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Influence of Both Endophyte Infestation in Fescue Pastures and Calf Genotype on Subsequent Feedlot Performance of Steers[1,2]

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Abstract

Three experiments were conducted to determine the influence of both the concentration of endophytic fungus infestation in tall fescue pastures and calf genotype on the subsequent health and performance of steers in the feedlot. In Exp. 1 and 2, Angus steers grazed fescue pastures in Georgia containing low, moderate, or high endophyte infestations for 182 d (Exp. 1) or 78 d (Exp. 2) with 12 steers per treatment. Steers were transported 1,600 km to Texas in October (Exp. 1) and July (Exp. 2), were fed a 93% concentrate diet during the finishing period, and were harvested at an estimated backfat thickness of 12 mm. In both trials, DMI over the entire feeding period and carcass characteristics were not affected (P>0.05) by endophyte infestation. In both trials, pasture ADG decreased, and feedlot ADG and gain to feed ratio increased as the previous pasture endophyte infestation increased (P<0.05). Serum cholesterol concentrations tended (P<0.10) to decrease with increasing endophyte infestation during the first 14 d in the feedlot. In Exp. 3, Angus and Brahman × British crossbred steers grazed fescue pastures in Georgia containing low, moderate, or high endophyte in each of 2 yr. Six steers of each breed group were on each treatment each year. Steers were transported to Texas in late August of each year, were fed a 93% concentrate finishing diet, and were harvested at an estimated individual backfat thickness of 12 mm. As endophyte infestation increased, serum urea N concentrations and gain to feed ratios increased (P<0.05), whereas pasture ADG, initial BW, transit shrink, serum cholesterol concentrations, final BW, and carcass weights decreased (P<0.05) in Angus steers, but not in Brahman-cross steers. In these studies, the adverse effects of high endophyte infestations in fescue pastures appeared to carry over to the feedlot for ca. 14 d. However, steers from highly infested pastures can compensate for poor pasture performance with improved performance in the feedlot when no adverse health effects occur. Any impact of the endophyte seems to be similar in Brahman-cross and Angus steers.

(Key Words: Steers, Fescue, Endophyte, Performance, Genetics.)

Introduction

Approximately 80% of the tall fescue (*Festuca arundinacea Schreb.*) pastures in the Southeast and Midwest U.S. are infested with the endophytic fungus *Neotyphodium coenophialum* (7). Cattle that graze endophyte-infested pastures have lower feed intake, slower daily gains, and less heat tolerance than cattle that graze non-infested pastures (5, 10, 15). The adverse effects of the endophyte, exhibited as poor performance (12, 26) or decreased disease resistance (19), can apparently carry over for several weeks after calves are removed from high endophyte pastures. However, studies have shown that cattle moved from endophyte-infested fescue pastures to the feedlot exhibit a compensatory gain response (9, 13). Morrison et al. (17) and McMurphy et al. (15) suggested that cattle with greater heat tolerance (i.e., Brahman) can better tolerate the adverse effects of the fescue endophyte; however, the effects on subsequent feedlot performance are not known.

These studies were conducted to determine the effects of both endo-

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[2]The mention of trade or manufacturer names is made for information only and does not imply an endorsement, recommendation, or exclusion by USDA-ARS.

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[4]Retired.

TABLE 1. Composition of feedlot diets[a].

Item	Starter	Intermediate	Finisher
Corn, steam–flaked	40.0	59.0	78.0
Cottonseed hulls	32.6	19.8	7.0
Alfalfa, ground	10.0	6.6	3.2
Cottonseed meal	10.0	7.15	4.3
Molasses	5.0	5.0	5.0
Rock phosphate	0.4	0.2	–
Calcium carbonate	0.6	0.8	1.0
Salt	0.44	0.44	0.44
Trace mineral[b]	0.06	0.06	0.06
Potassium chloride	0.9	0.65	0.4
Urea	–	0.15	0.3
Ammonium sulfate	–	0.15	0.3
Vitamin A		5,000 IU/kg	
Vitamin E		100 IU/kg	
Decoquinate, mg/kg[c]	21	–	–
Monensin, mg/kg[d]	–	–	33
Tylosin, mg/kg[d]	–	–	11
Calculated composition			
Crude protein	12.50	12.35	12.22
NE_m, mcal/kg[e]	1.54	1.78	2.02
NE_g, mcal/kg[f]	0.93	1.15	1.36

[a]Values are percentages on a DM basis, unless otherwise stated.
[a]Trace mineral package contained 0.2% Co, 2.8% Cu, 14.1% Fe, 0.3% I, 15% Mg, 3% Mn, and 23.2% Zn.
[c]Deccox coccidiostat (Rhone–Poulenc, Inc., Atlanta, GA).
[d]Products of Elanco Products Co. (Indianapolis, IN).
[e]NE_m = net energy for maintenance.
[f]NE_g = net energy for BW gain.

phyte infestation in tall fescue pastures and calf genotype on the subsequent feedlot health, blood chemistry, performance, and carcass characteristics of yearling beef steers transported 1,600 km and fed to a constant fat endpoint.

Materials and Methods

All experiments followed guidelines for humane treatment of experimental animals as recommended by the Consortium (4).

Experiment 1. Angus steers (n = 36) grazed fescue pastures at the USDA-ARS Southern Piedmont Conservation Research Unit (Watkinsville, GA) for 182 d (April to October). Pastures consisted of high endophyte Kentucky-31 tall fescue, moderate endophyte Kentucky-31 tall fescue, and low endophyte Johnstone and Triumph tall fescue with 12 steers per treatment. Pastures were 0.7 ha, and forage availability was maintained at ca. 1,600 to 1,800 kg DM/ha using put-and-take grazing management. Steers were stratified by weight so that initial weights onto pasture were equal across treatments. Tiller endophyte frequency was estimated by microscopic examination of at least 20 tillers from each pasture at 28-d intervals throughout the study according to the method described by Belesky et al. (1). Mean endophyte infestation levels in the pastures were 59.0, 29.0, and 7.5%. On October 15, steers were removed from pastures and housed in a dry-lot without feed and water for 16 h. Steers were then weighed individually and provided bermudagrass hay and water ad libitum for 36 h. Steers were loaded onto a truck and hauled 1,600 km to the USDA Conservation and Production Research Laboratory (Bushland, TX). Steers were in transit for 26 h.

On arrival at Bushland, steers were unloaded and immediately processed. Processing consisted of individually weighing calves; obtaining rectal temperatures; bleeding by jugular venipuncture; treating for internal and external parasites (Ivomec®; Merck AgVet Division, Merck & Co., Rahway, NJ); vaccinating for infectious bovine rhinotracheitis and parainfluenza-3 virus (Modified Live IBR-PI3 Vaccine®; Sanofi Animal Health, Overland Park, KS); vaccinating for *Clostridium chauvoei, C. novyi, C. septicum,* and *C. sordelli* (Blacklegol®; Miles Animal Health, Shawnee Mission, KS); and subcutaneously implanting with 36 mg zeranol (Ralgro®; Schering Plough, Union, NJ) in the right ear.

Steers were assigned randomly to three pens equipped with individual feed monitoring units (Pinpointer 4000B®; AIS Corp., Cookville, TN) with four steers per treatment in each pen. Steers were provided a 50% concentrate diet ad libitum for 2 wk, were fed a 75% concentrate diet for 1 wk, and then were fed a 93% concentrate finishing diet until harvest (Table 1). Alfalfa hay was provided at 3 kg per steer during the first 3 d in the feedlot, and water was available at all times.

During the first 28 d in the feedlot, steers were scored each morning for signs of respiratory infection. One point was assigned for nasal or ocular discharge, and two points were assigned for anorexia (DMI < 0.5 kg/d) or a rectal temperature >40°C. Steers were weighed individually on d 7, 14, 28, 56, 84, 110, and 136. Blood samples were obtained by jugular venipuncture on d 0, 7, 14, and 28. Samples were allowed to clot at room temperature and were centrifuged at 3,000 × *g* for 30 min at 10°C, after which the serum was decanted and frozen. Serum was analyzed for urea N (14), free fatty acids (FFA) (22), and cholesterol (11) by colorimetric procedures. Ambient temperatures were obtained from the laboratory weather station located 100 m north of the research feedlot during the first 28 d after arrival (Figure 1).

Steers were harvested at a commercial packing plant when fat thickness at the 13th rib was subjectively estimated to be 12 mm. Final unshrunk BW were obtained on the day before harvest. Hot carcass weights were obtained within 1 h of harvest, and carcass measurements were obtained by trained personnel after a 24-h chilling period.

Data were statistically analyzed by analysis of covariance using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC). Animals were considered the experimental unit. Sources of variation included in the analyses were pen (block), treatment, and initial BW (covariate). Because there were no significant pen effects, pen was deleted from the model. Least squares means were calculated by SAS, and treatment effects were tested by linear and quadratic contrasts.

Experiment 2. Angus steers (n = 36; 12 per treatment) grazed the same fescue pastures used in Exp. 1 for 78 d (April through July). Fescue pastures designated as low, moderate, and high endophyte had infestation rates of 9.8, 26, and 59%, respectively. Steers were weighed, transported, processed, and fed in Pinpointer feeder units as in Exp. 1. Jugular blood samples were obtained on d 0, 7, 14, 28, and 57 after arrival at the feedlot. Serum was analyzed for urea

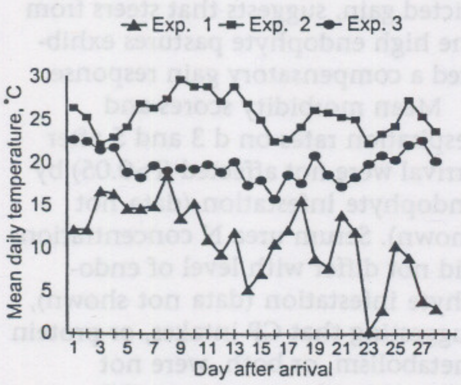

Figure 1. Mean daily ambient temperature at the feedlot in each of three experiments. Temperatures for yr 1 and 2 of Exp. 3 were similar; therefore, they were combined.

TABLE 2. Cumulative feedlot performance of steers from fescue pastures with three rates of endophyte infestation in Experiment 1[a].

	Endophyte infestation				
Item and time	Low	Moderate	High	SEM	PC[b]
Steers	12	12	12	–	–
Pasture ADG, kg	0.66	0.51	0.35	0.02	L**
Initial wt., kg[c]	333	313	283	7.0	L**
Transit shrink, kg	36.3	37.8	37.6	1.3	–
Transit shrink, %	10.8	12.0	13.3	0.28	L**
Days fed	108	117	120	4.4	L*
Cumulative ADG, kg					
wk 2	–0.25	–0.25	0.15	0.28	–
wk 4	0.66	0.98	1.05	0.18	–
wk 8	1.49	1.38	1.61	0.06	–
To finish	1.41	1.38	1.68	0.05	Q*
Predicted[d]	1.50	1.49	1.50	0.04	–
Cumulative daily DMI, kg					
wk 1	7.0	5.9	5.4	0.33	–
wk 2	8.1	7.3	6.8	0.32	–
wk 4	7.6	7.1	6.9	0.25	–
wk 8	8.1	7.5	7.6	0.21	–
To finish	9.1	9.0	9.2	0.19	–
Gain to feed, g ADG:kg DMI					
wk 4	85	136	144	20	L*
wk 8	186	184	214	17	Q*
To finish	154	155	183	5.4	Q*

[a]All values except initial weight are least squares means.

[b]PC = polynomial contrasts: L = linear, Q = quadratic, * = $P<0.05$, and ** = $P<0.01$.

[c]Shrunk (16 h) weight off pasture in Georgia. All performance data were calculated from initial weight.

[d]Daily gain predicted using the net energy system (18) based on large-frame and compensating medium-frame yearling steers.

N, FFA, and cholesterol, as described previously, and for P (6) and alkaline phosphatase (23) by colorimetric procedures. Daily ambient temperatures were obtained as in Exp. 1 (Figure 1).

Data were analyzed statistically by analysis of covariance using initial weight as a covariate. Animals were considered the experimental unit. Endophyte effects in fescue pastures were compared by linear and quadratic contrasts.

Experiment 3. In each of 2 yr, 18 Angus and 18 Brahman × British crossbred (Brahman-cross) steers grazed the same fescue pastures as those used in Exp. 1 and 2 from April to August 20 (yr 1) or August 26 (yr 2). Six steers of each breed group grazed the high, moderate, and low endophyte pastures each year. The Brahman-cross steers were of larger frame size than the straight-bred Angus steers and were heavier when placed on pasture. Steers were weighed, transported, processed, and fed in Pinpointer feeder units as in Exp. 1 and 2. Blood samples were obtained via jugular venipuncture immediately before loading in Georgia and on d 0, 7, 14, and 28 in the feedlot. Serum was analyzed for urea N, FFA, cholesterol, and alkaline phosphatase activity by previously described colorimetric procedures.

Data for yr 1 and 2 were combined and analyzed by the GLM procedure of SAS. Animals were considered the experimental unit. Treatment effects were analyzed as a 2 × 3 factorial arrangement and included the effects

TABLE 3. Carcass characteristics of steers in Exp. 1 and 2.

	Endophyte infestation				
Item	Low	Moderate	High	SEM	PC[a]
Experiment 1					
BW, kg	456	451	468	4.9	Q*
Carcass weight, kg	287	289	294	2.4	—
Dressing, %	63.7	64.2	62.8	0.01	—
Longissimus area, cm^2	70.6	74.0	73.2	0.83	—
Fat thickness, mm	13.3	12.6	12.6	0.55	—
Yield grade	3.17	2.95	3.02	0.08	—
Marbling score[b]	12.6	11.8	11.2	0.38	—
Quality grade[c]	10.7	10.0	10.4	0.14	—
KPH, %[d]	2.55	2.38	2.16	0.07	—
Experiment 2					
BW, kg	430	435	444	5.40	L*
Carcass weight, kg	273	277	281	3.50	—
Dressing, %	60.8	61.2	60.7	0.24	—
Longissimus area, cm^2	72.0	70.9	73.5	1.00	—
Fat thickness, mm	10.8	10.9	9.4	0.49	—
Yield grade	2.64	2.73	2.48	0.08	—
Marbling score[b]	10.2	10.3	10.0	0.08	—
Quality grade[c]	10.0	9.8	9.7	0.08	—
KPH, %[d]	2.08	2.09	1.95	0.04	—

[a]PC = polynomial contrasts: L = linear, Q = quadratic, and * = $P<0.55$.
[b]Marbling score: slight = 7 to 9, small = 10 to 12, modest = 13 to 15.
[c]Quality grade: Select = 7 to 9; Choice = 10 to 12.
[d]KPH = kidney, pelvic, and heart fat.

of endophyte-infestation treatment, breed, and treatment × breed. Year, year × treatment, year × breed, and year × treatment × breed interactions were also included in the model; however, no interactions involving year were observed. Breed effects were tested by F test, and endophyte effects were tested by linear and quadratic contrasts. The residual mean square was used as the error term for all comparisons.

Results and Discussion

Mean ambient temperatures for the first 28 d in the feedlot for the three experiments are presented in Figure 1. In Exp. 3, mean daily temperatures during the first 28 d in the feedlot were very similar in both years; therefore, the average of the 2 yr is presented. Mean ambient temperatures were higher in Exp. 2 than in Exp. 1; Exp. 3 temperatures were intermediate.

Experiment 1. Because of poorer (linear effect, $P<0.01$; Table 2) performance on the fescue pastures in Georgia, initial feedlot BW decreased (linear effect, $P<0.01$) as endophyte infestation increased. Weight loss during transit did not differ among treatments; however, as a percentage of initial BW, transit shrink increased with increasing endophyte infestation ($P<0.05$).

Average daily BW gains during the first 56 d in the feedlot were not significantly affected ($P>0.10$) by endophyte infestation, although there was a tendency ($P=0.11$) for steers from high endophyte pastures to have greater ADG than steers from low and moderate endophyte pastures (Table 2). Although performance data were corrected to a constant initial BW (the covariant) and the cattle were fed to a constant back-fat endpoint, average days on feed increased ($P<0.05$) as endophyte infestation increased, which suggests that there was a carry-over effect of the endophyte that might have affected fat deposition. At harvest, daily BW gains for the entire feeding period were greater in steers from high endophyte pastures than in steers from low or moderately infested pastures (quadratic effect, $P<0.05$). These results agree with previous studies (13) in which cattle grazing endophyte-infested pastures compensated during the feedlot phase compared with cattle grazing non-infested pastures. Predicted ADG calculated using the net energy system and based on large-frame and compensating medium-frame yearling steers (18) were similar for all treatments. Calves from high endophyte pastures tended to gain more than predicted, whereas steers from moderate and low endophyte pastures tended to gain less than predicted.

Dry matter intakes (Table 2) were not affected ($P>0.05$) by endophyte infestation. However, during the first 4 wk in the feedlot, DMI tended ($P=0.11$) to decrease as endophyte infestation level increased, which suggests that the endophyte effect did carry over to the feedlot for 2 to 4 wk.

Gain to feed ratios (Table 2) were highest ($P<0.05$) for steers from high endophyte pastures throughout the experiment. This finding, as well as the differences in actual and predicted gain, suggests that steers from the high endophyte pastures exhibited a compensatory gain response.

Mean morbidity scores and respiration rates on d 3 and 5 after arrival were not affected ($P>0.05$) by endophyte infestation (data not shown). Serum urea N concentrations did not differ with level of endophyte infestation (data not shown), suggesting that CP intakes, or protein metabolism, or both, were not affected by the endophyte (20). Compared with steers from high and moderate endophyte pastures, steers from low endophyte pastures had lower ($P<0.05$) serum FFA concentrations on d 7 in the feedlot (300, 294, and 178 μmol/L, respectively). This trend might have been a result of the differences in energy intake at the time of sampling. In agreement with the findings of Stuedemann et al. (25), during the first 14 d in the feedlot, serum cholesterol concentrations tended ($P<0.10$) to decrease with increasing endophyte infestation (79, 71, and 63 mg/100 mL for low, moderate, and high endophyte, respectively), suggesting that the effects of the endophyte on fat metabolism (25) may carry over into the feedlot for several weeks.

Carcass characteristics were not affected ($P>0.05$) by endophyte infestation (Table 3). This finding was expected because steers were harvested at or near a constant endpoint of 12 mm backfat rather than at a constant days on feed. Lusby et al. (13) also noted no effect of endophyte infestation on carcass variables, although they reported that steers from high endophyte pastures tended to have lower quality grades than steers from low endophyte pastures. If calves from endophyte-infected pastures have a higher incidence of respiratory disease at the feedlot than calves from non-infested pastures (19), it might be expected that they would have lower quality grades (16).

TABLE 4. Cumulative feedlot performance of steers in Exp. 2[a].

	Endophyte infestation				
Item .and& time	Low	Moderate	High	SEM	PC[b]
Steers	12	12	12	–	–
Pasture ADG, kg	0.37	0.18	0.06	0.03	L**
Initial wt., kg[c]	285	276	257	5.0	L**
Transit shrink, kg	21.8	18.8	18.0	1.3	L†
Transit shrink, %	7.98	6.98	6.56	0.47	L†
Days fed	105	103	104	3.2	–
Cumulative ADG, kg					
wk 2	2.04	2.10	1.78	0.19	–
wk 4	1.87	2.14	2.17	0.10	–
wk 8	1.85	1.98	1.99	0.06	–
To finish	1.68	1.78	1.85	0.04	–
Predicted[d]	1.74	9.65	1.74	0.03	–
Cumulative daily DMI, kg					
wk 2	7.76	7.04	6.55	0.50	–
wk 4	8.23	7.92	7.45	0.39	–
wk 8	8.91	8.85	8.32	0.29	–
To finish	9.61	9.65	9.69	0.16	–
Gain to feed, g ADG:kg DMI					
wk 4	224	265	293	17.0	L*
wk 8	207	223	241	7.6	L*
To finish	174	184	191	3.3	–

[a]All values except initial weight are least squares means.

[b]PC = polynomial contrasts: L = linear, Q = quadratic, † = $P<0.10$, * = $P<0.05$, and ** = $P<0.01$.

[c]Shrunk (16 h) weight off pasture in Georgia. All performance data were calculated from initial weight.

[d]Daily gain predicted using the net energy system (18) based on large-frame and compensating medium-frame yearling steers.

Experiment 2. As in Exp. 1, ADG of steers on pasture in Georgia and initial feedlot BW of steers increased (linear effect, $P<0.01$) with decreasing endophyte infestation; however, the differences were smaller in magnitude than in Exp. 1 (Table 4). These smaller weight differences were probably caused by the shorter grazing period (78 *vs* 182 d) and lighter initial BW in Exp. 2. In addition, a severe drought occurred during the grazing period that limited forage availability on all treatments. Transit shrink in Exp. 2 was ca. 50% of transit shrink in Exp. 1 (19.8 *vs* 37.2 kg). The reason for these differences is not obvious but could be the result of factors such as differences in animal age, animal BW, forage availability, and gut fill before weighing.

As in Exp. 1, during the first 56 d in the feedlot and overall, steers from high endophyte pastures tended ($P=0.11$) to have faster ADG than did steers from low endophyte pastures; however, the differences were not statistically significant (Table 4). As in Exp. 1, steers from high endophyte pastures tended ($P=0.10$) to gain faster than predicted by the net energy system (18), whereas steers from low endophyte pastures tended to gain less than predicted.

Dry matter intakes were not affected by endophyte infestation, although DMI during the first 4 wk tended ($P=0.11$) to decrease with increasing endophyte infestation (Table 4). As in Exp. 1, this suggests a carry-over effect of the endophyte. On d 28, 56, and overall, gain to feed ratios increased with increasing endophyte infestation ($P<0.05$); Table 4). These results generally agree with those in Exp. 1.

Rectal temperatures (mean, 39.0 ± 0.8°C) and morbidity scores were not affected by endophyte infestation ($P>0.10$; data not shown). As in Exp. 1, no steers were treated for respiratory disease. Serum urea N, phosphorus, and alkaline phosphatase were not affected ($P>0.10$) by endophyte infestation in Exp. 2 (data not shown). In contrast in Exp. 1, serum cholesterol and FFA were not affected by endophyte infestation (data not shown). These differing results might have been the result of the shorter grazing period in Exp. 2. Carcass data were not affected by endophyte infestation (Table 3), which agrees

TABLE 5. Cumulative feedlot performance of Angus and Brahman-cross steers from fescue pastures with three rates of endophyte infestation in Exp. 3[a].

	Angus[b]			Brahman-cross[b]			
Item	Low	Moderate	High	Low	Moderate	High	SEM
Pasture ADG, kg[c,d]	0.29	0.17	0.04	0.57	0.56	0.45	0.015
Initial BW, kg[c,d,e]	294	276	262	355	346	328	5.3
Transit shrink, kg[c]	32.7	32.9	30.1	35.0	33.3	29.4	0.80
Transit shrink, %[c]	10.6	10.7	9.8	11.2	10.7	9.6	0.24
Days fed[d]	102	100	95	129	128	119	1.7
Cumulative ADG, kg							
wk 2[c]	1.69	2.92	2.73	1.64	1.95	2.81	0.14
wk 4	1.80	1.89	2.01	1.48	1.28	1.80	0.07
wk 8	2.13	2.29	2.43	1.88	1.95	2.21	0.04
To finish	1.78	1.87	1.97	1.58	1.57	1.76	0.03
Predicted[c,f]	1.70	1.74	1.77	1.46	1.51	1.60	0.02
Cumulative daily DMI, kg							
wk 2[d]	8.37	9.54	8.77	7.36	7.62	7.91	0.20
wk 4[d]	8.59	9.26	8.73	7.77	8.29	8.49	0.17
wk 8[d]	9.53	9.94	9.62	8.75	9.19	8.98	0.14
To finish[d]	10.45	10.69	10.78	9.70	10.26	0.13	
Gain to feed, g ADG:kg DMI							
wk 2[c]	178	322	327	234	269	341	18.0
wk 4	211	206	229	187	155	208	6.9
wk 8[c]	225	232	257	214	214	253	5.8
To finish[c]	171	175	184	163	161	173	2.1
Rectal temperature, °C							
Arrival[g]	39.5	39.5	40.5	39.5	39.5	39.6	0.06
d 14	37.8	37.9	37.9	37.9	37.9	37.9	0.01

[a]All values except initial weight are least squares means.
[b]Breed of steer and pre-transport fescue endophyte infestion.
[c]Linear fescue endophyte effect ($P<0.05$).
[d]Breed effect ($P<0.05$).
[e]Shrunk (16 h) weight off pasture in Georgia. Performance data were calculated from initial weight.
[f]Daily gain predicted using the net energy system (18).
[g]Fescue endophyte × steer breed interaction ($P<0.05$).

with results of Exp. 1.

Experiment 3. Because of differences in growth performance of steers on the fescue pastures in Georgia (linear effect, $P<0.05$), initial feedlot BW of steers decreased ($P<0.05$) as endophyte infestation increased (Table 5). The magnitude of the differences was similar in Angus and Brahman-cross steers, although Brahman-cross steers had a heavier ($P<0.05$) average initial feedlot BW than Angus steers.

As in Exp. 2, actual BW loss and BW loss as a percentage of initial BW during transit decreased ($P<0.05$; Table 5) as endophyte infestation increased. In calves transported a shorter distance (720 km), Lusby et al. (13) also noted decreased transport shrink in calves from high endophyte pastures. In contrast, in Exp. 1, when steers were shipped in the autumn rather in the summer, we noted a linear increase in transport shrink (initial BW%) with increased fescue infestation. A number of factors, including weather conditions, length of transport, length of fescue grazing period, previous forage DMI, and forage availability, could potentially affect transport shrink. Calves grazing endophyte-infested pastures have lower DMI than do calves grazing non-infested pastures (5, 24) although this effect may be seasonal (10, 15). Steers in the present studies were all fed bermudagrass hay for 36 h before shipment. If the endophyte affected intake of the hay, it would be expected to have a subsequent effect on transit shrink. Transport BW loss did not differ in Angus and Brahman-cross steers.

The ADG of both breeds during the first 14 d in the feedlot increased (linear effect, $P<0.05$) as previous endophyte infestation increased (Table 5). Daily BW gains during the rest of the study were not significantly affected ($P>0.10$) by endophyte

TABLE 6. Serum urea N, free fatty acids (FFA), cholesterol, and alkaline phosphatase of Angus and Brahman-cross steers from fescue pastures with three rates of endophyte infestation in Exp. 3.

	Angus[a]			Brahman-cross[a]			
Item	Low	Moderate	High	Low	Moderate	High	SEM
Urea N, mg/100 mL							
At loading[b]	13.3	12.8	13.7	12.3	13.4	14.0	0.68
Feedlot arrival[c]	10.6	10.6	10.5	10.0	9.6	9.8	0.43
Feedlot, d 28[c]	5.6	5.8	5.2	6.0	7.2	6.3	0.22
Cholesterol, mg/100 mL							
At loading[b,c]	110	98	80	138	130	129	4.10
Feedlot arrival[c]	95	90	78	115	119	120	2.80
Feedlot, d 28[c]	92	96	91	118	116	126	3.30
FFA, µmol/L							
At loading[c]	194	194	190	288	268	248	11.4
Feedlot arrival[c]	294	257	224	331	376	401	23.8
Feedlot, d 28	187	177	197	187	163	180	5.6
Alkaline phosphatase, units/100 mL							
At loading[c]	46.4	42.8	29.4	68.1	67.4	69.5	3.40
Feedlot arrival[c]	42.6	35.8	27.8	57.3	58.4	62.3	2.50
Feedlot, d 28[c]	107.8	111.2	99.4	146.4	147.0	168.5	5.90

[a]Breed of steer and pre-transport infestation.
[b]Linear fescue endophyte effect ($P<0.05$).
[c]Breed effect ($P<0.05$).

infestation or breed, although calves from the high endophyte pastures had numerically greater daily gains. These results tend to agree with the results of Exp. 1 and 2 and of Lusby et al. (13).

As with daily gains, days on feed and daily DMI were not affected by endophyte infestation in Exp. 3. These results agree with results of Exp. 2. However, in Exp. 1, days on feed increased with increased fescue endophyte infestation. These trial-to-trial differences may be attributed to differences in weather conditions. When corrected to a constant initial BW, Angus steers were on feed fewer days ($P<0.05$) and had greater ($P<0.05$) daily DMI than Brahman-cross steers at the same endophyte infestation level.

Although ADG and DMI were not affected by endophyte infestation, gain to feed ratios (Table 5) at wk 2, 8, and at harvest increased linearly ($P<0.05$) as endophyte infestation increased, which is similar to the effect noted in Exp. 1 and 2. Results were similar in Angus and Brahman-cross steers.

Some researchers (15, 17) have suggested that Brahman-cross cattle are more tolerant of the adverse effects of the fescue endophyte than are cattle of straight British breeding, whereas other reports (8) found no breed × endophyte interaction. In the present study, Angus steers from the moderate and high endophyte pastures tended to exhibit more visual signs (i.e., rough hair coat, gaunt appearance, increased rectal temperatures) of the endophyte infestation than did the Brahman-cross steers. Nonetheless, steer breed did not significantly affect ADG or gain to feed ratios at any of the endophyte infestation levels. These different results might reflect the severity of heat stress encountered by the animals during the studies (10, 13).

In Exp. 1 and 2, calves from high endophyte pastures tended to gain faster than predicted using the NRC (18) net energy system, whereas steers from low endophyte pastures tended to gain more slowly than predicted. In Exp. 3, ADG were underpredicted in all treatment combinations; however, the differences tended to be greater in steers from the high endophyte pastures.

At loading in Georgia, serum urea N increased ($P<0.05$) and serum cholesterol decreased ($P<0.05$) as endophyte infestation increased (Table 6). The increase in serum urea N tends to contradict the results of Bond et al. (2), who suggested that the endophyte did not affect plasma urea N values. However, in the present study, calves had been fed a common bermudagrass hay for ca. 36 h before the pre-transit blood sample was obtained. This suggests that calves from pastures with greater endophyte infestation might have consumed more of the bermudagrass hay (20). Stuedemann et al. (25) also noted that endophyte infestation decreased serum cholesterol concentrations, apparently by an effect on fat metabolism. On arrival at the

TABLE 7. Carcass characteristics of Angus and Brahman-cross steers from pastures with three rates of endophyte infestation in Exp. 3.

	Angus[a]			Brahman-cross[a]			
Item	Low	Moderate	High	Low	Moderate	High	SEM
Live BW, kg[b]	494	502	501	519	514	516	6.00
Carcass weight, kg[b]	300	302	302	338	333	326	4.30
Dressing, %[b]	60.3	60.2	60.3	65.0	64.7	63.2	0.20
Longissimus area, cm^2	75	76	76	82	77	80	0.80
Fat thickness, mm	10.8	12.2	11.0	10.8	13.1	9.9	0.38
Yield grade	2.69	2.79	2.61	2.82	3.17	2.64	0.06
Quality grade[b,c]	9.8	10.2	9.3	9.1	8.8	8.7	0.14
KPH, %[b,d]	1.92	1.82	1.82	1.96	1.96	2.05	0.04

[a]Breed of steer and pre-transport fescue endophyte infestation.
[b]Breed effect ($P<0.05$).
[c]Quality grade: Select = 7 to 9; Choice = 10 to 12.
[d]KPH = kidney, pelvic, and heart fat.

feedlot, serum cholesterol was not affected ($P>0.10$) by endophyte infestation. However, serum cholesterol concentrations tended to decrease with increased endophyte infestation in Angus steers but not in Brahman-cross steers. Endophyte infestation did not affect serum FFA or alkaline phosphatase concentrations. Serum alkaline phosphatase activity may be indicative of the rate of bone formation (21). Cole et al. (3) noted that calves grazing endophyte-infested fescue had lower serum alkaline phosphatase activity than did calves grazing bermudagrass during the summer but not during the fall and also noted a positive correlation between serum alkaline phosphatase concentrations and BW gains of calves.

Brahman-cross steers had higher ($P<0.05$) serum cholesterol and alkaline phosphatase concentrations than did Angus steers throughout the study. These results agree with effects noted in Angus and Brahman cows and calves (3). However, the greater serum cholesterol in Brahman-cross steers than in Angus steers in this study does not suggest a greater tolerance to the fescue endophyte (24) because the effect also occurred in steers from the low endophyte pastures and continued for 28 d in the feedlot. Brahman-cross steers also had higher ($P<0.05$) serum FFA concentrations than Angus steers at loading in Georgia and at arrival at the feedlot. The reason for these breed differences is not known.

In agreement with Exp. 1 and 2, no carcass characteristics were affected by endophyte infestation in Exp. 3 (Table 7). Brahman-cross steers had heavier final BW, heavier carcass weights, higher dressing percentages, lower quality grades, and higher percentages of kidney, pelvic, and heart fat ($P<0.05$) than did Angus steers, despite similar fat thickness and yield grades (Table 7).

Implications

In these and previous studies, yearling steers moved from tall fescue pastures heavily infested with endophyte compensated for their poorer performance on pasture with improved performance in the feedlot. In contrast to some research, performance of Brahman-cross steers from high endophyte pastures was not improved compared with the performance of Angus steers. Weather conditions during all experiments tended to be mild with few "hot" or "cold" days during the first 28 d in the feedlot. Because the endophyte seems to have an adverse effect on temperature-regulating mechanisms in cattle, especially during hot weather, weather conditions can have a marked influence on results. Consequently, these results in yearlings might not be applicable under extreme weather conditions or in young calves that have passed through stressful marketing channels.

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Literature Cited

1. Belesky, D.P.J.D., J. D. Robbins, J. A. Stuedemann, S. R. Wilkinson, and O. J. Devine. 1987. Fungal endophyte infection-loline derivative alkaloid concentration of grazed tall fescue. Agron J. 79:217.

2. Bond, J., J. B. Powell, D. J. Undersander, P. W. Moe, H. F. Tyrrell, and R. R. Oltjen. 1984. Forage composition and growth and physiological characteristics of cattle grazing

several varieties of tall fescue during summer conditions. J. Anim. Sci. 59:584.

3. Cole, N. A., M. A. Brown, and W. A. Phillips. 2001. Genetic × environment interactions on blood constituents of Angus, Brahman, and reciprocal-cross cows and calves grazing bermudagrass or endophyte-infected tall fescue. J. Anim. Sci. 79:1151.

4. Consortium. 1988. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. Consortium for Developing a Guide for the Care and Use of Agricultural Animals in Research and Teaching, Champaign, IL.

5. Crawford, R. J., J. R. Forwood, R. L. Belyea, and G. B. Farner. 1989. Relationship between level of endophyte infection and cattle gains on tall fescue. J. Prod. Agric. 2:147.

6. Daly, J. A., and G. Ertingshausen. 1972. Direct method for determining inorganic phosphate in serum with the centrifichem. J. Clin. Chem. 18:263.

7. Daniels, L. B., E. M. Piper, B. J. Hankins, G. Gee, T. S. Nelson, and J. Gergerich. 1985. Infestation level of *Acremonium coenophialum* in fescue in Arkansas. J. Anim. Sci. 61(Suppl. 1):332.

8. Goetsch, A. L., K. L. Landis, G. E. Murphy, B. L. Morrison, Z. B. Johnson, E. L. Piper, A. C. Hardin, and K. L. Hall. 1988. Supplements, parasite treatments and growth implants for Brahman or English crossbred steers grazing edophyte-infected or noninfected fescue in the spring and fall. Prof. Anim. Sci. 4:32.

9. Hancock, D. L., J. E. Williams, H. B. Hedrick, E. E. Beaver, S. M. Hannah, S. J. Miller, M. R. Ellerseick, G. B. Garner, R. E. Morrow, and J. R. Gerrish. 1988. Effects of previous forage systems on feedlot performance, body composition, and plasma variables of finishing steers. J. Anim. Sci. 66:2272.

10. Hemken, R. W., J. A. Boling, L. S. Bull, R. H. Hatton, R. C. Buckner, and L. P. Bush. 1981. Interaction of environmental temperature and anti-quality factors on the severity of summer fescue toxicosis. J. Anim. Sci. 52:710.

11. Henry, R. J. 1974. Clinical Chemistry: Principals and Technics. (2nd Ed.). Harper and Row, NY.

12. Hoveland, C. S., R. L. Haaland, C. C. King, Jr., W. B. Anthony, E. M. Clark, J. A. Clark, J. A. McGuire, L. A. Smith, H. W. Grimes, and J. L. Holliman. 1980. Association of epichloe typhina fungus and steer performance on tall fescue pasture. Agron. J. 72:1064.

13. Lusby, K. S., W. E. McMurphy, C. A. Strasia, S. C. Smith, and S. H. Muntz. 1990. Effects of fescue endophyte and interseeded clovers on subsequent finishing performance of steers. J. Prod. Agric. 3:103.

14. Marsh, W. H., B. Fingerhut, and H. Miller. 1965. Automated and manual direct methods for the determination of blood urea. Clin. Chem. 11:624.

15. McMurphy, W. E., K. S. Lusby, S. C. Smith, S. H. Muntz, and C. A. Strasia. 1990. Steer performance on tall fescue pasture. J. Prod. Agric. 3:100.

16. Montgomery, T. H., R. Adams, N. A. Cole, D. P. Hutcheson, and J. B. McLaren. 1984. Influence of feeder calf management and bovine respiratory disease on carcass traits of beef steers. Proc. Western Sect. ASAS 35:319.

17. Morrison, B. L., A. L. Goetsch, E. L. Piper, G. E. Murphy, K. M. Landis, Z. B. Johnson, A. C. Hardin, and K. L. Hall. 1988. Performance of English or Brahman crossbred steers grazing endophyte-infected or non-infected paddocks. J. Anim. Sci. 66(Suppl. 1):56.

18. NRC. 1984. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. (6th Rev. Ed.). National Academy of Sciences National Research Council, Washington, DC.

19. Perino, L. 1985. Possible fescue toxicosis in incoming feeder cattle. In Proc. Annu. Conv. Am. Assoc. Bovine Practitioners, Stillwater, OK. p 139.

20. Preston, R. L., D. D. Schankenberg, and W. H. Pfander. 1965. Protein utilization in ruminants. I. Blood urea nitrogen as affected by protein intake. J. Nutr. 86:281.

21. Roubicecek, C. B., and D. E. Ray. 1974. Serum alkaline phosphates in unsupplemented range cattle. J. Anim. Sci. 38:1185.

22. Smith, S. W. 1975. A new salting out technique for colorimetric free fatty acid assays. Anal. Biochem. 67:531.

23. SSCC. 1974. Committee of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended methods for the determination of four enzymes in blood Scand. J. Clin. Lab. Invest. 33:291.

24. Stokes, S. R., A. L. Goetsch, A. L. Jones, K. W. Beers, and E. L. Piper. 1986. Intake and digestion in growing dairy steers fed endophyte-infected fescue hay and supplemented with other forage. J. Anim. Sci. 63(Suppl. 1):292.

25. Stuedemann, J. A., T. S. Rumsey, J. Bond, S. R. Wilkinson, L. P. Bush, D. J. Williams, and A. B. Caudle. 1985. Association of blood cholesterol with occurrence of fat necrosis in cows and tall fescue summer toxicosis in steers. Am. J. Vet Res. 46:1990.

26. Stuedemann, J. A., S. R. Wilkinson, D. P. Belesky, O. J. Devine, D. L. Breedlove, F. N. Thompson, C. S. Hoveland, and H. Cirdia. 1985. Behavior of steers grazing high versus low endophyte infected Kentucky-31 tall fescue. J. Anim. Sci. 61(Suppl. 1):28.

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