PEER REVIEWED

Pasture Deworming and (or) Subsequent Feedlot Deworming with Fenbendazole. I. Effects on Grazing Performance, Feedlot Performance and Carcass Traits of Yearling Steers*

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Abstract

Seven hundred and thirty-four steers (629 lb, 286 kg) were utilized during a 118-day grazing period, after which six hundred and forty were placed in a feedlot for finishing (average of 121 days, range of 111 to 133 days) to measure the main effects and interactions of two pasture deworming treatments (negative control, strategically dewormed with fenbendazole) and two feedlot deworming treatments (negative control, dewormed with fenbendazole) on grazing performance, feedlot performance, carcass traits, and production economics for yearling steers. Strategic deworming with fenbendazole (FBZ) during the grazing phase increased pasture gain by 48 lb (22 kg; P = .014) compared to control steers. Final weight, daily gain, dry matter intake, and feed/gain ratios in the feedlot were affected by pasture treatment x feedlot treatment interactions, showing that while feedlot deworming improved performance of steers in all treatments, it had a much greater effect on performance of pasture control steers. On a live basis (deads not included), deworming with FBZ in the feedlot improved daily gain of pasture control steers by 13.4% (P < .001), compared with a 4.2% improvement (P = .01) for steers that had been strategically dewormed on pasture. Similarly, feedlot deworming improved feed/gain 4.65% (P < .0003) for pasture control steers, vs. a non-significant improvement of 0.4% (P = .74) for steers that had been strategically dewormed. On a carcass-adjusted basis, feedlot deworming of strategically dewormed steers increased daily gain 6.8% (P < .0001), and feed/gain by 2.9% (P = .07). Feedlot deworming of pasture control steers increased daily dry matter intake (DDMI) by 7.8% (P < .0001) compared to no feedlot deworming, while feedlot deworming increased DDMI by 3.2% (P < .005) in the same comparison for strategically dewormed steers. Carcass traits were affected similarly. Dressing percentage was increased by both strategic deworming on pasture (P = .08) and feedlot deworming with fenbendazole (P < .0001). Feedlot deworming of pasture control steers increased carcass weight by 49 lb (22 kg; P < .0001), while feedlot deworming of steers that were strategically dewormed on pasture increased carcass weight 21 lb (9.5 kg; P < .002). The percentage of choice carcasses was lower (P < .001), and the percentage of select carcasses was higher (P < .001) for the pasture control-feedlot control steers compared to the other treatment groups. Strategic deworming during grazing resulted in a net benefit of $33.75 per head, had steers been sold at the end of the grazing phase. For the com-

*Dedicated to the memory of Dr. Jerry R. Rains, who died on December 06, 1999.

plete grazing-finishing system, feedlot deworming of previously non-dewormed steers with FBZ produced a net benefit of $30.61 per head on a carcass-adjusted basis, while feedlot deworming of strategically dewormed steers produced a net benefit of $11.07. Under the conditions of this study, there were clear performance and economic benefits to strategically deworming grazing steers with FBZ on pasture, and to deworming yearling steers with FBZ that were entering the feedlot from summer pasture.

Introduction

Gastrointestinal parasites, particularly *Ostertagia ostertagi*, are a major cause of economic loss in ruminants throughout the world. It has become common practice in North America to administer a broad spectrum anthelmintic to calves and yearlings entering a grazing program or a feedlot. This has been done with limited knowledge of the economic benefits of deworming,[18] especially for yearling cattle in the feeding phase of production. As a result, many feedlot veterinarians and feedlot managers had begun to question the economic benefit resulting from deworming cattle, especially yearlings.

There are very few reports of studies comparing the use of modern anthelmintics and untreated controls in modern production settings. There is an abundance of information in the literature on the biology, life cycle and epidemiologic patterns of *O. ostertagi* and other gastrointestinal nematodes.[9,15,21,26] Additionally, the effects of gastrointestinal parasite infection on ruminant nutrition[17] and the pathophysiology of infection have been well reviewed.[4,8,10,23] Much of this very important information has been generated in well- controlled studies using small numbers of cattle.

To address the concerns of the feedlot industry, the impact of deworming on clinically and economically important outcomes, such as daily gain, feed intake, feed efficiency, carcass quality, and general health, needed to be described in a well controlled, production setting. The information from such a study can be integrated with our understanding of the parasites to make well informed, science-based decisions about deworming yearling cattle in North American feedlots.

Materials and Methods

This trial was conducted with the objective of measuring the effects and potential interactions of pasture deworming treatment (control vs. strategic deworming with fenbendazole) and feedlot deworming treatment (control vs. fenbendazole) on grazing performance, feedlot performance, carcass traits, and production economics of yearling steers. The trial was therefore conducted in two phases, with the pasture phase being conducted in southeastern Oklahoma and the feedlot phase being conducted in Colorado.

Pasture Phase

Seven hundred and fifty two crossbred yearling steers (avg. wt 629 lb, 286 kg) were purchased from four different locations (Aetna, KS; Dodge City, KS; El Reno, OK and Oklahoma City, OK). Cattle arrived at the pasture facility 3-7 days prior to the start of the experiment. During this period, all steers were administered a modified-live IBR-BVD-*Leptospira pomona* combination vaccine, a 7-way clostridial bacterin-toxoid, individually identified by a numbered ear clip tag, and kept in grass traps by origin. Seven hundred and thirty-four steers were used in the study.

Steers were individually weighed within each origin, implanted with a trenbolone acetate-estradiol growth implant[a] and randomly assigned to one of two pasture treatments by tossing a coin to determine the first treatment assignment, and then alternating treatments as the calves passed through the chute. Each calf received a second numbered ear tag that was color coded based upon origin and treatment. Pasture treatments were 1) non-dewormed controls, or 2) strategically dewormed with fenbendazole[b] (FBZ). Strategically dewormed steers received 2.27 mg/lb (5 mg/kg) BW of FBZ oral suspension at initial processing and a free-choice mineral at 28 and 56 days that contained FBZ. Composition of the free-choice mineral is given in Table 1.

Steers grazed predominantly bermuda grass pastures near Hugo, OK. The pastures had been grazed during the previous grazing season. There was no his-

Table 1. Fenbendazole free-choice mineral composition.

Ingredient	Amount
Fenbendazole	.50 % (2.27 g/lb)
Calcium, minimum	13.50 %
Calcium, maximum	16.20 %
Phosphorus, minimum	7.00 %
Salt, minimum	18.20 %
Salt, maximum	21.80 %
Magnesium, minimum	.20 %
Potassium, minimum	.40 %
Copper, minimum	1,250 ppm
Selenium, minimum	14 ppm
Zinc, minimum	3,000 ppm
Vitamin A, minimum	300,000 IU/lb
Vitamin D3, minimum	30,000 IU/lb
Vitamin E, minimum	100 IU/lb

tory regarding parasite control programs for cattle previously grazing the pastures. The study pastures (5 replicates/treatment) ranged from approximately 120 - 360 acres and were stocked at densities varying from approximately .5 - 1 steers/acre, depending upon forage quantity and grazeable area in each pasture. Within each pair of pastures, stocking rates were identical. Aerial photographs were utilized to cross-fence the pastures into two approximately equal halves with electric fencing. The two treatments were randomly assigned to each pasture by flipping a coin. Each source of steers comprised one pasture replicate except that steers originating from Dodge City comprised two pasture replicates. Steers were placed into their respective pastures 24 hr following randomization and remained there until the end of the trial.

All steers had access to a complete, free-choice mineral containing bambermycins[c] formulated to provide an intake of 20 mg/hd/d of the drug. Remaining bambermycins mineral was removed, and the mineral containing FBZ was placed in mineral feeders at days 28 and 56 of the trial for the strategically dewormed steers. The FBZ-containing mineral was consumed over a six day period.[12] Steers had access to stock tanks, ponds or creeks for water. All steers were fed 2 lb (0.91 kg)/hd/d of pelleted wheat midds for 30 days, beginning on day 13, because of less than adequate forage availability. Additionally, all steers were fed 2 lb (0.91 kg)/hd/d of an all-natural 38% protein cube from day 104 until the end of the trial, because of decreasing forage quality.

The trial was conducted from April to August, 1997. Steers were weighed off individually by pasture over a 3-day period on portable scales. To minimize weight variance due to shrinkage, steers within each replicate were mixed prior to being weighed. Average time of grazing was 118 days.

Feedlot Phase

Following the pasture phase, steers were shipped to a feedlot research facility near Wellington, Colorado. Steers were kept segregated by origin and pasture treatment groups. Processing included administration of a modified live IBR/BVD vaccine, a pour-on ectoparasiticide for grubs and external parasites,[d] and a zeranol[e] growth implant. Clorsulon[f] was administered to all steers at 28 days to minimize the potential confounding of results by the presence of liver flukes, and all steers received a terminal trenbalone acetate-estradiol combination growth implant[g] at 56 days.

Six hundred and forty steers were used for the feeding phase of the study. Of the original group of steers, the heaviest and lightest cattle, and any lame cattle, were not included in the feeding phase. This resulted in less weight variation across the group. The 640 remaining steers were computer randomized and stratified by weight within pasture replicate to 80 pens (8 head/pen), with 20 pens each assigned to the pasture-feedlot treatment combinations of 1) pasture control-feedlot control, 2) pasture control-dewormed in the feedlot, 3) strategically dewormed on pasture-feedlot control, and 4) strategically dewormed on pasture-dewormed in the feedlot. Steers that were dewormed in the feedlot received FBZ at 2.27 mg/lb (5 mg/kg) of BW. Because pasture replicates differed in size, each 20 pens of steers assigned to the four pasture-feedlot treatment combinations were comprised of 3 pens of steers from pasture one, 5 pens from pasture two, 2 pens from pasture three, 7 pens from pasture 4, and 3 pens from pasture 5.

Steers were fed a steam flaked corn-based ration once daily. A series of four adaptation, or "step-up" rations were utilized prior to the finisher (Table 2). Steers were placed on the final ration at 28 days. The finisher ration contained 13.5% crude protein, and provided 300 mg monensin and 90 mg tylosin per head daily. Initial and final weights were single day, individual full weights obtained in the morning before feeding. Complete health records were maintained. All animals that died during the study were necropsied.

The feedlot phase of the trial was begun August 26 and 27, 1997. Steers were slaughtered when they were appraised to have adequate finish for marketing. There were three slaughter dates, and all steers from the same origin and pasture group were slaughtered on the same day. Time on feed for the different groups ranged from 111 to 133 days, with an average time on feed of 121 days for all steers in a treatment. Steers were slaughtered at a commercial packing plant. Hot carcass weight and liver condemnation scores were obtained at slaughter. Yield grade and quality grade data, including ribeye area, backfat thickness, KPH fat, and marbling score were collected by trained personnel following a 36-hour carcass chill.

Fecal sampling and egg counts

Fecal grab samples were obtained per rectum at initial processing prior to the start of the pasture phase from approximately 14% of the steers from each origin. Subsequent fecal samples were obtained from the trial pastures 21 days after each treatment of steers with FBZ (samples obtained on days 21, 49 and 77). Rectal grab samples were obtained from all steers at the end of the grazing phase (118 days). These samples served to establish off-pasture fecal egg counts as well as initial feedlot fecal egg counts.

During the feedlot phase, 25% of the steers were sampled at 14, 28, and 56 days of the study. The same steers were sampled on each of the sampling days. All steers were then sampled upon obtaining final weights before slaughter. Fecal samples were analyzed using the Modified Wisconsin Sugar Flotation Technique to establish worm egg counts. Results are reported as eggs/g of feces.

Table 2. Composition of feedlot rations (100% DM basis).

Ingredient	Ration 1	Ration 2	Ration 3	Ration 4	Finisher
Steam flaked corn	43.6	50.8	57.5	71.2	83.1
Corn silage	3.5	24.5	26.1	14.1	5.0
Alfalfa hay	46.1	16.2	7.7	5.5	2.2
Liquid supplement	6.7	8.5	8.7	9.2	9.7

Statistical Analyses

Data were analyzed using the statistical analysis package of SAS.[19] Grazing performance of steers was analyzed using analysis of variance for a randomized block design. Pasture replicate served as the experimental unit.

Feedlot performance, combined grazing and feedlot performance, and carcass data were analyzed using a split-plot model. The main plot effect of pasture treatment was tested using pasture replicate x pasture treatment as the error term. Sub-plot effects of feedlot treatment and the feedlot treatment x pasture treatment interaction were tested with residual error. Pen was used as the experimental unit for all feedlot performance and carcass data, with the exception that individual animal was used in Chi-square analyses of non-parametric data (e.g., percentage of choice carcasses, distribution of yield and quality grades, liver condemnations, health data).

Fecal worm egg counts were also analyzed using split-plot models. For egg counts during the grazing phase, the main plot effect of pasture treatment was tested by the main plot error term of pasture replicate x pasture treatment. The sub-plot effects of sampling day and the pasture treatment x sampling day interaction were tested with residual error. Feedlot fecal egg counts were analyzed with a split-split-plot model. The main plot effect of pasture treatment was tested using pasture replicate x pasture treatment as the error term. Sub-plot effects of feedlot treatment and the pasture treatment x feedlot treatment interaction were tested by the sub-plot error term of pasture replicate x pasture treatment x feedlot treatment. Sub-sub plot effects of sampling day and the resulting two- and three-way interactions of sampling day with pasture treatment and feedlot treatment were tested with residual error.

Results

Pasture phase. Strategically dewormed steers gained 48 more pounds (22 kg; P = .014) than did control steers during the 118-day grazing phase (Table 3). This, despite the fact that overall grazing performance was not very impressive. A cool, wet spring delayed forage growth, hence, steers were supplemented with 2 lb (0.91 kg)/hd/d of pelleted wheat midds for 30 days at the beginning of the study. The summer of 1997 was hot and dry in the region of the country where this experiment was conducted, which likely had a negative impact on forage quantity and (or) quality. The fecal egg count data (Table 4) showed steers shedding an average of 12 to 17 eggs/g at day 0. A treatment x sampling day interaction (P < .001) showed that average egg counts for strategically dewormed steers declined throughout the grazing season, while egg counts for control steers increased, and then declined slightly by day 118.

Feedlot performance. Performance data are presented three ways in Table 5: excluding animals that died (deads out), including animals that died (deads included), and on a carcass-adjusted basis. Final weights were full weights, and not adjusted for shrink (ie, no "pencil shrink" was used). Deads-out and carcass-adjusted performance data were calculated from the means of individual animals within a pen. Analysis of the deads-included data was conducted on gross pen weights, rather than pen means obtained from individual animals within the pen.

Pasture deworming treatment and feedlot deworming treatment interacted on all feedlot performance variables in Table 5. Generally, these interactions can be interpreted as showing that while deworming with FBZ in the feedlot improved performance of steers regardless of pasture deworming treatment, the response was more dramatic in steers that had not been strategically dewormed while on pasture. For example, in the deads out

Table 3. Least squares means for the effect of strategic deworming with fenbendazole on grazing performance of steers.

Item	Control	Dewormed	S.E.M[a]	Probability
Pasture reps.	5	5		
No. steers	371	363		
Initial wt, lb	627	632	3.0	.32
Final wt, lb	737	790	10.8	.026
Gain, lb/hd	110	158	8.2	.014
Daily gain, lb	.93	1.34	.070	.014

[a]Standard error of the mean.

performance analysis, deworming with FBZ in the feedlot improved ADG by 13.4% (P < .001) for pasture control steers, compared with a 4.2% improvement (P = .01) for steers that had been strategically dewormed on pasture. Similarly, feedlot deworming improved feed/gain 4.65% (P < .0003) for pasture control steers, vs. a non-significant improvement of 0.4% (P = .74) for steers that had been strategically dewormed. Feedlot deworming of pasture control steers increased daily dry matter intake (DDMI) by 7.8% (P < .0001) compared to no feedlot deworming, while feedlot deworming increased DDMI by 3.2% (P < .005) in the same comparison for strategically dewormed steers.

Table 4. Least squares means for the effects of strategic deworming with fenbendazole and day of sampling on average fecal egg counts of grazing steers.

	Fecal egg counts (eggs/g)[a]		
Day	Control	Dewormed	Pooled S.E.M[b]
0	12	17	6.6
21	24	11	7.6
49	78	7	7.4
77	67	2	7.6
118	47	9	2.6

[a]Treatment x sampling day interaction (P < .0001).
[b]Pooled standard error of the mean (total n=1033 samples).

Performance differences were more dramatic in the analysis in which deads were included (Table 5), since four steers in the pasture control-feedlot control treatment, and one steer in the pasture dewormed-feedlot control treatment died during the trial. Feedlot deworming of pasture control steers increased daily gain 18.4% (P < .0001) and feed/gain 10.3% (P < .0008), while feedlot deworming of steers that had been strategically dewormed on pasture improved daily gain 5.7% (P < .0001) and feed/gain 2.3% (P = .066).

Performance data in Table 5 are also expressed on a carcass adjusted basis. Final weights were calculated by dividing hot carcass weight by a dressing percentage of 60.41, which was the average dressing percentage for all treatments in the trial. For carcass adjusted data, feedlot deworming of pasture control steers increased daily gain 17.7% (P < .0001) and feed/gain 8.4% (P <

Table 5. Least squares means for the effects of pasture strategic deworming and (or) feedlot deworming with fenbendazole on feedlot performance of steers (121 days on feed).

Pasture trt:	Control		Dewormed			Probability[b]		
Feedlot trt:	Control	Dewormed	Control	Dewormed	S.E.M[a]	P	F	P*F
No. pens	20	20	20	20				
No. steers	155	160	159	160				
Initial wt, lb	726	725	779	779	1.0			
Final wt, lb	1212	1275	1295	1315	6.4	.015	.0001	.0008
Performance (deads out)								
Daily gain, lb	4.03	4.57	4.29	4.47	.052	.56	.0001	.0005
DDMI, lb[c]	21.55	23.23	23.17	23.90	.187	.008	.0001	.0095
Feed/gain	5.38	5.13	5.42	5.40	.048	.25	.004	.015
Performance (deads included)								
Daily gain, lb	3.85	4.56	4.22	4.46	.071	.26	.0001	.0009
DDMI, lb[c]	21.75	23.24	23.24	23.91	.208	.013	.0001	.04
Feed/gain	5.75	5.16	5.55	5.42	.124	.70	.003	.059
No. deads	4	0	1	0				
Carcass adjusted performance[d]								
Final wt, lb	1197	1277	1293	1327	7.8	.0075	.0001	.0025
Daily gain, lb	3.90	4.59	4.27	4.56	.063	.18	.0001	.0015
Feed/gain	5.56	5.09	5.43	5.27	.064	.84	.0001	.013

[a] Standard error of the mean.
[b] Probability values for effects of pasture treatment (P), feedlot treatment (F), and the pasture treatment x feedlot treatment interaction (P*F).
[c] Daily dry matter intake.
[d] Final weights were calculated as hot carcass weights divided by the average dressing percentage (60.41%) for all treatments.

.0001), while feedlot deworming of steers that had been strategically dewormed on pasture improved daily gain 6.8% (P < .0001) and feed/gain 2.9% (P = .07). Greater improvements in daily gain and feed efficiency from feedlot deworming when data are expressed on a carcass adjusted basis are attributable to the fact that feedlot deworming improved (P < .0001) dressing percentage of steers (Table 9).

Feedlot health data are presented in Table 6. There was a significant (P < .001) treatment effect on the number of steers treated for medical reasons and the total number of treatments administered. Although a significant (P < .03) Chi-square statistic existed for treatment effect on the number of dead animals, there were not enough deaths for a valid statistical test. Three of the deaths in the pasture control-feedlot control treatment were attributed to clinical parasitism upon postmortem inspection, the fourth steer died of pulmonary edema and heart failure. Death of the steer in the pasture dewormed-feedlot control group was due to acute interstitial pneumonia and associated pulmonary emphysema. Medical records for the remaining steers are presented in Table 7.

Fecal egg counts during the feedlot phase were affected by a pasture treatment x feedlot treatment x sampling day interaction (P < .01; Table 8). The data show that strategically dewormed steers entered the feedlot with lower worm egg counts than pasture control steers. Deworming in the feedlot reduced egg counts for both strategically dewormed steers and pasture control steers, but the reduction was much greater for the pasture control steers. Over time, egg counts for steers dewormed in the feedlot remained low, while those of steers not dewormed in the feedlot increased to day 28, then decreased until slaughter. Fecal egg counts at slaughter were similar across all treatments, despite the fact that significant differences in animal performance occurred in both the pasture and feedlot phases of the trial.

Table 6. Feedlot health data.

Pasture trt:	Control		Dewormed	
Feedlot trt:	**Control**	**Dewormed**	**Control**	**Dewormed**
No. dead	4	0	1	0
No. treated[a]	22	13	6	4
% of steers	13.8	8.1	3.8	2.5
% of treated	49	29	13	9
No. treatments[a]	34	13	6	4
% of trtmnts.	60	23	10	7

[a]Treatment difference (P<.001; Chi-square).

Table 7. Feedlot medical records.

Date	Animal ID	Diagnosis	Disposition
Pasture Control: Feedlot Control			
8/27/97	1321	Pinkeye	Return to pen
8/27/97	1333	Pinkeye	Return to pen
8/27/97	1351	Pinkeye	Return to pen
8/27/97	1372	Pinkeye	Return to pen
8/27/97	1422	Pinkeye	Return to pen
8/28/97	1133	Respiratory Disease	Return to pen
9/2/97	1422	Scours	Return to pen
9/2/97	1428	Respiratory Disease	Return to pen
9/2/97	1531	Scours	Return to pen
9/3/97	1133	Noneater	Return to pen
9/4/97	1353	Noneater	Return to pen
9/4/97	1412	Noneater	Return to pen
9/6/97	1371	Noneater	Return to pen
9/18/97	1371	Lump Jaw	Return to pen
9/20/97	1435	Hypothermia	Return to pen
9/21/97	1526	Pinkeye	Return to pen
9/29/97	1548	Foot Rot	Return to pen
10/2/97	1373	Respiratory Disease	Return to pen
10/3/97	1222	Foot Rot	Return to pen
10/3/97	1425	Noneater	Return to pen
10/5/97	1131	Respiratory Bloat	Return to pen
10/9/97	1133	Respiratory Disease	Return to pen
10/9/97	1435	Scours	Return to pen
10/10/97	1131	Respiratory Disease	Return to pen
10/10/97	1135	Scours	Return to pen
10/12/97	1312	Respiratory Disease	Return to pen
10/13/97	1342	Respiratory Disease	Return to pen
10/17/97	1131	Bloat	Return to pen
10/23/97	1425	Respiratory Disease	Return to pen
10/26/97	1435	Respiratory Disease	Return to pen
10/28/97	1131	Bloat	Return to pen
10/30/97	1133	Respiratory Disease	Return to pen
11/1/97	1211	Noneater	Return to pen
11/6/97	1131	Foot Rot	Return to pen
Pasture Control: Feedlot Dewormed			
8/26/97	2214	Pinkeye	Return to pen
8/27/97	2331	Pinkeye	Return to pen
8/27/97	2353	Pinkeye	Return to pen
8/27/97	2367	Pinkeye	Return to pen
8/28/97	2215	Respiratory Disease	Return to pen
9/3/97	2351	Noneater	Return to pen
9/6/97	2554	Foot Rot	Return to pen
9/7/97	2373	Pinkeye	Return to pen
10/7/97	2421	Scours	Return to pen
10/22/97	2541	Cellulitis	Return to pen
10/27/97	2357	Respiratory Disease	Return to pen
11/4/97	2112	Respiratory Disease	Return to pen
11/20/97	2227	Lameness	Return to pen
Pasture Dewormed: Feedlot Control			
8/26/97	3114	Pinkeye	Return to pen
8/26/97	3132	Pinkeye	Return to pen
8/27/97	3368	Pinkeye	Return to pen
8/29/97	3427	Upset Stomach	Return to pen
10/7/97	3312	Foot Rot	Return to pen
11/6/97	3552	Cut on head	Return to pen
Pasture Dewormed: Feedlot Dewormed			
8/26/97	4126	Pinkeye	Return to pen
8/27/97	4315	Pinkeye	Return to pen
10/27/97	4212	Respiratory Disease	Return to pen
10/30/97	4373	Respiratory Disease	Return to pen

Table 8. Least squares means for the effects of strategic deworming on pasture and (or) feedlot deworming with fenbendazole on fecal egg counts[a] (eggs/g) of finishing steers.

Pasture trt:	Control		Dewormed		Pooled
Feedlot trt:	Control	Dewormed	Control	Dewormed	S.E.M.[b]
Sampling day					
0	47.5	49.6	6.5	9.6	3.32
14	94.8	0	52.4	.4	6.16
28	71.0	.6	45.1	1.4	6.18
56	18.8	4.1	5.7	2.8	6.16
Slaughter	7.8	7.0	4.6	5.5	3.28

[a] Pasture treatment x feedlot treatment x day interaction (P < .01).
[b] Pooled standard error of the mean (total n=1653 samples).

Carcass traits. Dressing percentage (Table 9) was increased by both strategic deworming on pasture (P = .08) and feedlot deworming with fenbendazole (P < .0001). Hot carcass weights were affected by a pasture treatment x feedlot treatment interaction (P < .0025) that reflected feedlot gain data. Feedlot deworming of pasture control steers increased carcass weight by 49 lb (22 kg; P < .0001), while feedlot deworming of steers that were strategically dewormed on pasture increased carcass weight 21 lb (9.5 kg; P < .002). Increases in ribeye area and backfat as affected by treatment seemed to be the result of increased growth rates and heavier carcass weights provided by deworming.

Feedlot deworming increased (P < .0001) average yield grade compared with those not dewormed in the feedlot. The distribution of yield grades differed (P < .001) among treatments, showing that steers from the pasture control-feedlot control treatment had more yield grade 1 carcasses, and fewer yield grade 3 carcasses than did steers from the other treatments. Marbling scores were affected by a pasture treatment x feedlot treatment interaction (P < .0027), which showed that while deworming with FBZ in the feedlot resulted in an increase in marbling score, the magnitude of increase was greater for pasture control steers vs. those strategically dewormed on pasture. Additionally, the distribution of quality grades differed (P < .001) among treatments. The percentage of choice carcasses was lower, and the percentage of select carcasses was higher for the pasture control-feedlot control steers compared to the other treatment groups. These data, together with hot carcass weight and the other measures of carcass finish (backfat, KPH fat, yield grade data), reflect differences in pasture and feedlot growth rates. There was no effect of treatment (P = .80) on the percentage of liver condemnations from abscesses or flukes. The low incidence of liver flukes is interesting since steers grazed in a reported fluke endemic area during the pasture phase of the study.

Combined grazing-finishing performance. Average total time of grazing and feedlot finishing for steers in this trial was 239 days. Pasture treatment x feedlot treatment interactions affected both total gain (P < .0011) and daily gain (P < .0012) in this study (Table 10). The interaction shows that while feedlot deworming was beneficial to both the pasture control and dewormed groups, the magnitude of gain response was much greater for the pasture control group. Deworming the pasture control steers in the feedlot increased total grazing-finishing gain by 68 lb (31 kg; P < .0001) as compared to control steers. Feedlot deworming of strategically dewormed steers increased total gain by 23 lb (10.5 kg; P = .016), a lesser response, despite still being significantly different. Strategic deworming, followed by deworming upon feedlot entry, increased total gain 102 lb (46 kg; P < .0001) vs. control steers.

Economics. Had steers been sold at the end of the grazing phase, strategic deworming with FBZ would have resulted in a net benefit of $33.75 per head (Table 11). In the grazing-finishing system analysis (Table 12), feedlot deworming of previously non-dewormed steers with FBZ produced a net benefit of $20.41 per head on a live basis, or $30.61 per head on a carcass adjusted basis. Feedlot deworming of strategically dewormed steers produced a net benefit of $2.67 on a live basis, or $11.07 on a carcass- adjusted basis. Economic evaluation with deads included showed a net benefit to feedlot deworming of pasture control steers or those strategically dewormed on pasture of $35.46 or $6.43 per head, respectively.

Discussion

The increased pasture gain of treated steers was not unexpected. Summaries[12,24] representing various geographical regions across North America have shown improved weight gains ranging from 14 to 90 lb (6.4 - 41

Table 9. Least squares means for the effects of pasture strategic deworming and (or) feedlot deworming with fenbendazole on slaughter and carcass traits.

Pasture trt:	**Control**		**Dewormed**			**Probability[b]**		
Feedlot trt:	**Control**	**Dewormed**	**Control**	**Dewormed**	**S.E.M[a]**	**P**	**F**	**P*F**
Dressing pct.	59.66	60.61	60.37	61.02	.169	.08	.0001	.37
Hot weight, lb	723	772	781	802	4.7	.0075	.0001	.0025
Ribeye area, in^2	12.79	13.09	13.27	13.42	.124	.0342	.0628	.5138
Backfat, in	.32	.39	.38	.40	.010	.19	.0001	.0242
KPH fat, %	3.02	3.19	3.03	3.23	.064	.61	.0027	.84
Yield grade	2.34	2.61	2.54	2.65	.050	.149	.0001	.089
YG Distribution [c]								
YG 1, %	26.9	12.6	14.2	11.9				
YG 2, %	61.7	60.9	62.6	58.3				
YG 3, %	10.7	25.2	23.2	27.8				
YG 4, %	.7	1.3	0	2.0				
Marbling [d]	3.59	4.02	3.88	4.03	.048	.0368	.0001	.0027
QG Distribution [e]								
Choice, %	29.0	52.0	44.6	55.2				
Select, %	65.1	47.4	53.5	44.2				
Standard, %	5.9	.6	1.9	.6				
Liver condemnations								
Abscessed, %	13.2	13.6	13.5	13.0				
Flukes, %	2.0	.6	.6	.6				

[a] Standard error of the mean.
[b] Probability values for effects of pasture treatment (P), feedlot treatment (F), and the pasture treatment x feedlot treatment interaction (P*F).
[c] Distribution of yield grades. Treatment difference (P < .001; Chi-square).
[d] $Slight^{50}$ = 3.5, $small^{0}$ = 4.0, $small^{50}$ = 4.5.
[e] Distribution of quality grades. Treatment difference (P < .001; Chi-square).

kg) during 81-217 day grazing periods when FBZ was used in a strategic deworming program. In a Virginia study,[25] steers were allocated to one of three treatment groups: FBZ oral drench at processing followed by access to FBZ medicated blocks at days 21 and 42, ivermectin injectable administered at processing followed by access to FBZ medicated blocks at day 35, and nontreated controls. Steers treated strategically with FBZ or treated with ivermectin at processing followed by access to FBZ medicated blocks gained 64 and 37 lb (29 and 17 kg), respectively, more than controls during the 111 day grazing season. In Canada, two studies on the effect of deworming yearling steers on pasture have shown conflicting results. In the first study,[14] there was no economic advantage to treating cattle on pasture, while in a second trial, 773 lb (351 kg) steers treated with ivermectin at turnout gained 16.7 lb (7.6 kg) more than untreated controls during the 120 day grazing season, resulting in an economic benefit of $8.72 (CAN) per treated animal.[13] The lower weight gain of pasture calves with subclinical parasite infections are largely due to reduced forage intake. Comparisons of infected cattle with uninfected cattle have shown a reduced intake of 20 to 25%.[17,22]

Most cattle arriving at a feedlot have no known history of treatment for parasites. Some may have been recently treated for internal parasites and some may never have been treated. Larval contamination of pastures where the cattle had grazed will vary considerably. As a result, the 4.2 to 13.4% improvement in gain and the 0.4 to 4.65% improvement in feed efficiency seen in treated steers in this study are likely representative of many incoming feedlot cattle. In an Idaho study,[11] yearling steers from California were grazed on pastures with a history of producing GI nematodiasis. Steers dewormed at feedlot entry had 8.8 to 9.5% improved gain and 4.4 to 5.2% better feed efficiency than nontreated controls. In a four trial summary, Myers and Grant[16] reported 3.2% improvement in gain and negligible differences in feed efficiency when dewormed cattle were compared to controls.

Lowered daily gain and loss of feed efficiency in parasitized feedlot cattle in this study can be partially explained by reduced voluntary feed intake. The de-

Table 10. Least squares means for the effects of pasture strategic deworming and (or) feedlot deworming with fenbendazole on total grazing-finishing gain by steers (239 days).

Pasture trt:	Control		Dewormed			Probability[b]		
Feedlot trt:	Control	Dewormed	Control	Dewormed	S.E.M[a]	P	F	P*F
No. pens	20	20	20	20				
No. steers	155	160	159	160				
Total gain, lb	584	652	663	686	7.0	.0097	.0001	.0011
Daily gain, lb	2.44	2.73	2.77	2.87	.0293	.0099	.0001	.0012

[a] Standard error of the mean.
[b] Probability values for effects of pasture treatment (P), feedlot treatment (F), and the pasture treatment x feedlot treatment interaction (P*F).

gree of inappetence varies in relation to the parasite burden.[10] As much as 73% of the difference in weight gain in young calves has been attributed to depression in appetite.[5] Other possible causes of lower gain and loss of feed efficiency include the parasite burden effect on GI motility, GI secretions, digestion, absorption and effects on protein and energy metabolism.[4] The difference in feed intake between treated and nontreated groups in our study was greater than that previously reported in feedlot cattle.[1,11]

To our knowledge, this is the first North American study to comprehensively report differences in carcass quality due to differences in deworming strategies. When feedlot cattle are sold on a carcass-value basis, differences in carcass traits can have a significant economic impact. While hot carcass weight is a function of live weight and dressing percentage, marbling score and quality grade strongly influence carcass value. Steers not dewormed at feedlot entry had more yield grade 1 carcasses. This at first may seem to be positive, but instead should be attributed to carcasses of lesser overall quality and value. Other reports on the relationship between anthelmintic treatment or parasite infection and carcass quality of steers fed in North American feedlots are scanty. A recent U.S. study of the effect of deworming on carcass traits showed no difference in carcass yield, yield grade distribution or quality grade between yearlings dewormed at feedlot entry and nontreated controls.[11]

Table 11. Economics of strategic deworming with fenbendazole on profitability during the grazing phase.

Item	Control	Dewormed
On pasture wt, lb [a]	627	632
Off pasture wt, lb [a]	737	790
Pasture costs, $/hd [b]	598.22	604.22
Profit (loss), $/hd [c]	(45.47)	(11.72)
Net benefit, $/hd		33.75

[a] Data from Table 1.
[b] Assumes 630 lb steers purchased at $80/cwt., 10% interest, $60/head pasture rent, $10/head processing and veterinary, $10/head mineral, $6/head for strategic deworming.
[c] Yearling feeders priced at $75/cwt.

In Holstein steers, calves inoculated with *O. ostertagi* had lower dressing weight, lower dressing percent, smaller rib-eye area, higher water-holding capacity and lower crude protein content than control calves.[27] Another report on Friesian steers showed that treatment for GI parasites resulted in carcasses with a higher dressing percentage, superior carcass measurements, and a higher percentage of carcasses that "graded satisfactorily" than did nontreated controls.[3] A study from Argentina reported similar findings.[6] It is difficult to compare carcass differences between European, Latin American and North American studies because of differences in cattle type, feeding strategies and carcass quality and grading standards. It remains significant, though, that the majority of studies have reported that GI parasite burden or lack of treatment for parasites results in a loss of carcass quality and value.

There was a relationship in our study between the number of steers treated for various ailments in the feedlot and the parasite control group to which they were assigned. More of the pasture control-feedlot control steers were treated for pinkeye, respiratory disease, scours, bloat and as "non-eaters" than were steers in other groups. While it is possible that some pasture control-feedlot control steers were called "sick" because of rough haircoats or less body condition, in other words they did not appear as thrifty or were not as "attractive" as steers in other groups, it appears that there were in fact more health problems in this group. *O. ostertagi* infections, and possibly other nematodes, strongly stimulate the host gut immune system, which may diminish the host's ability

Table 12. Economics of strategic deworming and (or) feedlot deworming with fenbendazole in a combined grazing-finishing system.

Pasture trt:	**Control**		**Dewormed**	
Feedlot trt:	**Control**	**Dewormed**	**Control**	**Dewormed**
Pasture costs, $/hd [a]	598.22	598.22	604.22	604.22
Feedlot costs, $/hd [b]	230.94	246.53	243.75	252.48
Final weight [c]	1164	1224	1243	1262
Live basis (deads out)				
Total costs, $/hd	829.16	844.75	847.97	856.70
Profit (loss), $/hd [d]	(130.76)	(110.35)	(102.17)	(99.50)
Breakeven, $/cwt [e]	71.23	69.02	68.22	67.88
Live basis (deads included)				
Dead animals, n	4	0	1	0
Total costs, $/hd [f]	844.21	844.75	847.97	856.70
Profit (loss), $/hd	(145.81)	(110.35)	(105.93)	(99.50)
Breakeven, $/cwt [e]	72.53	69.02	68.52	67.88
Carcass-adjusted basis				
Final weight, lb [c]	1149	1226	1241	1274
Profit (loss), $/hd [d]	(139.76)	(109.15)	(103.37)	(92.30)
Breakeven, $/cwt [e]	72.07	68.84	69.47	67.18

[a] Assumes 630 lb steers purchased at $80/cwt, 10% interest, $60/head pasture rent, $10/head processing and veterinary, $10/head mineral, $6/head for strategic deworming.
[b] Assumes ration cost of $145/ton of DM, $20/hd processing and veterinary, 10% interest (animals and 1/2 of feed), $.20/cwt trucking, $1.20/head for deworming.
[c] Data from Table 3, minus a 4% pencil shrink.
[d] Finished steers priced at $60/cwt.
[e] For finished steers.
[f] Assumes value of deads to be equal to pasture costs ($598.22 per head for pasture control steers, $604.22 per head for strategically dewormed steers).

to mount immune responses to vaccination or to other diseases.[7] In another report, calves naturally infected with internal parasites and vaccinated with *Brucella abortus* (strain 19) vaccine had lower serum antibody titers against *B. abortus* than calves with negligible parasite infections, suggesting that parasitism caused a depression of non-specific humoral immunity.[22] Four of the five dead cattle in this study were from the pasture control-feedlot control group, and 3 of 4 deaths in this group were thought to be the direct result of clinical parasitism. No lesions were found at necropsy in these 3 steers that could be associated with any other cause of death.

Summary and Conclusion

This trial was designed and conducted to evaluate the effects and interaction of strategic pasture deworming with feedlot deworming, and to determine the impact of deworming yearling beef steers on clinically relevant outcomes; pasture and feedlot gain, feed efficiency, carcass quality and general health. Recommendations on experimental design[2,20] and data analysis were followed to the greatest extent possible. Feedlots can expect to receive cattle representative of both pasture treatment groups. As a result, economic returns from deworming yearling cattle at feedlot entry can realistically mimic the benefits seen here. To ensure data are useful over different geographical areas and varying management systems, further studies are encouraged.

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Footnotes

[a]Revalor® - G. Hoechst Roussel Vet, Clinton, NJ 08809
[b]Safe-Guard®. Hoechst Roussel Vet, Clinton, NJ 08809
[c]Gainpro®. Hoechst Roussel Vet, Clinton, NJ 08809

[d]Tiguvon® (fenthion). Bayer Corp, Shawnee Mission, KS 66201
[e]Ralgro® Implants. Schering-Plough Animal Health, Union NJ 07083
[f]Curatrem®. Merial Limited, Iselin, NJ 08830
[g]Revalor® - S. Hoechst Roussel Vet, Clinton, NJ 08809

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Abstract

Diagnosis of Lyme Disease in Two Cows by the Detection of *Borrelia burgdorferi* DNA

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Two cows from different herds in a district of Switzerland known to harbour ixodid ticks had erythematous lesions on the hairless skin of the udder, were in poor general condition with a poor appetite and decreased milk production, and had a stiff gait and swollen joints. *Borrelia burgdorferi sensu strictu* DNA was detected in samples of synovial fluid and milk from one of the cows and *Borrelia afzelii* DNA was detected in synovial fluid from the other by means of a real-time PCR.