Influence of Alkaloid Concentration of Tall Fescue Straw on the Nutrition, Physiology, and Subsequent Performance of Beef Steers[1,2]

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ABSTRACT: Two experiments were conducted to evaluate digestion, performance, and physiological responses to *Acremonium coenophialum*-infected tall fescue straw offered to vary ergovaline concentrations. In Exp. 1, 16 Hereford × Angus ruminally cannulated steers (370 ± 12 kg BW, mean ± SE) were blocked by age and BW and, within block, randomly assigned to one of four treatments containing graded concentrations of ergovaline in the diet: 1) 0 ppb, 2) 158 ppb, 3) 317 ppb, and 4) 475 ppb. Alkaloid concentrations were produced using various mixtures of two varieties of tall fescue straw that had similar genetic and phenotypic characteristics but differed in degree of endophyte incidence and associated concentrations of alkaloids. In the 36-d digestion study, feed intake, apparent DMD, and total tract NDF digestion were not influenced by alkaloid concentration ($P > .10$). Differences were observed with digesta kinetics; specifically indigestible ADF (IADF) fill and outflow decreased linearly with increasing alkaloid concentration ($P < .10$). These differences, however, may be attributed to differences in IADF concentration of the diets. Physiological variables (heart rates, respiration rates, and rectal, ear, and tailhead skin surface temperatures) were not influenced by alkaloid concentration ($P > .10$). Concentration of serum prolactin measured weekly tended ($P < .10$) to decrease with increasing alkaloid concentration of the diet. At the conclusion of the study, each steer was injected with 100 μg of thyrotropin-releasing hormone (TRH). All steers responded to the TRH challenge ($P < .10$); however, responses did not differ ($P > .10$) between alkaloid concentrations of the basal diet ($P > .10$). In Exp. 2, 84 Hereford × Angus weaned steer calves (220 ± 15 kg BW) were sorted into three BW blocks (heavy, medium, and light) and, within blocks, were assigned randomly to the same treatments as in Exp. 1 for an 84-d feeding period. Feed intake tended ($P < .10$) to decrease as alkaloid concentration of the diet increased. However, weight gain and feed efficiency did not differ ($P > .10$) among alkaloid concentrations. In conclusion, the endophyte-produced alkaloids associated with feeding tall fescue straw during the winter months did not cause health problems or reductions in animal performance. However, decreases in circulating prolactin with increasing alkaloid concentration of the diet suggest a possible subclinical effect.

Key Words: Beef Cattle, *Festuca arundinacea*, Straw, Alkaloids, Nutrition, Physiology

J. Anim. Sci. 1994. 72:1068–1075

Introduction

The fungal endophyte *Acremonium coenophialum* in tall fescue (*Festuca arundinacea* Schreb.) has been implicated as the causative agent of fescue toxicosis. Jacobson et al. (1970) reported reduced weight gains, increased respiration rates, and increased rectal temperatures with yearling cattle grazing endophyte-infected tall fescue pasture. Other symptoms of fescue toxicosis include rough hair coats, increased salivation, nervousness, and overall reduced performance (Hoveland et al., 1983). Recommendations of diluting fescue diets or grazing fescue after the growing season have been suggested to reduce the risks associated with consumption of endophyte-infected tall fescue.

In the Pacific Northwest, a large volume of grass seed residue is produced (> 500,000 t) and has potential as a winter feed resource for mature, gestating beef cattle. Concern over the presence of the endophyte in several of the grass seed species, however, has curtailed its use. To date, most of the

[1]Oregon State Univ. Agric. Exp. Sta. tech. paper 10156.

[2]Appreciation is expressed to George Rottinghouse (Univ. of Missouri, Columbia) for conducting the ergovaline assays and to Dennis Hallford (New Mexico State Univ.) for conducting the prolactin assays. In addition, appreciation is expressed to Holly Imbach for providing technical assistance during the data collection aspects of these studies.

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Received February 22, 1993.
Accepted December 20, 1993.

endophyte alkaloid research has focused on grazed pasture, seed-based diets, or moderate to good-quality tall fescue hays. No research has been conducted to evaluate the feeding of straw with high alkaloid concentrations and its subsequent effect on animal performance. In addition, very little is known about whether the consumption by cattle of straw containing high concentrations of endophyte during the winter can induce symptoms of fescue toxicosis, specifically, vasoconstriction of the extremities. Therefore, this research was conducted to evaluate the effect of consuming *A. coenophialum*-infected tall fescue straw with varied ergovaline concentrations on nutrition, physiology, and performance of beef cattle.

Materials and Methods

Harvesting and Treatment of Residues. Two varieties of tall fescue straw ('Bonanza' and 'Titan' turf-type) were selected to assess endophyte effects on nutrient utilization by beef cattle. The two varieties were similar genetically and phenotypically but differed in alkaloid concentrations. The 'Titan' straw contained 475 ppb of ergovaline, whereas the ergovaline in 'Bonanza' straw was not detectable (< 50 ppb). The 'Bonanza' straw came from a 3rd-yr stand and was baled 15 d after seed harvest, and the 'Titan' straw came from a 2nd-yr stand and was baled 27 d after seed harvest. Both varieties were grown in the Willamette Valley of Oregon and are common varieties grown for turf-seed production. Windrows were not raked before baling and both straw varieties were stored in hay sheds until they were transported to Burns, after which bales were stored in stacks until chopping and feeding occurred. Straw was coarsely chopped every 3 wk with a hay shredder and stored in covered hay sheds. Because the two varieties of tall fescue straw differed in preliminary CP concentration (avg CP 7.1% and 4.9% for 'Titan' and 'Bonanza', respectively), second-cutting alfalfa (CP = 18.9%) was chopped and mixed with the 'Bonanza' straw (16% alfalfa to 84% 'Bonanza' tall fescue) to ensure isonitrogenous basal diets. Chemical analyses of the basal diets were composited across time (Table 1).

Experiment 1, Digestion/Physiology Study. In early February 1992, 16 ruminally cannulated steers (370 ± 12 kg BW) were used in a randomized complete block design. Steers were blocked by age and BW and, within block, randomly assigned to the following tall fescue straw diets containing graded concentrations of ergovaline: 1) 0 ppb, 2) 158 ppb, 3) 317 ppb, and 4) 475 ppb. Ergovaline concentrations were established using the following 'Bonanza':'Titan' ratios: 1) 100% 'Bonanza', 2) 67% 'Bonanza':33% 'Titan', 3) 33% 'Bonanza':67% 'Titan', and 4) 100% 'Titan'. Steers were individually fed on a daily basis at 120% of the previous 5-d average intake. In addition, all steers

Table 1. Chemical composition of feeds (Exp. 1 and 2)[a]

Item	'Titan'	'Bonanza'	Alfalfa pellets
CP, %	6.3	5.3	19.4
ADIN, %[b]	9.4	11.6	5.5
NDF, %	67.4	71.1	50.5
ADF, %	44.6	49.2	34.1
IADF, %[c]	23.4	28.0	20.5
Ergovaline, ppb	475	< 50	

[a]Chemical composition expressed on a DM basis.
[b]Expressed as a percentage of total nitrogen.
[c]IADF = indigestible acid detergent fiber.

were supplemented daily with alfalfa pellets at .5% of BW of individual steers. As a result, actual total diet concentrations of ergovaline will be somewhat less. The 36-d digestion study involved a 21-d adaptation period, 7-d intake period, 6 d of total fecal collections, 1 d of ruminal sampling, and 1 d of ruminal evacuations, respectively. Physiological variables were measured weekly at 1300 to determine rectal temperatures, skin surface temperatures by an infrared thermometer (Everest Interscience, Tustin, CA) of the tailhead (underside) and the ear (between the second and third rib), heart rates (area behind the left front elbow), and respiration rates. In addition, weekly blood samples were collected via jugular venipuncture into vacutainer tubes for prolactin (**PRL**) analysis. Blood samples were allowed to clot at room temperature overnight and then were centrifuged (International Centrifuge, Boston, MA) the next morning to remove the serum. Samples were centrifuged at 1,000 × *g* for 10 min and serum was removed and frozen at −20°C until further analysis. Ambient barn temperatures also were measured during the study. The average minimum and maximum temperatures were 1.2°C and 11.1°C, respectively, and ranged from −3.3°C to 18.9°C. Barn lighting was a function of the normal photoperiod in February in the Pacific Northwest. Intake and orts were measured daily for the duration of the experiment and were subsampled beginning on d 22 for DM and nutrient content determination. On d 28, fecal harnesses and bags were attached to the steers. Fecal bags were weighed, emptied, and subsampled daily at 1500. A 2.5% fecal subsample was dried, composited, and ground to pass through a 1-mm Wiley mill screen. On d 35, ruminal fluid samples were taken at 0 (prior to feeding), 3, 6, 9, and 12 h after feeding; fluid samples were analyzed for pH, ammonia, and VFA content. On d 36, each steer was emptied of reticuloruminal contents before daily feeding at 0800. One person would empty the fluid and particulate contents of an individual steer in a preweighed container. The contents were weighed, thoroughly mixed, and subsampled in triplicate to determine DM digesta kinetics. Contents were returned to the rumen and steers were fed after all 16 steers were evacuated. The entire evacuation process with eight trained technicians was completed in approximately 1 h (30 min per steer). At 1400, 5 h after feeding, steers were evacuated again in the same order with the procedure described for the first evacuation. Indigestible ADF (**IADF**) passage was determined by dividing the IADF intake by the quantity of IADF in the reticuloruminal contents (Van Soest, 1982). Digesta kinetics derived from the second evacuation (1400) is presumed not to be influenced by the first evacuation. In addition, previous research suggests that the evacuation procedure does not adversely affect ruminal microorganisms or digestive processes (Towne et al., 1986). On d 39 and d 40, two blocks of steers (eight steers) were subjected to a thyrotropin-releasing hormone (**TRH**; Sigma Chemical, St. Louis, MO) challenge to measure PRL stores in the pituitary. The steers were catheterized (Radiopaque FEP teflon i.v. catheters, Abbott Hospital, North Chicago, IL) in the jugular vein the afternoon before or morning of the challenge. Each steer was dosed with a 100-μg TRH injection via jugular catheter. Blood samples were collected starting at 1030 at –30, –15, 0 (before administration of TRH), and 15, 30, 45, 60, 90, 120, 150, and 180 min after administration of TRH. Catheters were kept clot-free by injections of a physiological saline-sodium citrate-benzyl alcohol solution. Blood samples were allowed to clot at room temperature overnight and then refrigerated until they were centrifuged for serum removal. Samples were centrifuged at 1,000 × g for 10 min and the serum was frozen at –20°C until further analysis.

Experiment 2, Performance Study. Eighty-four Hereford × Angus steers (220 ± 15 kg BW) were allotted into one of three BW blocks (light, medium, and heavy) and within BW blocks randomly assigned to the same treatments as described in Exp. 1 (seven steers/pen) for an 84-d performance trial. All diets were supplemented with alfalfa pellets at .5% BW of the average pen weight. Pens of steers were fed forage daily and orts were weighed and subsampled weekly. Every 28 d, steers were weighed after a 16-h shrink to measure live weight, from which gains and feed efficiencies were calculated. One steer on the 100% 'Titan' straw died on d 46 of the performance trial. Necropsy on the steer suggested there was no relationship between the animal's death and treatment or alkaloid effects. Weight gain data and pen intakes were adjusted to account for the removal of this steer.

Laboratory Analyses and Calculations. Feed, ort, fecal, and ruminal evacuation samples were dried at 55°C in a forced-air oven. Equal amounts of feed offered, orts, and fecal output were composited and ground to pass through a 1-mm Wiley mill screen. Ground straw and supplement samples were analyzed for DM and Kjeldahl N (AOAC, 1984), ADF, ADIN, and NDF (Goering and Van Soest, 1970). Indigestible ADF was determined (Cochran et al., 1986) to estimate an indigestible component of all diets. Representative core samples were obtained from the two varieties to determine ergovaline content just prior to the initiation of the experiments. In addition, samples obtained of the 'Titan' and 'Bonanza' straw remaining at the conclusion of the experiments indicated that ergovaline content did not decrease over time. Samples used in ergovaline determination were not oven dried, but are adjusted to reflect concentration on a DM basis. Ergovaline analysis of the feeds was completed at the University of Missouri by George Rottinghaus. Samples of each straw variety were analyzed by HPLC for ergovaline content (Hill et al., 1993). Ruminal pH was determined using a combination electrode (AOAC, 1984). After treating ruminal fluid samples with .1 N HCl (5 mL of acid to 5 mL of ruminal fluid) and 25% metaphosphoric acid (2 mL of acid to 8 mL of ruminal fluid), samples were frozen at –20°C until analysis for VFA and ammonia concentrations. Volatile fatty acid analysis was performed using a fused silica capillary column (Alltech Associates, Deerfield, IL) in a gas chromatograph (5890 Series II gas chromatograph, Hewlitt Packard, Analytical Group, San Fernando, CA). Ammonia determination was conducted using the phenol hypochlorite assay (Broderick and Kang, 1980) and samples were analyzed by a narrow-band spectrophotometer (Varian 634 spectrophotometer; Varian Techtron Pty. LTD., Springvale, Australia) at 630 nm. All PRL analysis was conducted at the New Mexico State University Endocrinology Laboratory using an RIA procedure (assay materials supplied by NIDDK) as described by Spoon and Hallford (1989). All samples were assayed in a single run with a coefficient of variation of 9.3%. When 25 ng of PRL was added to 1.0 mL of serum containing 15.9 ng of PRL, 40.1 ± 1.1 ng/mL was recovered (98%, n = 12).

Statistical Analyses. In Exp. 1, intake, DM digestibility, and digesta kinetics were analyzed as a randomized complete block design using the GLM procedures of SAS (1987). Individual steers were considered the experimental unit. Treatment means were separated using orthogonal polynomial contrasts comparing the concentrations of ergovaline in tall fescue straw diets. Physiological data, weekly PRL, pH, VFA, ammonia and TRH challenge PRL were analyzed as a randomized complete block design, split plot in time with respect to corresponding sampling dates or times (Steel and Torrie, 1980). Treatment and block were considered the whole-plot main effects, time and treatment × time were the subplot main effects, and treatment × block and residue error were used as the whole-plot and subplot error terms, respectively. In Exp. 2, intake, weight gain, and feed/gain ratios were analyzed as a randomized complete block design using orthogonal polynomial contrasts for

Table 2. Dry matter intake, total tract digestion, and digesta kinetics of beef steers offered tall fescue straw diets containing graded concentrations of ergovaline[a]

	Ergovaline, ppb					Contrasts, *P*-values		
Item	0	158	317	475	SEM[b]	Linear	Quadratic	Cubic
DM intake, kg/d								
Forage	6.2	5.8	5.7	6.3	.33	.97	.18	.92
Total	7.9	7.5	7.4	7.9	.32	.99	.20	.81
DM intake, % BW/d								
Forage	1.7	1.5	1.6	1.7	.09	.84	.14	.85
Total	2.1	2.0	2.0	2.2	.09	.84	.14	.86
Apparent DMD, %[c]	46.0	48.0	47.0	48.8	1.16	.19	.91	.29
Apparent ergovaline consumption								
mg/d	0	.90	1.81	3.00	—	—	—	—
μg/kg BW	0	2.48	4.88	8.09	—	—	—	—
Apparent DMD, %	46.0	48.0	47.0	48.8	1.16	.19	.91	.29
NDF digestion, %	44.0	44.0	42.8	44.3	1.35	.94	.94	.52
Digesta fill DM, kg								
0800	7.9	7.2	6.1	6.9	.38	.04	.08	.17
1400	10.8	10.2	9.3	10.1	.53	.24	.26	.42
Liquid fill, kg								
0800	54.1	55.0	49.3	50.9	2.19	.15	.86	.18
1400	71.2	72.9	67.5	66.3	3.62	.25	.69	.49
IADF fill, kg[d]								
0800	3.77	3.51	3.34	3.25	.20	.08	.67	.98
1400	4.66	4.23	3.62	4.01	.20	.02	.07	.23
IADF outflow, g/h	100	80	80	80	5	.008	.10	.73
IADF passage, %/h								
0800	2.5	2.3	2.3	2.4	.17	.68	.34	.96
1400	2.0	1.9	2.1	1.9	.11	.86	.73	.22

[a]Digesta kinetics were based on rumen evacuations just before feeding (0800) and 5 h after feeding (1400).
[b]Standard error of mean, n = 4.
[c]DMD = dry matter digestibility.
[d]IADF = indigestible acid detergent fiber.

means separated. Because steers were pen-fed, pen was considered the experimental unit.

Results and Discussion

Experiment 1, Digestion/Physiology Study. Neither straw nor total DMI was affected ($P < .10$) by alkaloid concentration of the diets; straw and total intakes averaged 6.0 kg and 7.7 kg, respectively. Total intakes on a percentage BW basis averaged 2.1% (Table 2). Apparent DM digestibility did not differ ($P > .10$) for all diets and ranged from 46 to 48.8%. Likewise, NDF digestion was not influenced by alkaloid concentration of diets ($P > .10$). These results are similar to those reported by Forcherio et al. (1992), in which energy and protein supplementation effects on digestion of endophyte-infected tall fescue hay were evaluated. They reported no differences ($P > .05$) in either hay or total DMI among the six treatments and saw similar total tract digestibility values for the four supplemented diets. Likewise, Peters et al. (1992) reported no differences in forage intake by beef cows grazing endophyte-infected and endophyte-free tall fescue pastures in June sampling periods of a 2-yr study. Intakes, estimated in August, were lower in 1 of 2 yr. It is unclear, however, whether ergovaline/alkaloids were a causative factor in decreasing intake.

Digestion Kinetics. Small differences were seen in digesta kinetics. Digesta fill for the 0800 evacuation showed a quadratic response ($P < .10$) to alkaloid concentration, with decreases in fill at the higher alkaloid concentrations (Table 2). No difference, however, was observed in DM fill ($P > .10$) for the 1400 evacuation. Indigestible ADF fill for both evacuations and IADF outflow decreased ($P < .10$) with increasing alkaloid concentrations, although passage rates were not different ($P > .10$) across treatments. This may be attributed to the physical nature of the diets rather than to differences related to alkaloid concentration, per se. Indigestible ADF contents of 'Titan' and 'Bonanza' straw were 23.4 and 28.0%, respectively. Thus, with similar DM intakes and DM fills, IADF fill and outflow changed as one variety of straw was increased at the expense of the other.

Changes in ruminal kinetics due to the presence of the endophyte have been reported previously. Goetsch et al. (1987) found a linear increase in NDF total

Table 3. Ruminal fermentation characteristics by beef steers offered tall fescue straw diets containing graded concentrations of ergovaline

Item	Ergovaline, ppb					Contrasts, P-values		
	0	158	317	475	SEM[a]	Linear	Quadratic	Cubic
pH	6.63	6.59	6.64	6.48	.03	.01	.07	.04
Ammonia, mg of NH_3 N/dL	4.8	5.1	4.7	4.5	.21	.18	.32	.36
A:P ratio[b]	4.08	4.04	4.03	3.74	.08	.02	.16	.39
Total VFA, m*M*	120.5	126.2	121.3	136.6	4.7	.06	.33	.17
Individual VFA	mol/100 mol							
Acetate	72.8	72.6	72.4	70.7	.40	.01	.12	.41
Propionate	17.9	18.0	18.0	19.0	.27	.03	.18	.46
Isobutyrate	.76	.74	.70	.59	.03	.001	.14	.71
Butyrate	7.0	7.3	7.5	8.4	.20	.001	.15	.41
Isovalerate	.63	.59	.56	.45	.04	.01	.46	.72
Valerate	.82	.77	.80	.85	.03	.30	.13	.63

[a]Standard error of mean, n = 4.
[b]Acetate:propionate ratio.

tract digestion as the percentage of endophyte-infected hay in the diet increased. In addition, they also reported linear and quadratic changes in ruminal passage rates of particulates due to increased amounts of endophyte-infected hay. Hannah and coworkers (1990) reported that ruminal and total tract OM, NDF, and cellulose digestibilities were less in diets containing 3 ppm of ergovaline than in diets containing 0 ppm of ergovaline. They also saw greater ruminal fluid dilution rates and fluid outflow due to the increased ergovaline concentration. These concentrations of ergovaline are 10-fold more concentrated than the ergovaline concentrations reported in this study. In addition, the ergovaline concentration in the previous study was derived from ergovaline associated with fungus-infected tall fescue seed, which may be more digestible than the straw fed in our experiments. Because of this, an increased amount of alkaloid may be absorbed, thus resulting in a greater impact on digestion within the rumen.

Ruminal Fermentation Characteristics. Only propionate and acetate:propionate ratio displayed significant treatment × time interactions ($P < .05$). However, the nature of these interactions did not preclude an evaluation of main effects. As a result, all ruminal fermentation characteristics are averaged across time and presented in Table 3. Ruminal pH showed a cubic response ($P < .05$), with a lower pH recorded at the high alkaloid concentration. Ammonia concentrations was not influenced by ergovaline concentration of the basal diets ($P > .10$) and averaged less than 5 mg of NH_3/dL. Ammonia concentrations less than 5 mg of NH_3/dL suggest that available N in the ruminal-reticular environment may be limiting (Satter and Slyter, 1974). Total ruminal VFA concentration tended ($P < .10$) to increase with increasing alkaloid concentrations. Specifically, the concentration of VFA was increased approximately 10% with an increase from 0 to 475 ppb of ergovaline concentration. Likewise, molar proportions of acetate, isobutyrate, and isovalerate decreased ($P < .10$), whereas propionate, acetate:propionate ratio, and butyrate increased ($P < .10$) linearly as alkaloid concentration increased in the diets.

Differences in VFA concentrations may be due to differences in diet quality rather than to alkaloid effects, per se. Increased propionate production during ruminal digestion is indicative of more efficient ruminal fermentation (Owens and Goetch, 1988). Likewise, the decreased pH and increased VFA concentrations with the increasing ergovaline concentrations indicate that the endophyte-infected straw was digested more efficiently or in greater quantity in the ruminal environment. In addition, liquid fill and digesta kinetics were not influenced by alkaloid concentrations and, as a result, are not likely involved in the observed differences in VFA concentrations or proportions. In contrast, total tract digestion was similar across the four treatments.

Physiological Response. Means for physiological constituents were averaged across time because no treatment × time interaction occurred ($P > .10$; Table 4). Heart rate, respiration rate, and rectal, tail, and ear temperatures did not differ ($P > .10$) across treatments. These results resemble findings by Hemken et al. (1981) in which no differences in DMI, rectal temperatures and respiration rates occurred when Holstein calves were fed endophyte-infected tall fescue forage at ambient temperatures below 32°C. Likewise, Ghorbani et al. (1989) also found no significant difference in daily feed intakes, rectal temperatures, respiration rates, serum PRL concentration, and ADG when they fed varying amounts of endophyte-infected tall fescue hay at environmental temperatures of 31 to 32°C (50% humidity). Osborn et al. (1992) reported similar findings when cattle

Table 4. Physiological response by beef steers offered tall fescue straw diets containing graded concentrations of ergovaline

Item	Ergovaline, ppb					Contrasts, *P*-values		
	0	158	317	475	SEM[a]	Linear	Quadratic	Cubic
Heart rate, beats/min	59.4	62.2	62.8	58.9	2.3	.93	.18	.82
Respiration rate, breaths/min	15.4	15.8	16.3	14.3	.87	.47	.22	.51
Temperature								
Rectal, °C	38.5	38.6	38.4	38.5	.06	.24	.60	.13
Tail head, °C	35.8	35.8	36.1	35.3	.20	.23	.11	.16
Inner ear, °C	25.8	26.2	27.1	27.7	.91	.15	.93	.87
Weekly prolactin, ng/mL	15.4	18.8	6.7	5.5	5.0	.09	.66	.27
TRH-challenge prolactin, ng/mL	8.14	23.0	11.4	6.3	6.0	.54	.13	.25

[a]Standard error of mean, n = 4.

consumed an endophyte-infected fescue diet at temperatures of 21°C. However, at temperatures of 32°C, they found that animals fed either endophyte-infected fescue or a fungus-free fescue diet mixed with 30 ppm of ergotamine tartrate exhibited symptoms of fescue toxicosis: feed intakes, heart rates, and infrared temperatures of the ear canal, pastern, coronary band, and tail tip all decreased and rectal temperatures and respiration rates were elevated.

Weekly PRL tended to decrease linearly ($P < .10$) across treatments as ergovaline increased in the diet. Goetsch and coworkers (1987) reported a linear decrease in PRL when they fed increasing endophyte-infected fescue hay to growing dairy steers. The magnitude of change in their study was similar to those in this study; PRL were 15, 11.2, .1, .8, and 0 ng/mL for 0, 25, 50, 75, and 100% infected fescue hay, respectively. However, at high endophyte infection, Goetsch et al. (1987) reported no detectable circulating PRL, contrary to this study, which showed measurable circulating PRL.

Prolactin concentrations reported in this study are lower than others reported for beef cattle in the literature. This can be attributed to reduced or minimal ambient temperatures and a shortened daily photoperiod, which occurs during winter, causing a decrease in PRL concentration in ruminants. In spring and summer, increases in temperature and photoperiod increase serum PRL concentration (Peters and Tucker, 1978). The PRL concentrations in this study, however, are comparable to serum PRL concentrations reported for steers in cooler environments. Smith and coworkers (1977), investigating the effect of altering ambient temperatures on serum PRL, measured PRL at 4.6 ng/mL at 4°C in Hereford steers. In addition, they also discovered that PRL recovered slowly as temperature was elevated. After 60 min at 18°C, serum PRL only averaged 5.2 ng/mL in these steers.

All the steers in this study responded to the TRH challenge ($P < .05$). The magnitude of response, however, did not differ ($P > .10$) across treatments (Figure 1). Maximum temperature for both days of TRH challenge was 13.3°C, well within the thermoneutral zone of cattle. The greatest concentration of PRL (34.3 ng of PRL/mL) occurred 30 min after the administration of TRH, after which time PRL returned toward baseline values.

Suppressed or reduced TRH-stimulated PRL concentrations have been reported in animals consuming high-endophyte diets. Thompson and coworkers (1987), investigating the effects of high-endophyte fescue on serum PRL throughout a grazing season, reported that both basal and TRH-stimulated PRL were decreased in yearling Angus steers. Lipham et al. (1989) also found similar results for basal and TRH-induced PRL in yearling Angus steers grazing high-endophyte fescue compared with those grazing endophyte-free fescue. Hurley et al. (1981) reported reduced basal PRL concentrations in steers feed GI-307 at three temperature ranges tested, including temperatures of 10 to 13°C. It was suggested that the toxic components of toxic fescue (GI-307) were active at all temperatures, not just in instances of warmer temperatures. Upon TRH administration, PRL releases were affected by both temperature and forage; the steers consuming the GI-307 fescue had lower PRL at all three temperature ranges tested (low 10 to 13°C, medium 21 to 23°C and high 34 to 35°C). In contrast, Hohenboken and coworkers (1991) reported a tendency for PRL suppression to occur after administering TRH to cows on fescue seed diets, but this response was sensitive to ambient temperatures.

Experiment 2, Performance Study. Forage and total DMI tended ($P < .10$) to increase with decreasing alkaloid (Table 5). However, steer weight gains and gain/feed ratios did not differ ($P > .10$), averaging 14.0 kg and .030, respectively. Because weight gains and feed efficiencies were similar across treatments, the differences in intake may be attributed to palatability differences due to the presence of alfalfa hay in the 'Bonanza' straw. No adverse health effects were

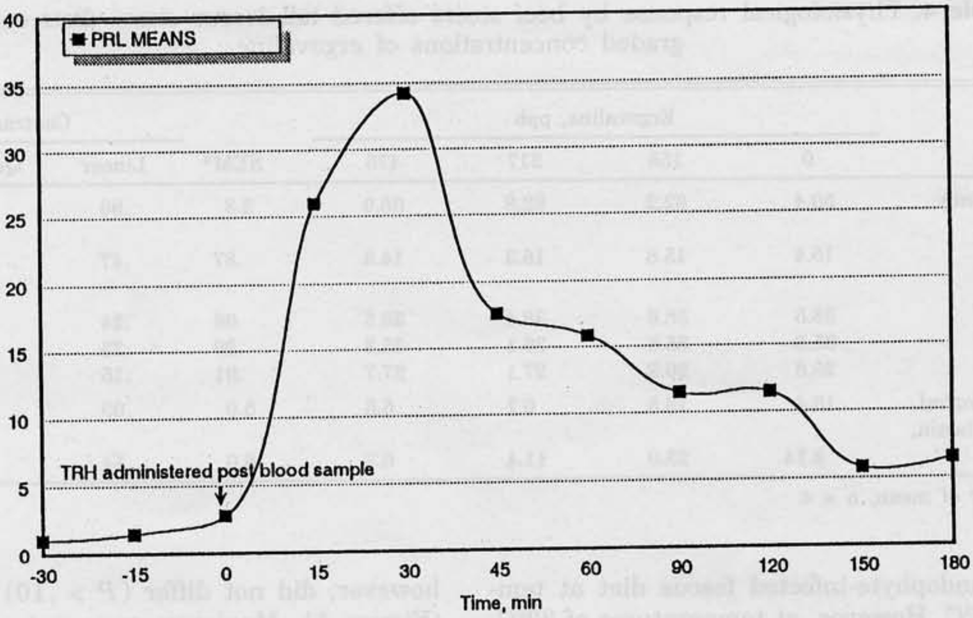

Figure 1. Thyrotropin-releasing hormone (TRH)-stimulated prolactin (PRL) response curve in beef steers consuming graded concentrations of ergovaline in tall fescue straw diets. No treatment or treatment × time interaction effects were observed ($P > .10$).

seen during the performance trial, even though steers fed 100% 'Titan' straw consumed 2 mg of ergovaline/d. On a kilogram of BW basis, these steers were consuming 9.10 μg of ergovaline/kg of BW per day. This value is similar to the amount of ergovaline consumed by mature cows in the study conducted by Peters et al. (1992) in which cows were consuming 8.5 μg of ergovaline/kg of BW and 11.7 μg of ergovaline/kg of BW on a daily basis for 1988 and 1989, respectively.

Absence of negative effects in feeding high-endophyte fescue in these studies may be due to lack of environmental stress and(or) to the physical composition of the straw. Both trials were conducted at average ambient maximum temperatures of 9°C in an arid environment. Hannah et al. (1990) reported no differences in intake and ruminal kinetics when diets containing levels of ergovaline up to 20 ppm were offered at lower ambient temperatures and humidity. Likewise, Peters et al. (1992) reported only minor differences in OM intakes during their 2-yr study in which temperatures near 32°C occurred, although the cows were consuming ergovaline in amounts between 4.2 and 6.0 mg/d for yr 1 and 2, respectively. However, Peters et al. (1992) did observe decreases in cow and calf gains on endophyte-infected tall fescue pasture. Their study used a more digestible feedstuff (pasture forage), which may have increased the chances of observing reduced performance and(or) other associated problems. Straw, which is more fibrous, has a longer retention time in the rumen and is not as digestible as seeds and(or) forages, which produce classical symptoms of fescue syndrome and(or)

Table 5. Performance data by beef steers offered tall fescue diets containing graded concentrations of ergovaline

	Ergovaline, ppb					Contrasts, P-values		
Item	0	158	317	475	SEM[a]	Linear	Quadratic	Cubic
Dry Matter intake, kg/d								
Straw	4.8	4.3	4.3	4.2	.18	.07	.34	.68
Total	5.8	5.4	5.3	5.3	.08	.08	.35	.68
Ergovaline intake								
mg/d	0	.68	1.36	2.00	—	—		
μg/kg BW	0	3.09	6.20	9.07	—	—		
Weight gain, kg	14.4	13.1	12.9	14.5	.98	.98	.50	.94
Gain/feed ratio	.030	.028	.029	.033	.007	.93	.61	.61

[a]Standard error of mean, n = 3.

reduced performance. Thus, although straw may have concentrations of alkaloids similar to these feeds, decreased intake, digestion, and subsequent host animal absorption of alkaloids may be lower, reducing the risk of toxicity problems or reduced gains.

Implications

Under the conditions of these studies, the endophyte-produced alkaloids associated with tall fescue straw did not cause fescue toxicosis, health problems, or reductions in animal performance. Dry matter intakes and digestive efficiencies were similar across treatments. Circulating prolactin concentrations, however, were decreased with endophyte-infected straw diets, indicating a possible subclinical effect. Further research is needed to evaluate the effects of endophyte-infected straw diets on late gestating and lactating beef cattle. Therefore, these studies suggest that properly supplemented low-quality straws containing up to 475 ppb of ergovaline can be fed in winter feeding programs for growing and early- to mid-gestating cows without decreasing animal health, nutrition, or performance.

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