS/kg of BW was the lowest concentration that was effective to reduce infection caused by coccidia. Ionophores in CS may negatively affect palatability of CS (5), further reducing consumption of LAS. Others (9, 11) reported increased intake of CS by calves fed an ionophore and challenged with coccidia. Use of LAS in MR provided 1 mg/kg of BW because MR was fed on the basis of BW.

Weekly intake of CS increased as age increased (Figure 3). Intake of CS increased more rapidly for calves fed LAS in MR than for other calves throughout the study. Intake of CS slowed for all calves during wk 5 because of the onset of coccidiosis, although the depression was ameliorated somewhat when LAS was fed in MR alone. Intake of CS appeared to recover in calves fed LAS in CS and in CS and MR by wk 6. Early weaning depends on adequate ruminal development, which, in turn, depends on the

TABLE 1. Least squares means of calf performance.

Item	Treatment[1]: No LAS in MR 3 mg of LAS/kg of CS		No LAS in MR 44 mg of LAS/kg of CS		80 mg of LAS/kg of MR 3 mg of LAS/kg of CS		80 mg of LAS/kg of MR 44 mg of LAS/kg of CS		Contrast[2] 1	2	3
	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	P		
Calves, no.	9	...	8	...	9	...	11	...			
BW											
d 0, kg	35.9	1.4	36.1	1.5	36.9	1.4	36.5	1.2	NS[3]	NS	NS
d 42, kg	49.8	2.1	51.7	2.3	58.2	2.1	54.4	1.9	0.01	NS	NS
BW Gain											
d 0 to 42, g/d	315	52	362	56	526	52	430	47	0.01	NS	NS
d 14 to 42, g/d	379	57	438	60	611	57	497	51	0.01	NS	0.13
Fecal oocysts, $\log_{10}$ count/g of feces	4.06	0.25	3.86	0.26	3.18	0.25	3.60	0.22	0.03	NS	NS
Fecal score[4]	1.63	0.07	1.63	0.07	1.42	0.07	1.45	0.06	0.009	NS	NS
Days scouring[5]	26.2	1.8	31.5	1.9	22.0	1.8	23.6	1.6	0.002	0.06	NS
Treatment[6]											
Calves treated, %	88.9	11.9	75.0	12.6	88.9	11.9	90.9	10.7	NS	NS	NS
Days, no.	8.0	1.4	5.6	1.5	6.2	1.4	6.9	1.3	NS	NS	NS
Rectal temperature, °C	38.8	0.4	38.6	0.4	38.7	0.4	38.7	0.3	NS	NS	NS
DMI, g/d											
Total	732	69	796	73	1006	69	841	63	0.03	NS	0.10
MR	494	24	494	26	544	24	521	22	0.12	NS	NS
CS	238	55	301	58	462	55	320	50	0.03	NS	0.07
BW Gain:DMI, g/kg	411	33	448	35	516	33	489	30	0.03	NS	NS

[1]LAS = Lasalocid, MR = milk replacer, and CS = calf starter.

[2]Contrasts: 1 = no LAS in MR versus 80 mg of LAS in MR, 2 = 3 mg of LAS in CS versus 44 mg of LAS in CS, 3 = interaction of 1 and 2.

[3]$P > 0.15$.

[4]Feces were scored on a four-point scale where 1 = normal fecal consistency to 4 = severe scours (7).

[5]Days with fecal score ≥2.

[6]Number of calves and days that calves were treated with antibiotics or antiinflammatory drugs.

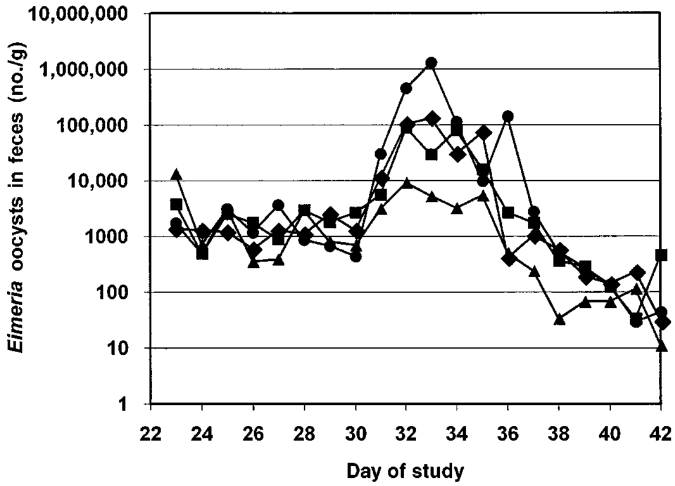

Figure 1. Excretion of *Eimeria* oocysts of calves fed lasalocid (LAS) in milk replacer (MR) and calf starter (CS) in the following combinations: 0 mg of LAS in MR and 3 mg of LAS/kg of CS (●), 0 mg of LAS in MR and 44 mg of LAS/kg of CS (■), 80 mg of LAS in MR and 3 mg of LAS/kg of CS (▲), and 80 mg of LAS in MR and 44 mg of LAS/kg of CS (♦). Pooled SE = 9335.

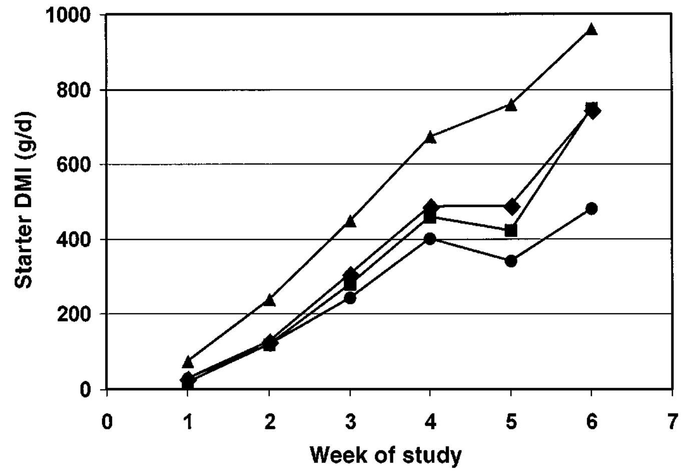

Figure 3. Weekly mean intake of calf starter (CS) of calves fed lasalocid (LAS) in milk replacer (MR) and CS in the following combinations: 0 mg of LAS in MR and 3 mg of LAS/kg of CS (●), 0 mg of LAS in MR and 44 mg of LAS/kg of CS (■), 80 mg of LAS in MR and 3 mg of LAS/kg of CS (▲), and 80 mg of LAS in MR and 44 mg of LAS/kg of CS (♦). Pooled SE = 80.

intake of CS. Calves infected with coccidia may become anorexic, thereby reducing the rate of their ruminal development and lengthening the preweaning period.

Mean BW gains from d 0 to 42 were improved when LAS was fed in MR ($P < 0.01$; Table 1). Weekly BW (Figure 4) indicated that LAS in MR controlled the effects of coccidiosis. Differences in BW became most apparent at 3 wk after infection, particularly in calves fed LAS in MR and in calves fed LAS in MR and CS.

Efficiency of BW gain was improved by 17% when LAS was included in MR ($P < 0.03$) but not in CS (Table 1). When LAS was fed in CS only, efficiency of

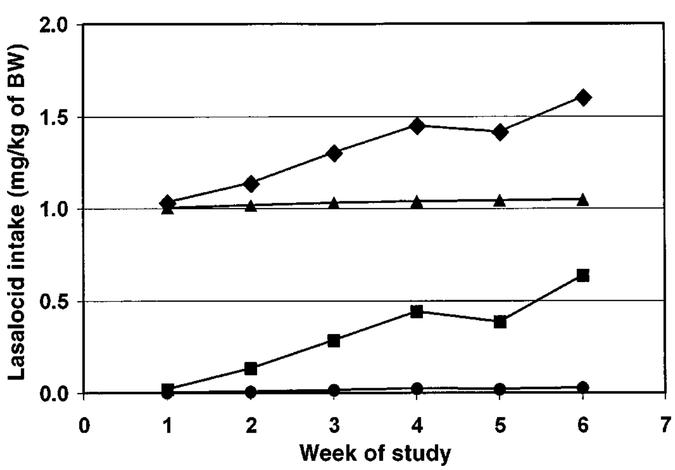

Figure 2. Intake of lasalocid (LAS) of calves fed LAS in milk replacer (MR) and calf starter (CS) in the following combinations: 0 mg of LAS in MR and 3 mg of LAS/kg of CS (●), 0 mg of LAS in MR and 44 mg of LAS/kg of CS (■), 80 mg of LAS in MR and 3 mg of LAS/kg of CS (▲), and 80 mg of LAS in MR and 44 mg of LAS/kg of CS (♦). Pooled SE = 0.04.

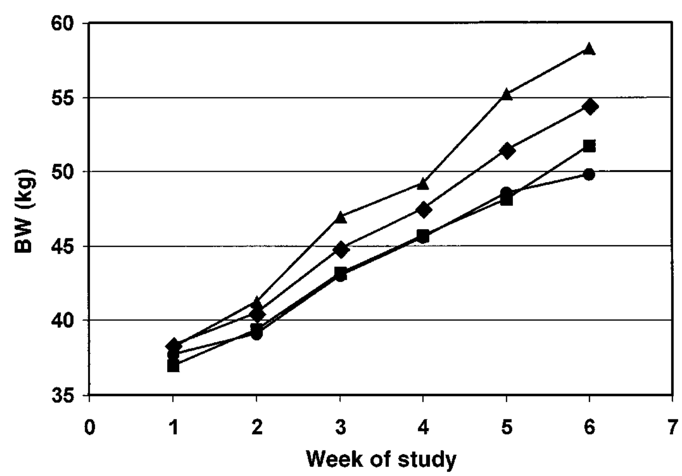

Figure 4. Weekly mean BW of calves fed lasalocid (LAS) in milk replacer (MR) and calf starter (CS) in the following combinations: 0 mg of LAS in MR and 3 mg of LAS/kg of CS (●), 0 mg of LAS in MR and 44 mg of LAS/kg of CS (■), 80 mg of LAS in MR and 3 mg of LAS/kg of CS (▲), and 80 mg of LAS in MR and 44 mg of LAS/kg of CS (♦). Pooled SE = 1.7.

BW gain was not different from calves fed no LAS. Improved feed efficiency in calves fed LAS in MR was probably due to reduced severity of coccidiosis, improved intake of CS, and digestibility when LAS was included in MR.

CONCLUSIONS

Calves fed LAS in MR consumed more MR and CS, had greater BW gain, shed fewer *Eimeria* oocysts, and scoured less frequently and severely than did calves fed no LAS or calves fed LAS in CS alone. The combination of LAS in MR and in CS did not improve performance above that of calves fed LAS in MR alone. When calves are infected with *Eimeria* spp. from an early age (2 to 3 wk of age), the low intake of CS may provide insufficient LAS (or other coccidiostat) to control coccidiosis effectively. When LAS was included in CS at 44 mg/kg of DM, intake of CS did not provide 1 mg of LAS/kg of BW throughout the study, indicating the need for the supplementation of LAS in MR. Other management conditions, such as the amount of MR or whole milk fed and the percentage of fat in MR, further affect the intake of LAS from CS. The use of coccidiostats in MR was an effective method to reduce the effects of coccidiosis in young calves infected at an early age.

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